Kentucky High School Athletic Association

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KENTUCKY MEDICAL ASSOCIATION / KENTUCKY HIGH SCHOOL ATHLETIC ASSOCIATION PROCEDURE FOR AVOIDING HEAT INJURY / ILLNESS THROUGH ANALYSIS OF HEAT INDEX AND RESTRUCTURING OF ACTIVITIES

Complete listing of support documents available at http://www.khsaa.org/sportsmedicine/

Original Procedure Made by the Kentucky Medical Association Committee on Physical Education and Medical Aspects of Sports to and for the Kentucky High School Athletic Association and adopted by the KHSAA Board of Control as recommendation for all schools, May, 2002
On site Procedures Revised by KHSAA Board of Control, February 13, 2003
On site procedures further Revised and Made Mandatory for all schools by the KHSAA Board of Control, May, 2005
On site procedures further revised with respect to testing instruments, March, 2007

INTRODUCTION

Following months of study, after one year of implementation and in an effort to help protect the health and safety of student-athletes participating in high school sports, the Kentucky Medical Association Committee on Physical Education and Medical Aspects of Sports issued a recommended procedure to the Kentucky High School Athletic Association for immediate implementation in 2002. This procedure called for the determination of the Heat Index (using on site devices to measure Temperature and Relative Humidity), and a guideline for activity to be conducted at that time based on the Heat Index reading. Though other procedures and measurements were considered, the application of the Heat Index appeared to be most readily implementable on a state wide basis, and appeared to be reliably tested in other areas.

Through the first five years of use of the procedure, minor adjustments were made in the reporting requirements, and the on site devices to be used. In May, 2005, the Board of Control through its policies directed that all member school comply with the testing and reporting requirements. In October, 2006, the member schools of the Association overwhelming approved at their Annual Meeting, a proposal to make such reporting not simply a Board of Control policy, but a school supported and approved Bylaw as it approved Proposal 9 to amend KHSAA Bylaw 17 (full details are available at
http://www.khsaa.org/annualmeeting/20062007/annualmeetingproposals20062007.pdf)

In March, 2007, the Kentucky Medical Association Committee on Physical Education and Medical Aspects of Sports recommended the elimination of all devices with the exception of the Digital Sling Psychrometer as a means of measuring at the competition/practice site.

GENERAL PROCEDURE

The procedure calls for the determination of the Temperature and Relative Humidity at the practice / contest site using a Digital Sling psychrometer It is important to note that media-related temperature readings (such as the Weather Channel, local radio, etc.), or even other readings in the general proximity are not permitted as they may not yield defensible results when considering the recommended scale. The readings must be made at the site.
Neither the KHSAA nor KMA has endorsed any particular brand of psychrometer and receives no endorsement fee or other consideration for any device sold. There are several models on the market that will properly perform the functions, including companies such as Medco and others. The KHSAA or your local Certified Athletic Trainer has easy access to catalogs with this type of equipment. In addition, the KHSAA web site has a variety of links to various dealers.

INDOOR AND OUTDOOR VENUES

While much of the original discussion concerning this package centered on outdoor sports, the Kentucky Medical Association Committee on Physical Education and Medical Aspects of Sports has advised the KHSAA that indoor sports, particularly in times of year or facilities where air conditioning may not be available, should be included in the testing. Such has been approved by the Board of Control as policy requirement. The recommendations contained in this package clearly cover both indoor and outdoor activity, as well as contact and non-contact sports.

PROCEDURE FOR TESTING

Thirty (30) minutes prior to the start of activity, temperature and humidity readings should be taken at the practice / competition site.

The information should be recorded on KHSAA Form GE20 and these records shall be available for inspection upon request. All schools will be required to submit this form. For 2007, there will be online reporting for submitting this form.

The temperature and humidity should be factored into the Heat Index Calculation and Chart and a determination made as to the Heat Index. If schools are utilizing a digital sling psychrometer that calculates the Heat Index, that number may be used to apply to the regulation table.

If a reading is determined whereby activity is to be decreased (above 95 degrees Heat Index), then re-readings would be required every thirty (30) minutes to determine if further activity should be eliminated or preventative steps taken, or if an increased level of activity can resume.

Using the following scale, activity must be altered and / or eliminated based on this Heat Index as determined –

Under 95 degrees Heat Index	❖ All sports ➢ Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire. ➢ Optional water breaks every 30 minutes for 10 minutes in duration ➢ Ice-down towels for cooling ➢ Watch/monitor athletes carefully for necessary action.
95 degrees to 99 degrees Heat Index	❖ All sports ➢ Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire. ➢ Mandatory water breaks every 30 minutes for 10 minutes in duration ➢ Ice-down towels for cooling ➢ Watch/monitor athletes carefully for necessary action. ❖ Contact sports and activities with additional equipment ➢ Helmets and other possible equipment removed while not involved in contact. ❖ Reduce time of outside activity. Consider postponing practice to later in the day. ❖ Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.
100 degrees to 104 degrees Heat Index	❖ All sports ➢ Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire. ➢ Mandatory water breaks every 30 minutes for 10 minutes in duration ➢ Ice-down towels for cooling ➢ Watch/monitor athletes carefully for necessary action. ➢ Alter uniform by removing items if possible ➢ Allow for changes to dry t-shirts and shorts. ➢ Reduce time of outside activity as well as indoor activity if air conditioning is unavailable. ➢ Postpone practice to later in day. ❖ Contact sports and activities with additional equipment ➢ Helmets and other possible equipment removed if not involved in contact or necessary for safety. If necessary for safety, suspend activity. ❖ Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.
Above 104 degrees Heat Index	❖ All Sports ➢ Stop all outside activity in practice and/or play, and stop all inside activity if air conditioning is unavailable.

This procedure is to be used until such time as the temperature is below 80 degrees as no combination of heat and humidity at that level will result in a need to curtail activity. The KHSAA will use September 15 as the standard date for the return of the Heat Index forms but reminds its member schools that the monitoring shall continue until such a time that no combination of heat and humidity at that level will result in a need to curtail activity.

SUMMARY

Though much more scientific information and other alternative methods for determining Heat Index and participation restrictions are being studied, these initial steps should help ensure the health and safety of the participants in high school sports. Adherence to these guidelines represents a conscious effort by the interscholastic community to emphasize health and safety on a much higher level than any loss of competitive preparation. Any further revisions or enhancements will be distributed to the members of the KHSAA.

Heat Index Calculation and Chart

Temperature (In Fahrenheit)

Relative Humidity at Site	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
100	84	87	91	95	99	103	107	112	116	121	126	132	137	143	149	155	161	168	174	181	188
99	84	87	91	94	98	102	106	111	116	120	125	131	136	142	147	153	160	166	172	179	186
98	84	87	90	94	98	102	106	110	115	120	124	130	135	140	146	152	158	164	171	177	184
97	84	87	90	94	97	101	105	110	114	119	124	129	134	139	145	151	157	163	169	176	182
96	83	87	90	93	97	101	105	109	113	118	123	128	133	138	144	149	155	161	167	174	180
95	83	86	90	93	97	100	104	108	113	117	122	127	132	137	142	148	154	160	166	172	179
94	83	86	89	93	96	100	104	108	112	116	121	126	131	136	141	147	152	158	164	170	177
93	83	86	89	92	96	99	103	107	111	116	120	125	130	135	140	145	151	157	162	169	175
92	83	86	89	92	95	99	103	106	111	115	119	124	129	133	139	144	149	155	161	167	173
91	83	86	89	92	95	98	102	106	110	114	118	123	127	132	137	143	148	154	159	165	171
90	83	86	88	91	95	98	102	105	109	113	117	122	126	131	136	141	147	152	158	164	170
89	83	85	88	91	94	98	101	105	109	113	117	121	125	130	135	140	145	151	156	162	168
88	83	85	88	91	94	97	101	104	108	112	116	120	125	129	134	139	144	149	155	160	166
87	83	85	88	91	94	97	100	104	107	111	115	119	124	128	133	138	143	148	153	159	164
86	83	85	88	90	93	96	100	103	107	110	114	118	123	127	132	136	141	146	152	157	163
85	83	85	87	90	93	96	99	102	106	110	113	117	122	126	130	135	140	145	150	155	161
84	82	85	87	90	93	96	99	102	105	109	113	117	121	125	129	134	139	144	149	154	159
83	82	85	87	90	92	95	98	101	105	108	112	116	120	124	128	133	137	142	147	152	158
82	82	85	87	89	92	95	98	101	104	108	111	115	119	123	127	132	136	141	146	151	156
81	82	84	87	89	92	94	97	100	104	107	110	114	118	122	126	131	135	140	144	149	155
80	82	84	86	89	91	94	97	100	103	106	110	113	117	121	125	129	134	138	143	148	153
79	82	84	86	89	91	94	96	99	102	106	109	113	116	120	124	128	133	137	142	146	151
78	82	84	86	88	91	93	96	99	102	105	108	112	115	119	123	127	131	136	140	145	150
77	82	84	86	88	90	93	96	98	101	104	108	111	115	118	122	126	130	135	139	144	148
76	82	84	86	88	90	93	95	98	101	104	107	110	114	117	121	125	129	133	138	142	147
75	82	84	85	88	90	92	95	97	100	103	106	109	113	116	120	124	128	132	136	141	145
74	82	83	85	87	89	92	94	97	100	103	106	109	112	116	119	123	127	131	135	140	144
73	82	83	85	87	89	91	94	96	99	102	105	108	111	115	118	122	126	130	134	138	143
72	82	83	85	87	89	91	93	96	99	101	104	107	111	114	117	121	125	129	133	137	141
71	81	83	85	87	89	91	93	96	98	101	104	107	110	113	116	120	124	127	131	136	140
70	81	83	85	86	88	90	93	95	98	100	103	106	109	112	116	119	123	126	130	134	138
69	81	83	84	86	88	90	92	95	97	100	102	105	108	111	115	118	122	125	129	133	137
68	81	83	84	86	88	90	92	94	97	99	102	105	108	111	114	117	121	124	128	132	136
67	81	83	84	86	88	90	92	94	96	99	101	104	107	110	113	116	120	123	127	131	135
66	81	82	84	86	87	89	91	93	96	98	101	103	106	109	112	115	119	122	126	129	133
65	81	82	84	85	87	89	91	93	95	98	100	103	105	108	111	114	118	121	125	128	132
64	81	82	84	85	87	89	91	93	95	97	99	102	105	108	110	114	117	120	123	127	131
63	81	82	84	85	87	88	90	92	94	97	99	101	104	107	110	113	116	119	122	126	130
62	81	82	83	85	86	88	90	92	94	96	98	101	103	106	109	112	115	118	121	125	128
61	81	82	83	85	86	88	90	91	93	96	98	100	103	105	108	111	114	117	120	124	127
60	81	82	83	84	86	88	89	91	93	95	97	100	102	105	107	110	113	116	119	123	126
59	81	82	83	84	86	87	89	91	93	95	97	99	102	104	107	109	112	115	118	122	125
58	81	82	83	84	85	87	89	90	92	94	96	99	101	103	106	109	111	114	117	120	124
57	80	81	83	84	85	87	88	90	92	94	96	98	100	103	105	108	111	113	116	119	123
56	80	81	83	84	85	86	88	90	92	93	95	98	100	102	105	107	110	113	115	118	122
55	80	81	82	84	85	86	88	89	91	93	95	97	99	101	104	106	109	112	114	117	120
54	80	81	82	83	85	86	87	89	91	93	94	96	99	101	103	106	108	111	114	116	119
53	80	81	82	83	84	86	87	89	90	92	94	96	98	100	103	105	107	110	113	116	118
52	80	81	82	83	84	86	87	88	90	92	94	96	98	100	102	104	107	109	112	115	117
51	80	81	82	83	84	85	87	88	90	91	93	95	97	99	101	104	106	108	111	114	116
50	80	81	82	83	84	85	86	88	89	91	93	95	97	99	101	103	105	108	110	113	115
49	80	81	82	83	84	85	86	88	89	91	92	94	96	98	100	102	105	107	109	112	115
48	80	81	81	82	84	85	86	87	89	90	92	94	96	97	100	102	104	106	109	111	114
47	80	81	81	82	83	85	86	87	88	90	92	93	95	97	99	101	103	105	108	110	113
46	80	80	81	82	83	84	86	87	88	90	91	93	95	96	98	100	103	105	107	109	112
45	80	80	81	82	83	84	85	87	88	89	91	92	94	96	98	100	102	104	106	109	111
44	80	80	81	82	83	84	85	86	88	89	91	92	94	96	97	99	101	103	106	108	110
43	79	80	81	82	83	84	85	86	87	89	90	92	93	95	97	99	101	103	105	107	109
42	79	80	81	82	83	84	85	86	87	88	90	91	93	95	96	98	100	102	104	106	109
41	79	80	81	82	82	83	85	86	87	88	90	91	93	94	96	98	100	101	104	106	108
40	79	80	81	81	82	83	84	85	87	88	89	91	92	94	95	97	99	101	103	105	107

Under 95 degrees Heat Index

- All sports
  - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire.
  - Optional water breaks every 30 minutes for 10 minutes in duration
  - Ice-down towels for cooling
  - Watch/monitor athletes carefully for necessary action.

95 degrees to 99 degrees Heat Index

- All sports
  - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire.
  - Mandatory water breaks every 30 minutes for 10 minutes in duration
  - Ice-down towels for cooling
  - Watch/monitor athletes carefully for necessary action.
- Contact sports and activities with additional equipment
  - Helmets and other possible equipment removed if not involved in contact.
- Reduce time of outside activity. Consider postponing practice to later in the day.
- Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.

100 degrees to 104 degrees Heat Index

- All sports
  - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire.
  - Mandatory water breaks every 30 minutes for 10 minutes in duration
  - Ice-down towels for cooling
  - Watch/monitor athletes carefully for necessary action.
  - Alter uniform by removing items if possible
  - Allow for changes to dry t-shirts and shorts.
  - Reduce time of outside activity as well as indoor activity if air conditioning is unavailable.
  - Postpone practice to later in day.
- Contact sports and activities with additional equipment
  - Helmets and other possible equipment removed if not involved in contact or necessary for safety. If necessary for safety, suspend activity.
- Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.

Above 104 degrees Heat Index

- All Sports
  - Stop all outside activity in practice and/or play, and stop all inside activity if air conditioning is unavailable.

Heat Index Calculation and Chart

Temperature (In Fahrenheit)

Relative Humidity at Site

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
100	84	87	91	95	99	103	107	112	116	121	126	132	137	143	149	155	161	168	174	181	188
99	84	87	91	94	98	102	106	111	116	120	125	131	136	142	147	153	160	166	172	179	186
98	84	87	90	94	98	102	106	110	115	120	124	130	135	140	146	152	158	164	171	177	184
97	84	87	90	94	97	101	105	110	114	119	124	129	134	139	145	151	157	163	169	176	182
96	83	87	90	93	97	101	105	109	113	118	123	128	133	138	144	149	155	161	167	174	180
95	83	86	90	93	97	100	104	108	113	117	122	127	132	137	142	148	154	160	166	172	179
94	83	86	89	93	96	100	104	108	112	116	121	126	131	136	141	147	152	158	164	170	177
93	83	86	89	92	96	99	103	107	111	116	120	125	130	135	140	145	151	157	162	169	175
92	83	86	89	92	95	99	103	106	111	115	119	124	129	133	139	144	149	155	161	167	173
91	83	86	89	92	95	98	102	106	110	114	118	123	127	132	137	143	148	154	159	165	171
90	83	86	88	91	95	98	102	105	109	113	117	122	126	131	136	141	147	152	158	164	170
89	83	85	88	91	94	98	101	105	109	113	117	121	125	130	135	140	145	151	156	162	168
88	83	85	88	91	94	97	101	104	108	112	116	120	125	129	134	139	144	149	155	160	166
87	83	85	88	91	94	97	100	104	107	111	115	119	124	128	133	138	143	148	153	159	164
86	83	85	88	90	93	96	100	103	107	110	114	118	123	127	132	136	141	146	152	157	163
85	83	85	87	90	93	96	99	102	106	110	113	117	122	126	130	135	140	145	150	155	161
84	82	85	87	90	93	96	99	102	105	109	113	117	121	125	129	134	139	144	149	154	159
83	82	85	87	90	92	95	98	101	105	108	112	116	120	124	128	133	137	142	147	152	158
82	82	85	87	89	92	95	98	101	104	108	111	115	119	123	127	132	136	141	146	151	156
81	82	84	87	89	92	94	97	100	104	107	110	114	118	122	126	131	135	140	144	149	155
80	82	84	86	89	91	94	97	100	103	106	110	113	117	121	125	129	134	138	143	148	153
79	82	84	86	89	91	94	96	99	102	106	109	113	116	120	124	128	133	137	142	146	151
78	82	84	86	88	91	93	96	99	102	105	108	112	115	119	123	127	131	136	140	145	150
77	82	84	86	88	90	93	96	98	101	104	108	111	115	118	122	126	130	135	139	144	148
76	82	84	86	88	90	93	95	98	101	104	107	110	114	117	121	125	129	133	138	142	147
75	82	84	85	88	90	92	95	97	100	103	106	109	113	116	120	124	128	132	136	141	145
74	82	83	85	87	89	92	94	97	100	103	106	109	112	116	119	123	127	131	135	140	144
73	82	83	85	87	89	91	94	96	99	102	105	108	111	115	118	122	126	130	134	138	143
72	82	83	85	87	89	91	93	96	99	101	104	107	111	114	117	121	125	129	133	137	141
71	81	83	85	87	89	91	93	96	98	101	104	107	110	113	116	120	124	127	131	136	140
70	81	83	85	86	88	90	93	95	98	100	103	106	109	112	116	119	123	126	130	134	138
69	81	83	84	86	88	90	92	95	97	100	102	105	108	111	115	118	122	125	129	133	137
68	81	83	84	86	88	90	92	94	97	99	102	105	108	111	114	117	121	124	128	132	136
67	81	83	84	86	88	90	92	94	96	99	101	104	107	110	113	116	120	123	127	131	135
66	81	82	84	86	87	89	91	93	96	98	101	103	106	109	112	115	119	122	126	129	133
65	81	82	84	85	87	89	91	93	95	98	100	103	105	108	111	114	118	121	125	128	132
64	81	82	84	85	87	89	91	93	95	97	99	102	105	108	110	114	117	120	123	127	131
63	81	82	84	85	87	88	90	92	94	97	99	101	104	107	110	113	116	119	122	126	130
62	81	82	83	85	86	88	90	92	94	96	98	101	103	106	109	112	115	118	121	125	128
61	81	82	83	85	86	88	90	91	93	96	98	100	103	105	108	111	114	117	120	124	127
60	81	82	83	84	86	88	89	91	93	95	97	100	102	105	107	110	113	116	119	123	126
59	81	82	83	84	86	87	89	91	93	95	97	99	102	104	107	109	112	115	118	122	125
58	81	82	83	84	85	87	89	90	92	94	96	99	101	103	106	109	111	114	117	120	124
57	80	81	83	84	85	87	88	90	92	94	96	98	100	103	105	108	111	113	116	119	123
56	80	81	83	84	85	86	88	90	92	93	95	98	100	102	105	107	110	113	115	118	122
55	80	81	82	84	85	86	88	89	91	93	95	97	99	101	104	106	109	112	114	117	120
54	80	81	82	83	85	86	87	89	91	93	94	96	99	101	103	106	108	111	114	116	119
53	80	81	82	83	84	86	87	89	90	92	94	96	98	100	103	105	107	110	113	116	118
52	80	81	82	83	84	86	87	88	90	92	94	96	98	100	102	104	107	109	112	115	117
51	80	81	82	83	84	85	87	88	90	91	93	95	97	99	101	104	106	108	111	114	116
50	80	81	82	83	84	85	86	88	89	91	93	95	97	99	101	103	105	108	110	113	115
49	80	81	82	83	84	85	86	88	89	91	92	94	96	98	100	102	105	107	109	112	115
48	80	81	81	82	84	85	86	87	89	90	92	94	96	97	100	102	104	106	109	111	114
47	80	81	81	82	83	85	86	87	88	90	92	93	95	97	99	101	103	105	108	110	113
46	80	80	81	82	83	84	86	87	88	90	91	93	95	96	98	100	103	105	107	109	112
45	80	80	81	82	83	84	85	87	88	89	91	92	94	96	98	100	102	104	106	109	111
44	80	80	81	82	83	84	85	86	88	89	91	92	94	96	97	99	101	103	106	108	110
43	79	80	81	82	83	84	85	86	87	89	90	92	93	95	97	99	101	103	105	107	109
42	79	80	81	82	83	84	85	86	87	88	90	91	93	95	96	98	100	102	104	106	109
41	79	80	81	82	82	83	85	86	87	88	90	91	93	94	96	98	100	101	104	106	108
40	79	80	81	81	82	83	84	85	87	88	89	91	92	94	95	97	99	101	103	105	107

Under 95 degrees Heat Index

- All sports
  - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire.
  - Optional water breaks every 30 minutes for 10 minutes in duration
  - Ice-down towels for cooling
  - Watch/monitor athletes carefully for necessary action.

95 degrees to 99 degrees Heat Index

- All sports
  - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire.
  - Mandatory water breaks every 30 minutes for 10 minutes in duration
  - Ice-down towels for cooling
  - Watch/monitor athletes carefully for necessary action.
- Contact sports and activities with additional equipment
  - Helmets and other possible equipment removed if not involved in contact.
- Reduce time of outside activity. Consider postponing practice to later in the day.
- Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.

100 degrees to 104 degrees Heat Index

- All sports
  - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire.
  - Mandatory water breaks every 30 minutes for 10 minutes in duration
  - Ice-down towels for cooling
  - Watch/monitor athletes carefully for necessary action.
  - Alter uniform by removing items if possible
  - Allow for changes to dry t-shirts and shorts.
  - Reduce time of outside activity as well as indoor activity if air conditioning is unavailable.
  - Postpone practice to later in day.
- Contact sports and activities with additional equipment
  - Helmets and other possible equipment removed if not involved in contact or necessary for safety. If necessary for safety, suspend activity.
- Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.

Above 104 degrees Heat Index

- All Sports
  - Stop all outside activity in practice and/or play, and stop all inside activity if air conditioning is unavailable.

KENTUCKY HIGH SCHOOL ATHLETIC ASSOCIATION
HEAT INDEX MEASUREMENT AND RECORD

School: ______________________________

Sport: ______________________________

DATE	TIME	TEMP	HUMIDITY	HEAT INDEX (from chart)	ACTIVITY REVISION??	SIGNATURE

Using the following scale, activity should be altered and / or eliminated based on this Heat Index as determined –

Under 95 degrees Heat Index	Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire. Optional water breaks every 30 minutes for 10 minutes in duration. Ice-down towels for cooling . Watch/monitor athletes carefully for necessary action.
95 degrees to 99 degrees Heat Index	Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire. Mandatory water breaks every 30 minutes for 10 minutes in duration. Ice-down towels for cooling. Watch/monitor athletes carefully for necessary action. Contact sports and activities with additional equipment. Helmets and other possible equipment removed if not involved in contact. Reduce time of outside activity. Consider postponing practice to later in the day. Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.
100 degrees to 104 degrees Heat Index	All sports - Provide ample amounts of water. This means that water should always be available and athletes should be able to take in as much water as they desire. Mandatory water breaks every 30 minutes for 10 minutes in duration. Ice-down towels for cooling. Watch/monitor athletes carefully for necessary action. Alter uniform by removing items if possible. Allow for changes to dry t-shirts and shorts. Reduce time of outside activity as well as indoor activity if air conditioning is unavailable. Postpone practice to later in day. Contact sports and activities with additional equipment. Helmets and other possible equipment removed if not involved in contact or necessary for safety. If necessary for safety, suspend activity. Re-check temperature and humidity every 30 minutes to monitor for increased Heat Index.
Above 104 degrees Heat Index	Stop all outside activity in practice and/or play, and stop all inside activity if air conditioning is unavailable.

National Federation
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Heat Stress and Athletic Participatic

Early fall football, cross country, soccer and field hockey practices are conduct very hot and humid weather in many parts of the United States. Due to the equi and uniform needed in football, most of the heat problems have been associatec football. From 1995 through the 2000 football season there have been 14 high heat stroke deaths in football. This is not acceptable. There are no excuses for heatstroke deaths, if the proper precautions are taken. During hot weather condi the athlete is subject to the following:

HEAT CRAMPS – Painful cramps involving abdominal muscles and extremiti caused by intense, prolonged exercise in the heat and depletion of salt and wate profuse sweating.

HEAT SYNCOPE – Weakness fatigue and fainting due to loss of salt and wat sweat and exercise in the heat. Predisposes to heat stroke.

HEAT EXHAUSTION (WATER DEPLETION) – Excessive weight loss, re sweating, elevated skin and core body temperature, excessive thirst, weakness, headache and sometimes unconsciousness.

HEAT EXHAUSTION (SALT DEPLETION) – Exhaustion, nausea, vomitin muscle cramps, and dizziness due to profuse sweating and inadequate replacem body salts.

HEAT STROKE – An acute medical emergency related to thermoregulatory f Associated with nausea, seizures, disorientation, and possible unconsciousness coma. It may occur suddenly without being preceded by any other clinical signs individual is usually unconscious with a high body temperature and a hot dry sk stroke victims, contrary to popular belief, may sweat profusely).

It is believed that the above-mentioned heat stress problems can be controlled p certain precautions are taken. According to the American Academy of Pediatric Committee on Sports Medicine, heat related illnesses are all preventable.(Spor Medicine: Health Care for Young Athletes, American Academy of Pediatrics, J 2000). The following practices and precautions are recommended:

1. Each athlete should have a physical examination with a medical history wl entering a program and an annual health history update. History of previous hea illness and type of training activities before organized practice begins should be included. State High School Associations recommendations should be followed

2. It is clear that top physical performance can only be achieved by an athlete in top physical condition. Lack of physical fitness impairs the performance of a athlete who participates in high temperatures. Coaches should know the **PHYS CONDITION** of their athletes and set practice schedules accordingly.

3. Along with physical conditioning the factor of acclimatization to heat is important. Acclimatization is the process of becoming adjusted to heat and it is essential to provide for **GRADUAL ACCLIMATIZATION TO HOT WEAT** It is necessary for an athlete to exercise in the heat if he/she is to become acclin to it. It is suggested that a graduated physical conditioning program be used anc 80% acclimatization can be expected to occur after the first 7-10 days. Final sta acclimatization to heat are marked by increased sweating and reduced salt concentration in the sweat.

4. The old idea that water should be withheld from athletes during workouts has **SCIENTIFIC FOUNDATION**. The most important safeguard to the health of athlete is the replacement of water. Water must be on the field and readily avail the athletes at all times. It is recommended that a minimum 10-minute water bre scheduled for every half hour of heavy exercise in the heat. Athletes should rest shaded area during the break. **WATER SHOULD BE AVAILABLE IN UNLIMITED QUANTITIES**.

5. Check and be sure athletes are drinking the water. Replacement by thirst alc inadequate. Test the air prior to practice or game using a wet bulb, globe, tempe index (WBGT index) which is based on the combined effects of air temperature relative humidity, radiant heat and air movement. The following precautions are recommended when using the WBGT Index: (ACSM's Guidelines for the Team Physician, 1991)

Below 64 – Unlimited activity

65-72 – Moderate risk

74-82 – High risk

82 plus – Very high risk

6. There is also a weather guide for activities that last 30 minutes or more (Fo Mathews, 1981) which involves know the relative humidity and air temperature

AIR TEMP	DANGER ZONE	CRITICAL ZONE
70 F	80% RH	100% RH
75 F	70% RH	100% RH
80 F	50% RH	80% RH
85 F	40% RH	68% RH
90 F	30% RH	55% RH
95 F	20% RH	40% RH
100 F	10% RH	30% RH

RH = RELATIVE HUMIDITY

One other method of measuring the relative humidity is the use of a sling psychrometer, which measures wet bulb temperature. The wet bulb temperature be measured prior to practice and the intensity and duration of practice adjusted accordingly. Recommendations are as follows:

Under 60 F …………………. Safe but always observe athletes

61-65 F …………………….. Observe players carefully

66-70 F …………………….. Caution

71-75 F …………………….. Shorter practice sessions and more frequent wate ……………………………….and rest breaks

75 plus F …………………… Danger level and extreme caution

7. Cooling by evaporation is proportional to the area of the skin exposed. In extremely hot and humid weather reduce the amount of clothing covering the b much as possible. NEVER USE RUBBERIZED CLOTHING.

8. Athletes should weigh each day before and after practice and WEIGHT CH CHECKED. Generally a 3 percent weight loss through sweating is safe and ove percent weight loss is in the danger zone. Over a 3 percent weight loss the athle should not be allowed to practice in hot and humid conditions. Observe the athl closely under all conditions. Do not allow athletes to practice until they have adequately replaced their weight.

9. Observe athletes carefully for signs of trouble, particularly athletes who los significant weight and the eager athlete who constantly competes at his/her cap Some trouble signs are nausea, incoherence, fatigue, weakness, vomiting, cram weak rapid pulse, visual disturbance and unsteadiness.

10. Teams that encounter hot weather during the season through travel or follo unseasonably cool period, should be physically fit but will not be environmenta Coaches in this situation should follow the above recommendations and substit more frequently during games.

11. Know what to do in case of an emergency and have your emergency plans with copies to all your staff. Be familiar with immediate first aid practice and prearranged procedures for obtaining medical care, including ambulance servic

HEAT STROKE – *THIS IS A MEDICAL EMERGENCY* – DEL COULD BE FATAL. Immediately cool body while waiting for transfer to a hospital. Remove clothing and place ice bags on the neck, in the axilla (armpit) the groin areas. Fan athlete and spray with cold water to enhance evaporation.

HEAT EXHAUSTION – *OBTAIN MEDICAL CARE AT ONCE*. Cool body would for heat stroke while waiting for transfer to hospital. Give fluids if athlet to swallow and is conscious.

SUMMARY – The main problem associated with exercising in the hot weathe water loss through sweating. Water loss is best replaced by allowing the athlete unrestricted access to water. Water breaks two or three times every hour are bet one break an hour. Probably the best method is to have water available at all tin to allow the athlete to drink water whenever he/she needs it. Never restrict the a of water an athlete drinks, and be sure the athletes are drinking the water. The s amount of salt lost in sweat is adequately replaced by salting food at meals. Tal your medical personnel concerning emergency treatment plans.

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NCAA®

GUIDE LINE 2c

Prevention of Heat Illness

June 1975 • Revised June 1998

Practice or competition in hot and/or humid environmental conditions poses special problems for student-athletes. Heat stress and resulting heat illness is a primary concern in these conditions. Although deaths from heat illness are rare, constant surveillance and education are necessary to prevent heat-related problems. The following practices should be observed:

1. An initial complete medical history and physical evaluation, followed by the completion of a yearly health-status questionnaire before practice begins, should be required. A history of previous heat illness, and the type and duration of training activities for the previous month, also are essential.

2. Prevention of heat illness begins with aerobic conditioning, which provides partial acclimatization to the heat. Student-athletes should gradually increase exposure to hot and/or humid environmental conditions over a period of seven to 10 days to achieve heat acclimatization. Each exposure should involve a gradual increase in the intensity and duration of exercise until the exercise is comparable to that likely to occur in competition. When conditions are extreme, training or competition should be held during a cooler time of day. Hydration should be maintained during training and acclimatization.

3. Clothing and protective gear can increase heat stress. Dark colors absorb solar radiation, and clothing and protective gear interfere with the evaporation of sweat and other avenues of heat loss. Frequent rest periods should be scheduled so that the gear and clothing can be loosened to allow heat loss. During the acclimatization process, it may be advisable to use a minimum of protective gear and clothing and to practice in T-shirts, shorts, socks and shoes. Excessive tape and outer clothing that restrict sweat evaporation should be avoided. Rubberized suits should never be used.

4. To identify heat stress conditions, regular measurements of environmental conditions are recommended. Use the ambient temperature and humidity to assess heat stress (see Figure 1). Utilize the wet-bulb temperature, dry-bulb temperature and globe temperature to assess the potential impact of humidity, air temperature and solar radiation. A wet-bulb temperature higher than 75 degrees Fahrenheit (24 degrees Celsius) or warm-weather humidity above 90 percent may represent dangerous conditions, especially if the sun is shining or the athletes are not acclimatized. A wet-bulb globe temperature (WBGT) higher than 82 degrees Fahrenheit (28 degrees Celsius) suggests that careful control of all activity be undertaken.

5. Dehydration (hypohydration) must be avoided not only because it hinders performance, but also

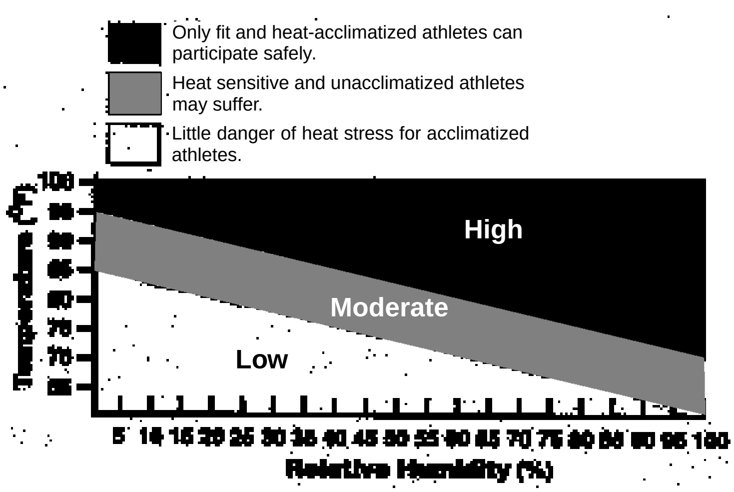

Figure 1: Temperature-Humidity Activity Index

because it can result in profound heat illness. Fluid replacement must be readily available. Student-athletes should be encouraged to drink as much and as frequently as comfort allows. They should drink one to two cups of water in the hour preceeding practice or competition, and continue drinking during activity (every 15-20 minutes). For activity up to two hours in duration, most weight loss represents water loss, and that fluid loss should be replaced as soon as possible. Following activity, the athlete should rehydrate with a volume that exceeds the amount lost during the activity. A two-pound weight loss represents approximately one quart of fluid loss.

Carbohydrate/electrolyte drinks, while not necessary to maintain performance, seem to enhance fluid intake. If carbohydrate-replacement fluids are provided, care must be taken to ensure adequate gastric emptying of the fluid. Therefore, carbohydrate concentration should not exceed eight percent. Electrolyte solutions are seldom necessary since sodium and potassium should be maintained with a normal diet.

6. By recording the body weight of each student-athlete before and after workout or practice, progressive hypohydration or loss of body fluids can be detected, and the potential harmful effects of hypohydration can be avoided. Those who lose five percent of their body weight or more over a period of several days should be evaluated medically and their activity restricted until rehydration has occurred.

7. Some student-athletes may be more susceptible to heat illness. Susceptible individuals include those with: inadequate acclimatization or aerobic fitness, excess body fat, a history of heat illness, a febrile condition, inadequate rehydration, and those who regularly push themselves to capacity. Also, prescription and over-the-counter drugs, such as antihistamines and pseudoephedrine, may increase the risk of heat illness.

Prevention of Heat Illness

8. Student-athletes should be informed of and monitored for signs of heat illness such as: cessation of sweating, weakness, cramping, rapid and weak pulse, pale or flushed skin, excessive fatigue, nausea, unsteadiness, disturbance of vision and incoherency. If heat illness is suspected, prompt emergency treatment is recommended. When training in hot and/or humid conditions, athletes should train with a partner or be under observation by a coach or athletic trainer.

First aid for heat illness

Heat exhaustion—Symptoms usually include profound weakness and exhaustion, and often dizziness, syncope, muscle cramps and nausea. Heat exhaustion is a form of shock due to depletion of body fluids. First aid should include rest in a cool, shaded environment. Fluids should be given orally. A physician should determine the need for electrolytes and additional medical care. Although rapid recovery is not unusual, student-athletes suffering from heat exhaustion should not be allowed to practice or compete for the remainder of that day.

Heatstroke—Heatstroke is a medical emergency. Medical care must be obtained at once; a delay in treatment can be fatal. This condition is characterized by a very high body temperature and usually (but not always) a hot, dry skin, which indicates failure of the primary temperature-regulating mechanism (sweating), and possibly seizure or coma. First aid includes immediate cooling of the body without causing the student-athlete to shiver. Recommended methods for cooling include using ice, immersion in cold water, or wetting the body and fanning vigorously. Victims of heatstroke should be hospitalized and monitored carefully.

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AMERICAN COLLEGE of SPORTS MEDICINE

POSITION STAND

Exertional Heat Illness during Training and Competition

This pronouncement was written for the American College of Sports Medicine by Lawrence E. Armstrong, Ph.D., FACSM (Chair); Douglas J. Casa, Ph.D., ATC, FACSM; Mindy Millard-Stafford, Ph.D., FACSM, Daniel S. Moran, Ph.D., FACSM; Scott W. Pyne, M.D., FACSM; and Wiliam O. Roberts, M.D., FACSM.

SUMMARY

Exertional heat illness can affect athletes during high-intensity or long-duration exercise and result in withdrawal from activity or collapse during or soon after activity. These maladies include exercise associated muscle cramping, heat exhaustion, or exertional heatstroke. While certain individuals are more prone to collapse from exhaustion in the heat (i.e., not acclimatized, using certain medications, dehydrated, or recently ill), exertional heatstroke (EHS) can affect seemingly healthy athletes even when the environment is relatively cool. EHS is defined as a rectal temperature greater than 40°C accompanied by symptoms or signs of organ system failure, most frequently central nervous system dysfunction. Early recognition and rapid cooling can reduce both the morbidity and mortality associated with EHS. The clinical changes associated with EHS can be subtle and easy to miss if coaches, medical personnel, and athletes do not maintain a high level of awareness and monitor at-risk athletes closely. Fatigue and exhaustion during exercise occur more rapidly as heat stress increases and are the most common causes of withdrawal from activity in hot conditions. When athletes collapse from exhaustion in hot conditions, the term heat exhaustion is often applied. In some cases, rectal temperature is the only discernable difference between severe heat exhaustion and EHS in on-site evaluations. Heat exhaustion will generally resolve with symptomatic care and oral fluid support. Exercise associated muscle cramping can occur with exhaustive work in any temperature range, but appears to be more prevalent in hot and humid conditions. Muscle cramping usually responds to rest and replacement of fluid and salt (sodium). Prevention strategies are essential to reducing the incidence of EHS, heat exhaustion, and exercise associated muscle cramping.

INTRODUCTION

This document replaces, in part, the 1996 Position Stand titled "Heat and Cold Illnesses during Distance Running" (9) and considers selected heat related medical conditions (EHS, heat exhaustion, and exercise associated muscle cramping) that may affect active people in warm or hot environments. These recommendations are intended to reduce the morbidity and mortality of exertional heat-related illness during physical activity, but individual physiologic responses to exercise and daily health status are variable, so compliance with these recommendations will not guarantee protection.

Heat illness occurs world wide with prolonged intense activity in almost every venue (e.g., cycling, running races, American football, soccer). EHS (1,27,62,64,65,109,132, 154,160,164) and heat exhaustion (54,71,149,150) occur most frequently in hot-humid conditions, but can occur in cool conditions, during intense or prolonged exercise (133). Heat exhaustion and exercise related muscle cramps do not typically involve excessive hyperthermia, but rather are a result of fatigue, body water and/or electrolyte depletion, and/or central regulatory changes that fail in the face of exhaustion.

This document will address recognition, treatment, and incidence reduction for heat exhaustion, EHS, and exercise associated muscle cramping, but does not include anesthesia-induced malignant hyperthermia, sunburn, anhidrotic heat exhaustion, or sweat gland disorders that are classified in other disease categories, because these disorders may or may not involve exercise or be solely related to heat exposure. Hyponatremia also occurs more frequently during prolonged activity in hot conditions, but is usually associated with excessive fluid intake and is addressed in the ACSM Exercise and Fluid Replacement Position Stand.

Evidence statements in this document are based on the strength of scientific evidence with regard to clinical outcomes. Because research ethics preclude the use of human subjects in the study of EHS and other exertional heat illnesses, this document employs the following criteria: A, recommendation based on consistent and good-quality patient- or subject-oriented evidence; B, recommendation based on inconsistent or limited-quality patient- or subject-oriented evidence; C, recommendation based on consensus, usual practice, opinion, disease-oriented evidence, or a case series for studies of diagnosis, treatment, prevention, or screening.

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General Background: Exhaustion, Hyperthermia, and Dehydration

Exhaustion is a physiologic response to work defined as the inability to continue exercise and occurs with heavy exertion in all temperature ranges. As ambient temperature increases beyond 20°C (68°F) and heat stress rises, the time to exhaustion decreases (58). From a clinical perspective it is difficult to distinguish athletes with exhaustion in cool conditions from those who collapse in hot conditions. Exercise that must be stopped due to exhaustion is likely triggered by some combination of hyperthermia-induced reduction of peripheral muscle activation due to decreased central activation (brain fatigue) (110,118), hydration level, peripheral effect of hyperthermia on muscle fatigue, depletion of energy stores, electrolyte imbalance, and/or other factors. Some combination of central, spinal cord, and peripheral responses to hyperthermia factor into the etiology of withdrawal or collapse from exhaustion during activity; the exact mechanisms have yet to be explained (90,114–116,171). The exercise-related exhaustion that occurs in hot conditions may be an extension of this phenomenon, but it is more pronounced, because depletion of energy stores occurs faster in hotter conditions, especially when athletes are not acclimatized to exercise in the heat (71). When physiologic exhaustion results in collapse, the clinical syndrome is often referred to as heat exhaustion. In both hot and cool environments, postexercise collapse also may be due to postural hypotension rather than heat exhaustion and postural changes usually resolve with leg elevation and rest in less than 30 min.

There are several variables that affect exhaustion in athletes including duration and intensity of exercise, environmental conditions, acclimatization to exercise-heat stress, innate work capacity ($\dot{V}O_{2max}$), physical conditioning, hydration status, and personal factors like medications, supplements, sleep, and recent illness. In human studies of exercise time to exhaustion at a fixed exercise load, both individuals and groups show a decrease in exercise capacity (time to exhaustion) and an increase in perceived exertion as environmental temperature and/or relative humidity increase and/or as total body water decreases. The combined effects of heat stress and dehydration reduce exercise capacity and performance to a greater degree than either alone. Compared to more moderate conditions, an athlete in hot conditions must either slow the pace to avoid collapse or maintain the pace and risk collapse before the task is completed.

Evidence statement. Dehydration reduces endurance exercise performance, decreases time to exhaustion, increases heat storage (11,12,16,41,57,141). *Evidence category A.*

Exertional hyperthermia, defined as a core body temperature above 40°C (104°F) (71,85,86,149,150), occurs during athletic or recreational activity and is influenced by exercise intensity, environmental conditions, clothing, equipment, and individual factors. Hyperthermia occurs during exercise when muscle-generated heat accumulates faster than heat dissipates via increased sweating and skin blood flow (3). Heat production during intense exercise is 15–20 times greater than at rest, and can raise core body temperature by 1°C (1.8°F) every 5 min if no heat is removed from the body (105). Prolonged hyperthermia may lead to EHS, a life-threatening condition with a high mortality rate if not promptly recognized and treated with body cooling.

The removal of body heat is controlled by central nervous system (CNS) centers in the hypothalamus and spinal cord, and peripheral centers in the skin and organs. Heat flow to maintain a functional core temperature requires a temperature gradient from the body core to the body shell. If the skin temperature remains constant, the gradient increases as the core temperature increases during exercise, augmenting heat removal. If the shell or skin temperature also rises during exercise, as a result of either the environment or internal heat production, the core to skin gradient may be lost (i.e., reducing heat dissipation) and the core temperature increases.

Wide variations of heat tolerance exist among athletes. The extent to which elevated body temperature below 40°C diminishes exercise performance and contributes to heat exhaustion (110) is unknown, but there is considerable attrition from exercise when rectal temperatures reach 39–40°C (144). In controlled laboratory studies, precooling the body will extend the time to exhaustion and preheating will shorten the time to exhaustion, but in both circumstances athletes tend to terminate exercise due to fatigue at a rectal temperature of about 40°C (104°F) (61).

In recent years, the importance of hyperthermia in fatigue and collapse has been investigated. These studies have shown that the brain temperature is always higher than core temperature and heat removal is decreased in the hyperthermic brain compared to control (119). Also, as brain temperature increases from 37 to 40°C during exercise, cerebral blood flow and maximal voluntary muscular force output decrease with concurrent changes in brain wave activity and perceived exertion (110,118). Brain hyperthermia may explain why some exercising individuals collapse with exhaustion, while others are able to override central nervous system controls and push themselves to continue exercising strenuously and develop life-threatening EHS.

It is not unusual for some athletes to experience prolonged hyperthermia without noticeable medical impairment, especially during competition. Elevated rectal temperatures up to 41.9°C (107.4°F) have been noted in soccer players, American football lineman, road runners, and marathoners who show no symptoms or signs of heat related physical changes (21,42,46,98,125,129,130,132, 161,165,176). This is significant because some athletes tolerate rectal temperatures well above the widely accepted threshold for EHS of >40°C without obvious clinical sequelae (71,85,86,104,149,150).

Dehydration occurs during prolonged exercise, more rapidly in hot environments when participants lose considerably more sweat than can be replaced by fluid intake (3,72,126). When fluid deficits exceed 3–5% of body weight, sweat production and skin blood flow begin to decline (19) reducing heat dissipation. Water deficits of 6–10% of body weight occur in hot weather, with or without clinically significant losses of sodium (Na^+) and chloride (Cl^-) (25,45,71,100,102,155,173) and reduce exercise tolerance by decreasing cardiac output, sweat production, and skin and muscle blood flow (12,41,57,71,101, 141,142). Dehydration may be either a direct (i.e., heat exhaustion, exercise associated muscle cramps) or indirect (i.e., heatstroke) factor in heat illness (10). Excessive sweating also results in salt loss, which has been implicated in exercise associated muscle cramps and in salt loss hyponatremia during long-duration (>8 h) endurance events in the heat.

In one study illustrating the cumulative affects of heat stress, a male soldier (32 yr, 180 cm, 110.47 kg, 41.4 $mL \cdot kg^{-1} \cdot min^{-1}$) participating in monitored, multiday, high-intensity exercise regimen at 41.2°C (106.0°F), 39% RH was asymptomatic with a postexercise rectal temperature of 38.3–38.9°C on days 3–7 (16). From the morning of day 5 to day 8, he lost 5.4 kg of body weight (4.8%) and had an increase of baseline heart rate, skin temperature and rectal temperature during days 6 and 7. On day 8, he developed heat exhaustion with unusual fatigue, muscular weakness, abdominal cramps, and vomiting with a rectal temperature of 39.6°C (103.3°F). His blood endorphin and cortisol levels were 6 and 2 times greater, respectively, than the other study subjects on day 8, indicating severe exercise-heat intolerance. Thirteen other males who maintained body weight near their prestudy baseline completed this protocol without incident. Because day-to-day dehydration affects heat tolerance, physical signs and hydration status should be monitored to reduce the incidence of heat exhaustion in hot environments.

When humans exercise near maximal levels, splanchnic and skin blood flow decrease as skeletal muscle blood flow increases to provide plasma glucose, remove heat, and remove metabolic products from working muscles (70). As the central controls for blood flow distribution fatigue due to a core temperature increase, the loss of compensatory splanchnic and skin vasoconstriction results in reduction of the total vascular resistance and worsens cardiac insufficiency (71,84). The loss of splanchnic vasoconstriction during exhaustion has been reproduced in a laboratory rat model and supports the assertion that loss of splanchnic vasoconstriction plays a role in heat exhaustion in athletes (70,73,84). This mechanism partially explains why exertional collapse is less likely to occur in cool environments, where cool, vasoconstricted skin helps maintain both cardiac filling and mean arterial pressure, and prolongs the time to exhaustion.

How EHS and heat exhaustion evolve, and in what sequence, are not completely understood (106). Some athletes tolerate hot conditions, dehydration, and hyperthermia well and are seemingly unaffected, while others discontinue activity in relatively less stressful conditions. The path that leads to EHS has been assumed to pass through heat exhaustion, however anecdotal and case study data seem to refute that notion as EHS can occur in relatively fresh athletes who develop symptomatic hyperthermia in 30–60 min of road racing in hot, humid conditions with no real signs of dehydration or heat exhaustion. If these athletes have heat exhaustion, then the duration and transition must be very short. Heat exhaustion should be protective for athletes in that, once exercise is stopped, the risk of developing exertional heat stroke is reduced because exercise-induced metabolic heat production decreases and heat dissipation to the environment increases. A program of prudent exercise in the heat along with acclimatization, improved cardiorespiratory physical fitness, and reasonable fluid replacement during exercise reduce the risk and incidence of both problems.

Evidence statement. Exertional heatstroke (EHS) is defined in the field by rectal temperature >40°C at collapse and by central nervous system changes. *Evidence category B*.

EXERTIONAL HEAT ILLNESSES

Exertional Heatstroke

Etiology. Exertional heatstroke (EHS) is defined by hyperthermia (core body temperature >40°C) associated with central nervous system disturbances and multiple organ system failure. When the metabolic heat produced by muscle during activity outpaces body heat transfer to the surroundings, the core temperature rises to levels that disrupt organ function. Almost all EHS patients exhibit sweat-soaked and pale skin at the time of collapse, as opposed to the dry, hot, and flushed skin that is described in the presentation of non-exertion-related (classic) heatstroke (162).

Predisposing factors. Although strenuous exercise in a hot-humid environment, lack of heat acclimatization, and poor physical fitness are widely accepted as the primary factors leading to EHS, even highly trained and heat-acclimatized athletes develop EHS while exercising at a high intensity if heat dissipation is inadequate relative to metabolic heat production (18,34,71). The greatest risk for EHS exists when the wet bulb globe temperature (WBGT) exceeds 28°C (82°F) (20,81,156) during high-intensity exercise (>75% $\dot{V}O_{2max}$) and/or strenuous exercise that lasts longer than 1 h as outlined below in "Monitoring the Environment." EHS also can occur in cool (8–18°C [45–65°F]) to moderate (18–28°C [65–82°F]) environments (14,56,132,133), suggesting that individual variations in susceptibility (14,22,55,56,66) may be due to inadequate physical fitness, incomplete heat acclimatization, or other temporary factors like viral illness or medications (81,133).

Evidence statement. Ten to 14 days of exercise training in the heat will improve heat acclimatization and reduce the risk of EHS. *Evidence category C*.

SPECIAL COMMUNICATIONS

The risk of EHS rises substantially when athletes experience multiple stressors such as a sudden increase in physical training, lengthy initial exposure to heat, vapor barrier protective clothing, sleep deprivation (14), inadequate hydration, and poor nutrition. The cumulative effect of heat exposure on previous days raises the risk of EHS, especially if the ambient temperature remains elevated overnight (14,168). Over-the-counter drugs and nutritional supplements containing ephedrine, synephrine, ma huang and other sympathomimetic compounds may increase heat production (23,121), but require verification as a cause of hyperthermia by controlled laboratory studies or field trials.

Appropriate fluid ingestion before and during exercise minimizes dehydration and reduces the rate at which core body temperature rises (46,60). However, hyperthermia may occur in the absence of significant dehydration when a fast pace or high-intensity exercise generates more metabolic heat than the body can remove (18,34,165). Skin disease (i.e., *miliaria rubra*), sunburn, alcohol use, drug abuse (i.e., ecstasy), antidepressant medications (69), obesity, age >40 yr, genetic predisposition to malignant hyperthermia, and a history of heat illness also have been linked to an increased risk of EHS in athletes (14,55, 85,150). Athletes should not exercise in a hot environment if they have a fever, respiratory infection, diarrhea, or vomiting (14,81). A study of 179 heat casualties at a 14-km race over 9 yr showed that 23% reported a recent gastrointestinal or respiratory illness (128). A similar study of 10 military patients with EHS reported that three had a fever and six recalled at least one warning sign of impending illness prior to collapse (14).

In American football, EHS usually occurs during the initial 4 d of preseason practice, which for most players takes place during the hottest and most humid time of the summer when athletes are the least fit. This emphasizes the importance of gradually introducing activity to induce acclimatization, carefully monitoring changes in behavior or performance during practices, and selectively modifying exercise (i.e., intensity, duration, rest periods) in high-risk conditions. Three factors may influence the early season EHS risk in American football players: (a) failure of coaches to adjust the intensity of the practice to the current environmental conditions, following the advice of the sports medicine staff; (b) unfit and unacclimatized players practicing intensely in the heat; and (c) vapor barrier equipment introduced before acclimatization.

One study of 10 EHS cases (14) reported that eight incidents occurred during group running at a 12.1–13.8 $km \cdot h^{-1}$ pace in environmental temperatures of ≥25°C (77°F), suggesting that some host factor altered exercise-heat tolerance on the day that EHS occurred. Heat tolerance is often less in individuals who have the lowest maximal aerobic power (i.e., $\dot{V}O_{2max} \leq 40\ mL \cdot kg^{-1} \cdot min^{-1}$) (14,64,96). To maintain pace when running in a group, these less fit individuals must function at higher exercise intensities to maintain the group's pace and are likely to have higher rectal temperatures at the end of a run compared to individuals with a higher $\dot{V}O_{2max}$. Air flow and heat dissipation also are reduced for runners in a pack.

More clinical and scientific reports of EHS involve males, and some hypotheses have been advanced (14). First, men may simply be in more EHS prone situations (i.e., military combat and American football). Second, men may be predisposed because of gender-specific hormonal, physiological, psychological, or morphological (i.e., muscle mass, body surface area-to-mass ratio) differences. Women, however, are not immune to the disorder, and the number of women who experience EHS may rise with the increased participation of women in strenuous sports.

Evidence statement. The following conditions increase the risk of EHS: obesity, low physical fitness level, lack of heat acclimatization, dehydration, a previous history of EHS, sleep deprivation, sweat gland dysfunction, sunburn, viral illness, diarrhea, or certain medications. *Evidence category B*. Physical training, cardiorespiratory fitness, and heat acclimatization reduce the risk of EHS. *Evidence category C*.

Pathophysiology. The underlying pathophysiology of EHS occurs when internal organ tissue temperatures rise above critical levels, cell membranes are damaged, and cell energy systems are disrupted, giving rise to a characteristic clinical syndrome (56,149). As a cell is heated beyond its thermal threshold (i.e., about 40°C), a cascade of events occurs that disrupts cell volume, metabolism, acid–base balance, and membrane permeability leading initially to cell and organ dysfunction and finally to cell death and organ failure (71,91,175). This complex cascade of events explains the variable onset of brain, cardiac, renal, gastrointestinal, hematologic, and muscle dysfunction among EHS patients.

The extent of multisystem tissue morbidity and the mortality rate are directly related to the area in degree-minutes under the body core temperature vs. time graph and

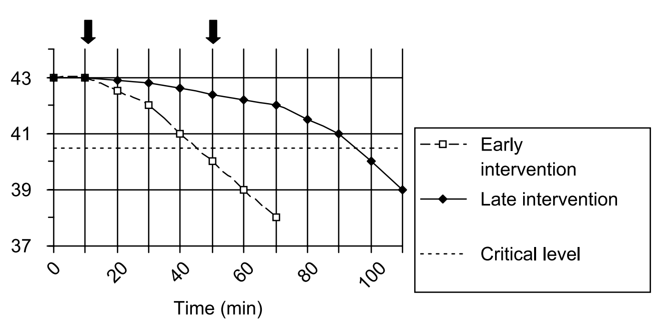

FIGURE 1— Cooling curves for early and late cooling interventions. The area under the early intervention curve above 40.5°C (the dashed line) in degree-minutes is approximately 60 while the area under the late intervention curve (cooling at 50 min) is >145. The prognosis based on area under the cooling curve for the late intervention is poor. Cooling can be delayed when heat stoke is not recognized early in the evaluation or if the athlete is transported before cooling is initiated. The arrow marks the start of cooling at 10 min for early intervention and 50 min for late intervention.

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the length of time required to cool central organs to <40°C (14,20,47,48). Tissue thresholds and the duration of temperature elevation, rather than the peak core body temperature, determine the degree of injury (72). When cooling is rapidly initiated and both the body temperature and cognitive function return to the normal range within an hour of onset of symptoms, most EHS patients recover fully (47,48). EHS victims who are recognized and cooled immediately theoretically tolerate about 60°C·min (120°F·min; area under the cooling curve) above 40.5°C without lasting sequelae (see Fig. 1). Conversely, athletes with EHS who go unrecognized or are not cooled quickly, and have more than 60°C·min of temperature elevation above 40.5°C, tend to have increased morbidity and mortality. Outcomes of 20 "light" and 16 "severe" cases of EHS during military training (150) showed that coma was relatively brief in light cases when hyperthermia was limited to <1 h, despite evidence of multiple organ involvement that was confirmed with elevated serum muscle and liver enzymes (74,172). Severe EHS cases were moribund at the time of admission and died early with evident central nervous system damage (150). The primary difference between light and severe EHS cases appears to be the length of time between collapse and the initiation of cooling therapy (14,20,47,48).

Hyperthermia of heart muscle tissue directly suppresses cardiac function, but the dysfunction is reversible with body cooling, as demonstrated by echocardiography (133). Cardiac tissue hyperthermia reduces cardiac output, oxygen delivery to tissues, and the vascular transport of heat from deep tissues to the skin. Cardiac insufficiency or failure associated with hyperthermia accelerates the elevation of core temperature and increases tissue hypoxia, metabolic acidosis and organ dysfunction. The concurrent heating of the brain begins a cascade of cerebral and hypothalamic failure that also accelerates cell death by disrupting the regulation of blood pressure and blood flow. Interestingly, direct hyperthermia-induced brain dysfunction may lead to collapse that can be "lifesaving," if stopping exercise allows the body to cool or the collapse triggers medical evaluation that leads to cooling therapy.

Exercise stimulates increased blood flow to working muscle. During a maximal effort, for example, approximately 80–85% of maximal cardiac output is distributed to active muscle tissue (139). As core temperature increases during exercise, the thermoregulatory response increases peripheral vasodilatation and blood flow to the cutaneous vascular beds to augment body cooling. The brain also regulates blood pressure during exercise by decreasing blood flow to splanchnic organs. This decreased intestinal blood flow limits vascular heat exchange in the gut and promotes bowel tissue hyperthermia and ischemia. Gut cell membrane breakdown allows lipopolysaccharide fragments from intestinal gram-negative bacteria to leak into the systemic circulation, increasing the risk of endotoxic shock. Dehydration can accentuate these effects on the GI tract and speed the process.

Rhabdomyolysis, the breakdown of muscle fibers, occurs in EHS as muscle tissue exceeds the critical temperature threshold of cell membranes (i.e., about 40°C). Although eccentric and concentric muscle overuse is a common cause of rhabdomyolysis, muscle membrane permeability increases due to hyperthermia and occurs earlier in exercise when the muscle tissues are hyperthermic (71,74). As heat decomposes cell membranes, myoglobin is released and may cause renal tubular toxicity and obstruction if renal blood flow is inadequate. Intracellular potassium is also released into the extracellular space, increasing serum levels and potentially inducing cardiac arrhythmias. Heating renal tissue above its critical threshold can directly suppress renal function and induce acute renal failure that is worsened by sustained hypotension, crystallization of myoglobin, disseminated intravascular coagulation, and the metabolic acidosis associated with exercise (31,70,153).

Incidence. The incidence of EHS varies from event to event and increases with rising ambient temperature and relative humidity. Limited data exist regarding the incidence of EHS during athletic activities. While fatal outcomes are often reported in the press, there is limited reporting of non fatal EHS unless it involves high profile athletes. In most cases, fatal EHS is a rare event that strikes "at random" in sports like American football, especially during the initial four days of preseason conditioning, where the incidence of fatal EHS was about 1 in 350,000 participants from 1995 through 2002 (131). Fatal EHS in American football players often occurs when air temperature is 26–30°C (78–86°F) and relative humidity is 50–80% (87). EHS is observed more often during road racing and other activities that involve continuous, high-intensity exercise. The Twin Cities Marathon, which is run in cool conditions, averages <1 EHS per 10,000 finishers (136); this incidence rises as the WBGT rises. In contrast, one popular 11.5-km road race, staged in hot and humid summer conditions (WBGT 21–27°C), averages 10–20 EHS cases per 10,000 entrants (18,34). The same race course, run in cool conditions, had no cases of EHS (A Crago, M.D., personal communication). Such a high incidence burdens the medical care system and suggests that the summer event is not scheduled at the safest time for the runners.

Recognition. Immediate recognition of EHS cases is paramount to survival (68). The appearance of signs and symptoms depends on the degree and duration of hyperthermia (14,48,71,81,150). The symptoms and signs are often nonspecific and include disorientation, confusion, dizziness, irrational or unusual behavior, inappropriate comments, irritability, headache, inability to walk, loss of balance and muscle function resulting in collapse, profound fatigue, hyperventilation, vomiting, diarrhea, delirium, seizures, or coma. Thus, any change of personality or performance should trigger an assessment for EHS, especially in hot-humid conditions. In collision sports like American football, EHS has been initially mistaken for concussion; among nonathletes, EHS also has been initially misdiagnosed as psychosis.

A body core temperature estimate is vital to establishing an EHS diagnosis, and rectal temperature should be measured in any athlete who collapses or exhibits signs or symptoms consistent with EHS. Ear (aural canal or tympanic membrane), oral, skin over the temporal artery, and axillary temperature measurements should not be used to diagnose EHS because they are spuriously lowered by the temperature of air, skin, and liquids that contact the skin (18,134,135). Oral temperature measurements also are affected by hyperventilation, swallowing, ingestion of cold liquids, and face fanning (33,151). At the time of collapse, systolic blood pressure <100 mm Hg, tachycardia, hyperventilation, and a shocklike appearance (i.e., sweaty, cool skin) are common.

Evidence statement. Ear (i.e., aural), oral, skin, temporal, and axillary temperature measurements should not be used to diagnose or distinguish EHS from exertional heat exhaustion. *Evidence category B*. Early symptoms of EHS include clumsiness, stumbling, headache, nausea, dizziness, apathy, confusion, and impairment of consciousness (71,85,149,161). *Evidence category B*.

Treatment. EHS is a life-threatening medical emergency that requires immediate whole body cooling for a satisfactory outcome (14,44,48,72,82,85,120,132,149). Cooling should be initiated and, if there are no other life-threatening complications, completed on-site prior to evacuation to the hospital emergency department. Athletes who rapidly become lucid during cooling usually have the best prognosis.

The most rapid whole body cooling rates (i.e., range 0.15–0.24°C·min^{-1}) have been observed with cold water and ice water immersion therapy (13,43,47,63,78,83,111, 125,163), and both have the lowest morbidity and mortality rates (47). An aggressive combination of rapidly rotating ice water-soaked towels to the head, trunk and extremities and ice packs to the neck, axillae and groin, (e.g., as currently used at the Twin Cities, Chicago, and Marine Corps marathons) provides a reasonable rate of cooling (i.e., range 0.12–0.16°C·min^{-1}). Ice packs to the neck, axilla, and groin will decrease body temperature in the range of 0.04–0.08°C·min^{-1} (13). Warm air mist and fanning techniques provide slower whole body cooling rates and are most effective only when the relative humidity is low because this method depends heavily on evaporation for cooling efficacy. Although some patients exhibit a misleading "lucid interval" that often delays the diagnosis, observation and cooling therapy should continue until rectal temperature and mental acuity indicate that treatment is successful. Road race competitors, with rectal temperatures of >42°C and profound CNS dysfunction, who are identified and treated immediately in ice water baths, often leave the medical tent without hospitalization or discernable sequelae (18,34,134).

Evidence statement. Cold water immersion provides the fastest whole body cooling rate and the lowest morbidity and mortality for EHS. *Evidence category A*. When water immersion is unavailable, ice water towels/ sheets combined with ice packs on the head, trunk, and extremities provide effective but slower whole body cooling. *Evidence category C*.

TABLE 1. Suggested equipment and supplies for treatment of heat related illness.

Stretchers
Cots
Wheelchairs
Bath towels
High temperature rectal thermometers (>43°C, >110°F)
Disposable latex-free gloves
Stethoscopes
Blood pressure cuffs
Intravenous (IV) tubing and cannulation needles
D5%NS and NS IV fluids in 1-L bags
3% saline IV fluid in 250-mL bags
Sharps and biohazard disposal containers
Alcohol wipes, tape, and gauze pads
Tables for medical supplies
Water supply for tubs or ice water buckets
Tub for immersion therapy
Fans for cooling
Oxygen tanks with regulators and masks
Ice, crushed or cubed
Plastic bags
Oral rehydration fluids
Cups for oral fluids
Glucose blood monitoring kits
Sodium analyzer and chemistry chips
Diazepam IV 5 mg or midazolam IV 1 mg vials
Defibrillator (automatic or manual)

[a] Revised from references (2) and (117).

A medical record should be completed for each athlete who receives treatment (2,132). This provides a record of care and information that can be used to improve the medical plan for future EHS incidents. Table 1 lists the equipment and supplies needed to evaluate and treat exertional heat illnesses that may occur during an athletic event.

EHS casualties often present with cardiovascular collapse and shock. Immediate cooling can reverse these conditions but, if prolonged core temperature elevation and multiple organ failure exist, the victim will require extensive intervention beyond body cooling and fluid replacement. Clinical, hematological, serum chemistry, and diagnostic imaging assessments should be initiated during cooling when possible, but tests that delay body cooling should not be employed unless they are critical to survival (39). Clinical markers of disseminated intravascular coagulation, prolonged elevation of liver and muscle enzymes in the serum, multiple organ failures, and prolonged coma are associated with a grave prognosis.

Preserving intravascular volume with normal saline (NS) infusion improves renal blood flow to protect the kidney from rhabdomyolysis and improves tissue perfusion in all organs for heat exchange, oxygenation, and removal of waste products. Dantrolene, a direct muscle relaxant that alters muscle contractility and calcium channel flow in membranes, purportedly is effective for treating rhabdomyolysis and athletes who have a genetic predisposition to malignant hyperthermia (104), but additional investigations are needed to clarify its efficacy in

EHS. The sheer volume of dantrolene needed to reverse malignant hyperthermia precludes its routine use in the field, but empiric use may be considered in EHS athletes who do not respond to aggressive cooling techniques. Seizures triggered by heat-induced brain dysfunction can be controlled with intravenous benzodiazepines until the brain is cooled and the electrochemical instability is reversed. Treatment of multiple organ system failure associated with prolonged EHS is beyond the scope of this position paper; accepted protocols can be found in most medical texts and handbooks.

Return to training or competition. There are no evidence-based recommendations regarding the return of athletes to training after an episode of EHS. For the majority of patients who receive prompt cooling therapy, the prognosis for full recovery and rapid return to activity is good (47,48,123,147). Nine out of 10 prior heatstroke patients tested about two months after an EHS episode demonstrated normal thermoregulation, exercise-heat tolerance, and heat acclimatization with normal sweat gland function, whole body sodium and potassium balance, and blood constituents (14). One of these patients was found to be heat intolerant during laboratory testing at 2 and 7 months after EHS, but was heat tolerant at 1 yr. Physiological and psychological recovery from EHS may require longer than a year, especially in those who experience severe hepatic injury (28,140).

Five recommendations have been proposed for the return to training and competition (37).

1. Refrain from exercise for at least 7 d following release from medical care.
2. Follow up in about 1 wk for physical exam and repeat lab testing or diagnostic imaging of affected organs that may be indicated, based on the physician's evaluation.
3. When cleared for activity, begin exercise in a cool environment and gradually increase the duration, intensity, and heat exposure for 2 wk to acclimatize and demonstrate heat tolerance.
4. If return to activity is difficult, consider a laboratory exercise-heat tolerance test about one month post-incident (14,98,103,138).
5. Clear the athlete for full competition if heat tolerance exists after 2–4 wk of training.

Evidence statement. EHS casualties may return to practice and competition when they have reestablished heat tolerance. *Evidence category B.*

Exertional Heat Exhaustion

Exhaustion defined as the inability to continue to exercise, occurs with heavy exertion in all temperatures and may or may not be associated with physical collapse. From a clinical perspective it is difficult to distinguish athletes who collapse with exhaustion in cool conditions from those in hot conditions. Exertional heat exhaustion was first described between 1938 and 1944 in medical reports (6,30,169,170) involving laborers and military personnel in the deserts of North Africa (4) and Iraq (89). These reports differentiated heat syncope (i.e., orthostatic hypotension) from heat exhaustion involving significant fluid-electrolyte losses and cardiovascular insufficiency (67,93,170,167). Heat exhaustion is also postulated to be the result of central failure that protects the body against overexertion in stressful situations (99). This paradigm suggests that heat exhaustion is a brain-mediated "safety brake" against excess activity in any environment (114,115,158).

Etiology. Heat exhaustion related to dehydration is more common in hot conditions. Rectal temperature can be elevated in heat exhaustion, because circulatory insufficiency predisposes to elevated core body temperatures (16). Laboratory and field studies have shown that exercise in 34–39°C (93–102°F) at 40–50% $\dot{V}O_{2max}$ does not induce heat exhaustion unless dehydration is present, and that identical exercise performed in a cool environment does not induce heat exhaustion (35,143).

Several lines of evidence suggest that heat exhaustion results from the central fatigue that induces widespread peripheral vascular dilation and associated collapse (11). A Saudi Arabian research group (146) measured echocardiography images of heat exhaustion patients who had participated in consecutive days of desert walking during a religious pilgrimage. These images showed that heat exhaustion involved tachycardia and high cardiac output with peripheral vasodilatation, characteristic of high output heart failure. The vasodilatation lowered peripheral vascular resistance resulting in hypotension and cardiovascular insufficiency. The blood volume pooled in the skin and extremities reduces intravascular heat transport from the core to the body surface and, in turn, heat loss from the skin surface. If the air humidity is high, evaporative cooling is impaired because the air is nearly saturated with moisture, signaling the body to increase cutaneous blood flow to support nonevaporative radiation and convection heat loss. This likely explains why both EHS and heat exhaustion occur more frequently on humid days.

Predisposing factors. There are several factors that predispose athletes to heat exhaustion, including the variables that affect exhaustion during exercise. Three studies of underground miners identified that the following factors were associated with an increasing number of heat exhaustion cases: a body mass index > 27 $kg \cdot m^{-2}$; work during the hottest months of the year; elevated urine specific gravity, hematocrit, hemoglobin, or serum osmolality suggesting inadequate fluid intake; an air temperature > 33°C and an air velocity < 2.0 $m \cdot s^{-1}$ (50–52).

Evidence statement. Dehydration and high body mass index increase the risk of exertional heat exhaustion. *Evidence category B*. Ten to 14 days of exercise training in the heat will improve heat acclimatization and reduce the risk of exertional heat exhaustion. *Evidence category C.*

Incidence. Heat exhaustion is the most common heat-related disorder observed in active populations (5,75, 79,85,97), but the incidence has not been systematically tracked with respect to sport participation. The incidence among religious pilgrims, who walked in the desert at 35–50°C (95–122°F) and had variable fitness and age, was 4 per 10,000 individuals per day (5). Reserve soldiers participating in summer maneuvers at 49–54°C (120–130°F) were affected at a rate of 13 per 10,000 individuals per day (97). Presumably fit competitors running in a 14-km road race with mild air temperatures of 11–20°C (52–68°F) were affected at the rate of 14 per 10,000 individuals per day (127), demonstrating the effects of increased intensity in less stressful heat. During a 6-day youth soccer tournament with early morning WBGT > 28°C (82°F), 34 players out of 4000 (85 per 10,000 incidence) were treated for heat exhaustion with a large increase in cases on the second day of the tournament, demonstrating the effects of cumulative exposure (54). These groups demonstrate the interactions of exercise duration, exercise intensity, and environment on the incidence of exertional heat exhaustion.

Recognition. The signs and symptoms of heat exhaustion are neither specific nor sensitive. During the acute stage of heat exhaustion the blood pressure is low, the pulse and respiratory rates are elevated, and the patient appears sweaty, pale, and ashen. Other signs and symptoms include headache, weakness, dizziness, "heat sensations" on the head or neck, chills, "goose flesh", nausea, vomiting, diarrhea, irritability, and decreased muscle coordination (71,72,76). Muscle cramps may or may not accompany heat exhaustion (70). In the field, rectal temperature measurement may discriminate between severe heat exhaustion (<40°C, 104°F) and EHS (>40°C) (36). If rectal temperature cannot be measured promptly, empiric heatstroke cooling therapy should be considered, especially if there are CNS symptoms. One study systematically examined the role of exercise in heat exhaustion by observing 14 healthy males (15) who ran 8.3–9.8 $km \cdot d^{-1}$ on a treadmill at 63–72% $\dot{V}O_{2max}$ for eight consecutive days in a 41°C (106°F), 39% RH environment and all the common signs and symptoms of heat exhaustion occurred in this study group (see section above titled, "Recognition").

Treatment. An athlete with the clinical picture of exertional heat exhaustion should be moved to a shaded or air conditioned area, have excess clothing removed, placed in the supine position with legs elevated, and have the heart rate, blood pressure, respiratory rate, rectal temperature, and central nervous system status monitored closely. The vast majority of athletes will resolve their collapse with leg elevation, oral fluids, and rest. Heat exhaustion does not always involve elevated core temperature, but cooling therapy will often improve the medical status. An athlete with suspected heat exhaustion who does not improve with these simple measures should be transported to an emergency facility.

Oral fluids are preferred for rehydration in athletes who are conscious, able to swallow well, and not losing fluids via vomiting or diarrhea. As long as the blood pressure, pulse, and rectal temperature are normal and no ongoing fluid losses exist, intravenous fluids should not be required. Intravenous fluid administration facilitates rapid recovery from heat exhaustion (50–52,72) in those who are unable to ingest oral fluids or have more severe dehydration. The decision to utilize intravenous fluids in dehydrated casualties hinges on the patient's orthostatic pulse, blood pressure change, other clinical signs of dehydration, and ability to ingest oral fluids. Progressive clouding of consciousness should trigger a detailed evaluation for hyperthermia, hypothermia, hyponatremia, hypoglycemia, and other medical problems (112,113). Muscle twitching or cramping that is not easily relieved by stretching may be associated with symptomatic hyponatremia. If dehydration is not clinically obvious in the collapsed athlete with suspected heat exhaustion, consider dilutional hyponatremia as a potential cause of the collapse before administering intravenous fluids (102).

The most commonly recommended IV fluids for rehydrating athletes are NS or 5% dextrose in NS. For empirical field treatment, the primary goal is intravascular volume expansion with saline, to protect organ function and improve blood pressure in athletes with signs of shock. The 5% dextrose solution provides glucose for cell energy. Current protocols suggest starting with NS unless the blood glucose is low. Intravenous fluids (1–4 L) have been used to speed recovery in miners (50–52) and are also used during the half time of soccer matches and American football games, although this practice is not evidence based nor recommended.

The vast majority of athletes with heat exhaustion recover on site and, when clinically stable, may be discharged in the company of a friend or relative with instructions for continued rest and rehydration. A simple check of urine volume and color (i.e., pale yellow or straw color) for the next 48 h will help gauge the recovery process. Prognosis is best when mental acuity was not altered and the athlete becomes alert quickly, following rest and fluids. An athlete with severe heat exhaustion should be instructed to follow-up with a physician (29,36,132).

Return to training or competition. An immediate return to exercise or labor following heat exhaustion is not prudent or advised. Athletes with milder forms of heat exhaustion can often return to training or work within 24–48 h, with instructions for gradually increasing the intensity and volume of activity. Neither rest nor body cooling allows heat exhaustion cases to recover to full exercise capacity on the same day (3). In a series of 106 cases of heat exhaustion in underground miners, 4 were sent to the hospital for treatment and 102 were treated on site and released to home. Of 77 miners who returned to work the next day, 30 had persistent mild symptoms of headache and fatigue, and were not allowed to return to normal work duties that day.

Of the asymptomatic miners, 46 of 47 returned to normal duties while 22 of the 30 symptomatic miners were restricted to an air conditioned environment. All of these workers were back to full duties by the third day and none required further medical treatment (52). Serious complications are very rare. Athletes who are rehydrated during games with intravenous fluids and allowed to return to play often are profuse sweaters suffering from dehydration, rather than true heat exhaustion casualties.

Exercise-Associated Muscle Cramps (Exertional Heat Cramps)

Etiology. Exercise associated muscle cramps (EAMC), also called heat cramps, are painful spasms of skeletal muscles that are commonly observed following prolonged, strenuous exercise, often in the heat (95). EAMC is especially prevalent in tennis and American football players (26). EAMC is common in long distance races, where intensity or duration often exceeds that experienced during daily training.

Cramps that occur in the heat are thought by some to differ from EAMC (71) because the cramping is accentuated by large sodium and water losses and that cramps in the heat may present with different signs and symptoms (24,25,71,88). EAMC in the heat often appear unheralded and occur in the legs, arms or abdomen (25,71,92,94,95, 166), although runners, skaters, and skiers who exercise to fatigue in moderate to cool temperatures present in a similar clinical manner. Tennis players who experience recurrent heat cramps are reportedly able to feel a cramp coming on and can abort the cramps with rest and fluids (24). Few investigations have measured fluid-electrolyte balance in EAMC patients, but some have reported whole body sodium deficiencies (24,25,26,88,92,166). Some individuals have a peculiar susceptibility to EAMC that may be related to genetic or metabolic abnormalities in skeletal muscle or lipid metabolism (159).

Predisposing factors. Three factors are usually present in EAMC: exercise-induced muscle fatigue, body water loss, and large sweat Na^+ loss (24,26,85). EAMC seems to be more frequent in long-duration, high-intensity events; indeed, the competitive schedule of certain athletic events may predispose to EAMC. In multiday tennis tournaments, competitors often play more than one match a day, with only an hour between matches. This format induces muscle fatigue, impedes both fluid and electrolyte replacement between matches, and often results in debilitating EAMC (24,25). A similar scenario occurs during the two-a-day practices or competitions and/or other multiday tournaments, both of which are associated with large sweat losses.

Pathophysiology. Sweat Na^+ losses that are replaced with hypotonic fluid have been proposed as the primary cause of EAMC (24,25,32,53,71,92,95,96,166). Sugar cane cutters who experienced EAMC were found to have low urinary Na^+ levels (versus healthy laborers) and the authors concluded a whole body Na^+ deficit existed (92,95). A young tennis player with a history of recurring EAMC successfully treated this disorder by increasing his dietary salt intake (24). In anecdotal reports, steel mill workers prevent EAMC when they increase their consumption of table salt (88,166). Significant quantities of intracellular calcium, magnesium, and potassium (K^+) are not lost during activity, so painful cramps in hot environments are likely not related to changes in those levels (25).

The resting electrical potentials of nerve and muscle tissues are affected by the concentrations of Na^+, Cl^- and K^+ on both sides of the cell membrane. Intracellular dilution or water expansion is believed to play a role in the development of EAMC (88,95). EAMC apparently are less likely to occur when interstitial or extracellular edema is observed (88).

Incidence. The incidence of EAMC has not been reported in any large epidemiologic study of athletes. In a 12-yr summary of marathon medical encounters, there were 1.2 cases of EAMC per 1000 race entrants and cramping accounted for 6.1% of medical encounters (136).

Recognition. In EAMC, the affected muscle or muscle group is contracted tightly causing pain that is sometimes excruciating. The affected muscles often appear to be randomly involved, and as one bundle of muscle fibers relax, an adjacent bundle contracts, giving the impression that the spasms wander (88). Twitches first may appear in the quadriceps and subsequently in another muscle group (25). Most EAMC spasms last 1–3 min, but the total series may span 6–8 h (95). Intestinal cramps (i.e., due to gaseous bloating or diarrhea) and gastrointestinal infections have been mistaken for abdominal EAMC (71,95).

EAMC can be confused with tetany. However, the characteristic flexion at metacarpophalangeal joints and the extension at interphalangeal joints of the fingers, give the hand its typical tetany appearance. Tetany rarely occurs concurrent with heat cramps, but is commonly observed in hyperventilation syndrome, hypokalemia associated with diuretic use, and in wrestlers who lose weight via dehydration (95).

Treatment. EAMC responds well to rest, prolonged stretch with the muscle groups at full length, and oral NaCl ingestion in fluids or foods (i.e., 1/8–1/4 teaspoon of table salt added to 300–500 mL of fluids or sports drink, 1–2 salt tablets with 300–500 mL of fluid, bullion broth, or salty snacks). Intravenous NS fluids provide rapid relief from severe EAMC (88,95) in some cases. Calcium salts, sodium bicarbonate, quinine, and dextrose have not produced consistent benefits when treating EAMC (25,95). In refractory muscle cramping, intravenous benzodiazepines effectively relieve muscle cramps through central mechanisms. The use of these medications requires close monitoring and excludes athletes from return to activity. Cramping also occurs in dilutional hyponatremia, so protracted cramping without clinical signs of dehydration

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should trigger the measurement of serum Na+ before administering IV NS to treat the spasms.

Return to training or competition. Many athletes with EAMC are able to return to play during the same game with rest and fluid replacement, while some require at least a day to recover following treatment. If the muscle cramping is associated with heat exhaustion or symptomatic hyponatremia (71), the recommendations for the more severe problem should guide the return to play.

Prevention. EAMC that occur in hot conditions seem to be prevented by maintaining fluid and salt balance. Athletes with high sweat Na^+ levels and sweat rates, or who have a history of EAMC, may need to consume supplemental Na^+ during prolonged activities to maintain salt balance (25,71,137) and may need to increase daily dietary salt to 5–10 $g{\cdot}d^{-1}$ when sweat losses are large (95,166). This is especially important during the heat acclimatization phase of training. Calculating sweat Na^+ losses and replacing that Na^+ during and after activity allowed two athletes with previously debilitating EAMC to compete successfully in hot conditions (24). There are anecdotal reports of EAMC resolution in American football and in soccer players who increase their oral salt intake before, during, and after activity.

ATHLETE SAFETY AND REDUCTION OF HEAT RELATED ILLNESS

Events should be scheduled to avoid extremely hot and humid months, based on the historical local weather data. During summer months, all events, games, and practices should be scheduled during the cooler hours of the day (e.g., early morning). Unseasonably hot days in spring and fall will increase the risk of exertional heat illnesses because competitors are often not sufficiently acclimatized.

Heat acclimatization is the best known protection against both EHS and heat exhaustion. Acclimatization requires gradually increasing the duration and intensity of exercise during the initial 10–14 d of heat exposure, although maximal protection may take up to 12 wk (17). In a study of mortality, the minimum temperatures at which fatal heat stroke occurred decreased at higher latitudes (i.e., northern Europe), and the minimum temperature for fatal cases increased as the summer months progressed at the same latitude (80). Thus, natural heat acclimatization that occurs from living in a given geographic area and the recommended exercise limits and modifications, must consider regional climatic differences. Fitness also confers some protection such that prolonged, near-maximal exertion should be avoided before acquired physical fitness and heat acclimatization are sufficient to support high-intensity, long-duration exercise training or competition (59,122,124,152). Event-specific physical training in the heat reduces the incidence of heat exhaustion (36) by enhancing cardiovascular function and fluid-electrolyte homeostasis.

All athletes should be monitored for signs and symptoms of heat strain, especially during the acclimatization period and when environmental conditions become more stressful, because early recognition decreases both the severity of the episode and the time lost from activity. Athletes, who are adequately rested, nourished, hydrated, and acclimatized to heat are at less risk for heat exhaustion (67). If an athlete experiences recurrent episodes of heat exhaustion, a careful review of fluid intake, diet, whole-body sodium balance,

TABLE 2. WBGT levels for modification or cancellation of workouts or athletic competition for healthy adults.[a,f]

WBGT [b]			Training and Noncontinuous Activity	
°F	°C	Continuous Activity and Competition	Nonacclimatized, Unfit, High-Risk Individuals [c]	Acclimatized, Fit, Low-Risk Individuals [c,d]
≤50.0	≤10.0	Generally safe; EHS can occur associated with individual factors	Normal activity	Normal activity
50.1–65.0	10.1–18.3	Generally safe; EHS can occur	Normal activity	Normal activity
65.1–72.0	18.4–22.2	Risk of EHS and other heat illness begins to rise; high-risk individuals should be monitored or not compete	Increase the rest:work ratio. Monitor fluid intake.	Normal activity
72.1–78.0	22.3–25.6	Risk for all competitors is increased	Increase the rest:work ratio and decrease total duration of activity.	Normal activity. Monitor fluid intake.
78.1–82.0	25.7–27.8	Risk for unfit, nonacclimatized individuals is high	Increase the rest:work ratio; decrease intensity and total duration of activity.	Normal activity. Monitor fluid intake.
82.1–86.0	27.9–30.0	Cancel level for EHS risk	Increase the rest:work ratio to 1:1, decrease intensity and total duration of activity. Limit intense exercise. Watch at-risk individuals carefully	Plan intense or prolonged exercise with discretion[f]; watch at-risk individuals carefully
86.1–90.0	30.1–32.2		Cancel or stop practice and competition.	Limit intense exercise[f] and total daily exposure to heat and humidity; watch for early signs and symptoms
≥90.1	>32.3		Cancel exercise.	Cancel exercise uncompensable heat stress[e] exists for all athletes[f]

[a] revised from reference (38).
[b] wet bulb globe temperature.
[c] while wearing shorts, T-shirt, socks and sneakers.
[d] acclimatized to training in the heat at least 3 wk.
[e] internal heat production exceeds heat loss and core body temperature rises continuously, without a plateau.
[f] Differences of local climate and individual heat acclimatization status may allow activity at higher levels than outlined in the table, but athletes and coaches should consult with sports medicine staff and should be cautious when exceeding these limits.

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TABLE 3. Modifying practice sessions for exercising children.

WBGT		
°F	°C	Restraints on Activities
<75.0	<24.0	All activities allowed, but be alert for prodromes of heat-related illness in prolonged events
75.0–78.6	24.0–25.9	Longer rest periods in the shade; enforce drinking every 15 min
79.0–84.0	26.0–29.0	Stop activity of unacclimatized persons and high-risk persons; limit activities of all others (disallow long-distance races, cut the duration of other activities)
>85.0	>29.0	Cancel all athletic activities

Notes:
1. Source: reference (7).
2. These guidelines do not account for clothing. Although the effects of the uniform clothing and protective equipment (i.e., American football) on sweating and body temperature in younger athletes are unknown, uniforms should be considered when determining playing/practice limitations based on the WBGT.
3. Eight to 10 practices are recommended for heat acclimatization (30–45 min each; one per day or one every other day).
4. Differences of local climate and individual heat acclimatization status may allow activity at higher levels than outlined in the table, but athletes and coaches should consult with sports medicine staff and should be cautious when exceeding these limits.

recovery interval, and heat acclimatization should be undertaken and corrected (36). Athletes should have a monitored fluid replacement plan (8,9) to stay within 2% of the baseline body weight (i.e., initial weight in multiday events or practices) (30).

Activity modification in high-risk situations. The events posing the greatest risk of EHS, heat exhaustion and EAMC involve high-intensity exercise in a hot-humid environment. Athletes may not have adequate experience to withdraw voluntarily, and often assume that the act of conducting a competition or practice implies safe conditions for the activity. The internal motivation of athletes to succeed under any circumstances plays a role in EHS risk and must be recognized by coaches and administrators when making the decision to conduct an event in high-risk conditions.

One athlete experiencing heat-related symptoms (i.e., the "weak link") often indicates that other exertional heat casualties will soon follow (75,97). Medical providers, event directors, coaches and athletes should be prepared to postpone, reschedule, modify, or cancel activities when environmental conditions pose undue risk, based on predetermined safety guidelines established for that event. The pressures exerted by parents, peers, coaches, administrators, and competition may encourage ill, fatigued, or dehydrated athletes to participate when the environmental conditions are unsafe.

Independent of an athlete's heat acclimatization or fitness, practice sessions and competitions should be modified with unlimited fluid access, longer and/or more rest breaks to facilitate heat dissipation, shorter playing times to decrease heat production, and/or delays when the moderate or higher environment risk categories exist (Table 2). The following factors should be considered when modifying training or events: environmental conditions, heat acclimatization status of participants, fitness and age of participants, intensity and duration of exercise, time of day, clothing or uniform requirements, sleep deprivation, nutrition, availability of fluids, frequency of fluid intake, and playing surface heat reflection and radiation (i.e., grass, asphalt) (157). During high heat stress conditions, remove equipment and extra clothing to reduce heat storage. Allow a minimum of 3, and preferably 6, hours of recovery and rehydration time between practice sessions and games.

Evidence Statement. Practice and competition should be modified on the basis of air temperature, relative humidity, sun exposure, heat acclimatization status, age, and equipment requirements by decreasing the duration and intensity of exercise and by removing clothing. *Evidence category C.*

Monitoring the environment. Event organizers should monitor the weather conditions before and during practice and competition. Ideally, heat stress should be measured at the event site for the most accurate meteorological data. Factors that affect heat injury risk include ambient temperature, relative humidity, wind speed, and solar radiant heat; as a minimum standard, the

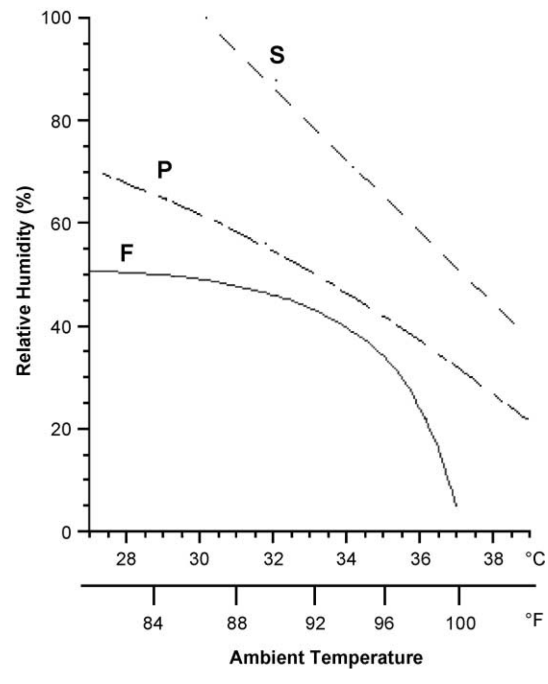

FIGURE 2— Environmental conditions that are critical for American football players wearing different clothing ensembles [S refers to a clothing ensemble of shorts, socks and sneakers; P (practice uniform) refers to helmet, undershirt, shoulder pads, jersey, shorts, socks and sneakers; F (full game uniform) refers to helmet, undershirt, shoulder pads, jersey, shorts, socks, sneakers, game pants, thigh pads and knee pads]. The zone above and to the right of each clothing ensemble (F, P, S) represents uncompensable heat stress with rising core temperature during exercise [redrawn with permission from reference (87); illustrates exercise at 35% $\dot{V}O_{2max}$; uncompensable heat stress is defined in Table 2, footnote f]. The zone below and to the left of lines F, P and S represents compensable heat stress with heat balance possible.

dry bulb temperature and relative humidity should be considered in the decision to modify activity. The WBGT is used in athletic, military, and industrial settings (49,76,162,174) to gauge heat risk because it incorporates measurements of radiant heat (T_{bg}) and air water content (T_{wb}). The WBGT is calculated using the following formula (174):

$$\text{WBGT} = (0.7T_{wb}) + (0.2T_{bg}) + (0.1T_{db})$$

where T_{wb} is the wet bulb temperature, T_{bg} is the black globe temperature, and T_{db} is the shaded dry bulb temperature (49). T_{wb} is measured with a dry bulb thermometer that is covered with a water-saturated cloth wick. T_{bg} is measured by inserting a dry bulb thermometer into a standard black metal globe. Both T_{wb} and T_{bg} are measured in direct sunlight. In this formula, T_{wb} accounts for 70% of the WBGT.

A portable monitor that measures the WBGT is useful to determine heat stress on site (49,77,162,174), but cost limits this use in many situations. Devices that measure temperature, relative humidity and wet bulb temperature can be purchased for less than $75. These measurements can be mathematically converted to WBGT using shareware provided by a nonprofit source (177). When the WBGT is not available, on-site ambient temperature and relative humidity data can be applied to standardized algorithms or charts to estimate heat risk.

The risk of EHS and exertional heat exhaustion (while wearing shorts, socks, shoes, and a T-shirt) due to environmental stress can be stratified into three activity categories, as depicted in Table 2; these involve either continuous activity and competition, or training and noncontinuous activity. Large posters or signs should be displayed at the athletic venue or along the race course, to describe the risk of heat exhaustion and EHS. If the WBGT index is above 28°C (82°F), consideration should be given to canceling or rescheduling continuous competitive events until less stressful conditions prevail (117). Table 3, regarding children, presents a modified version of a previous publication (7). Although children have been considered "less heat tolerant" in the past, current data collected on boys does not necessarily support this belief (78,148). However, until more research is available, it is prudent to regard children as an "at risk" group. The decision to modify activity is often in the hands of coaches, who must be willing to make safety related changes for practices and games, based on environmental conditions.

Uniforms. Before athletes are acclimatized to heat, the effect of uniforms on body heat storage is significant, especially in American football. Helmets, protective pads, gloves and garments trap heat and reduce heat dissipation. Exercise-related metabolic heat production raises core body temperature without a plateau and readily induces an "uncompensable" heat stress situation. Athletes should

TABLE 4. Evidence-based statements, evaluated in terms of the strength of supporting scientific evidence. Criteria (column 2) are defined in the Summary section.

	Level of Evidence	References
Dehydration reduces endurance exercise performance, decreases time to exhaustion, increases heat storage.	A	11,12,16,41,57,141
Exertional heatstroke (EHS) is defined in the field by rectal temperature >40°C at collapse and by central nervous system changes.	B	37,39,56,71,150,156,175
The following conditions increase the risk of EHS or exertional heat exhaustion: obesity, low physical fitness level, lack of heat acclimatization, dehydration, a previous history of EHS, sleep deprivation, sweat gland dysfunction, sunburn, viral illness, diarrhea, or certain medications.	B	14,22,45,55,60,66,69,85,99,149,150,164,173
Physical training and cardiorespiratory fitness reduce the risk of EHS.	C	17,29,59,122,124,152
Cold water immersion provides the fastest whole body cooling rate and the lowest morbidity and mortality for EHS.	A	2,13,14,43,44,47,48,49,63,68,72,82,83,85,111,125,134,149,175
When water immersion is unavailable, ice water towels/sheets combined with ice packs on the head, trunk, and extremities provide effective but slower whole body cooling.	C	
Dehydration and high body mass index increase the risk of exertional heat exhaustion.	B	17,29,59,122,124,152
10–14 days of exercise training in the heat will improve heat acclimatization and reduce the risk of EHS.	B	14,17,85,175
10–14 days of exercise training in the heat will improve heat acclimatization and reduce the risk of exertional heat exhaustion.	B	14,17,85,175
EHS casualties may return to practice and competition when they have reestablished heat tolerance.	B	14,38,55,56,81,103,138
Ear (i.e., aural), oral, skin, temporal, and axillary temperature measurements should not be used to diagnose or distinguish EHS from exertional heat exhaustion.	B	18,36,39,134,135
Early symptoms of EHS include clumsiness, stumbling, headache, nausea, dizziness, apathy, confusion, and impairment of consciousness.	B	71,85,149,161
Practice and competition should be modified on the basis of air temperature, relative humidity, sun exposure, heat acclimatization status, age, and equipment requirements by decreasing the duration and intensity of exercise and by removing clothing.	C	38,49,108,157,174
Athletes should exercise with a partner in high-risk conditions, each being responsible for monitoring the other's well being.	C	49,128,157

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remove as much protective equipment as possible to permit heat loss and to reduce the risks of hyperthermia, especially during acclimatization. Figure 2 demonstrates uncompensable heat stress in varying hot environments; it can guide coaches and athletes who select the practice uniform for a range of environmental conditions.

The National Collegiate Athletic Association (NCAA) regulates the introduction and use of protective padding for collegiate football players to aid heat acclimatization (107, 108). The current regulations allow players to wear helmets during the first 2 d of practice, helmets and shoulder pads during days 3 and 4, and the full uniform after the fifth day. These regulations also reduce the number and duration of workouts during the initial 5 d of summer training to one per day and limit "two a day" sessions to an every-other-day format for the remainder of the season. Although NCAA heat acclimatization strategies were designed for collegiate American football players, the model (107) is also recommended as a minimum standard for younger athletes. Specific recommendations should be uniquely designed for other age groups and sports to improve athlete safety.

Monitoring athletes across consecutive days. Athletes practicing or competing during multiple-day and/or multiple-session same day events in hot and humid conditions should be monitored for signs and symptoms of heat illness and the cumulative effects of dehydration (3,12,41,57,141). Day-to-day body weight measurements (40) and urine color should be used to assess progressive dehydration and increased risk for heat illness. Replace fluid deficits before the next practice session (40). Wireless deep body temperature sensors transmit gastrointestinal temperature (145) and can be used to monitor high-risk athletes who have a history of EHS, although this is not a practical strategy for most athletes and will pose a potential risk for an athlete who might require an MRI.

Education. The education of athletes, coaches, administrators, medical providers (especially on site personnel and community emergency response teams) can help with reduction, recognition, and treatment of heat related illness. Counsel athletes about the importance of being well-hydrated, well-fed, well-rested, and acclimatized to heat. Have athletes "buddy up" to monitor each other for signs of subtle changes of performance or behavior.

Evidence statement. Athletes should exercise with a partner in high-risk conditions, each being responsible for the other's well being. *Evidence category C*.

CONCLUSION

The challenges of hot environments and exercise are complex and difficult to fully comprehend because athletes are variably affected during high-intensity exercise in hot-humid environments. EHS, the most severe form of heat illness, cannot be studied in the laboratory because the risks of severe hyperthermia are ethically unacceptable for human research. Thus, our knowledge depends on the judicious field documentation of athletes who push beyond normal physiological limits. The survival of these athletes depends on prompt recognition and the most effective cooling therapy (i.e., ice water immersion or rapidly rotating ice water towels combined with ice packs) to limit tissue exposure due to destructive hyperthermia. The existing evidence is summarized in Table 4.

This Position Stand replaces, in part, the 1996 Position Stand "Heat and Cold Illnesses during Running," Med. Sci. Sport Exerc. 28(12):i–x, 1996.

This pronouncement was reviewed for the American College of Sports Medicine by the Pronouncements Committee and by Anne L. Friedlander, Ph.D.; James P. Knochel, M.D.; Christopher T. Minson, Ph.D., FACSM; Denise L. Smith, Ph.D., FACSM; and Jeffrey J. Zachwieja, Ph.D., FACSM.

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National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses

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Objective: To present recommendations for the prevention, recognition, and treatment of exertional heat illnesses and to describe the relevant physiology of thermoregulation.

Background: Certified athletic trainers evaluate and treat heat-related injuries during athletic activity in ''safe'' and high-risk environments. While the recognition of heat illness has improved, the subtle signs and symptoms associated with heat illness are often overlooked, resulting in more serious problems for affected athletes. The recommendations presented here provide athletic trainers and allied health providers with an integrated scientific and practical approach to the prevention, recognition, and treatment of heat illnesses. These recommendations can be modified based on the environmental conditions of the site, the specific sport, and individual considerations to maximize safety and performance.

Recommendations: Certified athletic trainers and other allied health providers should use these recommendations to establish on-site emergency plans for their venues and athletes. The primary goal of athlete safety is addressed through the prevention and recognition of heat-related illnesses and a well-developed plan to evaluate and treat affected athletes. Even with a heat-illness prevention plan that includes medical screening, acclimatization, conditioning, environmental monitoring, and suitable practice adjustments, heat illness can and does occur. Athletic trainers and other allied health providers must be prepared to respond in an expedient manner to alleviate symptoms and minimize morbidity and mortality.

Key Words: heat cramps, heat syncope, heat exhaustion, heat stroke, hyponatremia, dehydration, exercise, heat tolerance

Heat illness is inherent to physical activity and its incidence increases with rising ambient temperature and relative humidity. Athletes who begin training in the late summer (eg, football, soccer, and cross-country athletes) experience exertional heat-related illness more often than athletes who begin training during the winter and spring.[1–5] Although the hot conditions associated with late summer provide a simple explanation for this difference, we need to understand what makes certain athletes more susceptible and how these illnesses can be prevented.

PURPOSE

This position statement provides recommendations that will enable certified athletic trainers (ATCs) and other allied health providers to (1) identify and implement preventive strategies that can reduce heat-related illnesses in sports, (2) characterize factors associated with the early detection of heat illness, (3) provide on-site first aid and emergency management of athletes with heat illnesses, (4) determine appropriate return-to-play procedures, (5) understand thermoregulation and physiologic responses to heat, and (6) recognize groups with special concerns related to heat exposure.

ORGANIZATION

This position statement is organized as follows:

1. Definitions of exertional heat illnesses, including exercise-associated muscle (heat) cramps, heat syncope, exercise (heat) exhaustion, exertional heat stroke, and exertional hyponatremia;
2. Recommendations for the prevention, recognition, and treatment of exertional heat illnesses;
3. Background and literature review of the diagnosis of exertional heat illnesses; risk factors; predisposing medical conditions; environmental risk factors; thermoregulation, heat acclimatization, cumulative dehydration, and cooling therapies;

Table 1. Signs and Symptoms of Exertional Heat Illnesses

Condition Sign or Symptom*
Exercise-associated muscle (heat) cramps[6,9–11]
Dehydration
Thirst
Sweating
Transient muscle cramps
Fatigue
Heat syncope[10,12]
Dehydration
Fatigue
Tunnel vision
Pale or sweaty skin
Decreased pulse rate
Dizziness
Lightheadedness
Fainting
Exercise (heat) exhaustion[6,9,10,13]
Normal or elevated body-core temperature
Dehydration
Dizziness
Lightheadedness
Syncope
Headache
Nausea
Anorexia
Diarrhea
Decreased urine output
Persistent muscle cramps
Pallor
Profuse sweating
Chills
Cool, clammy skin
Intestinal cramps
Urge to defecate
Weakness
Hyperventilation
Exertional heat stroke[6,9,10,14]
High body-core temperature (>40°C [104°F])
Central nervous system changes
Dizziness
Drowsiness
Irrational behavior
Confusion
Irritability
Emotional instability
Hysteria
Apathy
Aggressiveness
Delirium
Disorientation
Staggering
Seizures
Loss of consciousness
Coma
Dehydration
Weakness
Hot and wet or dry skin
Tachycardia (100 to 120 beats per minute)
Hypotension
Hyperventilation
Vomiting
Diarrhea
Exertional hyponatremia[15–18]
Body-core temperature <40°C (104°F)
Nausea
Vomiting
Extremity (hands and feet) swelling
Low blood-sodium level
Progressive headache
Confusion
Significant mental compromise
Lethargy
Altered consciousness
Apathy
Pulmonary edema
Cerebral edema
Seizures
Coma

*Not every patient will present with all the signs and symptoms for the suspected condition.

4. Special concerns regarding exertional heat illnesses in prepubescent athletes, older athletes, and athletes with spinal-cord injuries;
5. Hospitalization and recovery from exertional heat stroke and resumption of activity after heat-related collapse; and
6. Conclusions.

DEFINITIONS OF EXERTIONAL HEAT ILLNESSES

The traditional classification of heat illness defines 3 categories: heat cramps, heat exhaustion, and heat stroke.[6–8] However, this classification scheme omits several other heat- and activity-related illnesses, including heat syncope and exertional hyponatremia. The signs and symptoms of the exertional heat illnesses are listed in Table 1.

Heat illness is more likely in hot, humid weather but can occur in the absence of hot and humid conditions.

Exercise-Associated Muscle (Heat) Cramps

Exercise-associated muscle (heat) cramps represent a condition that presents during or after intense exercise sessions as an acute, painful, involuntary muscle contraction. Proposed causes include fluid deficiencies (dehydration), electrolyte imbalances, neuromuscular fatigue, or any combination of these factors.[6,9–11,19]

Heat Syncope

Heat syncope, or orthostatic dizziness, can occur when a person is exposed to high environmental temperatures.[19] This condition is attributed to peripheral vasodilation, postural pooling of blood, diminished venous return, dehydration, reduction in cardiac output, and cerebral ischemia.[10,19] Heat syncope usually occurs during the first 5 days of acclimatization, before the blood volume expands,[12] or in persons with heart disease or those taking diuretics.[10] It often occurs after standing for long periods of time, immediately after cessation of activity, or after rapid assumption of upright posture after resting or being seated.

Exercise (Heat) Exhaustion

Exercise (heat) exhaustion is the inability to continue exercise associated with any combination of heavy sweating, dehydration, sodium loss, and energy depletion. It occurs most frequently in hot, humid conditions. At its worst, it is difficult to distinguish from exertional heat stroke without measuring rectal temperature. Other signs and symptoms include pallor, persistent muscular cramps, urge to defecate, weakness, fainting, dizziness, headache, hyperventilation, nausea, anorexia, diarrhea, decreased urine output, and a body-core temperature that generally ranges between 36°C (97°F) and 40°C (104°F).[6,9,10,13,19]

Exertional Heat Stroke

Exertional heat stroke is an elevated core temperature (usually >40°C [104°F]) associated with signs of organ system failure due to hyperthermia. The central nervous system neurologic changes are often the first marker of exertional heat stroke. Exertional heat stroke occurs when the temperature regulation system is overwhelmed due to excessive endogenous heat production or inhibited heat loss in challenging environmental conditions[20] and can progress to complete thermoregulatory system failure.[19,21] This condition is life threatening and can be fatal unless promptly recognized and treated. Signs and symptoms include tachycardia, hypotension, sweating (although skin may be wet or dry at the time of collapse), hyperventilation, altered mental status, vomiting, diarrhea, seizures, and coma.[6,10,14] The risk of morbidity and mortality is greater the longer an athlete's body temperature remains above 41°C (106°F) and is significantly reduced if body temperature is lowered rapidly.[22–24]

Unlike classic heat stroke, which typically involves prolonged heat exposure in infants, elderly persons, or unhealthy, sedentary adults in whom body heat-regulation mechanisms are inefficient,[25–27] exertional heat stroke occurs during physical activity.[28] The pathophysiology of exertional heat stroke is due to the overheating of organ tissues that may induce malfunction of the temperature-control center in the brain, circulatory failure, or endotoxemia (or a combination of these).[29,30] Severe lactic acidosis (accumulation of lactic acid in the blood), hyperkalemia (excessive potassium in the blood), acute renal failure, rhabdomyolysis (destruction of skeletal muscle that may be associated with strenuous exercise), and disseminated intravascular coagulation (a bleeding disorder characterized by diffuse blood coagulation), among other medical conditions, may result from exertional heat stroke and often cause death.[25]

Exertional Hyponatremia

Exertional hyponatremia is a relatively rare condition defined as a serum-sodium level less than 130 mmol/L. Low serum-sodium levels usually occur when activity exceeds 4 hours.[19] Two, often-additive mechanisms are proposed: an athlete ingests water or low-solute beverages well beyond sweat losses (also known as water intoxication), or an athlete's sweat sodium losses are not adequately replaced.[15–18] The low blood-sodium levels are the result of a combination of excessive fluid intake and inappropriate body water retention in the water-intoxication model and insufficient fluid intake and inadequate sodium replacement in the latter. Ultimately, the intravascular and extracellular fluid has a lower solute load than the intracellular fluids, and water flows into the cells, producing intracellular swelling that causes potentially fatal neurologic and physiologic dysfunction. Affected athletes present with a combination of disorientation, altered mental status, headache, vomiting, lethargy, and swelling of the extremities (hands and feet), pulmonary edema, cerebral edema, and seizures. Exertional hyponatremia can result in death if not treated properly. This condition can be prevented by matching fluid intake with sweat and urine losses and by rehydrating with fluids that contain sufficient sodium.[31,32]

RECOMMENDATIONS

The National Athletic Trainers' Association (NATA) advocates the following prevention, recognition, and treatment strategies for exertional heat illnesses. These recommendations are presented to help ATCs and other allied health providers maximize health, safety, and sport performance as they relate to these illnesses. Athletes' individual responses to physiologic stimuli and environmental conditions vary widely. These recommendations do not guarantee full protection from heat-related illness but should decrease the risk during athletic participation. These recommendations should be considered by ATCs and allied health providers who work with athletes at risk for exertional heat illnesses to improve prevention strategies and ensure proper treatment.

Prevention

1. Ensure that appropriate medical care is available and that rescue personnel are familiar with exertional heat illness prevention, recognition, and treatment. Table 2 provides general guidelines that should be considered.[7] Ensure that ATCs and other health care providers attending practices or events are allowed to evaluate and examine any athlete who displays signs or symptoms of heat illness[33,34] and have the authority to restrict the athlete from participating if heat illness is present.

2. Conduct a thorough, physician-supervised, preparticipation medical screening before the season starts to identify athletes predisposed to heat illness on the basis of risk factors[34–36] and those who have a history of exertional heat illness.

3. Adapt athletes to exercise in the heat (acclimatization) gradually over 10 to 14 days. Progressively increase the intensity and duration of work in the heat with a combination of strenuous interval training and continuous exercise.[6,9,14,33,37–44] Well-acclimatized athletes should train for 1 to 2 hours under the same heat conditions that will be present for their event.[6,45,46] In a cooler environment, an athlete can wear additional clothing during training to induce or maintain heat acclimatization. Athletes should maintain proper hydration during the heat-acclimatization process.[47]

4. Educate athletes and coaches regarding the prevention, recognition, and treatment of heat illnesses[9,33,38,39,42,48–51] and the risks associated with exercising in hot, humid environmental conditions.

5. Educate athletes to match fluid intake with sweat and urine losses to maintain adequate hydration.* (See the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes.''[52]) Instruct athletes to drink sodium-containing fluids to keep their urine clear to light yellow to improve hydration[33,34,52–55] and to replace fluids between practices on the same day and on successive days to maintain less than 2% body-weight change. These strategies will lessen the risk of acute and chronic dehydration and decrease the risk of heat-related events.

*References 9, 29, 37, 38, 40, 41, 43, 52–66.

Table 2. Prevention Checklist for the Certified Athletic Trainer*

1. Pre-event preparation
   ______Am I challenging unsafe rules (eg, ability to receive fluids, modify game and practice times)?
   ______Am I encouraging athletes to drink before the onset of thirst and to be well hydrated at the start of activity?
   ______Am I familiar with which athletes have a history of a heat illness?
   ______Am I discouraging alcohol, caffeine, and drug use?
   ______Am I encouraging proper conditioning and acclimatization procedures?
2. Checking hydration status
   ______Do I know the preexercise weight of the athletes (especially those at high risk) with whom I work, particularly during hot and humid conditions?
   ______Are the athletes familiar with how to assess urine color? Is a urine color chart accessible?
   ______Do the athletes know their sweat rates and, therefore, know how much to drink during exercise?
   ______Is a refractometer or urine color chart present to provide additional information regarding hydration status in high-risk athletes when baseline body weights are checked?
3. Environmental assessment
   ______Am I regularly checking the wet-bulb globe temperature or temperature and humidity during the day?
   ______Am I knowledgeable about the risk categories of a heat illness based on the environmental conditions?
   ______Are alternate plans made in case risky conditions force rescheduling of events or practices?
4. Coaches' and athletes' responsibilities
   ______Are coaches and athletes educated about the signs and symptoms of heat illnesses?
   ______Am I double checking to make sure coaches are allowing ample rest and rehydration breaks?
   ______Are modifications being made to reduce risk in the heat (eg, decrease intensity, change practice times, allow more frequent breaks, eliminate double sessions, reduce or change equipment or clothing requirements, etc)?
   ______Are rapid weight-loss practices in weight-class sports adamantly disallowed?
5. Event management
   ______Have I checked to make sure proper amounts of fluids will be available and accessible?
   ______Are carbohydrate-electrolyte drinks available at events and practices (especially during twice-a-day practices and those that last longer than 50 to 60 minutes or are extremely intense in nature)?
   ______Am I aware of the factors that may increase the likelihood of a heat illness?
   ______Am I promptly rehydrating athletes to preexercise weight after an exercise session?
   ______Are shaded or indoor areas used for practices or breaks when possible to minimize thermal strain?
6. Treatment considerations
   ______Am I familiar with the most common early signs and symptoms of heat illnesses?
   ______Do I have the proper field equipment and skills to assess a heat illness?
   ______Is an emergency plan in place in case an immediate evacuation is needed?
   ______Is a kiddy pool available in situations of high risk to initiate immediate cold-water immersion of heat-stroke patients?
   ______Are ice bags available for immediate cooling when cold-water immersion is not possible?
   ______Have shaded, air-conditioned, and cool areas been identified to use when athletes need to cool down, recover, or receive treatment?
   ______Are fans available to assist evaporation when cooling?
   ______Am I properly equipped to assess high core temperature (ie, rectal thermometer)?
7. Other situation-specific considerations

*Adapted with permission from Casa.[7]

Table 3. Wet-Bulb Globe Temperature Risk Chart[62–67]*

WBGT	Flag Color	Level of Risk	Comments
<18°C (<65°F)	Green	Low	Risk low but still exists on the basis of risk factors
18–23°C (65–73°F)	Yellow	Moderate	Risk level increases as event progresses through the day
23–28°C (73–82°F)	Red	High	Everyone should be aware of injury potential; individuals at risk should not compete
>28°C (82°F)	Black	Extreme or hazardous	Consider rescheduling or delaying the event until safer conditions prevail; if the event must take place, be on high alert

*Adapted with permission from Roberts.[67]

6. Encourage athletes to sleep at least 6 to 8 hours at night in a cool environment,[41,35,50] eat a well-balanced diet that follows the Food Guide Pyramid and United States Dietary Guidelines,[56–58] and maintain proper hydration status. Athletes exercising in hot conditions (especially during twice-a-day practices) require extra sodium from the diet or rehydration beverages or both.

7. Develop event and practice guidelines for hot, humid weather that anticipate potential problems encountered based on the wet-bulb globe temperature (WBGT) (Table 3) or heat and humidity as measured by a sling psychrometer (Figure 1), the number of participants, the nature of the activity, and other predisposing risk factors.[14,51] If the WBGT is greater than 28°C (82°F, or ''very high'' as indicated in Table 3, Figure 1), an athletic event should be delayed, rescheduled, or moved into an air-conditioned space, if possible.[69–74] It is important to note that these measures are based on the risk of environmental stress for athletes wearing shorts and a T-shirt; if an

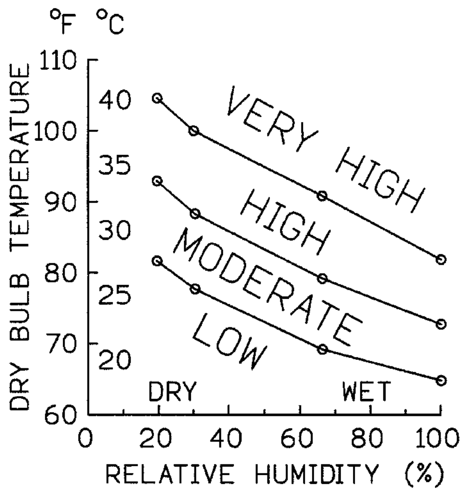

Figure 1. Risk of heat exhaustion or heat stroke while racing in hot environments. However, Figure 2 may be better suited for estimating heat-stroke risk when equipment is worn. Reprinted with permission from Convertino VA, Armstrong LE, Coyle EF, et al. American College of Sports Medicine position stand: exercise and fluid replacement. *Med Sci Sports Exerc.* 1996;28:i–vii.[31]

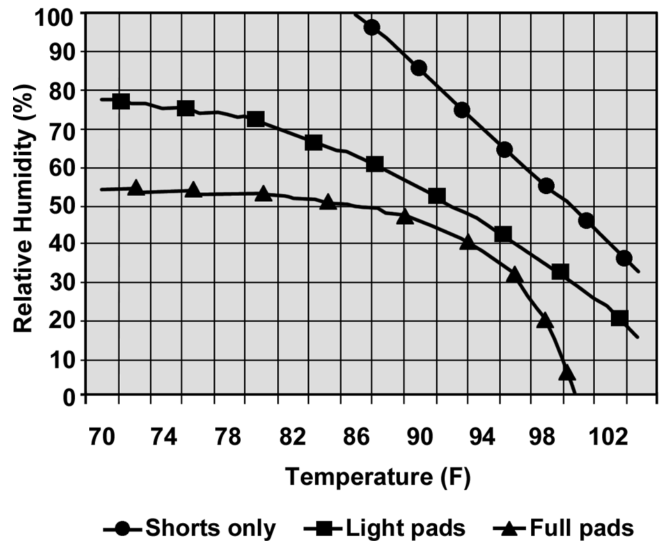

Figure 2. Heat stress risk temperature and humidity graph. Heat-stroke risk rises with increasing heat and relative humidity. Fluid breaks should be scheduled for all practices and scheduled more frequently as the heat stress rises. Add 5° to temperature between 10 AM and 4 PM from mid May to mid September on bright, sunny days. Practices should be modified for the safety of the athletes to reflect the heat-stress conditions. Regular practices with full practice gear can be conducted for conditions that plot to the left of the triangles. Cancel all practices when the temperature and relative humidity plot is to the right of the circles; practices may be moved into air-conditioned spaces or held as walk-through sessions with no conditioning activities.

Conditions that plot between squares and circles: increase rest-to-work ratio with 5- to 10-minute rest and fluid breaks every 15 to 20 minutes; practice should be in shorts only with all protective equipment removed.

Conditions that plot between triangles and squares: increase rest-to-work ratio with 5- to 10-minute rest and fluid breaks every 20 to 30 minutes; practice should be in shorts with helmets and shoulder pads (not full equipment).

Adapted with permission from Kulka J, Kenney WL. Heat balance limits in football uniforms: how different uniform ensembles alter the equation. *Physician Sportsmed.* 2002;30(7):29–39.[68]

athlete is wearing additional clothing (ie, football uniform, wetsuit, helmet), a lower WBGT value could result in comparable risk of environmental heat stress (Figure 2).[75,76] If the event or practice is conducted in hot, humid conditions, then use extreme caution in monitoring the athletes and be proactive in taking preventive steps. In addition, be sure that emergency supplies and equipment are easily accessible and in good working order. The most important factors are to limit intensity and duration of activity, limit the amount of clothing and equipment worn, increase the number and length of rest breaks, and encourage proper hydration.

Modify activity under high-risk conditions to prevent exertional heat illnesses.[19,21] Identify individuals who are susceptible to heat illnesses. In some athletes, the prodromal signs and symptoms of heat illnesses are not evident before collapse, but in many cases, adept medical supervision will allow early intervention.

8. Check the environmental conditions before and during the activity, and adjust the practice schedule accordingly.[29,38,41,42,60] Schedule training sessions to avoid the hottest part of the day (10 AM to 5 PM) and to avoid radiant heating from direct sunlight, especially in the acclimatization during the first few days of practice sessions.[9,29,33,34,38,40,50,60]

9. Plan rest breaks to match the environmental conditions and the intensity of the activity.[33,34] Exercise intensity and environmental conditions should be the major determinants in deciding the length and frequency of rest breaks. If possible, cancel or postpone the activity or move it indoors (if air conditioned) if the conditions are "extreme or hazardous" (see Table 3) or "very high" (see Figure 1) or to the right of the circled line (see Figure 2). General guidelines during intense exercise would include a work:rest ratio of 1:1, 2:1, 3:1, and 4:1 for "extreme or hazardous" (see Table 3) or "very high" (see Figure 1), "high," "moderate," or "low" environmental risk, respectively.[41,77] For activities such as football in which equipment must be considered, please refer to Figure 2 for equipment modifications and appropriate work:rest ratios for various environmental conditions. Rest breaks should occur in the shade if possible, and hydration during rest breaks should be encouraged.

10. Implement rest periods at mealtime by allowing 2 to 3 hours for food, fluids, nutrients, and electrolytes (sodium and potassium) to move into the small intestine and bloodstream before the next practice.[34,50,77]

11. Provide an adequate supply of proper fluids (water or sports drinks) to maintain hydration[9,34,38,40,50,60] and institute a hydration protocol that allows the maintenance of hydration status.[34,49] Fluids should be readily available and served in containers that allow adequate volumes to be ingested with ease and with minimal interruption of exercise.[49,52] The goal should be to lose no more than 2% to 3% of body weight during the practice session (due to sweat and urine losses).[78–82] (See the "National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes."[52])

12. Weigh high-risk athletes (in high-risk conditions, weigh all athletes) before and after practice to estimate the amount of body water lost during practice and to ensure a return to prepractice weight before the next practice. Following exercise athletes should consume approximately 1–1.25 L (16 oz) of fluid for each kilogram of body water lost during exercise.†

†*References 6, 9, 29, 33, 38, 40, 49, 60, 77, 83.*

13. Minimize the amount of equipment and clothing worn by the athlete in hot or humid (or both) conditions. For example, a full football uniform prevents sweat evaporation from more than 60% of the body.[29,33,40,51,77] Consult Figure 2 for possible equipment and clothing recommendations. When athletes exercise in the heat, they should wear loose-fitting, absorbent, and light-colored clothing; mesh clothing and new-generation cloth blends have been specially designed to allow more effective cooling.‡

14. Minimize warm-up time when feasible, and conduct warm-up sessions in the shade when possible to minimize the radiant heat load in ''high'' or ''very high'' or ''extreme or hazardous'' (see Table 3, Figure 1) conditions.[77]

15. Allow athletes to practice in shaded areas and use electric or cooling fans to circulate air whenever feasible.[66]

16. Include the following supplies on the field, in the locker room, and at various other stations:

- A supply of cool water or sports drinks or both to meet the participants' needs (see the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes''[52] for recommendations regarding the appropriate composition of rehydration beverages based on the length and intensity of the activity)[29,34,38]
- Ice for active cooling (ice bags, tub cooling) and to keep beverages cool during exercise[29,38]
- Rectal thermometer to assess body-core temperature[39,74,75,87,88]
- Telephone or 2-way radio to communicate with medical personnel and to summon emergency medical transportation[38,39,48]
- Tub, wading pool, kiddy pool, or whirlpool to cool the trunk and extremities for immersion cooling therapy[35,65]

17. Notify local hospital and emergency personnel before mass participation events to inform them of the event and the increased possibility of heat-related illnesses.[41,89]

18. Mandate a check of hydration status at weigh-in to ensure athletes in sports requiring weight classes (eg, wrestling, judo, rowing) are not dehydrated. Any procedures used to induce dramatic dehydration (eg, diuretics, rubber suits, exercising in a sauna) are strictly prohibited.[52] Dehydrated athletes exercising at the same intensity as euhydrated athletes are at increased risk for thermoregulatory strain (see the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes''[52]).

Recognition and Treatment

19. Exercise-associated muscle (heat) cramps:

- An athlete showing signs or symptoms including dehydration, thirst, sweating, transient muscle cramps, and fatigue is likely experiencing exercise-associated muscle (heat) cramps.
- To relieve muscle spasms, the athlete should stop activity, replace lost fluids with sodium-containing fluids, and begin mild stretching with massage of the muscle spasm.
- Fluid absorption is enhanced with sports drinks that contain sodium.[52,60,87] A high-sodium sports product may be added to the rehydration beverage to prevent or relieve cramping in athletes who lose large amounts of sodium in their sweat.[19] A simple salted fluid consists of two 10-grain salt tablets dissolved in 1 L (34 oz) of water. Intravenous fluids may be required if nausea or vomiting limits oral fluid intake; these must be ordered by a physician.[6,7,52,90,91]
- A recumbent position may allow more rapid redistribution of blood flow to cramping leg muscles.

20. Heat syncope:

- If an athlete experiences a brief episode of fainting associated with dizziness, tunnel vision, pale or sweaty skin, and a decreased pulse rate but has a normal rectal temperature (for exercise, 36°C to 40°C [97°F to 104°F]), then heat syncope is most likely the cause.[19]
- Move the athlete to a shaded area, monitor vital signs, elevate the legs above the level of the head, and rehydrate.

21. Exercise (heat) exhaustion:

- Cognitive changes are usually minimal, but assess central nervous system function for bizarre behavior, hallucinations, altered mental status, confusion, disorientation, or coma (see Table 1) to rule out more serious conditions.
- If feasible, measure body-core temperature (rectal temperature) and assess cognitive function (see Table 1) and vital signs.[19] Rectal temperature is the most accurate method possible in the field to monitor body-core temperature.[34,74,75,87,88] The ATC should not rely on the oral, tympanic, or axillary temperature for athletes because these are inaccurate and ineffective measures of body-core temperature during and after exercise.[75,89,92]
- If the athlete's temperature is elevated, remove his or her excess clothing to increase the evaporative surface and to facilitate cooling.[6,93]
- Cool the athlete with fans,[94] ice towels,[29,38] or ice bags because these may help the athlete with a temperature of more than 38.8°C (102°F) to feel better faster.
- Remove the athlete to a cool or shaded environment if possible.
- Start fluid replacement.[6,52,93,95]
- Transfer care to a physician if intravenous fluids are needed[6,52,90,91,96] or if recovery is not rapid and uneventful.

22. Exertional heat stroke:

- Measure the rectal temperature if feasible to differentiate between heat exhaustion and heat stroke. With heat stroke, rectal temperature is elevated (generally higher than 40°C [104°F]).[19]
- Assess cognitive function, which is markedly altered in exertional heat stroke (see Table 1).
- Lower the body-core temperature as quickly as possible.[34,70,77] The fastest way to decrease body temperature is to remove clothes and equipment and immerse the body (trunk and extremities) into a pool or tub of cold water (approximately 1°C to 15°C [35°F to 59°F]).[32,91,92,97–99] Aggressive cooling is the most critical factor in the treatment of exertional heat stroke. Circulation of the tub water may enhance cooling.
- Monitor the temperature during the cooling therapy and recovery (every 5 to 10 minutes).[39,87] Once the athlete's rectal temperature reaches approximately 38.3°C to 38.9°C (101°F to 102°F), he or she should be removed from the pool or tub to avoid overcooling.[40,100]
- If a physician is present to manage the athlete's medical care on site, then initial transportation to a medical facility may not be necessary so immersion can continue uninterrupted.

‡*References 8, 9, 29, 33, 38, 40, 53, 59, 84–86.*

If a physician is not present, aggressive first-aid cooling should be initiated on site and continued during emergency medical system transport and at the hospital until the athlete is normothermic.

- Activate the emergency medical system.
- Monitor the athlete's vital signs and other signs and symptoms of heat stroke (see Table 1).[34,95]
- During transport and when immersion is not feasible, other methods can be used to reduce body temperature: removing the clothing; sponging down the athlete with cool water and applying cold towels; applying ice bags to as much of the body as possible, especially the major vessels in the armpit, groin, and neck; providing shade; and fanning the body with air.[39,95]
- In addition to cooling therapies, first-aid emergency procedures for heat stroke may include airway management. Also a physician may decide to begin intravenous fluid replacement.[87]
- Monitor for organ-system complications for at least 24 hours.

23. Exertional hyponatremia:

- Attempt to differentiate between hyponatremia and heat exhaustion. Hyponatremia is characterized by increasing headache, significant mental compromise, altered consciousness, seizures, lethargy, and swelling in the extremities. The athlete may be dehydrated, normally hydrated, or overhydrated.[19]
- Attempt to differentiate between hyponatremia and heat stroke. In hyponatremia, hyperthermia is likely to be less (rectal temperature less than 40°C [104°F]).[19] The plasma-sodium level is less than 130 mEq/L and can be measured with a sodium analyzer on site if the device is available.
- If hyponatremia is suspected, immediate transfer to an emergency medical center via the emergency medical system is indicated. An intravenous line should be placed to administer medication as needed to increase sodium levels, induce diuresis, and control seizures.
- An athlete with suspected hyponatremia should not be administered fluids until a physician is consulted.

24. Return to activity

In cases of exercise-associated muscle (heat) cramps or heat syncope, the ATC should discuss the athlete's case with the supervising physician. The cases of athletes with heat exhaustion who were not transferred to the physician's care should also be discussed with the physician. After exertional heat stroke or exertional hyponatremia, the athlete must be cleared by a physician before returning to athletic participation.[92] The return to full activity should be gradual and monitored.[8,87]

BACKGROUND AND LITERATURE REVIEW

Diagnosis

To differentiate heat illnesses in athletes, ATCs and other on-site health care providers must be familiar with the signs and symptoms of each condition (see Table 1). Other medical conditions (eg, asthma, status epilepticus, drug toxicities) may also present with similar signs and symptoms. It is important to realize, however, that an athlete with a heat illness will not exhibit all the signs and symptoms of a specific condition, increasing the need for diligent observation during athletic activity.

Nonenvironmental Risk Factors

Athletic trainers and other health care providers should be sensitive to the following nonenvironmental risk factors, which could place athletes at risk for heat illness.

Dehydration. Sweating, inadequate fluid intake, vomiting, diarrhea, certain medications,[89,101–103] and alcohol[104,105] or caffeine[106] use can lead to fluid deficit. Body-weight change is the preferred method to monitor for dehydration in the field, but a clinical refractometer is another accurate method (specific gravity should be no more than 1.020).[34,49,107–110] Dehydration can also be identified by monitoring urine color or body-weight changes before, during, and after a practice or an event and across successive days.[53,54]

The signs and symptoms of dehydration are thirst, general discomfort, flushed skin, weariness, cramps, apathy, dizziness, headache, vomiting, nausea, heat sensations on the head or neck, chills, decreased performance, and dyspnea.[52] Water loss that is not regained by the next practice increases the risk for heat illness.[110]

Barriers to Evaporation. Athletic equipment and rubber or plastic suits used for ''weight loss'' do not allow water vapor to pass through and inhibit evaporative, convective, and radiant heat loss.[111,112] Participants who wear equipment that does not allow for heat dissipation are at an increased risk for heat illness.[113] Helmets are also limiting because a significant amount of heat is dissipated through the head.

Illness. Athletes who are currently or were recently ill may be at an increased risk for heat illness because of fever or dehydration.[114–116]

History of Heat Illness. Some individuals with a history of heat illness are at greater risk for recurrent heat illness.[8,117]

Increased Body Mass Index (Thick Fat Layer or Small Surface Area). Obese individuals are at an increased risk for heat illness because the fat layer decreases heat loss.[118] Obese persons are less efficient and have a greater metabolic heat production during exercise. Conversely, muscle-bound individuals have increased metabolic heat production and a lower ratio of surface area to mass, contributing to a decreased ability to dissipate heat.[119–121]

Wet-Bulb Globe Temperature on Previous Day and Night. When the WBGT is high to extreme (see Table 3), the risk of heat-related problems is greater the next day; this appears to be one of the best predictors of heat illness.[121] Athletes who sleep in cool or air-conditioned quarters are at less risk.

Poor Physical Condition. Individuals who are untrained are more susceptible to heat illness than are trained athletes. As the $\dot{V}O_2max$ of an individual improves, the ability to withstand heat stress improves independent of acclimatization and heat adaptation.[122] High-intensity work can easily produce 1000 kcal/h and elevate the core temperature of at-risk individuals (those who are unfit, overweight, or unacclimatized) to dangerous levels within 20 to 30 minutes.[123]

Excessive or Dark-Colored Clothing or Equipment. Excessive clothing or equipment decreases the ability to thermoregulate, and dark-colored clothing or equipment may cause a greater absorption of heat from the environment. Both should be avoided.[113]

Overzealousness. Overzealous athletes are at a higher risk for heat illness because they override the normal behavioral adaptations to heat and decrease the likelihood of subtle cues being recognized.

Lack of Acclimatization to Heat. An athlete with no or minimal physiologic acclimatization to hot conditions is at an increased risk of heat-related illness.[8,37,83,124]

Medications and Drugs. Athletes who take certain medications or drugs, particularly medications with a dehydrating effect, are at an increased risk for a heat illness.[101–106,125–136] Alcohol, caffeine, and theophylline at certain doses are mild diuretics.[106,137,138] Caffeine is found in coffee, tea, soft drinks, chocolate, and several over-the-counter and prescription medications.[139] Theophylline is found mostly in tea and anti-asthma medications.[140]

Electrolyte Imbalance. Electrolyte imbalances do not usually occur in trained, acclimatized individuals who engage in physical activity and eat a normal diet.[141] Most sodium and chloride losses in athletes occur through the urine, but athletes who sweat heavily, are salty sweaters, or are not heat acclimatized can lose significant amounts of sodium during activity.[142] Electrolyte imbalances often contribute to heat illness in older athletes who use diuretics.[143,144]

Predisposing Medical Conditions

The following predisposing medical conditions add to the risk of heat illness.

Malignant Hyperthermia. Malignant hyperthermia is caused by an autosomal dominant trait that causes muscle rigidity, resulting in elevation of body temperature due to the accelerated metabolic rate in the skeletal muscle.[145–147]

Neuroleptic Malignant Syndrome. Neuroleptic malignant syndrome is associated with the use of neuroleptic agents and antipsychotic drugs and an unexpected idiopathic increase in core temperature during exercise.[148–151]

Arteriosclerotic Vascular Disease. Arteriosclerotic vascular disease compromises cardiac output and blood flow through the vascular system by thickening the arterial walls.[115,152]

Scleroderma. Scleroderma is a skin disorder that decreases sweat production, thereby decreasing heat transfer.[149,153]

Cystic Fibrosis. Cystic fibrosis causes increased salt loss in sweat and can increase the risk for hyponatremia.[154,155]

Sickle Cell Trait. Sickle cell trait limits blood-flow distribution and decreases oxygen-carrying capacity. The condition is exacerbated by exercise at higher altitudes.[156,157]

Environmental Risk Factors

When the environmental temperature is above skin temperature, athletes begin to absorb heat from the environment and depend entirely on evaporation for heat loss.[113,158,159] High relative humidity inhibits heat loss from the body through evaporation.[61]

The environmental factors that influence the risk of heat illness include the ambient air temperature, relative humidity (amount of water vapor in the air), air motion, and the amount of radiant heat from the sun or other sources.[2,9,41] The relative risk of heat illness can be calculated using the WBGT equation.[2,43,50,69,77,160,161] Using the WBGT index to modify activity in high-risk settings has virtually eliminated heat-stroke deaths in United States Marine Corps recruits.[159] Wet-bulb globe temperature is calculated using the wet-bulb (wb), dry-bulb (db), and black-globe (bg) temperature with the following equation[49,62,85,162,163]:

$$\mathrm{WBGT} = 0.7\mathrm{T_{wb}} + 0.2\mathrm{T_{bg}} + 0.1\mathrm{T_{db}}$$

When there is no radiant heat load, $\mathrm{T_{db}} = \mathrm{T_{bg}}$, and the equation is reduced[62] to

$$\mathrm{WBGT} = 0.7\mathrm{T_{wb}} + 0.3\mathrm{T_{db}}$$

This equation is used to estimate risk as outlined in Table 3.[13,40,50,61,85] This index was determined for athletes wearing a T-shirt and light pants.[158] The WBGT calculation can be performed using information obtained from electronic devices[42] or the local meteorologic service, but conversion tables for relative humidity and $\mathrm{T_{db}}$ are needed to calculate the wet-bulb temperature.[50,162] The predictive value from the meteorologic service is not as accurate as site-specific data for representing local heat load but will suffice in most situations. When WBGT measures are not possible, environmental heat stress can be estimated using a sling psychrometer (see Figures 1, 2).

Several recommendations have been published for distance running, but these can also be applied to other continuous activity sports. The Canadian Track and Field Association recommended that a distance race should be cancelled if the WBGT is greater than 26.7°C (80°F).[39] The American College of Sports Medicine guidelines from 1996 recommended that a race should be delayed or rescheduled when the WBGT is greater than 27.8°C (82°F).[31,72,73] In some instances, the event will go on regardless of the WBGT; ATCs should then have an increased level of suspicion for heat stroke and focus on hydration, emergency supplies, and detection of exertional heat illnesses.

Thermoregulation

Thermoregulation is a complex interaction among the central nervous system (CNS), the cardiovascular system, and the skin to maintain a body-core temperature of 37°C.[9,43,51,164] The CNS temperature-regulation center is located in the hypothalamus and is the site where the core temperature setpoint is determined.[9,43,82,158,164–166] The hypothalamus receives information regarding body-core and shell temperatures from peripheral skin receptors and the circulating blood; body-core temperature is regulated through an open-ended feedback loop similar to that in a home thermostat system.[158,165,167,168] Body responses for heat regulation include cutaneous vasodilation, increased sweating, increased heart rate, and increased respiratory rate.[38,43,51,164,165]

Body-core temperature is determined by metabolic heat production and the transfer of body heat to and from the surrounding environment using the following heat-production and heat-storage equation[166,167]:

$$S = M \pm R \pm K \pm Cv - E$$

where S is the amount of stored heat, M is the metabolic heat production, R is the heat gained or lost by radiation, K is the conductive heat lost or gained, Cv is the convective heat lost or gained, and E is the evaporative heat lost.

Basal metabolic heat production fasting and at absolute rest is approximately 60 to 70 kcal/h for an average adult, with 50% of the heat produced by the internal organs. Metabolic heat produced by intense exercise may approach 1000 kcal/h,[51,164] with greater than 90% of the heat resulting from muscle metabolism.[9,40,42,166]

Heat is gained or lost from the body by one or more of the following mechanisms[9,85]:

Table 4. Physiologic Responses After Heat Acclimatization Relative to Nonacclimatized State

Physiologic Variable	After Acclimatization (10–14 Days' Exposure)
Heart rate	Decreases[46,145]
Stroke volume	Increases[145,147]
Body-core temperature	Decreases[145]
Skin temperature	Decreases[152]
Sweat output/rate	Increases[46,47,149]
Onset of sweat	Earlier in training[46,145]
Evaporation of sweat	Increases[47,152]
Salt in sweat	Decreases[9,50]
Work output	Increases[46,50]
Subjective discomfort (rating of perceived exertion [RPE])	Decreases[50,145]
Fatigue	Decreases[50]
Capacity for work	Increases[46,50]
Mental disturbance	Decreases[50]
Syncopal response	Decreases[9,50]
Extracellular fluid volume	Increases[50]
Plasma volume	Increases[50,150]

Radiation. The energy is transferred to or from an object or body via electromagnetic radiation from higher to lower energy surfaces.[9,43,51,85,166]

Conduction. Heat transfers from warmer to cooler objects through direct physical contact.[9,43,51,85,166] Ice packs and cold-water baths are examples of conductive heat exchange.

Convection. Heat transfers to or from the body to surrounding moving fluid (including air).[9,43,51,85,166] Moving air from a fan, cycling, or windy day produces convective heat exchange.

Evaporation. Heat transfers via the vaporization of sweat§ and is the most efficient means of heat loss.[51,158,169] The evaporation of sweat from the skin depends on the water saturation of the air and the velocity of the moving air.[170–172] The effectiveness of this evaporation for heat loss from the body diminishes rapidly when the relative humidity is greater than 60%.[9,20,164]

Cognitive performance and associated CNS functions deteriorate when brain temperature rises. Signs and symptoms include dizziness, confusion, behavior changes, coordination difficulties, decreased physical performance, and collapse due to hyperthermia.[168,173] The residual effects of elevated brain temperature depend on the duration of the hyperthermia. Heat stroke rarely leads to permanent neurologic deficits[51]; however, some sporadic symptoms of frontal headache and sleep disturbances have been noted for up to 4 months.[168,174,175] When permanent CNS damage occurs, it is associated with cerebellar changes, including ataxia, marked dysarthria, and dysmetria.[174]

Heat Acclimatization

Heat acclimatization is the physiologic response produced by repeated exposures to hot environments in which the capacity to withstand heat stress is improved.[14,43,75,176,177] Physiologic responses to heat stress are summarized in Table 4. Exercise heat exposure produces progressive changes in thermoregulation that involve sweating, skin circulation, thermoregulatory setpoint, cardiovascular alterations, and endocrine adjustments.[29,43,178] Individual differences affect the onset and decay of acclimatization.[29,45,179] The rate of acclimatization is related to aerobic conditioning and fitness; more conditioned athletes acclimatize more quickly.[43,45,180] The acclimatization process begins with heat exposure and is reasonably protective after 7 to 14 days, but maximum acclimatization may take 2 to 3 months.[45,181,182] Heat acclimatization diminishes by day 6 when heat stress is no longer present.[180,183] Fluid replacement improves the induction and effect of heat acclimatization.[184–187] Extra salt in the diet during the first few days of heat exposure also improves acclimatization; this can be accomplished by encouraging the athlete to eat salty foods and to use the salt shaker liberally during meals.

Cumulative Dehydration

Cumulative dehydration develops insidiously over several days and is typically observed during the first few days of a season during practice sessions or in tournament competition. Cumulative dehydration can be detected by monitoring daily prepractice and postpractice weights. Even though a small decrease in body weight (less than 1%) may not have a detrimental effect on the individual, the cumulative effect of a 1% fluid loss per day occurring over several days will create an increased risk for heat illness and a decrease in performance.[110]

During intense exercise in the heat, sweat rates can be 1 to 2.5 L/h (about 1 to 2.25 kilograms [2 to 5 pounds] of body weight per hour) or more, resulting in dehydration. Unfortunately, the volume of fluid that most athletes drink voluntarily during exercise replaces only about 50% of body-fluid losses.[188] Ideally, rehydration involves drinking at a rate sufficient to replace all of the water lost through sweating and urination.[60,77] If the athlete is not able to drink at this rate, he or she should drink the maximum tolerated. Use caution to ensure that athletes do not overhydrate and put themselves at risk for the development of hyponatremia. However, hydration before an event is essential to help decrease the incidence of heat illnesses. For more information on this topic, see the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes.''[52]

Cooling Therapies

The fastest way to decrease body-core temperature is immersion of the trunk and extremities into a pool or tub filled with cold water (between 1°C [35°F] and 15°C [59°F]).[39,88,91,97] Conditions that have been associated with immersion therapy include shivering and peripheral vasoconstriction; however, the potential for these should not deter the medical staff from using immersion therapy for rapid cooling. Shivering can be prevented if the athlete is removed from the water once rectal temperature reaches 38.3°C to 38.9°C (101°F to 102°F). Peripheral vasoconstriction may occur, but the powerful cooling potential of immersion outweighs any potential concerns. Cardiogenic shock has also been a proposed consequence of immersion therapy, but this connection has not been proven in cooling heat-stroke patients.[39] Cold-water immersion therapy was associated with a zero percent fatality rate in 252 cases of exertional heat stroke in the military.[89] Other forms of cooling (water spray; ice packs covering the body; ice packs on axillae, groin, and neck; or blowing air) decrease body-core temperature at a slower rate compared with cold-water im-

§*References 9, 40, 43, 50, 51, 85, 159, 165, 166.*

mersion.[97] If immersion cooling is not being used, cooling with ice bags should be directed to as much of the body as possible, especially the major vessels in the armpit, groin, and neck regions (and likely the hands and feet), and cold towels may be applied to the head and trunk because these areas have been demonstrated on thermography[173,189] to have the most rapid heat loss.

SPECIAL CONCERNS

Most research related to heat illness has been performed on normal, healthy adults. Child athletes, older athletes, and athletes with spinal-cord injuries have been studied less frequently. The following are suggestions for special populations or those with special conditions.

Children (Prepubescents)

Exercise in hot environments and heat tolerance are affected by many physiologic factors in children. These include decreased sweat gland activity,[190] higher skin temperatures,[191–193] decreased cardiac output (increased heart rate and lower stroke volume) due to increased peripheral circulation,[194] decreased exercise economy,[195] decreased ability to acclimatize to heat (slower and takes longer),[192] smaller body size (issues related to body surface-to-mass ratio), maturational differences,[190] and predisposing conditions (obesity, hypohydration, childhood illnesses, and other disease states).[190,192,196]

- Decrease the intensity of activities that last longer than 30 minutes,[197] and have the athlete take brief rests[50] if the WBGT is between 22.8°C and 27.8°C (73°F and 82°F); cancel or modify the activity if the WBGT is greater than 27.8°C (82°F).[31,69–73] Modification could involve longer and more frequent rest breaks than are usually permitted within the rules of the sport (eg, insert a rest break before halftime).
- Encourage children to ingest some fluids at least every 15 to 30 minutes during activity to maintain hydration, even if they are not thirsty.[197]
- Use similar precautions as listed earlier for adults.

Older Athletes (>50 Years Old)

The ability of the older athlete to adapt is partly a function of age and also depends on functional capacity and physiologic health status.[198–206]

- The athlete should be evaluated by a physician before exercise, with the potential consequences of predisposing medical conditions and illnesses addressed.[9,34–36] An increase has been shown in the exercise heart rate of 1 beat per minute for each 1°C (1.8°F) increase in ambient temperature above neutral (23.9°C [75°F]).[207] Athletes with known or suspected heart disease should curtail activities at lower temperatures than healthy athletes and should have cardiovascular stress testing before participating in hot environments.
- Older athletes have a decreased ability to maintain an adequate plasma volume and osmolality during exercise,[198,208] which may predispose them to dehydration. Regular fluid intake is critical to avoid hyperthermia.

Athletes with Spinal-Cord Injuries

As sport participation for athletes with spinal-cord injuries increases from beginner to elite levels, understanding the disability,[209,210] training methods, and causes of heat injury will help make competition safer.[211] For example, the abilities to regulate heart rate, circulate the blood volume, produce sweat, and transfer heat to the surface vary with the level and severity of the spinal-cord lesion.[208,212–218]

- Monitor these athletes closely for heat-related problems. One technique for determining hyperthermia is to feel the skin under the arms of the distressed athlete.[211] Rectal temperature may not be as accurate for measuring core temperature as in other athletes due to decreased ability to regulate blood flow beneath the spinal-cord lesion.[218–220]
- If the athlete is hyperthermic, provide more water, lighter clothing, or cooling of the trunk,[211,213] legs,[211] and head.[213]

HOSPITALIZATION AND RECOVERY

After an episode of heat stroke, the athlete may experience impaired thermoregulation, persistent CNS dysfunction,[221,222] hepatic insufficiency, and renal insufficiency.[39,223] For persons with exertional heat stroke and associated multisystem tissue damage, the rate of recovery is highly individualized, ranging up to more than 1 year.[8,86,221] In one study, 9 of 10 patients exhibited normal heat-acclimatization responses, thermoregulation, whole-body sodium and potassium balance, sweat-gland function, and blood values about 2 months after the heat stroke.[8] Transient or persistent heat intolerance was found in a small percentage of patients.[83] For some athletes, a history of exertional heat stroke increases the chance of experiencing subsequent episodes.[39]

An athlete who experiences heat stroke may have compromised heat tolerance and heat acclimatization after physician clearance.[35,224,225] Decreased heat tolerance may affect 15% to 20% of persons after a heat stroke-related collapse,[226,227] and in a few individuals, decreased heat tolerance has persisted up to 5 years.[35,224,228] Additional heat stress may reduce the athlete's ability to train and compete due to impaired cardiovascular and thermoregulatory responses.[115,228–230]

After recovery from an episode of heat stroke or hyponatremia, an athlete's physical activity should be restricted[8,86] and the gradual return to sport individualized by his or her physician. The athlete should be monitored on a daily basis by the ATC during exercise.[86] During the return-to-exercise phase, an athlete may experience some detraining and deconditioning not directly related to the heat exposure.[8,86] Evaluate the athlete over time to determine whether there has been a complete recovery of exercise and heat tolerance.[8,86]

CONCLUSIONS

Athletic trainers and other allied health providers must be able to differentiate exercise-associated muscle (heat) cramps, heat syncope, exercise (heat) exhaustion, exertional heat stroke, and exertional hyponatremia in athletes.

This position statement outlines the NATA's current recommendations to reduce the incidence, improve the recognition, and optimize treatment of heat illness in athletes. Education and increased awareness will help to reduce both the frequency and the severity of heat illness in athletes.

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American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN

Policy Statement

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Climatic Heat Stress and the Exercising Child and Adolescent (RE9845)

AMERICAN ACADEMY OF PEDIATRICS

Committee on Sports Medicine and Fitness

ABSTRACT. For morphologic and physiologic reasons, exercising children do not adapt as effectively as adults when exposed to a high climatic heat stress. This may affect their performance and well-being, as well as increase the risk for heat-related illness. This policy statement summarizes approaches for the prevention of the detrimental effects of children's activity in hot or humid climates, including the prevention of exercise-induced dehydration.

Heat-induced illness is preventable. Physicians, teachers, coaches, and parents need to be aware of the potential hazards of high-intensity exercise in hot or humid climates and to take measures to prevent heat-related illness in children and adolescents.

Exercising children do not adapt to extremes of temperature as effectively as adults when exposed to a high climatic heat stress.[1] The adaptation of adolescents falls in between. The reasons for these differences include:

1. Children have a greater surface area-to-body mass ratio than adults, which causes a greater heat gain from the environment on a hot day and a greater heat loss to the environment on a cold day.
2. Children produce more metabolic heat per mass unit than adults during physical activities that include walking or running.[2]
3. Sweating capacity is considerably lower in children than in adults,[1,3,4] which reduces the ability of children to dissipate body heat by evaporation.

Exercising children are able to dissipate heat effectively in a neutral or mildly warm climate. However, when air temperature exceeds 35°C (95°F), they have a lower exercise tolerance than do adults. The higher the air temperature, the greater the effect on the child.[4-7] It is important to emphasize that humidity is a major component of heat stress, sometimes even more important than air temperature.

On transition to a warmer climate, exercising persons must allow time to become acclimatized. Intense and prolonged exercise undertaken before acclimatization may be detrimental to the child's physical performance and well-being and may lead to heat-related illness, including heat exhaustion or fatal heat stroke.[8] The rate of acclimatization for children is slower than that of adults.[9] A child will need as many as 8 to 10 exposures (30 to 45 minutes each) to the new climate to acclimatize sufficiently. Such exposures can be taken at a rate of one per day or one every other day.

Children frequently do not feel the need to drink enough to replenish fluid loss during prolonged exercise. This may lead to severe dehydration.[10,11] Children with mental retardation are at special risk for not recognizing the need to replace the fluid loss. A major consequence of dehydration is an excessive increase in core body temperature. Thus, the dehydrated child is more prone to heat-related illness than the fully hydrated child.[12,13] For a given level of hypohydration, children are subject to a greater increase in core body temperature than are adults.[10] Although water is an easily available drink, a flavored beverage may be preferable because the child may drink more of it.[14,15] Another important way to enhance thirst is by adding sodium chloride (approximately 15 to 20 mmol/L, or 1 g per 2 pints) to the flavored solution. This has been shown to increase voluntary drinking by 90%, compared with unflavored water.[15] The above concentration is found in commercially available sports drinks. Salt tablets should be avoided, because of their high content of sodium chloride.

The likelihood of heat intolerance increases with conditions that are associated with excessive fluid loss (febrile state, gastrointestinal infection, diabetes insipidus, diabetes mellitus), suboptimal sweating (spina bifida, sweating insufficiency syndrome), excessive sweating (selected cyanotic congenital heart defects), diminished thirst (cystic fibrosis),[11,12] inadequate drinking (mental retardation, young children who may not comprehend the importance of drinking), abnormal hypothalamic thermoregulatory function (anorexia nervosa, advanced undernutrition, prior heat-related illness), and obesity.[7,8]

Proper health habits can be learned by children and adolescents. Athletes who may be exposed to hot climates should follow proper guidelines for heat acclimatization, fluid intake, appropriate clothing, and adjustment of activity according to ambient temperature and humidity. High humidity levels, even when air temperature is not excessive, result in high heat stress.

Based on this information, the American Academy of Pediatrics recommends the following for children and adolescents:

1. The intensity of activities that last 15 minutes or more should be reduced whenever relative humidity, solar radiation, and air temperature are above critical levels. For specific recommendations, see Table 1. One way of increasing rest periods on a hot day is to substitute players frequently.
2. At the beginning of a strenuous exercise program or after traveling to a warmer climate, the intensity and duration of exercise should be limited initially and then gradually increased during a period of 10 to 14 days to accomplish acclimatization to the heat. When such a period is not available, the length of time for participants during practice and competition should be curtailed.
3. Before prolonged physical activity, the child should be well-hydrated. During the activity, periodic drinking should be enforced (eg, each 20 minutes 150 mL [5 oz] of cold tap water or a flavored salted beverage for a child weighing 40 kg (88 lbs) and 250 mL [9 oz] for an adolescent weighing 60 kg (132 lbs)), even if the child does not feel thirsty. Weighing before and after a training session can verify hydration status if the child is weighed wearing little or no clothing.
4. Clothing should be light-colored and lightweight and limited to one layer of absorbent material to facilitate evaporation of sweat. Sweat-saturated garments should be replaced by dry garments. Rubberized sweat suits should never be used to produce loss of weight.

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TABLE 1
Restraints on Activities at Different Levels of Heat Stress*

WBGT		Restraints on Activities
°C	°F	
<24	<75	All activities allowed, but be alert for prodromes of heat-related illness in prolonged events
24.0-25.9	75.0-78.6	Longer rest periods in the shade; enforce drinking every 15 minutes
26-29	79-84	Stop activity of unacclimatized persons and other persons with high risk; limit activities of all others (disallow long-distance races, cut down further duration of other activities)
>29	>85	Cancel all athletic activities

* From the American Academy of Pediatrics, Committee on Sports Medicine and Fitness.[16] WBGT is *not* air temperature. It indicates wet bulb globe temperature, an index of climatic heat stress that can be measured on the field by the use of a psychrometer. This apparatus, available commercially, is composed of 3 thermometers. One (wet bulb [WB]) has a wet wick around it to monitor humidity. Another is inside a hollow black ball (globe [G]) to monitor radiation. The third is a simple thermometer (temperature [T]) to measure air temperature. The heat stress index is calculated as WBGT = 0.7 WB temp + 0.2 G temp + 0.1 T temp.
It is noteworthy that 70% of the stress is due to humidity, 20% to radiation, and only 10% to air temperature.

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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American College of Sports Medicine Position Stand: Exercise and Fluid Replacement

Summary

American College of Sports Medicine. Position Stand on Exercise and Fluid Replacement. *Med. Sci. Sports Exerc.,* Vol. 28, No. 1, pp. i–vii, 1996. It is the position of the American College of Sports Medicine that adequate fluid replacement helps maintain hydration and, therefore, promotes the health, safety, and optimal physical performance of individuals participating in regular physical activity. This position statement is based on a comprehensive review and interpretation of scientific literature concerning the influence of fluid replacement on exercise performance and the risk of thermal injury associated with dehydration and hyperthermia. Based on available evidence, the American College of Sports Medicine makes the following general recommendations on the amount and composition of fluid that should be ingested in preparation for, during, and after exercise or athletic competition:

1) It is recommended that individuals consume a nutritionally balanced diet and drink adequate fluids during the 24-h period before an event, especially during the period that includes the meal prior to exercise, to promote proper hydration before exercise or competition.
2) It is recommended that individuals drink about 500 ml (about 17 ounces) of fluid about 2 h before exercise to promote adequate hydration and allow time for excretion of excess ingested water.
3) *During* exercise, athletes should start drinking early and at regular intervals in an attempt to consume fluids at a rate sufficient to replace all the water lost through sweating (i.e., body weight loss), or consume the maximal amount that can be tolerated.
4) It is recommended that ingested fluids be cooler than ambient temperature [between 15° and 22°C (59° and 72°F)] and flavored to enhance palatability and promote fluid replacement. Fluids should be readily available and served in containers that allow adequate volumes to be ingested with ease and with minimal interruption of exercise.
5) Addition of proper amounts of carbohydrates and/or electrolytes to a fluid replacement solution is recommended for exercise events of duration greater than 1 h since it does not significantly impair water delivery to the body and may enhance performance. During exercise lasting less than 1 h, there is little evidence of physiological or physical performance differences between consuming a carbohydrate-electrolyte drink and plain water.
6) During intense exercise lasting longer than 1 h, it is recommended that carbohydrates be ingested at a rate of 30–60 g · h^{-1} to maintain oxidation of carbohydrates and delay fatigue. This rate of carbohydrate intake can be achieved without compromising fluid delivery by drinking 600–1200 ml · h^{-1} of solutions containing 4%–8% carbohydrates (g · 100 ml^{-1}). The carbohydrates can be sugars (glucose or sucrose) or starch (e.g., maltodextrin).
7) Inclusion of sodium (0.5–0.7 g · l^{-1} of water) in the rehydration solution ingested during exercise lasting longer than 1 h is recommended since it may be advantageous in enhancing palatability,

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promoting fluid retention, and possibly preventing hyponatremia in certain individuals who drink excessive quantities of fluid. There is little physiological basis for the presence of sodium in an oral rehydration solution for enhancing intestinal water absorption as long as sodium is sufficiently available from the previous meal.

Introduction

Disturbances in body water and electrolyte balance can adversely affect cellular as well as systemic function, subsequently reducing the ability of humans to tolerate prolonged exercise. Water lost during exercise-induced sweating can lead to dehydration of both intracellular and extracellular fluid compartments of the body. Even a small amount of dehydration (1% body weight) can increase cardiovascular strain as indicated by a disproportionate elevation of heart rate during exercise, and limit the ability of the body to transfer heat from contracting muscles to the skin surface where heat can be dissipated to the environment. Therefore, consequences of body water deficits can increase the probability for impairing exercise performance and developing heat injury.

The specific aim of this position statement is to provide appropriate guidelines for fluid replacement that will help avoid or minimize the debilitating effects of water and electrolyte deficits on physiological function and exercise performance. These guidelines will also address the rationale for inclusion of carbohydrates and electrolytes in fluid replacement drinks.

Hydration before Exercise

Fluid replacement following exercise represents hydration prior to the next exercise bout. Any fluid deficit prior to exercise can potentially compromise thermoregulation during the next exercise session if adequate fluid replacement is not employed. Water loss from the body due to sweating is a function of the total thermal load that is related to the combined effects of exercise intensity and ambient conditions (temperature, humidity, wind speed) (62,87). In humans, sweating can exceed 30 g · min^{-1} (1.8 kg · h^{-1}) (2,31). Water lost with sweating is derived from all fluid compartments of the body, including the blood (hypovolemia) (72), thus causing an increase in the concentration of electrolytes in the body fluids (hypertonicity) (85). People who begin exercise when hypohydrated with concomitant hypovolemia and hypertonicity display impaired ability to dissipate body heat during subsequent exercise (26,28, 61,85,86). They demonstrate a faster rise in body core temperature and greater cardiovascular strain (28,34, 82,83). Exercise performance of both short duration and high power output, as well as prolonged moderate intensity endurance activities, can be impaired when individuals begin exercise with the burden of a previously incurred fluid deficit (1,83), an effect that is exaggerated when activity is performed in a hot environment (81).

During exercise, humans typically drink insufficient volumes of fluid to offset sweat losses. This observation has been referred to as "voluntary dehydration" (33,77). Following a fluid volume deficit created by exercise, individuals ingest more fluid and retain a higher percentage of ingested fluid when electrolyte deficits are also replaced (71). In fact, complete restoration of a fluid volume deficit cannot occur without electrolyte replacement (primarily sodium) in food or beverage (39,89). Electrolytes, primarily sodium chloride, and to a lesser extent potassium, are lost in sweat during exercise. The concentration of Na^+ in sweat averages ~ 50 mmol · 1^{-1} but can vary widely (20–100 mmol · 1^{-1}) depending on the state of heat acclimation, diet, and hydration (6). Despite knowing the typical electrolyte concentration of sweat, determination of a typical amount of total electrolyte loss during thermal or exercise stress is difficult because the amount and composition of sweat varies with exercise intensity and environmental conditions. The normal range of daily U.S. intake of sodium chloride (NaCl) is 4.6 to 12.8 g (~80–220 mmol) and potassium (K^+) is 2–4 g (50–100 mmol) (63). Exercise bouts that produce electrolyte losses in the range of normal daily dietary intake are easily replenished within 24 h following exercise and full rehydration is expected if adequate fluids are provided. When meals are consumed, adequate amounts of electrolytes are present so that the composition of the drink becomes unimportant. However, it is important that fluids be available during meal consumption since most persons rehydrate primarily during and after meals. In the absence of meals, more complete rehydration can be accomplished with fluids containing sodium than with plain water (32,55,71).

To avoid or delay the detrimental effects of dehydration during exercise, individuals appear to benefit from fluid ingested prior to competition. For instance, water ingested 60 min before exercise will enhance thermoregulation and lower heart rate during exercise (34,56). However, urine volume will increase as much as 4 times that measured without preexercise fluid intake. Pragmatically, ingestion of 400–600 ml of water 2 h before exercise should allow renal mechanisms sufficient time to regulate total body fluid volume and osmolality at optimal preexercise levels and help delay or avoid detrimental effects of dehydration during exercise.

Fluid Replacement during Exercise

Without adequate fluid replacement during prolonged exercise, rectal temperature and heart rate will become more elevated compared with a well-hydrated condition (13,19,29,54). The most serious effect of dehydration resulting from the failure to replace fluids during exercise is impaired heat dissipation, which can elevate body core temperature to dangerously high levels (i.e., >40° C). Exercise-induced dehydration causes hypertonicity of body fluids and impairs skin blood flow (26,53,54,65), and has been associated with reduced sweat rate (26,85), thus limiting evaporative heat loss, which accounts for more than 80% of heat loss in a hot-dry environment. Dehydration (i.e, 3% body weight loss) can also elicit significant reduction in cardiac output during exercise since a reduction in stroke volume can be greater than the increase in heart rate (53,80). Since a net result of electrolyte and water imbalance associated with failure to adequately replace fluids during exercise is an increased rate of heat storage, dehydration induced by exercise presents a potential for the development of heat-related disorders (24), including potentially life-threatening heat stroke (88,92). It is therefore reasonable to surmise that fluid replacement that offsets dehydration and excessive elevation in body heat during exercise may be instrumental in reducing the risk of thermal injury (37).

To minimize the potential for thermal injury, it is advocated that water losses due to sweating during exercise be replaced at a rate equal to the sweat rate (5,19,66,73). Inadequate water intake can lead to premature exhaustion. During exercise, humans do not typically drink as much water as they sweat and, at best, voluntary drinking only replaces about two-thirds of the body water lost as sweat (36). It is common for individuals to dehydrate by 2%–6% of their body weight during exercise in the heat despite the availability of adequate amounts of fluid (33,35,66,73). In many athletic events, the volume and frequency of fluid consumption may be limited by the rules of competition (e.g., number of rest periods or time outs) or their availability (e.g., spacing of aid stations along a race course). While large volumes of ingested fluids ($\geq 1\ 1 \cdot h^{-1}$) are tolerated by exercising individuals in laboratory studies, field observations indicate that most participants drink sparingly during competition. For example, it is not uncommon for elite runners to ingest less than 200 ml of fluid during distance events in a cool environment lasting more than 2 h (13,66). Actual rates of fluid ingestion are seldom more than $500\ ml \cdot h^{-1}$ (66,68) and most athletes allow themselves to become dehydrated by 2–3 kg of body weight in sports such as running, cycling, and the triathlon. It is clear that perception of thirst, an imperfect index of the magnitude of fluid deficit, cannot be used to provide complete restoration of water lost by sweating. As such, individuals participating in prolonged intense exercise must rely on strategies such as monitoring body weight loss and ingesting volumes of fluid during exercise at a rate equal to that lost from sweating, i.e., body weight reduction, to ensure complete fluid replacement. This can be accomplished by ingesting beverages that enhance drinking at a rate of one pint of fluid per pound of body weight reduction. While gastrointestinal discomfort has been reported by individuals who have attempted to drink at rates equal to their sweat rates, especially in excess of $1\ 1 \cdot h^{-1}$ (10,13,52,57,66), this response appears to be individual and there is no clear association between the volume of ingested fluid and symptoms of gastrointestinal distress. Further, failure to maintain hydration during exercise by drinking appropriate amounts of fluid may contribute to gastrointestinal symptoms (64,76). Therefore, individuals should be encouraged to consume the maximal amount of fluids during exercise that can be tolerated without gastrointestinal discomfort up to a rate equal to that lost from sweating.

Enhancing palatability of an ingested fluid is one way of improving the match between fluid intake and sweat output. Water palatability is influenced by several factors including temperature and flavoring (25,36). While most individuals prefer cool water, the preferred water temperature is influenced by cultural and learned behaviors. The most pleasurable water temperature during recovery from exercise was 5°C (78), although when water was ingested in large quantities, a temperature of ~15°–21°C was preferred (9,36). Experiments have also demonstrated that voluntary fluid intake is enhanced if the fluid is flavored (25,36) and/or sweetened (27). It is therefore reasonable to expect that the effect of flavoring and water temperature should increase fluid consumption during exercise, although there is insufficient evidence to support this hypothesis. In general, fluid replacement beverages that are sweetened (artificially or with sugars), flavored, and cooled to between 15° and 21° C should stimulate fluid intake (9,25,36,78).

The rate at which fluid and electrolyte balance will be restored is also determined by the rate at which ingested fluid empties from the stomach and is absorbed from the intestine into the blood. The rate at which fluid leaves the stomach is dependent on a complex interaction of several factors, such as volume, temperature, and composition of the ingested fluid, and exercise intensity. The most important factor influencing gastric emptying is the fluid volume in the stomach (52,68,75). However, the rate of gastric emptying of fluid is slowed proportionately with increasing glucose concentration above 8% (15,38). When gastric fluid volume is maintained at 600 ml or more, most individuals can still empty more than $1000\ ml \cdot h^{-1}$ when the fluids contain a 4%–8% carbohydrate concentration (19,68). Therefore, to promote gastric emptying, especially with the presence of 4%–8% carbohydrate in the fluid, it is advantageous to maintain the largest volume of fluid that can be tolerated in the stomach during exercise (e.g., 400–600 ml). Mild to moderate exercise appears to have little or no effect on gastric emptying while heavy exercise at intensities greater than 80% of maximal capacity may slow gastric emptying (12,15). Laboratory and field studies suggest that during prolonged exercise, frequent (every 15–20 min) consumption of moderate (150 ml) to large (350 ml) volumes of fluid is possible. Despite the apparent advantage of high gastric fluid volume for promoting gastric emptying, there should be some caution associated with maintaining high gastric fluid volume. People differ in their gastric emptying rates as well as their tolerance to gastric volumes, and it has not been determined if the ability to tolerate high gastric volumes can be improved by drinking during training. It is also unclear whether complaints of gastrointestinal symptoms by athletes during competition are a function of an unfamiliarity of exercising with a full stomach or because of delays in gastric emptying (57). It is therefore recommended that individuals learn their tolerance limits for maintaining a high gastric fluid volume for various exercise intensities and durations.

Once ingested fluid moves into the intestine, water moves out of the intestine into the blood. Intestinal absorptive capacity is generally adequate to cope with even the most extreme demands (30); and at intensities of exercise that can be sustained for more than 30 min, there appears to be little effect of exercise on intestinal function (84). In fact, dehydration consequent to failure to replace fluids lost during exercise reduces the rate of gastric emptying (64,76), supporting the rationale for early and continued drinking throughout exercise.

Electrolyte and Carbohydrate Replacement during Exercise

There is little physiological basis for the presence of sodium in an oral rehydration solution for enhancing intestinal water absorption as long as sodium is sufficiently available in the gut from the previous meal or in the pancreatic secretions (84). Inclusion of sodium (<50 mmol $\cdot$ 1^{-1}) in fluid replacement drinks during exercise has not shown consistent improvements in retention of ingested fluid in the vascular compartment (20,23,44,45). A primary rationale for electrolyte supplementation with fluid replacement drinks is, therefore, to replace electrolytes lost from sweating during exercise greater than 4–5 h in duration (3). Normal plasma sodium concentration is 140 mmol $\cdot$ 1^{-1}, making sweat (~50 mmol $\cdot$ 1^{-1}) hypotonic relative to plasma. At a sweat rate of 1.5 $\cdot$ h^{-1}, a total sodium deficit of 75 mmol $\cdot$ h^{-1} could occur during exercise. Drinking water can lower elevated plasma electrolyte concentrations back toward normal and restore sweating (85,86), but complete restoration of the extracellular fluid compartment cannot be sustained without replacement of lost sodium (39,70,89). In most cases, this can be accomplished by normal dietary intake (63). If sodium enhances palatability, then its presence in a replacement solution may be justified because drinking can be maximized by improving taste qualities of the ingested fluid (9,25).

The addition of carbohydrates to a fluid replacement solution can enhance intestinal absorption of water (30,84). However, a primary role of ingesting carbohydrates in a fluid replacement beverage is to maintain blood glucose concentration and enhance carbohydrate oxidation during exercise that lasts longer than 1 h, especially when muscle glycogen is low (11,14, 17,18,50,60). As a result, fatigue can be delayed by carbohydrate ingestion during exercise of duration longer than 1 h which normally causes fatigue without carbohydrate ingestion (11). To maintain blood glucose levels during continuous moderate-to-high intensity exercise, carbohydrates should be ingested throughout exercise at a rate of 30–60 g $\cdot$ h^{-1}. These amounts of carbohydrates can be obtained while also replacing relatively large amounts of fluid if the concentration of carbohydrates is kept below 10% (g $\cdot$ 100 ml^{-1} of fluid). For example, if the desired volume of ingestion is 600–1200 ml $\cdot$ h^{-1}, then the carbohydrate requirements can be met by drinking fluids with concentrations in the range of 4%–8% (19). With this procedure, both fluid and carbohydrate requirements can be met simultaneously during prolonged exercise. Solutions containing carbohydrate concentrations >0% will cause a net movement of fluid into the intestinal lumen because of their high osmolality, when such solutions are ingested during exercise. This can result in an effective loss of water from the vascular compartment and can exacerbate the effects of dehydration (43).

Few investigators have examined the benefits of adding carbohydrates to water during exercise events lasting less than 1 h. Although preliminary data suggest a potential benefit for performance (4,7,48), the mechanism is unclear. It would be premature to recommend drinking something other than water during exercise lasting less than 1 h. Generally, the inclusion of glucose, sucrose, and other complex carbohydrates in fluid replacement solutions have equal effectiveness in increasing exogenous carbohydrate oxidation, delaying fatigue, and improving performance (11,16,79,90). However, fructose should not be the predominant carbohydrate because it is converted slowly to blood glucose—not readily oxidized (41,42)—which does not improve performance (8). Furthermore, fructose may cause gastrointestinal distress (59).

Fluid Replacement and Exercise Performance

Although the impact of fluid deficits on cardiovascular function and thermoregulation is evident, the extent to which exercise performance is altered by fluid replacement remains unclear. Although some data indicate that drinking improves the ability to perform short duration athletic events (1 h) in moderate climates (7), other data suggest that this may not be the case (40). It is likely that the effect of fluid replacement on performance may be most noticeable during exercise of duration greater than 1 h and/or at extreme ambient environments.

The addition of a small amount of sodium to rehydration fluids has little impact on time to exhaustion during mild prolonged (>4 h) exercise in the heat (73), ability to complete 6 h of moderate exercise (5), or capacity to perform during simulated time trials (20,74). A sodium deficit, in combination with ingestion and retention of a large volume of fluid with little or no electrolytes, has led to low plasma sodium levels in a very few marathon or ultra-marathon athletes (3,67). Hyponatremia (blood sodium concentration between 117 and 128 mmol · l^{-1}) has been observed in ultra-endurance athletes at the end of competition and is associated with disorientation, confusion, and in most cases, grand mal seizures (67,69). One major rationale for inclusion of sodium in rehydration drinks is to avoid hyponatremia. To prevent development of this rare condition during prolonged (>4 h) exercise, electrolytes should be present in the fluid or food during and after exercise.

Maintenance of blood glucose concentrations is necessary for optimal exercise performance. To maintain blood glucose concentration during fatiguing exercise greater than 1 h (above 65% VO_{2max}), carbohydrate ingestion is necessary (11,49). Late in prolonged exercise, ingested carbohydrates become the main source of carbohydrate energy and can delay the onset of fatigue (17,19,21,22,51,58). Data from field studies designed to test these concepts during athletic competition have not always demonstrated delayed onset of fatigue (46,47,91), but the inability to control critical factors (such as environmental conditions, state of training, drinking volumes) make confirmation difficult. Inclusion of carbohydrates in a rehydration solution becomes more important for optimal performance as the duration of intense exercise exceeds 1 h.

Conclusion

The primary objective for replacing body fluid loss during exercise is to maintain normal hydration. One should consume adequate fluids during the 24-h period before an event and drink about 500 ml (about 17 ounces) of fluid about 2 h before exercise to promote adequate hydration and allow time for excretion of excess ingested water. To minimize risk of thermal injury and impairment of exercise performance during exercise, fluid replacement should attempt to equal fluid loss. At equal exercise intensity, the requirement for fluid replacement becomes greater with increased sweating during environmental thermal stress. During exercise lasting longer than 1 h, a) carbohydrates should be added to the fluid replacement solution to maintain blood glucose concentration and delay the onset of fatigue, and b) electrolytes (primarily NaCl) should be added to the fluid replacement solution to enhance palatability and reduce the probability for development of hyponatremia. During exercise, fluid and carbohydrate requirements can be met simultaneously by ingesting 600–1200 ml · h^{-1} of solutions containing 4%–8% carbohydrate. During exercise greater than 1 h, approximately 0.5–0.7 g of sodium per liter of water would be appropriate to replace that lost from sweating.

Acknowledgment

This pronouncement was reviewed for the American College of Sports Medicine by members-at-large, the Pronouncement Committee, and by: David L. Costill, Ph.D., FACSM, John E. Greenleaf, Ph.D., FACSM, Scott J. Montain, Ph.D., and Timothy D. Noakes, M.D., FACSM.

Heat and Cold Illnesses During Distance Running

American College of Sports Medicine Position Stand

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Summary

Many recreational and elite runners participate in distance races each year. When these events are conducted in hot or cold conditions, the risk of environmental illness increases. However, exertional hyperthemia, hypothermia, dehydration, and other related problems may be minimized with pre-event education and preparation. This position stand provides recommendations for the medical director and other race officials in the following areas: scheduling; organizing personnel, facilities, supplies, equipment, and communications providing competitor education; measuring environmental stress; providing fluids; and avoiding potential legal liabilities. This document also describes the predisposing conditions, recognition, and treatment of the four most common environmental illnesses: heat exhaustion, heatstroke, hypothermia, and frostbite. The objectives of this position stand are: 1) To educate distance running event officials and participants about the most common forms of environmental illness including predisposing conditions, warning signs, susceptibility, and incidence reduction. 2) To advise race officials of their legal responsibilities and potential liability with regard to event safety and injury prevention. 3) To recommend that race officials consult local weather archives and plan events at times likely to be of low environmental stress to minimize detrimental effects on participants. 4) To encourage race officials to warm participants about environmental stress on race day and its implications for heat and cold illness. 5) To inform race officials of preventive actions that may reduce debilitation and environmental illness. 6) To describe the personnel, equipment, and supplies necessary to reduce and treat cases of collapse and environmental illness.

Introduction

This document replaces the position stand titled *The Prevention of Thermal Injuries During Distance Running* (4). It considers problems that may affect the extensive community of recreational joggers and elite athletes who participate in distance running events. It has been expanded to include heat exhaustion, heatstroke, hypothermia, and frostbite–the most common environmental illnesses during races.

Because physiological responses to exercise in stressful environments may vary among participants, and because the health status of participants varies from day to day, compliance with these recommendations will not guarantee protection from environmentally induced illnesses. Nevertheless, these recommendations should minimize the risk of exertional hyperthermia, hypothermia, dehydration, and resulting problems in distance running and other forms of continuous athletic activity such as bicycle, soccer, and triathlon competition.

Managing a large road race is a complex task that requires financial resources, a communication network, trained volunteers, and teamwork. Environmental extremes impose additional burdens on the organizational and medical systems. Therefore, it is the position of the American College of Sports Medicine that the following RECOMMENDATIONS be employed by race managers and medical directors of community events that involve prolonged or intense exercise in mild and stressful environments.

1. Race Organization

a. Distance races should be scheduled to avoid extremely hot and humid and very cold months. The local weather history should be consulted when scheduling an event. Organizers should be cautious of unseasonably hot or cold days in early spring or late fall because entrants may not be sufficiently acclimatized. The wind chill index should be used to reschedule races on cold, windy days because flesh may freeze rapidly and cold injuries may result.

b. Summer events should be scheduled in the early morning or the evening to minimize solar radiation and air temperature. Winter events should be scheduled at midday to minimize the risk of cold injury.

c. The heat stress index should be measured at the site of the race because meteorological data from a distant weather station may vary considerably from local conditions (66). The wet bulb globe temperature (WBGT) index is widely used in athletic and industrial settings [see Appendix I;(87)]. If the WBGT index is above 28 °C (82 °F), or if the ambient dry bulb temperature is below -20 °C (-4 °F), consideration should be given to canceling the race or rescheduling it until less stressful conditions prevail. If the WBGT index is below 28 °'C, participants should be alerted to the risk of heat illness by using signs posted at the start of the race and at key positions along the race course [see Appendix I;(61)]. Also, race organizers should monitor changes in weather conditions. WBGT monitors can be purchased commercially, or Figure I may be used to approximate the risk of racing in hot environments based on air temperature and relative humidity. These two measures are available from local meteorological stations and media weather reports, or can be measured with a sling psychrometer.

d. An adequate supply of fluid must be available before the start of the race, along the race course, and at the end of the event. Runners should be encouraged to replace their sweat losses or consume 150-300 ml (5.3-10.5 oz) every 15 minutes (3). Sweat loss can be derived by calculating the difference between pre and postexercise body weight.

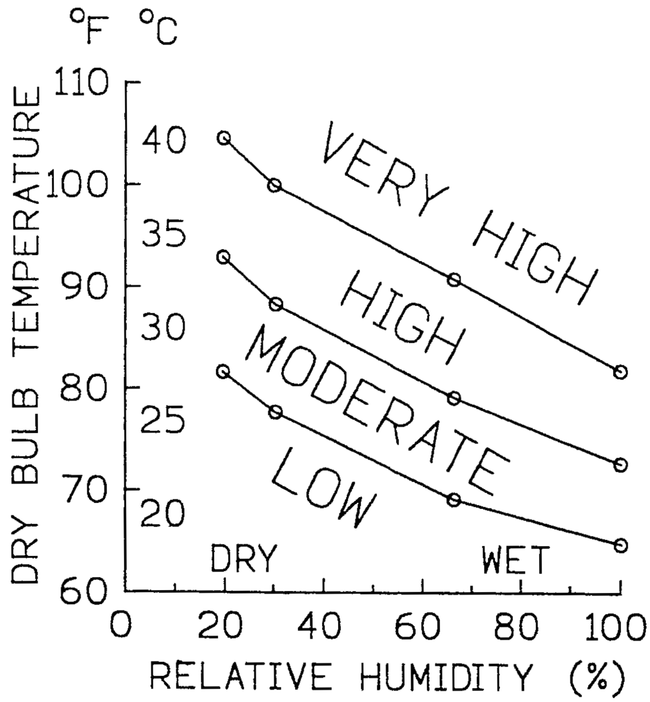

Figure 1 Risk of heat exhaustion or heatstroke while racing in hot environments. Figure drawn from data presented in American College of Sports Medicine Position stand: the prevention of thermal injuries during distance running. *Med. Sci. Sports Exerc.* 19:529-533, 1987.

e. Cool or cold (ice) water immersion is the most effective means of cooling a collapsed hyperthermic runner (25, 48, 49, 59, 88). Wetting runners externally by spraying or sponging during exercise in a hot environment is pleasurable but does not fully attenuate the rise in body core temperature (14, 88). Wetting the skin can result in effective cooling once exercise ceases.

f. Race officials should be aware of the warning signs of an impending collapse in both hot and cold environments and should warn runners to slow down or stop if they appear to be in difficulty.

g. Adequate traffic and crowd control must be maintained along the course at all times.

h. Radio communication or cellular telephones should connect various points on the course with an information processing center to coordinate emergency responses.

2. Medical Director

A sports medicine physician should work closely with the race director to enhance the safety and provide adequate medical care for all participants. The medical director should understand exercise physiology, interpretation of meteorological data, heat and cold illness prevention strategies, potential liability, and the treatment of medical problems associated with endurance events conducted in stressful environments.

3. Medical Support

a. Medical organization and responsibility: The medical director should alert local hospitals and ambulance services and make prior arrangements to care for casualties, including those with heat or cold injury. Medical personnel should have the authority to evaluate, examine, and stop runners who display signs of impending illness or collapse. Runners should be advised of this procedure prior to the event.

b. Medical facilities: Medical support staff and facilities must be available at the race site. The facilities should be staffed with personnel capable of instituting immediate and appropriate resuscitation measures. The equipment necessary to institute both cooling therapy (ice packs, child's wading pools filled with tap water or ice water, fans) and warming therapy (heaters, blankets, hot beverages) may be necessary at the same event. For example, medical personnel treated 12 cases of hyperthermia and 13 cases of hypothermia at an endurance triathlon involving 2300 competitors: air temperature was 85°F, water temperature was 58°F (92).

4. Competitor Education

The physical training and knowledge of competitive runners and joggers has increased greatly, but race organizers must not assume that all participants are well prepared or informed about safety. Distributing this position stand before registration, publicizing the event in the media, and conducting clinics or seminars before events are valuable educational procedures.

a. All participants should be advised that the following conditions may exacerbate heat illness: obesity (13, 39, 89), low degree of physical fitness (30, 63, 79, 83), dehydration (23, 34, 69, 83, 84, 95), lack of heat acclimatization (31, 51, 89), a previous history of heat stroke (82, 89), sleep deprivation (5), certain medications, including diuretics and antidepressants (31), and sweat gland dysfunction or sunburn (31). Illness 1 week prior to an event should preclude participation (32, 96), especially those involving fever, respiratory tract infections, or diarrhea (41, 46).

b. Prepubescent children sweat less than adults and have lower heat tolerance (11, 12).

c. Adequate training and fitness are important for full enjoyment of the event and will reduce the risk of heat illness and hypothermia (33, 64, 67, 85).

d. Prior training in the heat will promote heat acclimatization (6) and thereby reduce the risk of heat illness, especially if the training environment is warmer than that expected during a race (5, 51). Artificial heat acclimatization can be induced in cold conditions (6).

e. Adequate fluid consumption before and during the race can reduce the risk of heat illness, including disorientation and irrational behavior, particularly in longer events such as a marathon (23, 34, 95).

f. Excessive consumption of pure water or dilute fluid (i.e., up to 10 liters per 4 hours) during prolonged endurance events may lead to a harmful dilutional hyponatremia (60), which may involve disorientation, confusion, and seizure or coma. The possibility of hyponatremia may be the best rationale for inclusion of sodium chloride in fluid replacement beverages (3).

g. Participants should be advised of the early symptoms of heat illness, which may include clumsiness, stumbling, headache, nausea, dizziness, apathy, confusion, and impairment of consciousness (41,86).

h. Participants should be advised of the early symptoms of hypothemia (slurred speech, ataxia, stumbling gait) and frostbite (numbness, burning, pain, paresthesia) on exposed skin (36). Wet clothing, especially cotton, increases heat loss and the risk of hypothermia (68).

i. Participants should be advised to choose a comfortable running speed and not to run faster than environmental conditions or their cardiorespiratory fitness warrant (43, 71, 91).

j. It is helpful if novice runners exercise with a partner, each being responsible for the other's well-being (71).

5. Responsibilities and Potential Liability

The sponsors and directors of an endurance event are reasonably safe from liability due to injury if they avoid gross negligence and willful misconduct, carefully inform the participants of hazards, and have them sign waivers before the race (78). However, a waiver signed by a participant does not totally absolve race organizers of moral and/or legal responsibility. It is recommended that race sponsors and directors: 1) minimize hazards and make safety the first concern; 2) describe inherent hazards (i.e., potential course hazards, traffic control, weather conditions) in the race application; 3) require all entrants to sign a waiver; 4) retain waivers and records for 3 yrs; 5) warn runners of the predisposing factors and symptoms of environmental illness; 6) provide all advertised support services; 7) legally incorporate the race or organizations involved; and 8) purchase liability insurance (18, 78, 80).

Race directors should investigate local laws regarding Good Samaritan action. In some states physicians who do not accept remuneration may be classified as Good Samaritans. Race liability insurance may not cover physicians (78), therefore the malpractice insurance policy of each participating physician should be evaluated to determine if it covers services rendered at the race.

Medical and race directors should postpone, reschedule, or cancel a race if environmental conditions warrant, even though runners and trained volunteers arrive at the site and financial sponsorship has been provided. Runners may not have adequate experience to make the decision not to compete; their safety must be considered. Downgrading the race to a "fun run" does not absolve race supervisors from their responsibility or decrease the risk to participants (15, 66).

Background For This Position Stand

Dehydration is common during prolonged endurance events in both cold and hot environmental conditions because the average participant loses 0.5-1.5 quarts (0.47-1.42 liters) of sweat, and fluid replacement is usually insufficient (12, 42, 69). Runners may experience hyperthermia [body core temperature above 39°C (102.2°F)] or hypothermia [body core temperature below 35°C (95°F)], depending on the environmental conditions, caloric intake, fluid consumption, and clothing worn. Hyperthermia is a potential problem in warm and hot weather races when the body's rate of heat production is greater than its heat dissipation (2). Indeed, on extremely hot days, it is possible that up to 50% of the participants may require treatment for heat-related illnesses such as heat exhaustion and heatstroke (1, 66). Hypothermia is more likely to occur in cold or cool-windy conditions. Scanty clothing may provide inadequate protection from such environments, particularly near the end of a long race when running speed and heat production are reduced. Frostbite can occur in low air temperature and especially when combined with high wind speed. The race and medical directors should anticipate the above medical problems and be capable of responding to a large number of patients with adequate facilities, supplies, and support staff. The four most common heat and cold illnesses during distance running are heat exhaustion, heatstroke, hypothermia, and frostbite.

1. Heat Exhaustion

Body sweat loss can be significant in summer endurance races and may result in a body water deficit of 6-10% of body weight (41, 95). Such dehydration will reduce the ability to exercise in the heat because decreases in circulating blood volume, blood pressure, sweat production, and skin blood flow all inhibit heat loss (41, 81) and predispose the runner to heat exhaustion or the more dangerous hyperthermia and exertional heatstroke (41, 66).

Heat exhaustion, typically the most common heat illness among athletes, is defined as the inability to continue exercise in the heat (7). It represents a failure of the cardiovascular responses to workload, high external temperature, and dehydration (16, 41, 42). Heat exhaustion has no known chronic, harmful effects. Symptoms may include headache, extreme weakness, dizziness, vertigo, "heat sensations" on the head or neck, heat cramps, chills, "goose flesh" ("goose bumps"), vomiting, nausea, and irritability (41, 42). Hyperventilation, muscular incoordination, agitation, impaired judgment, and confusion also may be seen. Heat syncope (fainting) may or may not accompany heat exhaustion (41). The onset of heat exhaustion symptoms is usually sudden and the duration of collapse brief. During the acute stage of heat exhaustion, the patient looks ashen-gray, the blood pressure is low, and the pulse rate is elevated. Hyperthermia may add to the symptoms of heat exhaustion, even on relatively cool days (20, 22, 30, 37, 38, 43, 62, 90).

Although it is improbable that all heat exhaustion cases can be avoided, the most susceptible individuals are those who either exert themselves at or near their maximal capacities, are dehydrated, not physically fit, and not acclimatized to exercise in the heat. It is imperative that runners be adequately rested, fed, hydrated, and acclimatized (7); they should drink ample fluids before, during, and after exercise (3). Also, repeated bouts of exercise in the heat (heat acclimatization) reduce the incidence of both heat exhaustion and heat syncope. Heat acclimatization can best be accomplished by gradually increasing the duration and intensity of exercise training during the initial 10-14 d of heat exposure (6).

Oral rehydration is preferred for heat exhaustion patients who are conscious, coherent, and without vomiting or diarrhea. Intravenous (IV) fluid administration facilitates rapid recovery (42, 57). Although a variety of IV solutions have been used at races (42), a 5% dextrose sugar in either 0.45% saline (NACI) or 0.9% NaCl are the most common (1). Runners may require up to 4 1 of IV fluid if severely dehydrated (57).

2. Exertional Heatstroke

Heat production, mainly from muscles, during intense exercise is 15-20 times greater than at rest, and is sufficient to raise body core temperature by 1°C (1.8°F) each 5 minutes without thermoregulatory (heat loss) adjustments (56). When the rate of heat production exceeds that of heat loss for a sufficient period of time, severe hyperthermia occurs.

Heatstroke is the most serious of the syndromes associated with excess body heat. It is defined as a condition in which body temperature is elevated to a level that causes damage to the body's tissues, giving rise to a characteristic clinical and pathological syndrome affecting multiple organs (32, 83). After races, adult core (rectal) temperatures above 40.6°C (105.1°F) have been reported in conscious runners (24, 52, 69, 74, 77), and 42-43°C (107.6-109.4°F) in collapsed runners (72-74, 86, 90). Sweating is usually present in runners who experience exertional heatstroke (87).

Strenuous physical exercise in a hot environment has been notorious as the cause of heatstroke, but heatstroke also has been observed in cool-to-moderate [13-28°C (55-82°F)] environments (5, 32, 74), suggesting variations in individual susceptibility (5, 31, 32). Skin disease, sunburn, dehydration, alcohol or drug use/abuse, obesity, sleep loss, poor physical fitness, lack of heat acclimatization, advanced age, and a previous heat injury all have been theoretically linked to increased risk of heatstroke (5, 31, 51, 84). The risk of heatstroke is reduced if runners are well-hydrated, well-fed, rested, and acclimatized. Runners should not exercise if they have a concurrent illness, respiratory infection, diarrhea, vomiting, or fever (5, 7, 46). For example, a study of 179 heat casualties at a 14-km race showed that 23% reported a recent gastrointestinal or respiratory illness (70), whereas a study of 10 military heatstroke patients reported that three had a fever or disease and six recalled at least one warning sign of impending illness at the time of their heatstroke (5).

Appropriate fluid ingestion before and during prolonged running can minimize dehydration and reduce the rate of increase in body core temperature (24, 34). However, excessive hyperthermia may occur in the absence of significant dehydration, especially in races of less than 10 km, because the fast pace generates greater metabolic heat (90).

The mortality rate and organ damage due to heatstroke are proportional to the length of time between core temperature elevation and initiation of cooling therapy (5, 26). Therefore, prompt recognition and cooling are essential (1, 5, 22, 42, 48, 51, 62, 74, 83). A measurement of deep body temperature is vital to the diagnosis, and a rectal temperature should be measured in any casualty suspected of having heat illness or hypothermia. Ear (tympanic), oral, or axillary measurements are spuriously affected by peripheral (skin) and environmental temperatures and should not be used after exercise (8, 75, 76). When cooling is initiated rapidly, most heatstroke patients recover fully with normal psychological status (79), muscle energy metabolism (65), heat acclimatization, temperature regulation, electrolyte balance, sweat gland function, and blood constituents (5).

Many whole-body cooling techniques have been used to treat exertional heatstroke, including water immersion, application of wet towels or sheets, warm air spray, helicopter downdraft, and ice packs to the neck, underarm, and groin areas. There is disagreement as to which modality provides the most efficient cooling (7, 47, 97), because several methods have been used successfully. However, the fastest whole-body cooling rates (25, 48, 49, 59, 88) and the lowest mortality rates (25) have been observed during cool and cold water immersion. Whichever modality is utilized it should be simple and safe, provide great cooling power, and should not restrict other forms of therapy (i.e., cardiopulmonary resuscitation, defibrillation, IV cannulation). The advantages and disadvantages of various cooling techniques have been discussed (47, 75, 97).

Heatstroke is regarded as a medical emergency that might be fatal if not immediately diagnosed and properly treated. Early diagnosis is of utmost importance and time-consuming investigation should be postponed until body temperature is corrected and the patient is evacuated to a nearby medical facility that is aware of such conditions.

3. Hypothermia

Hypothermia [body core temperature below 36°C (97 °F)] occurs when heat loss is greater than metabolic heat production (94). Early signs and symptoms of hypothermia include shivering, euphoria, confusion, and behavior similar to intoxication. Lethargy, muscular weakness, disorientation, hallucinations, depression, or combative behavior may occur as core temperature continues to fall. If body core temperature falls below 31.1°C

(88°F), shivering may stop and the patient will become progressively delirious, uncoordinated, and eventually comatose if treatment is not provided (10).

During cool or cold weather marathons, the most common illnesses are hypothermia, exhaustion, and dehydration. The most common medical complaints are weakness, shivering, lethargy, slurred speech, dizziness, diarrhea, and thirst (1, 45). Runner complaints of feeling hot or cold do not always agree with changes in rectal temperature (74). Dehydration is common in cool weather (1, 45). Runners should attempt to replace fluids at a rate that matches their sweat and urine losses. Cases of hypothermia also occur in spring and fall because weather conditions change rapidly and runners wear inappropriate clothing that becomes sweat-soaked during training or competition (19).

Hypothermia may occur during races, for example when distance runners complete the second half of the event more slowly than the first half (54). Evaporative and radiative cooling increase because wet skin (from sweat, rain, or snow) and clothing are exposed to higher wind speed at a time when metabolic heat production decreases. Hypothermia also occurs after a race, when the temperature gradient between the body surface and the environment is high. Subfreezing ambient temperatures need not be present and hypothermia may develop even when the air temperature is 10-18°C (50-65°F) (19, 36, 74). A WBGT meter can be used to evaluate the risk of hypothermia (see Appendix 1). Cold wind increases heat loss in proportion to wind speed; i.e., wind chill factor. The relative degree of danger can be assessed (Fig. 2) (55). Wind speed can be estimated; if you feel the wind in your face the speed is at least 16 km per hour^{-1} (kph) [10 miles per hour^{-1} (mph)]; if small tree branches move or if snow and dust are raised, approximately 32 kph (20 mph); if large tree branches move, 48 kph (30 mph); if an entire tree bends, about 64 kph (40 mph) (9).

To reduce heat loss, runners should protect themselves from moisture, wind, and cold air by wearing several layers of light, loose clothing that insulate the skin with trapped air (17). An outer garment that is windproof, allows moisture to escape, and provides rain protection is useful. Lightweight nylon parkas may not offer thermal insulation but offer significant protection against severe wind chill, especially if a hood is provided. Wool and polyester fabrics retain some protective value when wet; cotton and goose down do not (10). Areas of the body that lose large amounts of heat (head, neck, legs, hands) should be covered (17).

Mild [34-36°C (93-97°F)] or moderate [30-34°C (86-93°F)] hypothermia should be treated before it progresses. Wet clothing should be replaced with dry material (sweatsuit, blanket) that is insulated from the ground and wind. Warm fluids should be consumed if patients are conscious, able to talk, and thinking clearly. Patients with moderate and severe [<30°C (86°F)] hypothermia should be insulated in a blanket and evacuated to a hospital immediately (19, 58). Although severe hypothermia should be treated in the field (27), it is widely recognized that life-threatening ventricular fibrillation is common in this state and may be initiated

Wind Chill Chart

AIR TEMPER-ATURE	ESTIMATED WIND SPEED IN MPH (KPH) 0 (0)	10 (16)	20 (32)	0 (48)	
30F (-1.I C)	30 (1.1)	16 (-8.9)	4 (-15.6)	-2 (-18.9)	LITTLE RISK
20 F (-6.7 C)	20 (-6-7)	4 (-15.6)	-10 (-23-3)	-18 (-27.8)	
10F (12.2 C)	10 (-12.2)	-9 (-22.8)	-25 (-31.7)	-33 (-36.1)	INCREASED RISK
0 F (-17.8 C)	0 (-17.8)	-24 (-31.1)	-39 (-39.4)	-48 (-44.4)	
-10 F (-23.3 C)	-10 (-23.3)	-33 (-36.1)	-53 (-47.2)	-63 (-52.8)	
-20 F (-28.9 C)	-20 (-28.9)	-46 (-43.3)	-67 (-55)	-79 (-61.7)	GREAT RISK

Figure 2 The risk of freezing exposed flesh in cold environments.
Reprinted from Milesko-Pytel, D. Helping the frostbitten patient. *Patient Care* 17:90-115, 1983.

by physical manipulation, chest compression, or intubation (10, 27, 58, 93). However, with conclusive evidence of cardiac standstill and breathlessness, emergency procedures (i.e., Basic Life Support, Advanced Cardiac Life Support) should be initiated. Life-support procedures (27) and commonly observed laboratory (i.e., electrolyte, acid-base) values (10, 58) have been described by others.

4. Frostbite

Frostbite involves crystallization of fluids in the skin or subcutaneous tissue after exposure to subfreezing temperatures [< -0.6°C (31°F)]. With low skin temperature and dehydration, cutaneous blood vessels constrict and circulation is attenuated because the viscosity of blood increases (55). Frostbite may occur within seconds or hours of exposure, depending upon air temperature, wind speed, and body insulation. Frostbitten skin can appear white, yellow-white, or purple, and is hard, cold, and insensitive to touch (55). Rewarming results in intense pain, skin reddening, and swelling. Blister formation is common and loss of extremities (fingers, toes, ears, hands, feet) is possible (36, 55). The degree of tissue damage depends on duration and severity of the freezing and effectiveness of treatment.

No data have been published regarding the incidence of frostbite among athletes during training or competition. Since winter running races are rarely postponed when environmental conditions are harsh, and frostbite is the most common cold injury in military settings (35), it is imperative that runners be aware of the dangers. Crosscountry ski races are postponed if the temperature at the coldest point of the course is less than -20 °C (-4 °F), due to the severe wind chill generated at race pace.

Runners risk frozen flesh within minutes if the air temperature and wind speed combine to present a severe wind chill. Because runners prefer to have unrestricted movement during races, and because they know that exercise results in body heating, they may not wear sufficient clothing. Runners can avoid frostbite and hypothermia in cold and windy conditions by protecting themselves by dressing adequately: wet skin or clothing will increase the risk of frostbite (21, 29).

When tissue freezes [skin temperature -2 ° -O °C, (28-32 °F)], water is drawn out of the cells and ice crystals cause mechanical destruction of skin and subcutaneous tissue (36). However, initial ice crystal formation is not as damaging to tissues as partial rethawing and refreezing (40). Therefore, the decision to treat severe frostbite in the field (versus transport to a hospital) should consider the possibility of refreezing. If there is no likelihood of refreezing, the tissue should be rapidly rewarmed (36, 40) in circulating warm water (40-43.3 °C, 104-110 °F), insulated, and the patient transported to a medical facility. Research on animals suggests that topical aloe vera and systemic ibuprofen may reduce tissue damage and speed rehabilitation in humans (9). Other aspects of hospital treatment protocols are detailed elsewhere (9, 36, 40).

Race Organization

The following suggestions constitute the ideal race medical team. They are offered for consideration, but are not intended as absolute requirements. Staff and equipment needs are unique to each race and may be revised after 1-2 yr, in light of the distinctive features of each race. Depending on the weather conditions, 2-12% of all entrants will typically enter a medical aid station (1, 45, 50, 74).

1. Medical Personnel

a. Provide medical assistance if the race is 10 km (6.2 miles) or longer.

b. Provide the following medical personnel per 1,000 runners: 1-2 physicians, 4-6 podiatrists, 1-4 emergency medical technicians, 2-4 nurses, 3-6 physical therapists, 3-6 athletic trainers, and 1-3 assistants. Approximately 75% of these personnel should be stationed at the finish area. Recruit one nurse (per 1,000 runners) trained in IV therapy.

c. Recruit emergency personnel from existing organizations (police, fire-rescue, emergency medical service).

d. One physician and 10-15 medical assistants serve as the triage team in the finish chute. Runners unable to walk are transported to the medical tent via wheelchair, litter, or two-person carry.

e. Consider one or two physicians and two to four nurses trained in the rehabilitative medical care of wheelchair athletes.

f. Medical volunteers should attend a briefing prior to the event to meet their supervisor and receive identification tags, weather forecast, instructions, and schedules. Supervisors from the following groups should be introduced: medical director; podiatry, nursing, physical therapy, athletic training, medical records, triage, wheelchair athlete care, and medical security (optional: chiropractic, massage therapy). Medical volunteers should be distinguished from other race volunteers; luminous/distinctive vests, coats, or hats work well.

2. Medical Aid Stations

a. Provide a primary medical aid station (250-1,500 ft^2 (23-139 m^2) for each 1,000 runners; see Table 1) at the finish area, with no public access. Place security guards at all entrances with instructions regarding who can enter.

b. Position secondary medical aid stations along the route at 2- to 3-km (1.2- to 1.9-mile) intervals for races over 10 km, and at the halfway point for shorter races (see Table 1). Some race directors have successfully secured equipment and medical volunteers from military reserve or national guard medical units, the American Red Cross, and the National Ski Patrol.

c. Station one ambulance per 3,000 runners at the finish area and one or more mobile emergency response vehicles on the course. Staff each vehicle with a nurse and radio person or cellular telephone. Stock each vehicle with a medical kit, automatic defibrillator, IV apparatus. blankets, towels, crushed ice, blood pressure cuffs, rehydration fluid, and cups.

d. Signs should be posted at the starting line and at each medical aid station to announce the risk of heat illness or cold injury (see Appendix 1).

e. A medical record card should be completed for each runner who receives treatment (1,74). This card provides details that can be used to plan the medical coverage of future events.

f. Provide personal protective equipment (gloves, gowns, face shields, eye protection) and hand washing facilities.

g. Provide portable latrines and containers for patients with vomiting and diarrhea.

h. Initial medical assessment must include rectal (not oral, aural, or axillary temperature; see ref. 8, 76), central nervous system function, and cardiovascular function. Rehydration and cooling or warming are the cornerstones of treatment (32, 41, 42, 50, 74, 94).

Medical aid stations

Item	Secondary Aid Station	Primary Aid Station
Stretchers (at 10 km and beyond)	2-5	4-10
Cots	10	30
Wheelchairs	0	1
Wool blankets (at 10 km and beyond)	6-10	12-20
Bath towels	5-10	10-20
High and low temperature rectal thermometers (37-43˚C; 99-110˚F) and (22-37˚C; 77-99˚F)[d]	5	10
Elastic bandages (2, 4, and 6 inch)	3 each	6 each
Gauze pads (4 x 4 inch)	1/2 case	1 case
Adhesive tape (1.5 inch)	1/2 case	1 case
Skin disinfectant	1 l	2 l
Surgical soap	1/2 case	1case
Band-aids	110	220
Moleskin	1/2 case	1 case
Petroleum jelly, ointments	1/2 case	1 case
Disposable latex gloves	80 pairs	175 pairs
Stethoscopes	1	2
Blood pressure cuffs	1	2
Intravenous (IV) stations[d]	1	2
IV fluid (D5:1/2 NS or D5:NS; 0.5 or 1l)[d]	15[e]	30[e]
Sharps and biohazard disposal containers[d]	1	2
Alcohol wipes	50	100
Small instrument kits	1	1
Athletic trainer's kit	1	1
Podiatrist's kit	1-2	2-4
Inflatable arm and leg splints	2 each	2 each
Tables for medical supplies	1	2
Hose with spray nozzle, running water[e]	1	2
Wading pool for water immersion[d]	1	2
Fans for cooling	1	2-4
Oxygen tanks with regulators and masks	0	2
Crushed ice in plastic bags	7 kg	14 kg
Rehydration fluids	50 l	100 l[e]
Cups (≥0.3l, 10 oz)	1250	2250
Eye drops	1	1
Urine dipsticksd	10	20
Glucose blood monitoring kits[d]	1	2
Inhalation therapy for asthmatics[d]	1	1
EMS ambulance or ACLS station	1	1
Injectable drugs[d]		
Oral drugs[d]		

Table 1 Suggested equipment and supplies per 1,000 runners[a].

[a] Revised from Adner, M. M., J. J. Scarlet, J. Casey, W. Robison, and 8, H. Jones. The Boston Marathon medical care team: ten years of experience. *Physician Sportsmed.* 16:99-106, 1988; Bodishbaugh, R. G. Boston marathoners get red carpet treatment in the medical tent. *Physician Sportsmed.* 16:139-143, 1988; and Noble, H. B. and D. Bachman. Medical aspects of distance race planning. *Physician Sportsmed.* 7:78-84, 1979.
[b] Increase supplies and equipment if the race course is out and back.
[c] At finish area.
[d] Supervised by a physician.
[e] Depends on environmental conditions.

3. Universal Precautions

All medical personnel may encounter blood-borne pathogens or other potentially infectious materials, and should observe the following precautions (53, 63):

a. Receive immunization against the hepatitis B virus prior to the event.

b. Recognize that blood and infectious body fluids may be encountered from needle sticks, cuts, abrasions, blisters, and clothing.

c. Reduce the likelihood of exposure by planning tasks carefully (i.e., prohibiting recapping of needles by a two-handed technique, minimizing splashing and spraying).

d. Wear personal protective equipment such as gloves, gowns, face shields and eye protection. Remove this equipment and dispose/decontaminate it prior to leaving the work area.

e. Wash hands after removing gloves or other personal protective equipment.

f. Dispose of protective coverings, needles, scalpels, and other sharp objects in approved, labeled biohazard containers.

g. Do not eat, drink, smoke, handle contact lenses, or any cosmetics/lip balm in the medical treatment area.

h. Decontaminate work surfaces, bins, pails, and cans [1/10 solution of household bleach (sodium hypochlorite) in water] after completion of procedures.

4. Fluid Stations

a. At the start and finish areas provide 0.34-0.45 1 (12-16 oz) of fluid per runner. At each fluid station on the race course (2-3 km apart), provide 0.28-0.34 1 (10-12 oz) of fluid per runner. Provide both water and a carbohydrate-electrolyte beverage in equal volumes.

b. In cool or cold weather [≤10˚C (50˚F)], an equivalent amount of warm fluid should be available.

c. Number of cups (>0.3 1, 10 oz) per fluid station on the course = number of entrants + 25% additional for spillage and double use. Double this total if the course is out and back.

d. Number of cups at start and finish area = (2 × number of entrants) + 25% additional.

e. Cups should be filled prior to the race and placed on tables to allow easy access. Runners drink larger volumes if volunteers hand them cups filled with fluid.

5. Communications/Surveillance

a. Provide two-way radio or telephone communication between the medical director, medical aid stations, mobile vans, and pick-up vehicles.

b. Arrange for radio-equipped vehicles to drive the race course (ahead and behind participants) and provide communication with the director and his/her staff. These vehicles should be stationed at regular intervals along the course to search the course for competitors who require emergency care and encourage compromised runners to stop.

c. Place radio-equipped observers along the course.

d. Notify local hospitals, police, and fire-rescue departments of the time of the event, number of participants, location of aid stations, extent of medical coverage, and the race course.

e. Use the emergency response system (telephone number 911) in urban areas.

6. Instructions to Runners

a. Advise each race participant to print name, address, telephone number, and medical problems on the back of the race number (pinned to the body). This permits emergency personnel to quickly identify unconscious runners. Inform emergency personnel that this information exists.

b. Inform race participants of potential medical problems at pre-race conferences and at the starting line. Signed registration forms should clearly state the types of heat or cold injuries that may arise from participation in this event.

c. Provide pre-event recommendations regarding training, fluid consumption, clothing selection, self-care, heat acclimatization, and signs or symptoms of heat/cold illness (88).

d. The race director should announce the following information to all participants by loudspeaker immediately prior to the race:

- Current and predicted maximum (or minimum) temperature, humidity, wind speed, and cloud cover;
- The WBGT category and the risks for hyperthermia or hypothermia (see Appendix 1);
- Location of aid stations, types of assistance, and fluid availability;
- Signs and symptoms of heat or cold illness;
- Recommended clothing;
- The need for fluid replacement before, during, and after the race;
- The policy of race monitors to stop runners who are ill;
- A request that runners seek help for impaired competitors who appear ill, who are not coherent, who run in the wrong direction, or who exhibit upper-body swaying and poor competitive posture;

- A warning to novice runners entering their first race that they should run at a comfortable pac and run with a partner;
- Warnings to runners who are taking medications or have chronic illnesses (asthma, hypertension, diabetes, cardiovascular problems).

This position stand replaces the 1987 ACSM position paper, "The Prevention of Thermal Injuries During Distance Running." This pronouncement was reviewed for the American College of Sports Medicine by members-at-large, the Pronouncements Committee, and by: Arthur E. Crago, M.D., Stafford W. Dobbin, M.D., Mary L. O'Toole, Ph.D., FACSM, LTC Katy L. Reynolds, M.D., John W. Robertson, M.D., FACSM.

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Appendix 1: Measurement of Environmental Stress

Ambient temperature is only one component of environmental heat or cold stress; others are humidity, wind speed, and radiant heat. The most widely used heat stress index is the wet bulb globe temperature (WBGT) index (96):

$$WBGT = (0.7\ T^{wb}) + (0.2\ T^{g}) + (0.\ 1\ T^{db})$$

where T^{wb} is the wet bulb temperature, T^{g} is the black globe temperature, and T^{db} is the shaded dry bulb temperature (28). T^{db} refers to air temperature measured with a standard dry bulb thermometer not in direct sunlight. T^{wb} is measured with a water-saturated cloth wick over a dry bulb thermometer (not immersed in water). T^{g} is measured by inserting a dry bulb thermometer into a standard black metal globe. Both T^{wb} and ^{T} are measured in direct sunlight.

A portable monitor that gives the WBGT index in degrees Celsius or degrees Fahrenheit has proven useful during races and in military training (28, 44, 87, 96). The measurement of air temperature alone is inadequate. The importance of humidity in total heat stress can be readily appreciated because T^{wb} accounts for 70% of the index whereas T^{db} accounts for only 10%.

The risk of heat illness (while wearing shorts, socks, shoes, and a t-shirt) due to environmental stress should be communicated to runners in four categories (see Fig. 1):

- Very high risk: WBGT above 28°C (82°F); high risk: WBGT 23-28°C (73-82°F);
- Moderate risk: WBGT 18-23°C (65-73°F);
- Low risk: WBGT below 18°C (65°F).

Large signs should be displayed, at the start of the race and at key points along the race course, to describe the risk of heat exhaustion and heatstroke (Fig. 1). When the WBGT index is above 28°C (82°F), the risk of heat exhaustion or heatstroke is very high; it is recommended that the race be postponed until less stressful conditions prevail, rescheduled, or canceled. High risk [WBGT index = 23-28°C (73-82°F)] indicates that runners should be aware that heat exhaustion or heatstroke may be experienced by any participant; anyone who is particularly sensitive to heat or humidity probably should not run. Moderate risk [WBGT index = 18-23°C (65-73°F)] reminds runners that heat and humidity will increase during the course of the race if conducted during the morning or early afternoon. Low risk [WBGT index below 18°C (65°F)] does not guarantee that heat exhaustion (even heatstroke, see ref. 5, 32) will not occur; it only indicates that the risk is low.

The risk of hypothermia (while wearing shorts, socks, shoes, and a t-shirt) also should be communicated to runners. A WBGT index below 10°C (50°F) indicates that hypothermia may occur in slow runners who run long distances, especially in wet and windy conditions. Core body temperatures as low as 92°F have been observed in 65°F conditions (74).

Playing Hot Quiz Questions and Answers

Quiz for your athletes to begin the video, activities, and discussion session. (All questions can be answered “true” or “false.”)

1. It’s a good idea to drink as much water as possible immediately after a long game or exercise session in the heat, especially if you have to play again soon (i.e., one to several hours later).

   Answer: **False.** Drinking water after competition is, of course, very helpful and necessary. But, you can drink too much water too fast! This can lead to feeling sick or possibly having very severe problems. Rehydrating after sweating a lot is important; however, it is also important to replace other nutrients such as electrolytes (primarily sodium and chloride) and carbohydrates.

2. Eating a banana or an orange is an effective way to prevent or resolve muscle cramping.

   Answer: **False.** Muscle cramping during competition in the heat, when you have been sweating considerably, is often due to the excessive loss of water and salt (sodium and chloride—not potassium) from sweating. Athletes who sweat a lot and are prone to cramping in the heat may benefit from increasing their salt intake before and after competition, when sweat losses are expected to be high.

3. If you eat well before you compete, water is all you will need to consume during a long match, game, or run.

   Answer: **False.** During any activity that lasts more than an hour, if the intensity is high enough, you will probably need to ingest some carbohydrates (e.g., sport drinks or certain snacks) to maintain your best performance. Even if you ate well earlier, this rule holds true—especially in the heat. Some athletes may need to consume some salt as well.

4. It’s better to sweat less during exercise in the heat.

   Answer: **False.** Although sweating extensively causes you to lose a lot of water, which can hurt your performance and increase your risk for heat illness, sweating is a good thing! Sweating cools your body. Sweating is a very high priority during exercise in the heat—for your safety and performance. The important thing is that if you tend to sweat a lot, make sure that you are well hydrated when you begin exercise and that you drink enough as often as you can during your activity.

5. The video *Playing Hot* will give you a lot of important information that will help you compete safely and closer to your best in the heat.

   True! *Enjoy the video!*

Fluid Pyramid

Use this handy chart to learn how much water you should be drinking daily, and during exercise.

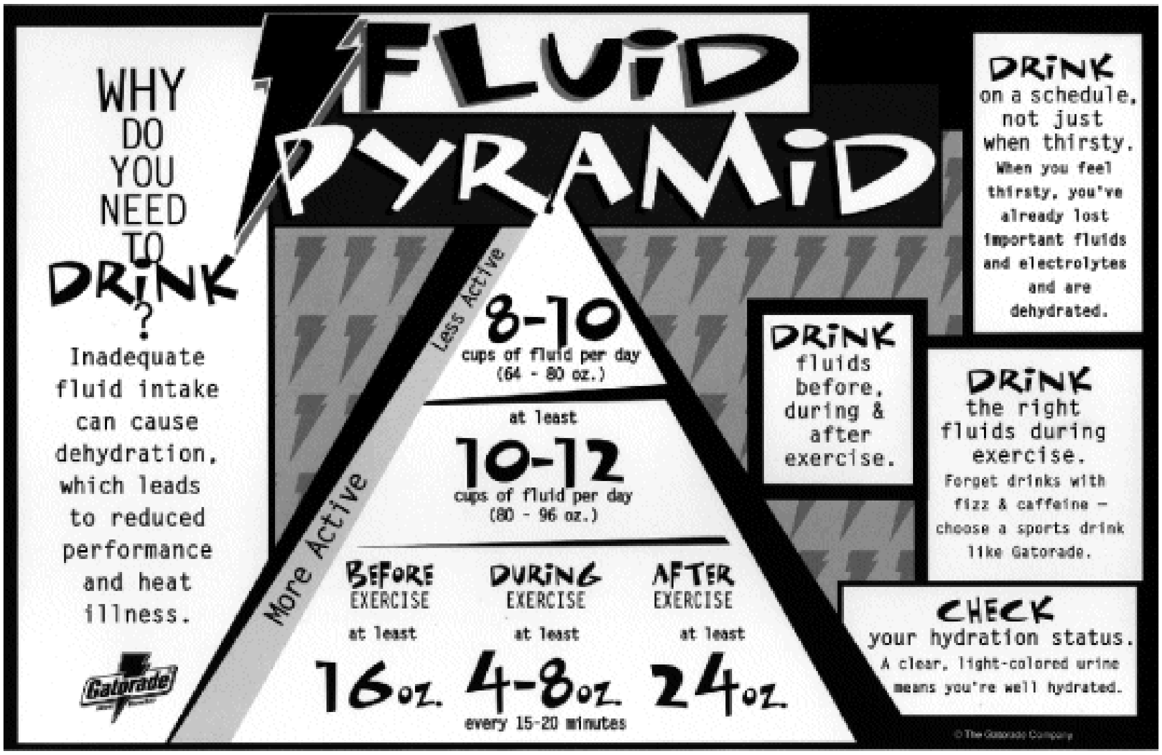

Figure 1 Fluid Pyramid.
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Heat-Related Disorders

Exposure to the combination of external heat stress and the inability to dissipate metabolically generated heat can lead to three heat-related disorders (see figure 2):

- Heat cramps
- Heat exhaustion
- Heat stroke

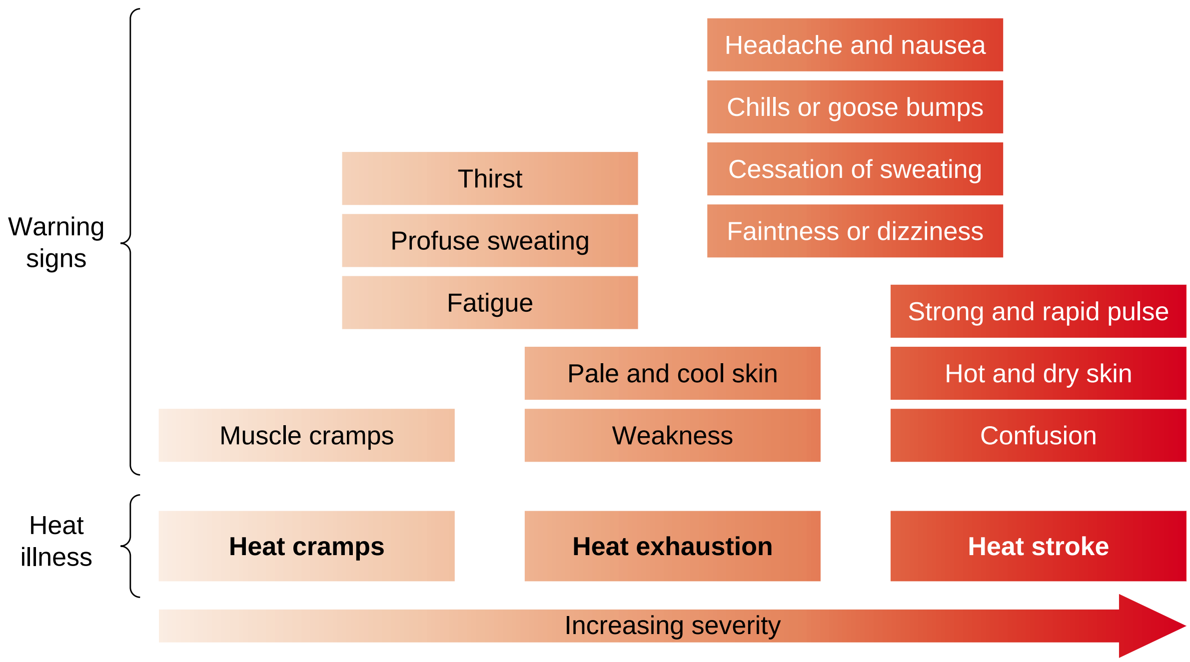

Figure 2 The warning signs of heat cramps, heat exhaustion, and heat stroke. ©PepsiCo 1995. Reprinted with permission.

Heat Cramps

Heat cramps, the least serious of the three heat disorders, is characterized by severe cramping of the skeletal muscles. It involves primarily the muscles that are most heavily used during exercise. This disorder is probably brought on by the mineral losses and dehydration that accompany high rates of sweating, but a cause-and-effect relationship has not been fully established. Heat cramps are treated by moving the stricken individual to a cooler location and administering fluids or a saline solution.

Heat Exhaustion

Heat exhaustion is typically accompanied by such symptoms as extreme fatigue, breathlessness, dizziness, vomiting, fainting, cold and clammy or hot and dry skin, hypotention (low blood pressure), and a weak, rapid pulse. It is caused by the cardiovascular system's inability to adequately meet the body's needs. Recall that during exercise in heat, your active muscles and your skin, through which excess heat is lost, compete for a share of your total blood volume. Heat exhaustion results when these simultaneous demands are not met. Heat exhaustion typically occurs when your blood volume decreases, by either excessive fluid loss or mineral loss from sweating.

With heat exhaustion, the thermoregulatory mechanisms are functioning but cannot dissipate heat quickly enough because there is insufficient blood volume to allow adequate distribution to the skin. Although the condition often occurs during mild to moderate exercise in the heat, it is not generally accompanied by a high rectal temperature. Some people who collapse from heat stress exhibit symptoms of heat exhaustion but have internal temperatures below 39 °C (102.2 °F). People who are poorly conditioned or unacclimatized to the heat are more susceptible to heat exhaustion.

Treatment for victims of heat exhaustion involves rest in a cooler environment with their feet elevated to avoid shock. If the person is conscious, administration of salt water is usually recommended. If the person is unconscious, medically supervised intravenous administration of saline solution is recommended. If allowed to progress, heat exhaustion can deteriorate to heat stroke.

Heat Stroke

Heat stroke is a life-threatening heat disorder that requires immediate medical attention. It is characterized by

- a rise in internal body temperature to a value exceeding 40 °C (104 °F),
- cessation of sweating,
- hot and dry skin,
- rapid pulse and respiration,
- usually hypertension (high blood pressure),
- confusion, and
- unconsciousness.

If left untreated, heat stroke progresses to coma, and death quickly follows. Treatment involves rapidly cooling the person's body in a bath of cold water or ice or wrapping the body in wet sheet and fanning the victim.

Heat stroke is caused by failure of the body's thermoregulatory mechanisms. Body heat production during exercise depend on exercise intensity and body weight, so heavier athletes run a higher risk of overheating than lighter athletes when exercising at the same rate and when both are about equally acclimatized to the heat.

For the athlete, heat stroke is a problem associated not only with extreme conditions. Studies have reported rectal temperatures above 40.5 ˚C (104.9 ˚F) in marathon runners who successfully completed race conducted under relatively moderate thermal conditions (e.g., 21.1 ˚C [70 ˚F] and 30% relative humidity). Even in shorter events, the body's core temperature can reach lift-threatening levels. As early as 1949, Robinson observed rectal temperatures of 41 ˚C (105.8 ˚F) in runners competing in events lasting only about 14 minutes, such as the 5-km race. Following a 10-km race conducted with an air temperature of 29.5 ˚C (85.1 ˚F), 80% relative humidity, and bright sun, one runner who collapsed had a rectal temperature of 43 ˚C (109.4 ˚F)! Without proper medical attention, such fevers can result in permanent central nervous system damage or death. Fortunately, this runner was rapidly cooled with ice and recovered without complication.

When exercising in the heat, if you suddenly feel chilled and goose bumps form on your skin, stop exercising, get into a cool environment, and drink plenty of cool fluids. The body's thermoregulatory system has become confused and think that the body temperature needs to be increased even more! Left untreated, this condition can lead to heat stroke and death.

Prevention of Hyperthermia

We can do little about environmental conditions. Thus, in threatening conditions, athletes must decrease their effort in order to reduce their heat production and their risk of developing hyperthermia (high body temperature). All athletes, coaches, and sports organizers should be able to recognize the symptoms of hyperthermia. Fortunately, our subjective sensations are well correlated with our body temperatures, as indicated on table 2 below. Although there is generally little concern when rectal temperature remains below 40 ˚C (104 ˚F) during prolonged exercise, athletes who experience throbbing pressure in their heads and chills should realize that they are rapidly approaching a dangerous situation that could prove fatal if they continue to exercise.

Subjective Symptoms Associated with Overheating

Rectal Temperature	Symptoms
40 ˚C – 40.5 ˚C (104 ˚F – 105 ˚F)	Cold sensation over stomach and back, with piloerection (goose bumps)
40.5 ˚C – 41.1 ˚C (105 ˚F – 106 ˚F)	Muscular weakness, disorientation, and loss of postural equilibrium
41.1 ˚C – 41.7 ˚C (106 ˚F – 107 ˚F)	Diminished sweating, loss of consciousness and hypothalamic control
≥42.2 ˚C (≥108 ˚F)	Death

To prevent heat disorders, several precautions should be taken. Competition and practice should not be held outdoors when the WBGT (see page 59) is over 28 ˚C (82.4 ˚F). As mentioned earlier, because WBGT reflects the humidity as well as the absolute temperature, it reflects the true physiological heat stress more accurately than does standard air temperature. Scheduling practices and contest either in the early morning or at night avoids the severe heat stress of midday. Fluids should be readily available, and athletes should be required to drink as much as they can, stopping every 10 to 20 minutes for a fluid break in warm temperatures.

Clothing is another important consideration. Obviously, the more clothing that is worn, the less body area exposed to the environment to allow heat exchange. The foolish practice of exercising in a rubberized suit to promote weight loss is an excellent illustration of how a dangerous microenvironment (the isolated environment inside the suit) can be created in which temperature and humidity can reach a sufficiently high level to block all heat loss from the body. This can rapidly lead to heat exhaustion or heat stroke. Football uniforms are another example. Areas that are covered by sweat-soaked clothing and padding are exposed to 100% humidity and higher temperatures, reducing the gradient between body surface and the environment.

Athletes should wear as little clothing as possible, when heat stress is a potential limitation to thermoregulation. The athlete should always underdress because the metabolic heat load will soon make extra clothing an unnecessary burden. When clothing is needed or required, it should be loosely woven to allow the skin to unload as much heat as possible and light colored to reflect heat back to the environment.

The American College of Sports Medicine (ACSM) has provided guidelines to help distance runners prevent heat-related injuries. A modified list of these recommendations appears in table 3 below.

Table 3 Guidelines for Distance Runners Competing Under Conditions of Heat Stress

1. Distance races should be scheduled to avoid extremely hot and humid conditions. If the WBGT index is above 28 ˚C (82 ˚F), canceling the race should be considered.
2. Summer events should be scheduled in the early morning or evening to minimize solar radiation and unusually high air temperature.
3. An adequate supply of fluid must be available before the start of the race, along the racecourse, and at the end of the event. Runners should be encouraged to replace their sweat losses or consume 150 to 300 ml (5.3 – 10.5 oz) every 15 minutes during the race.
4. Cool or cold (ice) water immersion is the most effective means of cooling a collapsed hyperthermic runner.

(continued)

Guidelines for Distance Runners
Competing Under Conditions of Heat Stress, *continued*

5. Runners should be aware of the early symptoms of hyperthermia, including
   - dizziness,
   - chilling,
   - headache or throbbing pressure in the temporal region, and
   - loss of coordination.
6. Race officials should be aware of the warning signs of an impending collapse in hot environments and should warn runners to slow down or stop if they appear to be in difficulty.
7. Organization personnel should reserve the right to stop runners who exhibit clear signs of heat stroke or heat exhaustion.

Note: These recommendations are based on the position stands published by the American College of Sports Medicine in 1987 and 1995.

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Keeping Your Players Hydrated

You may think that you've heard enough about the importance of drinking plenty of fluids and the benefits of staying well hydrated. After all, your players seem to drink a lot of water during exercise and most tend to avoid severe problems such as cramping or overheating. Yet many well-trained and informed tennis players continue to have hydration problems. The symptoms of inadequate or inappropriate hydration management range from simply feeling a little "off" and not quite playing at one's best to suffering painful heat cramps or heat exhaustion. These symptoms are commonly observed at many tennis tournaments, especially when it's hot.

The three primary nutritional factors related to keeping your players hydrated are **water**, **electrolytes**, and **carbohydrates**. These are also the nutrients that have the most immediate effect on performance—positive or negative, depending on management of their intake.

Water

Facts:

- Many players *begin* exercising while dehydrated.
- On-court sweat losses can be extensive—1 to 2.5 liters (~35-88 ounces) *per hour* is typical.
- *Any* water deficit can have a negative effect on a player's performance and well-being. The effects of a progressive water deficit due to inadequate fluid intake and/or excessive sweat losses include the following:

  - Increased cardiovascular strain—your heart has to work harder.
  - Decreased capacity for temperature regulation—you heat up more.
  - Decreased strength, endurance, and mental capacity—your intensity is lower, you tend to lose control, and you make inappropriate shot selections.
  - Increased rate of carbohydrate metabolism—you fatigue faster.
- Many players do not adequately *rehydrate* after play.

What you can do:

- Drink plenty of fluids (water, juice, milk, sport drinks) throughout the day.
- Don't forget to drink regularly during all practice and warm-up sessions.
- Drink another 12 to 16 ounces about one hour before you play.
- Drink at each changeover—typically, older adolescents and adults can comfortably drink up to 48 ounces or so per hour. This rate of fluid intake can prevent large fluid deficits from developing for most players.
- After play, drink about 150 percent of any fluid deficit that still remains. For example, if your weight is down 1 pound at the end of play, you will need to drink another 24 ounces.

Electrolytes

Facts:

- Players lose far more sodium and chloride (salt) from sweating than any other electrolyte.
- Sodium and chloride losses are greater with higher sweating rates.
- Players who are accustomed (acclimatized) to the heat tend to lose less sodium and chloride than players who are not acclimatized to the heat.
- Sodium deficits can lead to incomplete rehydration and muscle cramps.
- If players don't replace the salt they lose, they can't completely rehydrate.
- Excessive water consumption, combined with a large sweat-induced sodium deficit, can lead to severe hyponatremia (low blood sodium)—a very dangerous situation. Even mild hyponatremia can cause fatigue, apathy, nausea, or a headache.

What you can do:

- When you play in a hot environment (or any time you sweat a lot), add some salt to your diet, or eat certain high-salt foods, before and after you play. Salt contains 590 milligrams of sodium per 1/4 teaspoon (or 1.5 grams). Good food sources of sodium and chloride include:
  - salted pretzels,
  - many types of soups,
  - cheese,
  - salted sport drinks (or Pedialyte),
  - tomato sauce (pizza!), and
  - tomato juice.

Carbohydrates

Facts:

- Adequate carbohydrate intake is crucial to optimal tennis performance.
- Consuming carbohydrates before and after exercise can help restore some of your body water reserves.
- Playing tennis in the heat causes the body to use carbohydrates fast. So, even if you eat well before playing, after 60 to 90 minutes of intense singles play you'll probably need some supplemental carbohydrate to continue playing your best.
- Ingesting too many carbohydrates or too much of an inappropriate carbohydrate (e.g., fructose) can delay carbohydrate and fluid absorption and may cause gastrointestinal distress.

What you can do:

- Generally, 7 to 10 grams of carbohydrate per kilogram of body weight (~500 to 700 grams per day for a 155-pound player) is recommended for periods of intense training or competition.
- During exercise, 30 to 60 grams of carbohydrate per hour is most effective. Choose a sport drink whose *primary* carbohydrate is sucrose, glucose, or a glucose polymer (e.g., maltodextrin).

Adequate and well-timed water, electrolyte, and carbohydrate intake should be a priority for any athlete expecting to play well and safely. Yet athletes often overlook or underestimate the importance of these nutrients.

Adapted from Keeping Your Players Hydrated: What Are the Key Points? By Michael Bergeron, MD. From *High-Performance Coaching*, the USTA newsletter for tennis coaches, vol. 2, no. 2/2000. Used with permission of the USA Tennis Coaching Education Department.

Playing Hot:

Heat Illness in Sport

Playing Hot: Heat Illness in Sports
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Section One

OVERVIEW AND GOALS

Overview

This video and curriculum offer an introduction to preventing heat illness in youngsters while they participate in sport and physical activities. These materials emphasize the importance of proper hydration during physical activity, as well as alert you to the dangers that affect athletes when playing all types of sports in all kinds of weather.

Sponsored by an educational and research grant from Carl Lindner Sr., this video features an interview with Craig Lindner Jr., a collegiate tennis player who was in a coma after succumbing to heatstroke.

When the simple guidelines from this video are implemented, your athletes and students can play safely and perform at their best—in all kinds of weather.

The CD-ROM is divided into six sections. Section one contains an overview of the package. Section two instructs you, the coach or teacher, on using the package. Section three presents the key points on the videotape. Section four consists of handouts that can be photocopied and distributed to athletes and students. Section five provides further information for you to read and review before the start of the session. Section six is a resource section that includes citations of books, articles, Web sites, and other related information. These references are included to help you understand the information and important issues that are presented in the *Playing Hot* video so that you are prepared to answer questions and manage your athletes during competitions and practices in the heat.

Goals

The video and CD-ROM have two main goals:

1. To familiarize athletic directors, coaches, and physical education teachers with the research concerning proper hydration and sport participation.
2. To provide simple and clear information about proper hydration to athletes and students.

Section Two

HOW TO CONDUCT A SHORT SESSION WITH VIDEO, ACTIVITIES, AND DISCUSSION

The *Playing Hot* package was developed so that it can be used to educate athletes and students about heat-related illness during sport participation. The package can be used as a practice session before play or in a physical education health classroom.

The Resources

The *Playing Hot* package consists of an 18-minute videotape and a CD-ROM. The videotape is meant to raise awareness of heat-related illnesses that often (though not exclusively) occur in hot and humid environments. You should view the video and read the summary and handouts before showing them to students. These will provide additional facts to answer questions that arise during the class or practice session.

Options for Using the Resources

The video and accompanying handouts are *primarily* geared toward training and competing outdoors in the heat. However, most of the information presented is appropriate and useful for athletes training and competing indoors as well.

1. Have your athletes sit comfortably in a quiet area.
2. Give the short quiz orally. Your athletes can respond immediately to each question or write down the true-false answers so that all the responses can be discussed at once. Do not be particularly concerned about correct answers. The intent is to set the tone for discussion and to spark interest in watching the video. Briefly answer each question and indicate to your athletes that the video will discuss each of these points.
3. Show the video.
4. Review the key points of the video (some or all of the key points from the video summary) and answer questions.
5. Distribute and discuss the Fluid Pyramid and the Heat Index Chart, which are included in the handouts.

6. Ask your athletes to provide five tips that they can follow to prevent heat illness and optimize performance in the heat.
7. On another occasion, conduct the Body Weight, Fluid Intake, and Sweat Loss Activity (handout and directions included) with all or a selected group of your athletes.

Section Three

PLAYING HOT—KEY POINTS

Exercising in a hot environment is a challenge for any athlete. The video highlights some of the major concerns about training and competing in the heat. By watching this video and doing the activities, your athletes can reduce their risk of heat illness and increase their potential for optimal performance.

- Hot weather affects all athletes. A hot environment can make you feel uncomfortable and keep you from playing your best, and it can also be a serious threat to your health and well-being. Hot temperature combined with high humidity can increase the risk of heat illness.
- Exercise releases heat in your body, which causes your body temperature to rise. In a hot environment, this rise in core body temperature can be dramatic—especially with long-duration, high-intensity exercise.
- As core body temperature rises, performance tends to decrease due to physiological changes that reduce your capacity and desire to continue.
- Sweating is the body's primary way to get rid of heat during exercise. However, if you exercise when both the temperature and humidity are high, sweating is not very effective in removing heat. Heat and humidity combine to make the environment feel more stressful to the body and increase the risk for heat illness.
- Hydration (fluid intake and balance) is the *primary* concern for all athletes during exercise in the heat.
- Fluid losses via sweating can be extensive—1 to 2.5 liters *per hour* is common in many athletes. Some athletes sweat even more!
- Sweating can lead to significant dehydration if an athlete does not compensate by drinking enough. Dehydration leads to poorer performance and an increased risk for heat illness (heat cramps, heat exhaustion, or heat stroke).
- It is difficult—at times impossible—to match fluid intake with extensive sweating rates. Athletes should be well hydrated as they begin exercising and they should drink as much and as often as they can and are comfortable with during exercise, *especially* if they expect to sweat a lot.
- Extensive sweat loss can occur indoors as well.
- Electrolytes are also lost from sweating—primarily sodium and chloride, which together form salt.

- Sodium losses can be extensive—from 100 to more than 2,000 milligrams per liter of sweat. Some athletes with high sweating rates have been known to lose up to 5,000 milligrams of sodium each hour! Chloride losses are generally slightly less than sodium losses.
- A sodium deficit can make it difficult to rehydrate completely and may lead to heat cramps. Heat cramps can occur even when an athlete drinks a lot of water.
- Athletes who generally have high sodium and chloride losses through sweat may have to supplement their diet with salt or salty foods during competitions or while training in the heat. Tomato juice, pretzels, and salted sport drinks are some foods that can help prevent a severe progressive sodium deficit.
- Weighing yourself before and after exercise is a good way to determine your postexercise fluid deficit.
- To completely rehydrate, you need to drink about 150 percent of your postexercise fluid deficit. For example, if you weigh 1 pound less at the end of exercise, you need to drink 1.5 pounds or 24 ounces of fluid.
- You should drink fluids regularly throughout the day. These fluids can include water, milk, juice, and sport drinks. Too much caffeine can cause excessive urination and may cause dehydration before competition. Alcohol is not a good choice either.
- Drink fluids during exercise even if you don't feel thirsty. Thirst is not a good indicator of hydration status. If you feel thirsty while exercising, then you're probably already dehydrated.
- Sport drinks can be better than water alone, because they provide fluid, electrolytes (e.g., sodium and chloride), and carbohydrates.
- Immediately after exercise, it is important to replace water, carbohydrates, and salt before competing or exercising again.
- Adjusting (acclimatizing) to the heat helps an athlete tolerate excessive heat and can help to reduce the risk of heat injury.

Playing Hot Quiz Questions

All questions can be answered “true” or “false”

1. It’s a good idea to drink as much water as possible immediately after a long game or exercise session in the heat, especially if you have to play again soon (i.e., one to several hours later).

2. Eating a banana or an orange is an effective way to prevent or resolve muscle cramping.

3. If you eat well before you compete, water is all you will need to consume during a long match, game, or run.

4. It’s better to sweat less during exercise in the heat.

5. The video *Playing Hot* will give you a lot of important information that will help you compete safely and closer to your best in the heat.

Playing Hot Quiz Questions and Answers

Quiz for your athletes to begin the video, activities, and discussion session. (All questions can be answered "true" or "false.")

1. It's a good idea to drink as much water as possible immediately after a long game or exercise session in the heat, especially if you have to play again soon (i.e., one to several hours later).

   Answer: **False.** Drinking water after competition is, of course, very helpful and necessary. But, you can drink too much water too fast! This can lead to feeling sick or possibly having very severe problems. Rehydrating after sweating a lot is important; however, it is also important to replace other nutrients such as electrolytes (primarily sodium and chloride) and carbohydrates.

2. Eating a banana or an orange is an effective way to prevent or resolve muscle cramping.

   Answer: **False.** Muscle cramping during competition in the heat, when you have been sweating considerably, is often due to the excessive loss of water and salt (sodium and chloride—not potassium) from sweating. Athletes who sweat a lot and are prone to cramping in the heat may benefit from increasing their salt intake before and after competition, when sweat losses are expected to be high.

3. If you eat well before you compete, water is all you will need to consume during a long match, game, or run.

   Answer: **False.** During any activity that lasts more than an hour, if the intensity is high enough, you will probably need to ingest some carbohydrates (e.g., sport drinks or certain snacks) to maintain your best performance. Even if you ate well earlier, this rule holds true—especially in the heat. Some athletes may need to consume some salt as well.

4. It's better to sweat less during exercise in the heat.

   Answer: **False.** Although sweating extensively causes you to lose a lot of water, which can hurt your performance and increase your risk for heat illness, sweating is a good thing! Sweating cools your body. Sweating is a very high priority during exercise in the heat—for your safety and performance. The important thing is that if you tend to sweat a lot, make sure that you are well hydrated when you begin exercise and that you drink enough as often as you can during your activity.

5. The video *Playing Hot* will give you a lot of important information that will help you compete safely and closer to your best in the heat.

   True! *Enjoy the video!*

Fluid Pyramid

Use this handy chart to learn how much water you should be drinking daily, and during exercise.

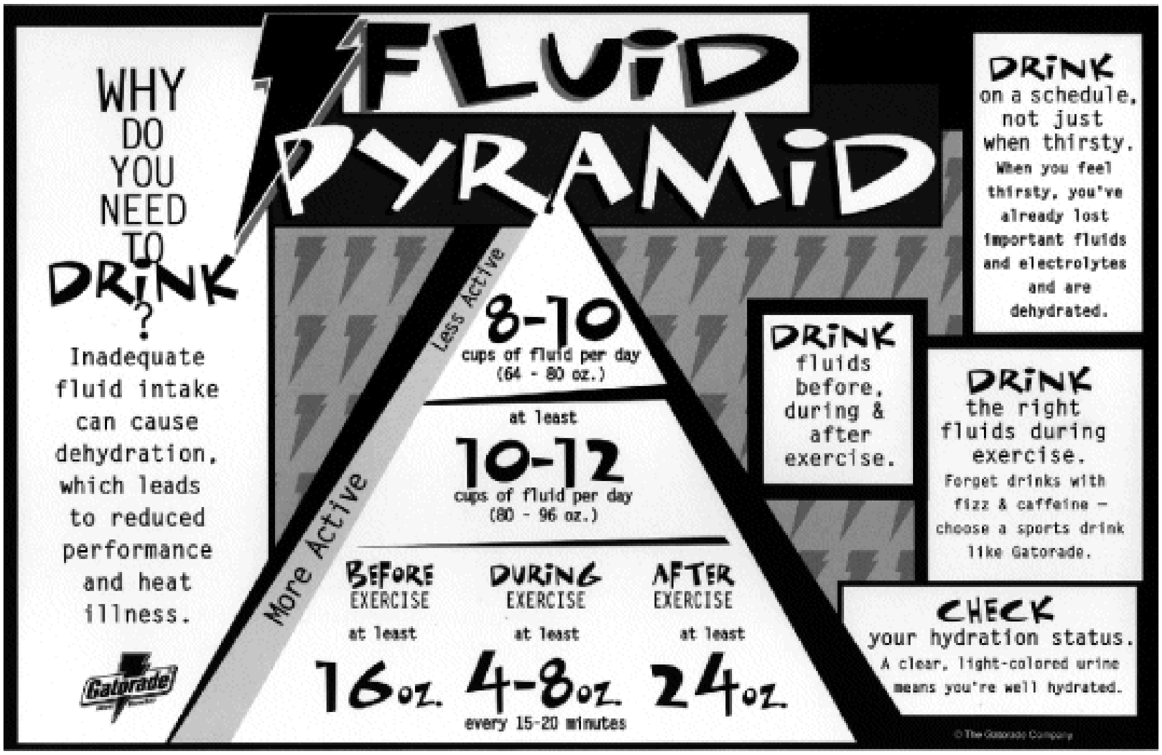

Figure 1 Fluid Pyramid.
From "Fluids 2000: Dehydration and Heat Illness." © 2000 Gatorade Sport Science Institute. Reprinted with permission. Visit the GSSI Web page at www.gssiweb.com

Heat Index Chart

This Heat Index Chart provides general guidelines for assessing the potential severity of heat stress. Individual reactions to heat will vary. Remember that heat illness can occur at lower temperatures than indicated on the chart. In addition, studies indicate that susceptibility to heat illness tends to increase with age.

How to Use the Heat Index Chart

1. Across the top of the chart, locate the environmental temperature (i.e., the air temperature).
2. Down the left side of the chart, locate the relative humidity.
3. Follow across and down to find the apparent temperature. Apparent temperature is the combined index of heat and humidity. It is the body's sensation of heat (the opposite of the wind chill factor).

Table 1 Heat Index

Relative Humidity	ENVIRONMENTAL TEMPERATURE (° F) 70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°
	Apparent Temperature*										
0%	64°	69°	73°	78°	83°	87°	91°	95°	99°	103°	107°
10%	65°	70°	75°	80°	85°	90°	95°	100°	105°	111°	116°
20%	66°	72°	77°	82°	87°	93°	99°	105°	112°	120°	130°
30%	67°	73°	78°	84°	90°	96°	104°	113°	123°	135°	148°
40%	68°	74°	79°	86°	93°	101°	110°	123°	137°	151°	
50%	69°	75°	81°	88°	96°	107°	120°	135°	150°		
60%	70°	76°	82°	90°	100°	114°	132°	149°			
70%	70°	77°	85°	93°	106°	124°	144°				
80%	71°	78°	86°	97°	113°	136°					
90%	71°	79°	88°	102°	122°						
100%	72°	80°	91°	108°							

* Combined index of heat and humidity: what it feels like to the body. Source: National Oceanic and Atmospheric Administration.

Note: Exposure to full sunshine can increase heat index values by up to 15° F.

Table 2 Heat Stress Risk

Apparent Temperature	Heat Stress Risk With Physical Activity and/or Prolonged Exposure
90° - 105°	Heat cramps or heat exhaustion possible
105° - 130°	Heat cramps or heat exhaustion likely; heatstroke possible
130° and up	Heatstroke highly likely

From "Fluids 2000: Dehydration and Heat Illness." © 2000 Gatorade Sports Science Institute. Reprinted with permission. Featured on Gatorade Sports Science Institute (GSSI) Web site (www.gssiweb.com).

Note: This Heat Index Chart is designed to provide general guidelines for assessing the potential severity of heat stress. Individual reactions to heat will vary. Remember that heat illness can occur at lower temperatures than indicated on the chart. In addition, studies indicate that susceptibility to heat disorders tends to increase with age.

Heat-Related Disorders

Exposure to the combination of external heat stress and the inability to dissipate metabolically generated heat can lead to three heat-related disorders (see figure 2):

- Heat cramps
- Heat exhaustion
- Heat stroke

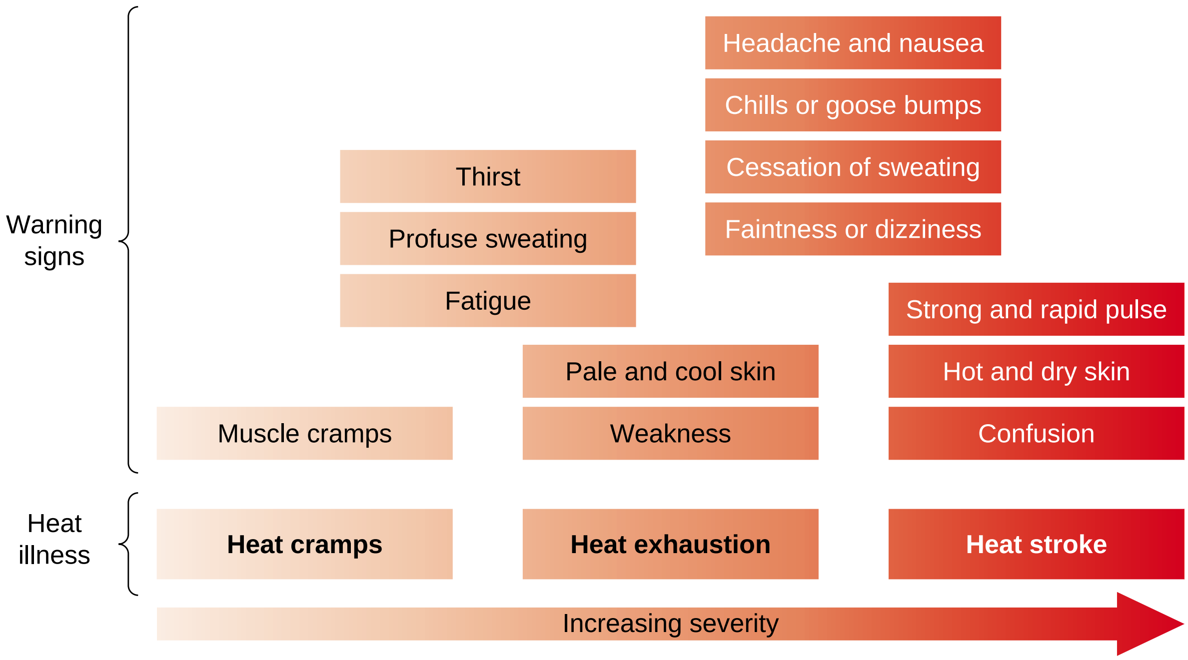

Figure 2 The warning signs of heat cramps, heat exhaustion, and heat stroke. ©PepsiCo 1995. Reprinted with permission.

Heat Cramps

Heat cramps, the least serious of the three heat disorders, is characterized by severe cramping of the skeletal muscles. It involves primarily the muscles that are most heavily used during exercise. This disorder is probably brought on by the mineral losses and dehydration that accompany high rates of sweating, but a cause-and-effect relationship has not been fully established. Heat cramps are treated by moving the stricken individual to a cooler location and administering fluids or a saline solution.

Heat Exhaustion

Heat exhaustion is typically accompanied by such symptoms as extreme fatigue, breathlessness, dizziness, vomiting, fainting, cold and clammy or hot and dry skin, hypotention (low blood pressure), and a weak, rapid pulse. It is caused by the cardiovascular system's inability to adequately meet the body's needs. Recall that during exercise in heat, your active muscles and your skin, through which excess heat is lost, compete for a share of your total blood volume. Heat exhaustion results when these simultaneous demands are not met. Heat exhaustion typically occurs when your blood volume decreases, by either excessive fluid loss or mineral loss from sweating.

With heat exhaustion, the thermoregulatory mechanisms are functioning but cannot dissipate heat quickly enough because there is insufficient blood volume to allow adequate distribution to the skin. Although the condition often occurs during mild to moderate exercise in the heat, it is not generally accompanied by a high rectal temperature. Some people who collapse from heat stress exhibit symptoms of heat exhaustion but have internal temperatures below 39 °C (102.2 °F). People who are poorly conditioned or unacclimatized to the heat are more susceptible to heat exhaustion.

Treatment for victims of heat exhaustion involves rest in a cooler environment with their feet elevated to avoid shock. If the person is conscious, administration of salt water is usually recommended. If the person is unconscious, medically supervised intravenous administration of saline solution is recommended. If allowed to progress, heat exhaustion can deteriorate to heat stroke.

Heat Stroke

Heat stroke is a life-threatening heat disorder that requires immediate medical attention. It is characterized by

- a rise in internal body temperature to a value exceeding 40 °C (104 °F),
- cessation of sweating,
- hot and dry skin,
- rapid pulse and respiration,
- usually hypertension (high blood pressure),
- confusion, and
- unconsciousness.

If left untreated, heat stroke progresses to coma, and death quickly follows. Treatment involves rapidly cooling the person's body in a bath of cold water or ice or wrapping the body in wet sheet and fanning the victim.

Heat stroke is caused by failure of the body's thermoregulatory mechanisms. Body heat production during exercise depend on exercise intensity and body weight, so heavier athletes run a higher risk of overheating than lighter athletes when exercising at the same rate and when both are about equally acclimatized to the heat.

For the athlete, heat stroke is a problem associated not only with extreme conditions. Studies have reported rectal temperatures above 40.5 ˚C (104.9 ˚F) in marathon runners who successfully completed race conducted under relatively moderate thermal conditions (e.g., 21.1 ˚C [70 ˚F] and 30% relative humidity). Even in shorter events, the body's core temperature can reach lift-threatening levels. As early as 1949, Robinson observed rectal temperatures of 41 ˚C (105.8 ˚F) in runners competing in events lasting only about 14 minutes, such as the 5-km race. Following a 10-km race conducted with an air temperature of 29.5 ˚C (85.1 ˚F), 80% relative humidity, and bright sun, one runner who collapsed had a rectal temperature of 43 ˚C (109.4 ˚F)! Without proper medical attention, such fevers can result in permanent central nervous system damage or death. Fortunately, this runner was rapidly cooled with ice and recovered without complication.

When exercising in the heat, if you suddenly feel chilled and goose bumps form on your skin, stop exercising, get into a cool environment, and drink plenty of cool fluids. The body's thermoregulatory system has become confused and think that the body temperature needs to be increased even more! Left untreated, this condition can lead to heat stroke and death.

Prevention of Hyperthermia

We can do little about environmental conditions. Thus, in threatening conditions, athletes must decrease their effort in order to reduce their heat production and their risk of developing hyperthermia (high body temperature). All athletes, coaches, and sports organizers should be able to recognize the symptoms of hyperthermia. Fortunately, our subjective sensations are well correlated with our body temperatures, as indicated on table 2 below. Although there is generally little concern when rectal temperature remains below 40 ˚C (104 ˚F) during prolonged exercise, athletes who experience throbbing pressure in their heads and chills should realize that they are rapidly approaching a dangerous situation that could prove fatal if they continue to exercise.

Subjective Symptoms Associated with Overheating

Rectal Temperature	Symptoms
40 ˚C – 40.5 ˚C (104 ˚F – 105 ˚F)	Cold sensation over stomach and back, with piloerection (goose bumps)
40.5 ˚C – 41.1 ˚C (105 ˚F – 106 ˚F)	Muscular weakness, disorientation, and loss of postural equilibrium
41.1 ˚C – 41.7 ˚C (106 ˚F – 107 ˚F)	Diminished sweating, loss of consciousness and hypothalamic control
≥42.2 ˚C (≥108 ˚F)	Death

To prevent heat disorders, several precautions should be taken. Competition and practice should not be held outdoors when the WBGT (see page 59) is over 28 ˚C (82.4 ˚F). As mentioned earlier, because WBGT reflects the humidity as well as the absolute temperature, it reflects the true physiological heat stress more accurately than does standard air temperature. Scheduling practices and contest either in the early morning or at night avoids the severe heat stress of midday. Fluids should be readily available, and athletes should be required to drink as much as they can, stopping every 10 to 20 minutes for a fluid break in warm temperatures.

Clothing is another important consideration. Obviously, the more clothing that is worn, the less body area exposed to the environment to allow heat exchange. The foolish practice of exercising in a rubberized suit to promote weight loss is an excellent illustration of how a dangerous microenvironment (the isolated environment inside the suit) can be created in which temperature and humidity can reach a sufficiently high level to block all heat loss from the body. This can rapidly lead to heat exhaustion or heat stroke. Football uniforms are another example. Areas that are covered by sweat-soaked clothing and padding are exposed to 100% humidity and higher temperatures, reducing the gradient between body surface and the environment.

Athletes should wear as little clothing as possible, when heat stress is a potential limitation to thermoregulation. The athlete should always underdress because the metabolic heat load will soon make extra clothing an unnecessary burden. When clothing is needed or required, it should be loosely woven to allow the skin to unload as much heat as possible and light colored to reflect heat back to the environment.

The American College of Sports Medicine (ACSM) has provided guidelines to help distance runners prevent heat-related injuries. A modified list of these recommendations appears in table 3 below.

Table 3 Guidelines for Distance Runners Competing Under Conditions of Heat Stress

1. Distance races should be scheduled to avoid extremely hot and humid conditions. If the WBGT index is above 28 ˚C (82 ˚F), canceling the race should be considered.
2. Summer events should be scheduled in the early morning or evening to minimize solar radiation and unusually high air temperature.
3. An adequate supply of fluid must be available before the start of the race, along the racecourse, and at the end of the event. Runners should be encouraged to replace their sweat losses or consume 150 to 300 ml (5.3 – 10.5 oz) every 15 minutes during the race.
4. Cool or cold (ice) water immersion is the most effective means of cooling a collapsed hyperthermic runner.

(continued)

Guidelines for Distance Runners Competing Under Conditions of Heat Stress, *continued*

5. Runners should be aware of the early symptoms of hyperthermia, including
   - dizziness,
   - chilling,
   - headache or throbbing pressure in the temporal region, and
   - loss of coordination.
6. Race officials should be aware of the warning signs of an impending collapse in hot environments and should warn runners to slow down or stop if they appear to be in difficulty.
7. Organization personnel should reserve the right to stop runners who exhibit clear signs of heat stroke or heat exhaustion.

Note: These recommendations are based on the position stands published by the American College of Sports Medicine in 1987 and 1995.

Adapted, with permission, from *Physiology of Sport and Exercise,* pp. 326–328. © 1994, 1999 by Jack H. Wilmore and David L. Costill.

Keeping Your Players Hydrated

You may think that you've heard enough about the importance of drinking plenty of fluids and the benefits of staying well hydrated. After all, your players seem to drink a lot of water during exercise and most tend to avoid severe problems such as cramping or overheating. Yet many well-trained and informed tennis players continue to have hydration problems. The symptoms of inadequate or inappropriate hydration management range from simply feeling a little "off" and not quite playing at one's best to suffering painful heat cramps or heat exhaustion. These symptoms are commonly observed at many tennis tournaments, especially when it's hot.

The three primary nutritional factors related to keeping your players hydrated are **water**, **electrolytes**, and **carbohydrates**. These are also the nutrients that have the most immediate effect on performance—positive or negative, depending on management of their intake.

Water

Facts:

- Many players *begin* exercising while dehydrated.
- On-court sweat losses can be extensive—1 to 2.5 liters (~35-88 ounces) *per hour* is typical.
- *Any* water deficit can have a negative effect on a player's performance and well-being. The effects of a progressive water deficit due to inadequate fluid intake and/or excessive sweat losses include the following:

    - Increased cardiovascular strain—your heart has to work harder.
    - Decreased capacity for temperature regulation—you heat up more.
    - Decreased strength, endurance, and mental capacity—your intensity is lower, you tend to lose control, and you make inappropriate shot selections.
    - Increased rate of carbohydrate metabolism—you fatigue faster.
- Many players do not adequately *rehydrate* after play.

What you can do:

- Drink plenty of fluids (water, juice, milk, sport drinks) throughout the day.
- Don't forget to drink regularly during all practice and warm-up sessions.
- Drink another 12 to 16 ounces about one hour before you play.
- Drink at each changeover—typically, older adolescents and adults can comfortably drink up to 48 ounces or so per hour. This rate of fluid intake can prevent large fluid deficits from developing for most players.
- After play, drink about 150 percent of any fluid deficit that still remains. For example, if your weight is down 1 pound at the end of play, you will need to drink another 24 ounces.

Electrolytes

Facts:

- Players lose far more sodium and chloride (salt) from sweating than any other electrolyte.
- Sodium and chloride losses are greater with higher sweating rates.
- Players who are accustomed (acclimatized) to the heat tend to lose less sodium and chloride than players who are not acclimatized to the heat.
- Sodium deficits can lead to incomplete rehydration and muscle cramps.
- If players don't replace the salt they lose, they can't completely rehydrate.
- Excessive water consumption, combined with a large sweat-induced sodium deficit, can lead to severe hyponatremia (low blood sodium)—a very dangerous situation. Even mild hyponatremia can cause fatigue, apathy, nausea, or a headache.

What you can do:

- When you play in a hot environment (or any time you sweat a lot), add some salt to your diet, or eat certain high-salt foods, before and after you play. Salt contains 590 milligrams of sodium per 1/4 teaspoon (or 1.5 grams). Good food sources of sodium and chloride include:
    - salted pretzels,
    - many types of soups,
    - cheese,
    - salted sport drinks (or Pedialyte),
    - tomato sauce (pizza!), and
    - tomato juice.

Carbohydrates

Facts:

- Adequate carbohydrate intake is crucial to optimal tennis performance.
- Consuming carbohydrates before and after exercise can help restore some of your body water reserves.
- Playing tennis in the heat causes the body to use carbohydrates fast. So, even if you eat well before playing, after 60 to 90 minutes of intense singles play you'll probably need some supplemental carbohydrate to continue playing your best.
- Ingesting too many carbohydrates or too much of an inappropriate carbohydrate (e.g., fructose) can delay carbohydrate and fluid absorption and may cause gastrointestinal distress.

What you can do:

- Generally, 7 to 10 grams of carbohydrate per kilogram of body weight (~500 to 700 grams per day for a 155-pound player) is recommended for periods of intense training or competition.
- During exercise, 30 to 60 grams of carbohydrate per hour is most effective. Choose a sport drink whose *primary* carbohydrate is sucrose, glucose, or a glucose polymer (e.g., maltodextrin).

Adequate and well-timed water, electrolyte, and carbohydrate intake should be a priority for any athlete expecting to play well and safely. Yet athletes often overlook or underestimate the importance of these nutrients.

Adapted from Keeping Your Players Hydrated: What Are the Key Points? By Michael Bergeron, MD. From *High-Performance Coaching*, the USTA newsletter for tennis coaches, vol. 2, no. 2/2000. Used with permission of the USA Tennis Coaching Education Department.

Body Weight, Fluid Intake, and Sweat Loss Activity

The following calculations will help you find out how much fluid you lose during a training session or competition. By doing this activity, you will be able to find out how well you managed fluid intake during exercise. Your coach will help you fill in the blanks and interpret the results. You will need an accurate scale to do this activity.

Body Weight (BW)

Pre BW: ____________________ pounds

Post BW: ____________________ pounds

Total BW change (post BW – pre BW = total BW change):
____________________ pounds

% BW deficit (total BW change ÷ pre BW x 100):
____________________ percent

The change in body weight is calculated from the preplay and postplay body weight measurements. (It's best to weigh yourself both times in the same *dry* clothes, such as shorts and a T-shirt.) Any loss in body weight must be compensated for by your cardiovascular system. Notably, a decrease in body weight of even just 1 percent can have a dramatic negative effect on performance, especially in the heat.

If you weighed less at the end of play (post BW) than you did at the beginning of play (pre BW), this means that the change in body weight (total BW change) was *negative* and you had a body weight *deficit.* It also means that you did not drink enough during exercise. To find out how much more you should have drunk to avoid losing any weight, do the following:

Multiply the number of pounds lost times 16 ounces. That will give you the number of *additional* ounces that you should have drunk to avoid losing weight during exercise.

For example, with a total BW change of –1.7 pounds, 1.7 x 16 = 27.2 ounces (drop the negative sign).

In this case, you should have drunk 27.2 *more* ounces of water to avoid losing any body weight during exercise.

If you weighed the same or gained weight by the end of play (meaning post BW is greater than pre BW), the total BW change will be *0* or *positive* and you will *not* have a body weight deficit*.* This means that you drank as much as or more than you sweated.

Fluid Intake

Preplay water container(s) weight (WCW):

____________________ pounds

Postplay WCW:

____________________ pounds

Total WCW change (post WCW – pre WCW):

____________________ pounds

Total fluid consumed:

____________________ ounces

This difference shows how much you drank. First you calculate the amount you drank in pounds by using the scale to weigh your water container(s) before and after play. To convert pounds to ounces, simply multiply the total WCW change by 16 ounces. (You can avoid this calculation if you know exactly how many ounces you drank.)

For example, with a WCW change of –1.0 pounds, 1.0 x 16 = 16 ounces (eliminate the negative sign). In this case, you drank 16 ounces during play.

Sweat Loss

A. Total BW change (post BW – pre BW = total BW change):

____________________ pounds

B. Convert to ounces (total BW change x 16):

____________________ ounces

C. Total fluid consumed:

____________________ ounces (from fluid intake calculation above)

If the result in “B” is *negative*, then take away the negative sign and add the amount of total BW change (in ounces) to the total fluid consumed (in ounces).

Total sweat loss (in ounces) = B + C (______________ + _____________)

If the result in “B” is *positive*, then subtract the amount of total BW change from the total fluid consumed.

Total sweat loss (in ounces) = C– B (______________ – _____________)

If the result in “B” equals zero, then your total sweat loss equals your total fluid consumed—great job!

Section Five

ARTICLES

Hydration and Physical Activity: Scientific Concepts and Practical Applications

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Introduction

Generally, research that is conducted under controlled laboratory conditions does not have an immediate impact on sports practitioners-coaches, trainers, athletes, etc., who rightly feel that the non-controlled, spontaneous, and somewhat unpredictable aspect of sport warrants field testing under less-controlled conditions. Of course, the most complete answer to a problem can be developed when the theoretical tenets of basic science can be melded with the more practical aspects of applied science.

The issue of hydration and physical performance has been studied for many years by both basic and applied scientists. In this issue of the GSSI Roundtable, we discuss a number of topics pertaining to dehydration and exercise with Gary Mack, Ph.D., a basic scientist, and Michael Bergeron, Ph.D., who has focused much of his research on the effects of dehydration in tennis players. Their responses to our questions follows.

What type of studies have you conducted regarding the effects of dehydration on physical performance?

Mack: Our studies have focused on two aspects of dehydration. First, we have examined the detrimental influence of dehydration on the body's ability to dissipate heat during a thermal load. These studies have focused on identifying the physiological mechanism by which hypovolemia and hyperosmolality, produced during dehydration, impose limitations in heat transfer from the body core to the skin, and a reduction in heat loss from the skin to the environment. Our studies have also characterized baroreflex modulation of skin blood flow and sweating in response to alterations in central blood volume, and the inhibition of thermal sweating by increases in plasma osmolality. Second, we have examined the phenomenon referred to as “involuntary dehydration.” In these studies we have examined the mechanisms that contribute to a delay in complete restitution of body fluids following a reduction in total body water. Our efforts have been directed to understanding the factors that contribute to this phenomenon so that we can improve rehydration practices.

Bergeron: Most of my recent studies have been more applied in nature. Our work has been directed toward examining fluid balance in tennis. Many of the tennis players that I have worked with have experienced significant performance decrements when they haven’t managed fluid balance well, and more than a few have suffered problems such as heat cramps and heat exhaustion during competition. However, with a sport such as tennis it is somewhat difficult to identify reliable and measurable outcome-related performance variables. Thus, much of my work in this area has been descriptive in nature, in an attempt to determine the extent and rate of fluid loss that players routinely encounter during competition. As a next step, we are developing projects to examine the effects of dehydration on a variety of tennis-specific psychomotor skills.

Dr. Mack, what are the physiological consequences of dehydration on one’s ability to perform physical activity?

Mack: Fluid deficits imposed voluntarily (i.e., by fluid restriction) or by previous thermal and/or exercise stress will impair subsequent work performance. Water losses due to sweating can often exceed 30 g/min. (1.8 kg/h). The consequences of a progressive loss of body water are a decrease in blood volume (hypovolemia) and an increase in the concentration of electrolytes in the body fluids (hypertonicity). Both of these conditions can impair the body’s ability to dissipate heat generated during exercise. The greater level of dehydration, the greater the degree of impairment.

Numerous studies have clearly demonstrated that cardiovascular strain is greater and body core temperature rises faster when a person exercises in a dehydrated condition, regardless of the environmental conditions. Of course, the decrement in performance is exaggerated when exercise is performed in a hot environment. Furthermore, the combined effects of dehydration and exercise in the heat can lead to heat-related disorders ranging from simple heat cramps to life-threatening heat stroke.

Dr. Bergeron, you have focused the majority of your research on tennis players. What is the profile of the athletes who have served as subjects in your studies?

Bergeron: Most of the players I have worked with were regionally or nationally ranked juniors, Division I collegiate players, or touring professionals. As a result of their regular training and competition schedules, which typically includes at least 2-3 hours a day on the court, these athletes generally have a high degree of cardiorespiratory fitness, a relatively low amount of body fat, and a unique blend of on-court endurance, speed, agility, and power. They usually train and compete year-round, and often play tennis in places in which they have very little time to adequately acclimatize to new environmental conditions. Their matches generally last from less than one hour to sometimes more than four hours. During tournaments, these players often play multiple, long matches on successive days. Clearly, their schedules can be grueling.

What type of sweat and electrolyte losses have you documented in the players you have studied?

Bergeron: Most of the sweat losses that we have calculated were incurred during matches in fairly hot and humid conditions. The ambient temperature was generally 90°F (32°C) or more and the relative humidity was around 60%. In general, during singles play the boys and girls (12-16 yrs.) and young women (18-22 yrs.) had sweating rates of 0.7-1.4 liters per hour; young men (18-30 yrs.) sweated at a rate of 1.2 to 2.5 liters per hour. Although the highest sweat rates that I have measured in a male and female were 3.4 liters and 2.5 liters per hour, respectively.

In heat-acclimatized young adult tennis players the sweat concentration of sodium has generally been a little above 20 mmol per liter, and sweat potassium losses have approximated 5 mmol per liter. However, in heat-acclimatized boys, the sweat sodium loss tends to be somewhat higher (approximately 40 mmol per liter). Even with a high degree of mineral conservation the on-court hourly loss of sodium for many of these players can easily exceed 1 gram. As we have observed with some players, the combination of very high sweat rates (2.5-3.4 liters per hour) coupled with moderate sweat sodium concentrations (35 to just over 60 mmol/L) can yield rather impressive on-court sweat sodium losses of 2,000 to almost 5,000 mg. per hour of play. Considering that tennis players routinely play multiple or long matches on successive days during tournaments, it is not surprising that many tournament players often begin matches in a dehydrated and sodium-deficient condition.

Dr. Mack, are these values out of line with those that you see in a laboratory setting?

Mack: Answering this question is not as clear-cut as it may seem. Several factors influence whole body sweat rate and the determination of sweat electrolyte composition. First, sweating and sweat composition is not uniform over the entire body. Second, sweat composition is dependent on the local sweat rate. Finally, progressive dehydration associated with prolonged exercise in the heat may modify regional sweat rates and thereby sweat composition. Thus, determination of an average sweat composition during exercise performed in the laboratory or field is not a simple measurement.

In our laboratory we sample sweat from five different skin sites and then use an equation which incorporates factors that account for the regional differences in sweat rate and adjusts for the relative contribution of each region to the total surface area of the body. Using this technique we have determined the average electrolyte composition of sweat in active college aged students under standard exercise protocols. Whole-body sweat rates of ~0.8 L/hr. induced with mild (40% $\dot{V}O_2$ max.) cycle ergometry in the heat (36°C; 30% RH) produces sweat with an average sodium concentration of 68 mmol/L and a potassium concentration of 4.7 mmol/L. However, these values may vary considerably with a range of 30 to 110 mmol Na/L and 2.5 to 9.3 mmol K/L. During prolonged exercise (up to six hours) in the heat, when sweat rates are maintained by simultaneous fluid replacement, individuals may lose in excess of 5 g of sodium (the equivalent of 12.5 g of table salt). At higher sweat rates (1.4 L/hr.) induced by intense treadmill exercise (70% $\dot{V}O_2$ max) we have measured an average whole body sodium concentration of 74 mmol/L (range of 40 to 104 mmol/L). Lower values of sweat sodium concentration, such as those in the tennis players described by Dr. Bergeron, are a function of the athletes' high level of fitness and degree of heat acclimatization.

Dr. Mack, the importance of sodium for rehydration purposes has been outlined in numerous articles. However, is there a downside to giving a healthy athlete "carte blanche" access to sodium?

Mack: During recovery from dehydration, electrolyte replacement ensures complete restoration of the extracellular fluid and a more complete restitution of water balance. The normal range of daily U.S. intake of sodium chloride is 2-9 grams (35-156 mmol sodium), and potassium is 2-4 grams (50-100 mmol). Electrolyte losses in these ranges are generally replenished within 24 hours following exercise if adequate fluid is consumed. In the absence of meals, more complete rehydration can be accomplished with fluids containing sodium than with plain water. The ideal salt concentration in the ingested fluid has not been determined. However, a consensus report sponsored by the National Academy of Sciences recommends that the solution should provide approximately 20-30 mmols of sodium per liter, 2 to 5 mmols of potassium per liter, and chloride as the only anion.

I don't think there is a documented downside to ad libitum sodium intake in healthy adults. Sodium intake must vary in proportion to the deficit in total body sodium content. Normal healthy adults have several sophisticated regulatory systems that act to regulate sodium intake and retention. In healthy individuals, when all these mechanisms are working properly, sodium balance is achieved without the need to restrict sodium intake.

Dr. Bergeron, are there other nutritional issues besides hydration status that you see in the athletes you work with?

Bergeron: It's clear that any time there is extensive and repetitive sweating, there is potential for developing a sodium deficit. This condition is often exacerbated when a susceptible athlete limits his or her salt intake. We are now in the process of looking more closely at other potential mineral imbalances that might develop in athletes during long periods of extensive sweating.

A tennis player's blood glucose level and carbohydrate stores are also a concern. Therefore, we always stress a high-carbohydrate diet, and we encourage players to consume a carbohydrate-electrolyte drink during and after matches, particularly if they are going to play again soon.

I also find that the daily caloric intake of many athletes is often inadequate. Unfortunately, the high dietary bulk associated with a high-calorie, high-carbohydrate diet is unappealing to some athletes. In these cases, high-carbohydrate, high-calorie drinks or snacks can be beneficial.

Do you see any carryover from your studies to other groups of athletes? To the "average" person who trains and competes in the heat?

Bergeron: Many of the college athletes that I have worked with, including swimmers, basketball players, and soccer players, tend to function in a chronically dehydrated condition, as evidenced by their high urine specific gravities or their inability to urinate prior to practices or games. I don't think that the typical athlete or the average recreational exerciser appreciates the extent of fluid and electrolyte losses that readily and routinely occur during most forms of physical activity. Generally, athletes should be able to urinate before and after they train or compete. If they are unable to do so, they likely have not consumed enough fluid. For those people who lose considerable sodium from extensive sweating, consuming more sodium-rich foods or adding salt to foods and fluids may be appropriate.

Mack: As I stated earlier, our studies have demonstrated that complete restoration of the extracellular fluid compartment (and blood volume) cannot be attained without replacement of the lost sodium. Furthermore, during prolonged exercise, a combination of sodium loss and the ingestion of large quantities of fluids with little or no electrolytes can lead to low plasma sodium. In ultra-endurance events, hyponatremia (blood sodium concentrations of less than 130 mmol/L) has been observed at the end of competition and is associated with problems of disorientation, confusion and, in some cases, grand-mal seizures. To prevent the development of hyponatremia or related conditions, sufficient electrolytes should be provided in fluid replacement beverages. This would certainly constitute a practical application of our research.

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Fluid Replacement: The American College Of Sports Medicine Position Stand

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Key Points

1. Recent scientific research has underscored the physiological and performance benefits of remaining well hydrated before, during, and following physical activity.
2. Maintaining hydration takes a concerted effort on the part of the athlete to modify drinking behavior throughout the training day.
3. The amount of fluid voluntarily ingested during physical activity is affected by the palatability of the beverage, the composition of the beverage, and by ease of use. These factors must be considered when planning a fluid-replacement regimen for athletes.
4. The goal for fluid intake during exercise should be to fully replace sweat losses. The physiological and performance benefits of doing so are well documented.
5. Rapid and complete rehydration following exercise requires the ingestion of sodium chloride to replace that which was lost in sweat and the consumption of a volume of fluid that is greater than that which was lost as sweat.

Introduction

In a book titled *Physiology of Man in the Desert,* E.F. Adolph and associates expertly described the negative impact of dehydration upon physiological function, physical performance, and health (Adolph et al., 1947). Their exhaustive research demonstrated that preventing dehydration by regular ingestion of fluids was indispensable in ensuring the physical and mental well-being of their subjects. Unfortunately, more than two decades passed before the value of regular fluid replacement during physical activity was widely recognized and practiced in the athletic setting. During this time, dozens of athletes and military recruits died from hyperthermia complicated by dehydration (Baumann, 1995). Although athletes and others continue to fall prey to exertional heat stroke, the frequency of deaths has been drastically reduced over the years (Bauman, 1995), in large part because the necessity of adequate fluid replacement has become well recognized.

Although information on fluid intake during physical activity eventually found its way into textbooks, classrooms, and onto the practice field, most of these recommendations were fairly general in nature. For example, documents published by the American College of Sports Medicine (1987), the United States military (Marriott & Rosemont, 1991), and the National Institute of Occupational Safety and Health (1986) included information on fluid replacement from which some general guidelines could be drawn. In the case of the American College of Sports Medicine (ACSM), recommendations for fluid replacement were included in a position stand entitled The Prevention of Thermal Injuries During Distance Running (ACSM, 1987). The ACSM article emphasized the need for regular fluid intake during races of 10 km and longer, and encouraged runners to ingest 100–200 ml (3–6 oz) at every aid station. The public health value of this recommendation was significant because it helped assure that race organizers included fluid stations in their events and that participants were given the opportunity to drink. However, depending upon the speed of the runner, the distance between aid stations, and the volume of fluid ingested at each station, the resulting fluid intake could vary widely, replacing a very large or very small portion of sweat loss.

This uncertainty has been addressed in the most recent position stand published the American College of Sports Medicine. The ACSM position stand on Exercise and Fluid Replacement (ACSM, 1996) provides clear and practical guidelines regarding fluid, carbohydrate, and electrolyte replenishment for athletes. In preparing the recommendations, a panel of experts in fluid homeostasis and related fields completed a comprehensive review of the scientific literature, making certain that each practical recommendation was well substantiated by research. As a result, the ACSM position stand will benefit the lay and scientific communities for years to come.

The ACSM Recommendations

The ACSM position stand contains a summary of practical recommendations supported by four pages of scientific review complemented by 92 references. The document begins by stating that, "It is the position of the American College of Sports Medicine that adequate fluid replacement helps maintain hydration and, therefore, promotes the health, safety, and optimal physical performance of individuals participating in regular physical activity."

The purpose of this Sports Science Exchange is to further underscore the scientific and practical relevance of the ACSM recommendations so that coaches, athletic trainers, physicians, dietitians, and athletes gain an increased appreciation of the value of remaining well hydrated during physical activity. The recommendations found in the ACSM position stand are highlighted below and are supplemented with scientific and practical information related to their content.

Fluid Ingestion Before Exercise

"It is recommended that individuals consume a nutritionally balanced diet and drink adequate fluids during the 24-h period before an event, especially during the period that includes the meal prior to exercise, to promote proper hydration before exercise or competition."

The physiological and performance benefits of entering training and competition well hydrated and with large stores of muscle and liver glycogen are widely accepted from a scientific standpoint. In terms of fluid balance, it is clear that athletes who enter competition in a dehydrated state are at a competitive disadvantage (Sawka, 1992). For example, in a study by Armstrong et al. (1985), subjects performed a 5,000-meter (~ 19 min) and 10,000-meter (~ 40 min) run in either a normally hydrated or dehydrated condition. When dehydrated by ~2% of body weight (by a diuretic given prior to exercise), their running speeds decreased significantly (by 6%–7%) in both events. To make matters worse, exercise in the heat exacerbates the performance-impairing effects of dehydration (Sawka et al., 1984).

Getting athletes to actually modify their drinking behavior during the training day is arguably a much larger challenge than convincing them about the scientific value of doing so. Dr. Ron Maughan, a sports scientist at the University of Aberdeen and an adviser to the 1996 British Olympic Team, indicated that the British athletes had to be schooled in mealtime drinking behavior during their training camps in Tallahassee, Florida. Unaccustomed to the decorum of buffet-line eating at an American university, the British athletes politely took just one beverage as they passed through the line while their American counterparts loaded up with three or four drinks. The British athletes were losing an important opportunity to rehydrate after hot-weather training. With a little prodding and some reminders, they became more aggressive mealtime drinkers. (R.J. Maughan, personal communication).

"It is recommended that individuals drink about 500 ml (about 17 ounces) of fluid about 2 h before exercise to promote adequate hydration and allow time for excretion of excess ingested water."

Laboratory subjects who ingest fluid in the hour before exercise exhibit lower core temperatures and heart rates during exercise than when no fluid is ingested (Greenleaf & Castle, 1971; Moroff & Bass, 1965). These physiological responses are undoubtedly beneficial as they reduce the strain on the body and lower the perception of exertion at a given workload (Montain & Coyle, 1992). When athletes live and train in warm environments, the value of adequate fluid intake prior to exercise cannot be overemphasized. This is apparent in the results of a study conducted on soccer players in Puerto Rico (Rico-Sanz et al., 1996). The athletes were studied during two weeks of training. When the players were allowed to drink fluids throughout the day as they wished (average intake = 2.7 L/d), their total body water at the end of one week was about 1.1 L lower than when they were mandated to drink 4.6 L of fluid per day. In other words, voluntary fluid consumption was insufficient to meet the players' daily fluid requirements, causing them to enter training and competition already dehydrated.

From a practical standpoint, the frequency of urination and the color and volume of urine can be monitored as a means of helping athletes assess their hydration status. Infrequent urination with a darkly colored urine of relatively small volume can be an indication of dehydration, a signal that the athlete should continue drinking before beginning exercise. Monitoring urine output is a common recommendation in occupational settings such as the mining industry in which the workers are constantly exposed to conditions of high heat and humidity.

Fluid Ingestion During Exercise

"During exercise, athletes should start drinking early and at regular intervals in an attempt to consume fluids at a rate sufficient to replace all the water lost through sweating, or consume the maximal amount that can be tolerated."

This is perhaps the most-significant recommendation in the position stand because it clearly identifies that the ideal goal of fluid intake during exercise is to prevent any amount of dehydration, and yet it recognizes that an optimal intake may be difficult under some circumstances. The value of maintaining full hydration is well illustrated by the studies of Montain and Coyle (1992) and Walsh et al. (1994). These researchers demonstrated that cardiovascular, thermoregulatory, and performance responses are optimized by replacing at least 80% of sweat loss during exercise. Montain and Coyle showed that larger volumes of fluid intake during exercise were associated with greater cardiac output, greater skin blood flow, lower core temperature, and a reduced rating of perceived exertion. The data of Walsh et al. reaffirmed that even low amounts of dehydration (1.8% of body weight, in this case) can impair exercise performance.

The dramatic impairment in physiological and performance response that occurs with dehydration is more easily understood when the limitations of the cardiovascular system are considered. In his text on Human Circulation: Regulation During Physical Stress, cardiovascular physiologist L.B. Rowell wrote that, "Perhaps the greatest stress ever imposed on the human cardiovascular system (except for severe hemorrhage) is the combination of exercise and hyperthermia. Together these stresses can present life-threatening challenges, especially in highly motivated athletes who drive themselves to extremes in hot environments. A long history of heat fatalities gives stark testimony to the gravity of the problem and the failure of various organizations to recognize and deal with it effectively." (Rowell, 1986). Rowell's statement is a dramatic but accurate way of explaining that both exercise and hemorrhage require the body to cope with progressively diminishing blood volume and blood pressure. Although the physiological challenge to the body occurs much more quickly and with decidedly deadlier potential in the case of hemorrhage, the slower progression of events that occurs as a result of sweat loss is no less challenging from a physiological standpoint.

It is recommended that ingested fluids be cooler than ambient temperature [between 15°and 22°C (59° and 72°F)] and flavored to enhance palatability and promote fluid replacement. Fluids should be readily available and served in containers that allow adequate volumes to be ingested with ease and with minimal interruption of exercise."

It is certainly no surprise that humans are inclined to drink more of beverages that are flavored and sweetened (Greenleaf, 1991) but the practical ramifications of this common-sense knowledge are important in the exercise setting. Any step that can be taken to increase voluntary fluid intake will help decrease the extent of dehydration and reduce the risk of health problems associated with dehydration and heat stress. In addition to having palatable beverages available for athletes to drink, a number of other practical steps should be taken. These include educating coaches, trainers, parents, and athletes about the benefits of proper hydration, making certain that fluids are easily available at all times, encouraging athletes to follow an organized regimen for fluid replacement, and weighing athletes before and after practice as a way to assess the effectiveness of their fluid intake (Broad, 1996).

The composition of beverages can also have a substantial effect on voluntary fluid intake, as illustrated by the research of Wilk and Bar-Or (1996). Young boys were studied during 3 h of intermittent exercise in the heat, during which time the subjects could drink ad libitum. The boys completed this protocol on three occasions; the beverages tested included water, a sports drink, and a flavored, artificially sweetened replica of the sports drink. The results showed that the boys ingested almost twice as much sports drink as they did water. Consumption of the placebo fell in between. Not only did flavoring and sweetness increase voluntary fluid intake, but the presence of sodium chloride in the sports drink further increased consumption (i.e., the subjects drank more sports drink than placebo).

The human thirst mechanism is sensitive to changes in plasma sodium concentration (and plasma osmolality) and to changes in blood volume (Hubbard et al., 1990). The increase in sodium concentration and the decrease in blood volume that accompany exercise result in an increased perception of thirst. Drinking plain water quickly removes the osmotic drive to drink and reduces the volume-dependent drive, causing the satiation of thirst. The resulting decrease in fluid intake occurs prematurely, occurring before adequate fluid has been ingested. The presence of low levels of sodium chloride in a beverage help maintain the osmotic drive for drinking, and assure greater fluid intake (Nose et al. 1988), a physiological certainty well understood by bartenders who make certain that their customers have easy access to salty snack foods.

“Addition of proper amounts of carbohydrates and/or electrolytes to a fluid replacement solution is recommended for exercise events of duration greater than 1 h since it does not significantly impair water delivery to the body and may enhance performance.”

The ergogenic effect of carbohydrate feeding during exercise has been extensively confirmed by research, much of which has been conducted using exercise bouts lasting from one to four-or-more hours (Coggan & Coyle, 1991). Ingestion of carbohydrate solutions containing combinations of sucrose, glucose, fructose, and maltodextrins results in improved exercise performance provided that at least 45 g of carbohydrate are ingested each hour (Coggan & Coyle, 1991). It should be noted that some researchers (Murray et al., 1991) have reported performance improvements even when subjects have ingested as little as 20–25 g/h, although a higher rate of carbohydrate intake is more advisable. However, the maximal rate at which exogenous carbohydrate can be utilized appears to be in the range of 60-75 g/h (ie, 1.0–1.5 g/min). No additional performance benefit is realized when subjects are fed greater amounts of carbohydrate (Murray et al., 1991).

The specific mechanism(s) by which performance is improved by carbohydrate feeding is still a matter of scientific inquiry, but there is general agreement that the improvement in performance is linked to an increased reliance on carbohydrate as fuel for active muscles (Coggan & Coyle, 1991). During intense physical activity, the metabolic demand for carbohydrate is high; carbohydrate ingestion satisfies part of that demand, helping assure the maintenance of carbohydrate oxidation.

“During exercise lasting less than 1 h, there is little evidence of physiological or physical performance differences between consuming a carbohydrate-electrolyte drink and plain water.”

During long-duration exercise (i.e., > 1 h), carbohydrate oxidation normally declines as muscle and liver glycogen stores fall to low levels. Considering these responses, it is not surprising that exercise scientists initially relied upon bouts of long-duration cycling or running to determine if carbohydrate feeding improved performance. Not until recently have scientists turned their attention to studying shorter-duration, intermittent exercise protocols lasting one h or less to determine if carbohydrate feeding elicits a similar ergogenic effect. At the time of the 1996 ACSM position stand, very few such studies had been published. Although much more research needs to be completed, the growing body of evidence (Ball et al., 1995; Below et al., 1995; Wagenmakers et al., 1996; Walsh et al., 1994) indicates that carbohydrate ingestion may indeed benefit performance during shorter duration exercise (i.e., 1 h or less) and during intermittent exercise such as high-intensity running (Nicholas et al., 1996), cycling (Jackson et al., 1995), and tennis play (Vergauwen et al., 1996).

An excellent comparison of the benefits of ingesting water or a sports drink during shorter-duration exercise was conducted by Below et al. (1994) who had subjects cycle for 50 min at 80%VO2max and then complete a “sprint to the finish” requiring 9-12 min. The subjects experienced a 6% improvement in performance when they consumed enough water to replace about 80% of their sweat loss (1330 ml) compared to when they ingested only 200 ml of water. However, when the subjects ingested 1330 ml of a sports drink, their performance improved by 12%, leading the authors to conclude that the benefits of hydration and carbohydrate feeding were additive.

The benefits of proper hydration and carbohydrate feeding that have been illustrated by numerous laboratory studies are often echoed by the experiences of the subjects in the studies. Dr. Edward Coyle of The University of Texas noted that the competitive cyclists who participate in his experiments “know that drinking is critical to surviving the Texas heat. What they usually don’t appreciate is that being well hydrated can help them thrive rather than just survive. After they learn how to fully replace fluids in our studies, they are amazed at how much better they feel as far as being cooler, having a lower heart rate, and generating more power." (E.F. Coyle, personal communication)

"During intense exercise lasting longer than 1 h, it is recommended that carbohydrates be ingested at a rate of 30–60 grams per hour to maintain oxidation of carbohydrates and delay fatigue. This rate of carbohydrate intake can be achieved without compromising fluid delivery by drinking 600–1200 ml per hour of solutions containing 4%–8% carbohydrates (grams per 100 ml). The carbohydrates can be sugars (glucose or sucrose) or starch (e.g., maltodextrin)."

As previously indicated, ingesting carbohydrate at the rate of about 60 g/h during exercise is associated with improved physical performance. Considering that most sports drinks contain 6% to 7% carbohydrate (i.e., 60–70 g carbohydrate per liter), the consumption of one L (~ one qt) of sports drink per hour will provide the needed amount of carbohydrate. However, many athletes sweat at rates substantially greater than one L/h (Broad et al., 1996) and so should drink more than 1 L/h. Consuming carbohydrate in excess of 60 g/h will not be detrimental to gastrointestinal comfort, physiological function, or performance provided that the carbohydrate concentration of the ingested beverage is not too high. Beverages containing greater than 7% carbohydrate (i.e., > 17 g carbohydrate per 236 ml [8 oz]) are associated with slower rates of intestinal absorption (Shi et al., 1995), which increases the risk of gastrointestinal distress (Davis et al., 1988; Peters et al., 1995).

Sports drinks usually contain more than one type of carbohydrate, most often combinations of sucrose, glucose, fructose, and maltodextrin. Such combinations are acceptable from both a sensory and a physiological perspective. Beverages containing mostly or solely fructose are not optimal because fructose is absorbed slowly by the intestine (Shi et al., 1995) and requires conversion to glucose by the liver before it can be metabolized by skeletal muscle, making fructose an ineffective fuel for improving performance (Murray et al., 1989). Research subjects who have had the unpleasant experience of participating in studies requiring the ingestion of fructose-only beverages can attest to the gastrointestinal limitations of fructose as the sole source of carbohydrate because vomiting and diarrhea are two common side effects when large amounts of fructose are ingested.

"Inclusion of sodium (0.5–0.7 grams per liter of water) in the rehydration solution ingested during exercise lasting longer than 1 h is recommended since it may be advantageous in enhancing palatability, promoting fluid retention, and possibly preventing hyponatremia in certain individuals who drink excessive quantities of fluid. There is little physiological basis for the presence of sodium in an oral rehydration solution for enhancing intestinal water absorption as long as sodium is sufficiently available from the previous meal."

Sweat contains more sodium and chloride than other minerals and, although sweat electrolyte values are normally substantially lower than plasma values (plasma = 138–142 mmol/L; sweat = 25–75 mmol/L), athletes who exercise in excess of two h each day can lose considerable amounts of sodium chloride. Consider, for example, a football lineman during two-a-day summer practices in which a total of 5 L of sweat is lost. If each liter of sweat contained 50 mmol sodium, the total sodium loss would be 5,750 mg, the equivalent of over 14 g of NaCl.

Food intake is usually accompanied by sodium chloride intake, and most research indicates that sodium deficits are rare among athletes or military personnel (Armstrong et al., 1987). However, there are occasions when sodium losses can present problems, as illustrated by Bergeron (1996) in a case study of a nationally ranked tennis player who suffered from frequent heat cramps. This player had both a high sweat rate (2.5 L/h) and higher-than-normal sweat sodium concentration (90 mmol/h). The muscle cramps were eliminated when he increased his daily dietary intake of sodium chloride from 5–10 g/day to 15–20 g/day, and increased his fluid intake to assure adequate hydration.

The ACSM position stand also indicates that ingesting sodium chloride in a beverage consumed during exercise can help ensure adequate fluid intake (Wilk & Bar-Or, 1996) and stimulate more-complete rehydration following exercise (Maughan et al., 1996). Both of these responses underscore the important role that sodium plays in maintaining the osmotic drive to drink and in providing an osmotic stimulus to retain fluid in the extracellular space.

It is true that the sodium content of a fluid-replacement beverage does not directly affect the rate of fluid absorption, as demonstrated by recent research (Gisolfi et al., 1995). This is because the amount of sodium that can be provided to the intestine by a beverage is miniscule compared to the amount of sodium that can be provided from the bloodstream. Plasma sodium freely diffuses into the gut following fluid intake because the concentration gradient for sodium between plasma and the contents of the intestine strongly favors sodium influx. The sodium content of the previous meal or of pancreatic secretions is of little importance in the fluid absorption process. That said, sodium chloride remains a critical ingredient in a properly formulated sports drink because it improves beverage palatability, helps maintain the osmotic drive for thirst, reduces the contribution of plasma sodium required in the gut prior to absorption, helps maintain plasma volume during exercise, and serves as the primary osmotic impetus for restoring extracellular fluid volume following exercise (Maughan et al., 1996; Nose et al., 1988).

Fluid Ingestion Following Exercise

Fluid intake following physical activity can be a critical factor in helping athletes recovery quickly between bouts of training and competition. Many athletes train more than once each day, making rapid rehydration an important consideration, particularly during training in warm weather. The ACSM position stand did not elaborate on recommendations for fluid intake after exercise, but in a recent Sports Science Exchange article, Maughan et al. (1996) provided a comprehensive review of this topic. The authors concluded that ingesting plain water is ineffective at restoring rehydration because water absorption causes plasma osmolality to fall, suppressing thirst and increasing urine output. When sodium is provided in fluids or foods, the osmotic drive to drink is maintained (Gonzalez-Alonso et al., 1992; Nose et al., 1988), and urine production is decreased. There are many occasions during training and competition when it is either difficult or unwise to ingest food, making it all the more important that athletes have access to fluid containing sodium chloride and other electrolytes.

Maughan et al. (1996) also emphasized the importance of ingesting fluid in excess of the deficit in body weight to account for obligatory urine losses. In other words, the advice normally given athletes —"drink a pint of fluid for every pound of body weight deficit"—must be amended to "drink at least a pint of fluid for every pound of body weight deficit". More-precise recommendations for how much fluid athletes should ingest to assure rapid and complete rehydration will evolve from future research; existing data indicate that ingestion of 150% or more of weight loss may be required to achieve normal hydration within six h following exercise (Shirreffs et al., 1996).

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Heat and Cold Illnesses During Distance Running

American College of Sports Medicine Position Stand

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Summary

Many recreational and elite runners participate in distance races each year. When these events are conducted in hot or cold conditions, the risk of environmental illness increases. However, exertional hyperthemia, hypothermia, dehydration, and other related problems may be minimized with pre-event education and preparation. This position stand provides recommendations for the medical director and other race officials in the following areas: scheduling; organizing personnel, facilities, supplies, equipment, and communications providing competitor education; measuring environmental stress; providing fluids; and avoiding potential legal liabilities. This document also describes the predisposing conditions, recognition, and treatment of the four most common environmental illnesses: heat exhaustion, heatstroke, hypothermia, and frostbite. The objectives of this position stand are: 1) To educate distance running event officials and participants about the most common forms of environmental illness including predisposing conditions, warning signs, susceptibility, and incidence reduction. 2) To advise race officials of their legal responsibilities and potential liability with regard to event safety and injury prevention. 3) To recommend that race officials consult local weather archives and plan events at times likely to be of low environmental stress to minimize detrimental effects on participants. 4) To encourage race officials to warm participants about environmental stress on race day and its implications for heat and cold illness. 5) To inform race officials of preventive actions that may reduce debilitation and environmental illness. 6) To describe the personnel, equipment, and supplies necessary to reduce and treat cases of collapse and environmental illness.

Introduction

This document replaces the position stand titled *The Prevention of Thermal Injuries During Distance Running* (4). It considers problems that may affect the extensive community of recreational joggers and elite athletes who participate in distance running events. It has been expanded to include heat exhaustion, heatstroke, hypothermia, and frostbite–the most common environmental illnesses during races.

Because physiological responses to exercise in stressful environments may vary among participants, and because the health status of participants varies from day to day, compliance with these recommendations will not guarantee protection from environmentally induced illnesses. Nevertheless, these recommendations should minimize the risk of exertional hyperthermia, hypothermia, dehydration, and resulting problems in distance running and other forms of continuous athletic activity such as bicycle, soccer, and triathlon competition.

Managing a large road race is a complex task that requires financial resources, a communication network, trained volunteers, and teamwork. Environmental extremes impose additional burdens on the organizational and medical systems. Therefore, it is the position of the American College of Sports Medicine that the following RECOMMENDATIONS be employed by race managers and medical directors of community events that involve prolonged or intense exercise in mild and stressful environments.

1. Race Organization

a. Distance races should be scheduled to avoid extremely hot and humid and very cold months. The local weather history should be consulted when scheduling an event. Organizers should be cautious of unseasonably hot or cold days in early spring or late fall because entrants may not be sufficiently acclimatized. The wind chill index should be used to reschedule races on cold, windy days because flesh may freeze rapidly and cold injuries may result.

b. Summer events should be scheduled in the early morning or the evening to minimize solar radiation and air temperature. Winter events should be scheduled at midday to minimize the risk of cold injury.

c. The heat stress index should be measured at the site of the race because meteorological data from a distant weather station may vary considerably from local conditions (66). The wet bulb globe temperature (WBGT) index is widely used in athletic and industrial settings [see Appendix I;(87)]. If the WBGT index is above 28 °C (82 °F), or if the ambient dry bulb temperature is below -20 °C (-4 °F), consideration should be given to canceling the race or rescheduling it until less stressful conditions prevail. If the WBGT index is below 28 °'C, participants should be alerted to the risk of heat illness by using signs posted at the start of the race and at key positions along the race course [see Appendix I;(61)]. Also, race organizers should monitor changes in weather conditions. WBGT monitors can be purchased commercially, or Figure I may be used to approximate the risk of racing in hot environments based on air temperature and relative humidity. These two measures are available from local meteorological stations and media weather reports, or can be measured with a sling psychrometer.

d. An adequate supply of fluid must be available before the start of the race, along the race course, and at the end of the event. Runners should be encouraged to replace their sweat losses or consume 150-300 ml (5.3-10.5 oz) every 15 minutes (3). Sweat loss can be derived by calculating the difference between pre and postexercise body weight.

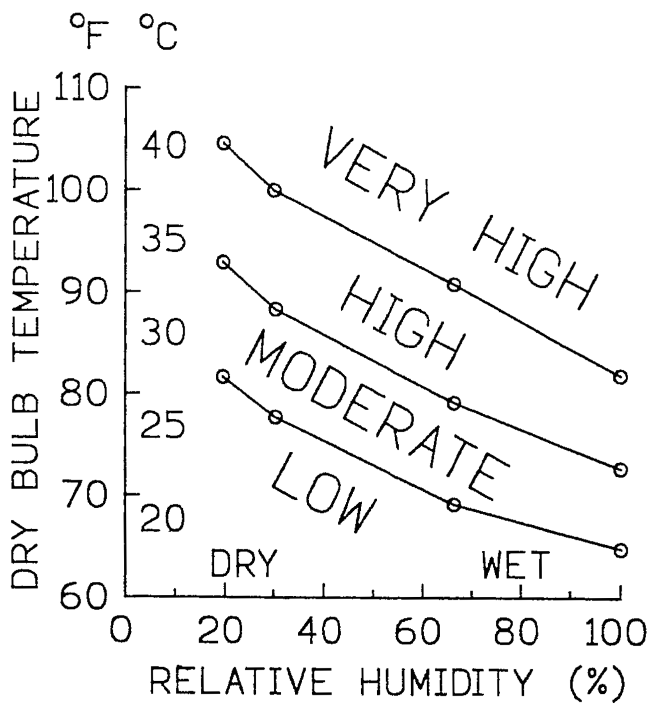

Figure 1 Risk of heat exhaustion or heatstroke while racing in hot environments. Figure drawn from data presented in American College of Sports Medicine Position stand: the prevention of thermal injuries during distance running. *Med. Sci. Sports Exerc.* 19:529-533, 1987.

e. Cool or cold (ice) water immersion is the most effective means of cooling a collapsed hyperthermic runner (25, 48, 49, 59, 88). Wetting runners externally by spraying or sponging during exercise in a hot environment is pleasurable but does not fully attenuate the rise in body core temperature (14, 88). Wetting the skin can result in effective cooling once exercise ceases.

f. Race officials should be aware of the warning signs of an impending collapse in both hot and cold environments and should warn runners to slow down or stop if they appear to be in difficulty.

g. Adequate traffic and crowd control must be maintained along the course at all times.

h. Radio communication or cellular telephones should connect various points on the course with an information processing center to coordinate emergency responses.

2. Medical Director

A sports medicine physician should work closely with the race director to enhance the safety and provide adequate medical care for all participants. The medical director should understand exercise physiology, interpretation of meteorological data, heat and cold illness prevention strategies, potential liability, and the treatment of medical problems associated with endurance events conducted in stressful environments.

3. Medical Support

a. Medical organization and responsibility: The medical director should alert local hospitals and ambulance services and make prior arrangements to care for casualties, including those with heat or cold injury. Medical personnel should have the authority to evaluate, examine, and stop runners who display signs of impending illness or collapse. Runners should be advised of this procedure prior to the event.

b. Medical facilities: Medical support staff and facilities must be available at the race site. The facilities should be staffed with personnel capable of instituting immediate and appropriate resuscitation measures. The equipment necessary to institute both cooling therapy (ice packs, child's wading pools filled with tap water or ice water, fans) and warming therapy (heaters, blankets, hot beverages) may be necessary at the same event. For example, medical personnel treated 12 cases of hyperthermia and 13 cases of hypothermia at an endurance triathlon involving 2300 competitors: air temperature was 85°F, water temperature was 58°F (92).

4. Competitor Education

The physical training and knowledge of competitive runners and joggers has increased greatly, but race organizers must not assume that all participants are well prepared or informed about safety. Distributing this position stand before registration, publicizing the event in the media, and conducting clinics or seminars before events are valuable educational procedures.

a. All participants should be advised that the following conditions may exacerbate heat illness: obesity (13, 39, 89), low degree of physical fitness (30, 63, 79, 83), dehydration (23, 34, 69, 83, 84, 95), lack of heat acclimatization (31, 51, 89), a previous history of heat stroke (82, 89), sleep deprivation (5), certain medications, including diuretics and antidepressants (31), and sweat gland dysfunction or sunburn (31). Illness 1 week prior to an event should preclude participation (32, 96), especially those involving fever, respiratory tract infections, or diarrhea (41, 46).

b. Prepubescent children sweat less than adults and have lower heat tolerance (11, 12).

c. Adequate training and fitness are important for full enjoyment of the event and will reduce the risk of heat illness and hypothermia (33, 64, 67, 85).

d. Prior training in the heat will promote heat acclimatization (6) and thereby reduce the risk of heat illness, especially if the training environment is warmer than that expected during a race (5, 51). Artificial heat acclimatization can be induced in cold conditions (6).

e. Adequate fluid consumption before and during the race can reduce the risk of heat illness, including disorientation and irrational behavior, particularly in longer events such as a marathon (23, 34, 95).

f. Excessive consumption of pure water or dilute fluid (i.e., up to 10 liters per 4 hours) during prolonged endurance events may lead to a harmful dilutional hyponatremia (60), which may involve disorientation, confusion, and seizure or coma. The possibility of hyponatremia may be the best rationale for inclusion of sodium chloride in fluid replacement beverages (3).

g. Participants should be advised of the early symptoms of heat illness, which may include clumsiness, stumbling, headache, nausea, dizziness, apathy, confusion, and impairment of consciousness (41,86).

h. Participants should be advised of the early symptoms of hypothemia (slurred speech, ataxia, stumbling gait) and frostbite (numbness, burning, pain, paresthesia) on exposed skin (36). Wet clothing, especially cotton, increases heat loss and the risk of hypothermia (68).

i. Participants should be advised to choose a comfortable running speed and not to run faster than environmental conditions or their cardiorespiratory fitness warrant (43, 71, 91).

j. It is helpful if novice runners exercise with a partner, each being responsible for the other's well-being (71).

5. Responsibilities and Potential Liability

The sponsors and directors of an endurance event are reasonably safe from liability due to injury if they avoid gross negligence and willful misconduct, carefully inform the participants of hazards, and have them sign waivers before the race (78). However, a waiver signed by a participant does not totally absolve race organizers of moral and/or legal responsibility. It is recommended that race sponsors and directors: 1) minimize hazards and make safety the first concern; 2) describe inherent hazards (i.e., potential course hazards, traffic control, weather conditions) in the race application; 3) require all entrants to sign a waiver; 4) retain waivers and records for 3 yrs; 5) warn runners of the predisposing factors and symptoms of environmental illness; 6) provide all advertised support services; 7) legally incorporate the race or organizations involved; and 8) purchase liability insurance (18, 78, 80).

Race directors should investigate local laws regarding Good Samaritan action. In some states physicians who do not accept remuneration may be classified as Good Samaritans. Race liability insurance may not cover physicians (78), therefore the malpractice insurance policy of each participating physician should be evaluated to determine if it covers services rendered at the race.

Medical and race directors should postpone, reschedule, or cancel a race if environmental conditions warrant, even though runners and trained volunteers arrive at the site and financial sponsorship has been provided. Runners may not have adequate experience to make the decision not to compete; their safety must be considered. Downgrading the race to a "fun run" does not absolve race supervisors from their responsibility or decrease the risk to participants (15, 66).

Background For This Position Stand

Dehydration is common during prolonged endurance events in both cold and hot environmental conditions because the average participant loses 0.5-1.5 quarts (0.47-1.42 liters) of sweat, and fluid replacement is usually insufficient (12, 42, 69). Runners may experience hyperthermia [body core temperature above 39°C (102.2°F)] or hypothermia [body core temperature below 35°C (95°F)], depending on the environmental conditions, caloric intake, fluid consumption, and clothing worn. Hyperthermia is a potential problem in warm and hot weather races when the body's rate of heat production is greater than its heat dissipation (2). Indeed, on extremely hot days, it is possible that up to 50% of the participants may require treatment for heat-related illnesses such as heat exhaustion and heatstroke (1, 66). Hypothermia is more likely to occur in cold or cool-windy conditions. Scanty clothing may provide inadequate protection from such environments, particularly near the end of a long race when running speed and heat production are reduced. Frostbite can occur in low air temperature and especially when combined with high wind speed. The race and medical directors should anticipate the above medical problems and be capable of responding to a large number of patients with adequate facilities, supplies, and support staff. The four most common heat and cold illnesses during distance running are heat exhaustion, heatstroke, hypothermia, and frostbite.

1. Heat Exhaustion

Body sweat loss can be significant in summer endurance races and may result in a body water deficit of 6-10% of body weight (41, 95). Such dehydration will reduce the ability to exercise in the heat because decreases in circulating blood volume, blood pressure, sweat production, and skin blood flow all inhibit heat loss (41, 81) and predispose the runner to heat exhaustion or the more dangerous hyperthermia and exertional heatstroke (41, 66).

Heat exhaustion, typically the most common heat illness among athletes, is defined as the inability to continue exercise in the heat (7). It represents a failure of the cardiovascular responses to workload, high external temperature, and dehydration (16, 41, 42). Heat exhaustion has no known chronic, harmful effects. Symptoms may include headache, extreme weakness, dizziness, vertigo, "heat sensations" on the head or neck, heat cramps, chills, "goose flesh" ("goose bumps"), vomiting, nausea, and irritability (41, 42). Hyperventilation, muscular incoordination, agitation, impaired judgment, and confusion also may be seen. Heat syncope (fainting) may or may not accompany heat exhaustion (41). The onset of heat exhaustion symptoms is usually sudden and the duration of collapse brief. During the acute stage of heat exhaustion, the patient looks ashen-gray, the blood pressure is low, and the pulse rate is elevated. Hyperthermia may add to the symptoms of heat exhaustion, even on relatively cool days (20, 22, 30, 37, 38, 43, 62, 90).

Although it is improbable that all heat exhaustion cases can be avoided, the most susceptible individuals are those who either exert themselves at or near their maximal capacities, are dehydrated, not physically fit, and not acclimatized to exercise in the heat. It is imperative that runners be adequately rested, fed, hydrated, and acclimatized (7); they should drink ample fluids before, during, and after exercise (3). Also, repeated bouts of exercise in the heat (heat acclimatization) reduce the incidence of both heat exhaustion and heat syncope. Heat acclimatization can best be accomplished by gradually increasing the duration and intensity of exercise training during the initial 10-14 d of heat exposure (6).

Oral rehydration is preferred for heat exhaustion patients who are conscious, coherent, and without vomiting or diarrhea. Intravenous (IV) fluid administration facilitates rapid recovery (42, 57). Although a variety of IV solutions have been used at races (42), a 5% dextrose sugar in either 0.45% saline (NACI) or 0.9% NaCl are the most common (1). Runners may require up to 4 1 of IV fluid if severely dehydrated (57).

2. Exertional Heatstroke

Heat production, mainly from muscles, during intense exercise is 15-20 times greater than at rest, and is sufficient to raise body core temperature by 1°C (1.8°F) each 5 minutes without thermoregulatory (heat loss) adjustments (56). When the rate of heat production exceeds that of heat loss for a sufficient period of time, severe hyperthermia occurs.

Heatstroke is the most serious of the syndromes associated with excess body heat. It is defined as a condition in which body temperature is elevated to a level that causes damage to the body's tissues, giving rise to a characteristic clinical and pathological syndrome affecting multiple organs (32, 83). After races, adult core (rectal) temperatures above 40.6°C (105.1°F) have been reported in conscious runners (24, 52, 69, 74, 77), and 42-43°C (107.6-109.4°F) in collapsed runners (72-74, 86, 90). Sweating is usually present in runners who experience exertional heatstroke (87).

Strenuous physical exercise in a hot environment has been notorious as the cause of heatstroke, but heatstroke also has been observed in cool-to-moderate [13-28°C (55-82°F)] environments (5, 32, 74), suggesting variations in individual susceptibility (5, 31, 32). Skin disease, sunburn, dehydration, alcohol or drug use/abuse, obesity, sleep loss, poor physical fitness, lack of heat acclimatization, advanced age, and a previous heat injury all have been theoretically linked to increased risk of heatstroke (5, 31, 51, 84). The risk of heatstroke is reduced if runners are well-hydrated, well-fed, rested, and acclimatized. Runners should not exercise if they have a concurrent illness, respiratory infection, diarrhea, vomiting, or fever (5, 7, 46). For example, a study of 179 heat casualties at a 14-km race showed that 23% reported a recent gastrointestinal or respiratory illness (70), whereas a study of 10 military heatstroke patients reported that three had a fever or disease and six recalled at least one warning sign of impending illness at the time of their heatstroke (5).

Appropriate fluid ingestion before and during prolonged running can minimize dehydration and reduce the rate of increase in body core temperature (24, 34). However, excessive hyperthermia may occur in the absence of significant dehydration, especially in races of less than 10 km, because the fast pace generates greater metabolic heat (90).

The mortality rate and organ damage due to heatstroke are proportional to the length of time between core temperature elevation and initiation of cooling therapy (5, 26). Therefore, prompt recognition and cooling are essential (1, 5, 22, 42, 48, 51, 62, 74, 83). A measurement of deep body temperature is vital to the diagnosis, and a rectal temperature should be measured in any casualty suspected of having heat illness or hypothermia. Ear (tympanic), oral, or axillary measurements are spuriously affected by peripheral (skin) and environmental temperatures and should not be used after exercise (8, 75, 76). When cooling is initiated rapidly, most heatstroke patients recover fully with normal psychological status (79), muscle energy metabolism (65), heat acclimatization, temperature regulation, electrolyte balance, sweat gland function, and blood constituents (5).

Many whole-body cooling techniques have been used to treat exertional heatstroke, including water immersion, application of wet towels or sheets, warm air spray, helicopter downdraft, and ice packs to the neck, underarm, and groin areas. There is disagreement as to which modality provides the most efficient cooling (7, 47, 97), because several methods have been used successfully. However, the fastest whole-body cooling rates (25, 48, 49, 59, 88) and the lowest mortality rates (25) have been observed during cool and cold water immersion. Whichever modality is utilized it should be simple and safe, provide great cooling power, and should not restrict other forms of therapy (i.e., cardiopulmonary resuscitation, defibrillation, IV cannulation). The advantages and disadvantages of various cooling techniques have been discussed (47, 75, 97).

Heatstroke is regarded as a medical emergency that might be fatal if not immediately diagnosed and properly treated. Early diagnosis is of utmost importance and time-consuming investigation should be postponed until body temperature is corrected and the patient is evacuated to a nearby medical facility that is aware of such conditions.

3. Hypothermia

Hypothermia [body core temperature below 36°C (97 °F)] occurs when heat loss is greater than metabolic heat production (94). Early signs and symptoms of hypothermia include shivering, euphoria, confusion, and behavior similar to intoxication. Lethargy, muscular weakness, disorientation, hallucinations, depression, or combative behavior may occur as core temperature continues to fall. If body core temperature falls below 31.1°C

(88°F), shivering may stop and the patient will become progressively delirious, uncoordinated, and eventually comatose if treatment is not provided (10).

During cool or cold weather marathons, the most common illnesses are hypothermia, exhaustion, and dehydration. The most common medical complaints are weakness, shivering, lethargy, slurred speech, dizziness, diarrhea, and thirst (1, 45). Runner complaints of feeling hot or cold do not always agree with changes in rectal temperature (74). Dehydration is common in cool weather (1, 45). Runners should attempt to replace fluids at a rate that matches their sweat and urine losses. Cases of hypothermia also occur in spring and fall because weather conditions change rapidly and runners wear inappropriate clothing that becomes sweat-soaked during training or competition (19).

Hypothermia may occur during races, for example when distance runners complete the second half of the event more slowly than the first half (54). Evaporative and radiative cooling increase because wet skin (from sweat, rain, or snow) and clothing are exposed to higher wind speed at a time when metabolic heat production decreases. Hypothermia also occurs after a race, when the temperature gradient between the body surface and the environment is high. Subfreezing ambient temperatures need not be present and hypothermia may develop even when the air temperature is 10-18°C (50-65°F) (19, 36, 74). A WBGT meter can be used to evaluate the risk of hypothermia (see Appendix 1). Cold wind increases heat loss in proportion to wind speed; i.e., wind chill factor. The relative degree of danger can be assessed (Fig. 2) (55). Wind speed can be estimated; if you feel the wind in your face the speed is at least 16 km per hour^{-1} (kph) [10 miles per hour^{-1} (mph)]; if small tree branches move or if snow and dust are raised, approximately 32 kph (20 mph); if large tree branches move, 48 kph (30 mph); if an entire tree bends, about 64 kph (40 mph) (9).

To reduce heat loss, runners should protect themselves from moisture, wind, and cold air by wearing several layers of light, loose clothing that insulate the skin with trapped air (17). An outer garment that is windproof, allows moisture to escape, and provides rain protection is useful. Lightweight nylon parkas may not offer thermal insulation but offer significant protection against severe wind chill, especially if a hood is provided. Wool and polyester fabrics retain some protective value when wet; cotton and goose down do not (10). Areas of the body that lose large amounts of heat (head, neck, legs, hands) should be covered (17).

Mild [34-36°C (93-97°F)] or moderate [30-34°C (86-93°F)] hypothermia should be treated before it progresses. Wet clothing should be replaced with dry material (sweatsuit, blanket) that is insulated from the ground and wind. Warm fluids should be consumed if patients are conscious, able to talk, and thinking clearly. Patients with moderate and severe [<30°C (86°F)] hypothermia should be insulated in a blanket and evacuated to a hospital immediately (19, 58). Although severe hypothermia should be treated in the field (27), it is widely recognized that life-threatening ventricular fibrillation is common in this state and may be initiated

Wind Chill Chart

AIR TEMPER-ATURE	ESTIMATED WIND SPEED IN MPH (KPH) 0 (0)	10 (16)	20 (32)	0 (48)	
30F (-1.I C)	30 (1.1)	16 (-8.9)	4 (-15.6)	-2 (-18.9)	LITTLE RISK
20 F (-6.7 C)	20 (-6-7)	4 (-15.6)	-10 (-23-3)	-18 (-27.8)	
10F (12.2 C)	10 (-12.2)	-9 (-22.8)	-25 (-31.7)	-33 (-36.1)	INCREASED RISK
0 F (-17.8 C)	0 (-17.8)	-24 (-31.1)	-39 (-39.4)	-48 (-44.4)	
-10 F (-23.3 C)	-10 (-23.3)	-33 (-36.1)	-53 (-47.2)	-63 (-52.8)	
-20 F (-28.9 C)	-20 (-28.9)	-46 (-43.3)	-67 (-55)	-79 (-61.7)	GREAT RISK

Figure 2 The risk of freezing exposed flesh in cold environments.
Reprinted from Milesko-Pytel, D. Helping the frostbitten patient. *Patient Care* 17:90-115, 1983.

by physical manipulation, chest compression, or intubation (10, 27, 58, 93). However, with conclusive evidence of cardiac standstill and breathlessness, emergency procedures (i.e., Basic Life Support, Advanced Cardiac Life Support) should be initiated. Life-support procedures (27) and commonly observed laboratory (i.e., electrolyte, acid-base) values (10, 58) have been described by others.

4. Frostbite

Frostbite involves crystallization of fluids in the skin or subcutaneous tissue after exposure to subfreezing temperatures [< -0.6°C (31°F)]. With low skin temperature and dehydration, cutaneous blood vessels constrict and circulation is attenuated because the viscosity of blood increases (55). Frostbite may occur within seconds or hours of exposure, depending upon air temperature, wind speed, and body insulation. Frostbitten skin can appear white, yellow-white, or purple, and is hard, cold, and insensitive to touch (55). Rewarming results in intense pain, skin reddening, and swelling. Blister formation is common and loss of extremities (fingers, toes, ears, hands, feet) is possible (36, 55). The degree of tissue damage depends on duration and severity of the freezing and effectiveness of treatment.

No data have been published regarding the incidence of frostbite among athletes during training or competition. Since winter running races are rarely postponed when environmental conditions are harsh, and frostbite is the most common cold injury in military settings (35), it is imperative that runners be aware of the dangers. Crosscountry ski races are postponed if the temperature at the coldest point of the course is less than -20 °C (-4 °F), due to the severe wind chill generated at race pace.

Runners risk frozen flesh within minutes if the air temperature and wind speed combine to present a severe wind chill. Because runners prefer to have unrestricted movement during races, and because they know that exercise results in body heating, they may not wear sufficient clothing. Runners can avoid frostbite and hypothermia in cold and windy conditions by protecting themselves by dressing adequately: wet skin or clothing will increase the risk of frostbite (21, 29).

When tissue freezes [skin temperature -2 ° -O °C, (28-32 °F)], water is drawn out of the cells and ice crystals cause mechanical destruction of skin and subcutaneous tissue (36). However, initial ice crystal formation is not as damaging to tissues as partial rethawing and refreezing (40). Therefore, the decision to treat severe frostbite in the field (versus transport to a hospital) should consider the possibility of refreezing. If there is no likelihood of refreezing, the tissue should be rapidly rewarmed (36, 40) in circulating warm water (40-43.3 °C, 104-110 °F), insulated, and the patient transported to a medical facility. Research on animals suggests that topical aloe vera and systemic ibuprofen may reduce tissue damage and speed rehabilitation in humans (9). Other aspects of hospital treatment protocols are detailed elsewhere (9, 36, 40).

Race Organization

The following suggestions constitute the ideal race medical team. They are offered for consideration, but are not intended as absolute requirements. Staff and equipment needs are unique to each race and may be revised after 1-2 yr, in light of the distinctive features of each race. Depending on the weather conditions, 2-12% of all entrants will typically enter a medical aid station (1, 45, 50, 74).

1. Medical Personnel

a. Provide medical assistance if the race is 10 km (6.2 miles) or longer.

b. Provide the following medical personnel per 1,000 runners: 1-2 physicians, 4-6 podiatrists, 1-4 emergency medical technicians, 2-4 nurses, 3-6 physical therapists, 3-6 athletic trainers, and 1-3 assistants. Approximately 75% of these personnel should be stationed at the finish area. Recruit one nurse (per 1,000 runners) trained in IV therapy.

c. Recruit emergency personnel from existing organizations (police, fire-rescue, emergency medical service).

d. One physician and 10-15 medical assistants serve as the triage team in the finish chute. Runners unable to walk are transported to the medical tent via wheelchair, litter, or two-person carry.

e. Consider one or two physicians and two to four nurses trained in the rehabilitative medical care of wheelchair athletes.

f. Medical volunteers should attend a briefing prior to the event to meet their supervisor and receive identification tags, weather forecast, instructions, and schedules. Supervisors from the following groups should be introduced: medical director; podiatry, nursing, physical therapy, athletic training, medical records, triage, wheelchair athlete care, and medical security (optional: chiropractic, massage therapy). Medical volunteers should be distinguished from other race volunteers; luminous/distinctive vests, coats, or hats work well.

2. Medical Aid Stations

a. Provide a primary medical aid station (250-1,500 ft^2 (23-139 m^2) for each 1,000 runners; see Table 1) at the finish area, with no public access. Place security guards at all entrances with instructions regarding who can enter.

b. Position secondary medical aid stations along the route at 2- to 3-km (1.2- to 1.9-mile) intervals for races over 10 km, and at the halfway point for shorter races (see Table 1). Some race directors have successfully secured equipment and medical volunteers from military reserve or national guard medical units, the American Red Cross, and the National Ski Patrol.

c. Station one ambulance per 3,000 runners at the finish area and one or more mobile emergency response vehicles on the course. Staff each vehicle with a nurse and radio person or cellular telephone. Stock each vehicle with a medical kit, automatic defibrillator, IV apparatus. blankets, towels, crushed ice, blood pressure cuffs, rehydration fluid, and cups.

d. Signs should be posted at the starting line and at each medical aid station to announce the risk of heat illness or cold injury (see Appendix 1).

e. A medical record card should be completed for each runner who receives treatment (1,74). This card provides details that can be used to plan the medical coverage of future events.

f. Provide personal protective equipment (gloves, gowns, face shields, eye protection) and hand washing facilities.

g. Provide portable latrines and containers for patients with vomiting and diarrhea.

h. Initial medical assessment must include rectal (not oral, aural, or axillary temperature; see ref. 8, 76), central nervous system function, and cardiovascular function. Rehydration and cooling or warming are the cornerstones of treatment (32, 41, 42, 50, 74, 94).

Medical aid stations

Item	Secondary Aid Station	Primary Aid Station
Stretchers (at 10 km and beyond)	2-5	4-10
Cots	10	30
Wheelchairs	0	1
Wool blankets (at 10 km and beyond)	6-10	12-20
Bath towels	5-10	10-20
High and low temperature rectal thermometers (37-43˚C; 99-110˚F) and (22-37˚C; 77-99˚F)[d]	5	10
Elastic bandages (2, 4, and 6 inch)	3 each	6 each
Gauze pads (4 x 4 inch)	1/2 case	1 case
Adhesive tape (1.5 inch)	1/2 case	1 case
Skin disinfectant	1 l	2 l
Surgical soap	1/2 case	1case
Band-aids	110	220
Moleskin	1/2 case	1 case
Petroleum jelly, ointments	1/2 case	1 case
Disposable latex gloves	80 pairs	175 pairs
Stethoscopes	1	2
Blood pressure cuffs	1	2
Intravenous (IV) stations[d]	1	2
IV fluid (D5:1/2 NS or D5:NS; 0.5 or 1l)[d]	15[e]	30[e]
Sharps and biohazard disposal containers[d]	1	2
Alcohol wipes	50	100
Small instrument kits	1	1
Athletic trainer's kit	1	1
Podiatrist's kit	1-2	2-4
Inflatable arm and leg splints	2 each	2 each
Tables for medical supplies	1	2
Hose with spray nozzle, running water[e]	1	2
Wading pool for water immersion[d]	1	2
Fans for cooling	1	2-4
Oxygen tanks with regulators and masks	0	2
Crushed ice in plastic bags	7 kg	14 kg
Rehydration fluids	50 l	100 l[e]
Cups (≥0.3l, 10 oz)	1250	2250
Eye drops	1	1
Urine dipsticksd	10	20
Glucose blood monitoring kits[d]	1	2
Inhalation therapy for asthmatics[d]	1	1
EMS ambulance or ACLS station	1	1
Injectable drugs[d]		
Oral drugs[d]		

Table 1 Suggested equipment and supplies per 1,000 runners[a].

[a] Revised from Adner, M. M., J. J. Scarlet, J. Casey, W. Robison, and 8, H. Jones. The Boston Marathon medical care team: ten years of experience. *Physician Sportsmed.* 16:99-106, 1988; Bodishbaugh, R. G. Boston marathoners get red carpet treatment in the medical tent. *Physician Sportsmed.* 16:139-143, 1988; and Noble, H. B. and D. Bachman. Medical aspects of distance race planning. *Physician Sportsmed.* 7:78-84, 1979.
[b] Increase supplies and equipment if the race course is out and back.
[c] At finish area.
[d] Supervised by a physician.
[e] Depends on environmental conditions.

3. Universal Precautions

All medical personnel may encounter blood-borne pathogens or other potentially infectious materials, and should observe the following precautions (53, 63):

a. Receive immunization against the hepatitis B virus prior to the event.

b. Recognize that blood and infectious body fluids may be encountered from needle sticks, cuts, abrasions, blisters, and clothing.

c. Reduce the likelihood of exposure by planning tasks carefully (i.e., prohibiting recapping of needles by a two-handed technique, minimizing splashing and spraying).

d. Wear personal protective equipment such as gloves, gowns, face shields and eye protection. Remove this equipment and dispose/decontaminate it prior to leaving the work area.

e. Wash hands after removing gloves or other personal protective equipment.

f. Dispose of protective coverings, needles, scalpels, and other sharp objects in approved, labeled biohazard containers.

g. Do not eat, drink, smoke, handle contact lenses, or any cosmetics/lip balm in the medical treatment area.

h. Decontaminate work surfaces, bins, pails, and cans [1/10 solution of household bleach (sodium hypochlorite) in water] after completion of procedures.

4. Fluid Stations

a. At the start and finish areas provide 0.34-0.45 1 (12-16 oz) of fluid per runner. At each fluid station on the race course (2-3 km apart), provide 0.28-0.34 1 (10-12 oz) of fluid per runner. Provide both water and a carbohydrate-electrolyte beverage in equal volumes.

b. In cool or cold weather [≤10˚C (50˚F)], an equivalent amount of warm fluid should be available.

c. Number of cups (>0.3 1, 10 oz) per fluid station on the course = number of entrants + 25% additional for spillage and double use. Double this total if the course is out and back.

d. Number of cups at start and finish area = (2 × number of entrants) + 25% additional.

e. Cups should be filled prior to the race and placed on tables to allow easy access. Runners drink larger volumes if volunteers hand them cups filled with fluid.

5. Communications/Surveillance

a. Provide two-way radio or telephone communication between the medical director, medical aid stations, mobile vans, and pick-up vehicles.

b. Arrange for radio-equipped vehicles to drive the race course (ahead and behind participants) and provide communication with the director and his/her staff. These vehicles should be stationed at regular intervals along the course to search the course for competitors who require emergency care and encourage compromised runners to stop.

c. Place radio-equipped observers along the course.

d. Notify local hospitals, police, and fire-rescue departments of the time of the event, number of participants, location of aid stations, extent of medical coverage, and the race course.

e. Use the emergency response system (telephone number 911) in urban areas.

6. Instructions to Runners

a. Advise each race participant to print name, address, telephone number, and medical problems on the back of the race number (pinned to the body). This permits emergency personnel to quickly identify unconscious runners. Inform emergency personnel that this information exists.

b. Inform race participants of potential medical problems at pre-race conferences and at the starting line. Signed registration forms should clearly state the types of heat or cold injuries that may arise from participation in this event.

c. Provide pre-event recommendations regarding training, fluid consumption, clothing selection, self-care, heat acclimatization, and signs or symptoms of heat/cold illness (88).

d. The race director should announce the following information to all participants by loudspeaker immediately prior to the race:

- Current and predicted maximum (or minimum) temperature, humidity, wind speed, and cloud cover;
- The WBGT category and the risks for hyperthermia or hypothermia (see Appendix 1);
- Location of aid stations, types of assistance, and fluid availability;
- Signs and symptoms of heat or cold illness;
- Recommended clothing;
- The need for fluid replacement before, during, and after the race;
- The policy of race monitors to stop runners who are ill;
- A request that runners seek help for impaired competitors who appear ill, who are not coherent, who run in the wrong direction, or who exhibit upper-body swaying and poor competitive posture;

- A warning to novice runners entering their first race that they should run at a comfortable pac and run with a partner;
- Warnings to runners who are taking medications or have chronic illnesses (asthma, hypertension, diabetes, cardiovascular problems).

This position stand replaces the 1987 ACSM position paper, "The Prevention of Thermal Injuries During Distance Running." This pronouncement was reviewed for the American College of Sports Medicine by members-at-large, the Pronouncements Committee, and by: Arthur E. Crago, M.D., Stafford W. Dobbin, M.D., Mary L. O'Toole, Ph.D., FACSM, LTC Katy L. Reynolds, M.D., John W. Robertson, M.D., FACSM.

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Appendix 1: Measurement of Environmental Stress

Ambient temperature is only one component of environmental heat or cold stress; others are humidity, wind speed, and radiant heat. The most widely used heat stress index is the wet bulb globe temperature (WBGT) index (96):

$$WBGT = (0.7\ T^{wb}) + (0.2\ T^{g}) + (0.\ 1\ T^{db})$$

where T^{wb} is the wet bulb temperature, T^{g} is the black globe temperature, and T^{db} is the shaded dry bulb temperature (28). T^{db} refers to air temperature measured with a standard dry bulb thermometer not in direct sunlight. T^{wb} is measured with a water-saturated cloth wick over a dry bulb thermometer (not immersed in water). T^{g} is measured by inserting a dry bulb thermometer into a standard black metal globe. Both T^{wb} and ^{T} are measured in direct sunlight.

A portable monitor that gives the WBGT index in degrees Celsius or degrees Fahrenheit has proven useful during races and in military training (28, 44, 87, 96). The measurement of air temperature alone is inadequate. The importance of humidity in total heat stress can be readily appreciated because T^{wb} accounts for 70% of the index whereas T^{db} accounts for only 10%.

The risk of heat illness (while wearing shorts, socks, shoes, and a t-shirt) due to environmental stress should be communicated to runners in four categories (see Fig. 1):

- Very high risk: WBGT above 28°C (82°F); high risk: WBGT 23-28°C (73-82°F);
- Moderate risk: WBGT 18-23°C (65-73°F);
- Low risk: WBGT below 18°C (65°F).

Large signs should be displayed, at the start of the race and at key points along the race course, to describe the risk of heat exhaustion and heatstroke (Fig. 1). When the WBGT index is above 28°C (82°F), the risk of heat exhaustion or heatstroke is very high; it is recommended that the race be postponed until less stressful conditions prevail, rescheduled, or canceled. High risk [WBGT index = 23-28°C (73-82°F)] indicates that runners should be aware that heat exhaustion or heatstroke may be experienced by any participant; anyone who is particularly sensitive to heat or humidity probably should not run. Moderate risk [WBGT index = 18-23°C (65-73°F)] reminds runners that heat and humidity will increase during the course of the race if conducted during the morning or early afternoon. Low risk [WBGT index below 18°C (65°F)] does not guarantee that heat exhaustion (even heatstroke, see ref. 5, 32) will not occur; it only indicates that the risk is low.

The risk of hypothermia (while wearing shorts, socks, shoes, and a t-shirt) also should be communicated to runners. A WBGT index below 10°C (50°F) indicates that hypothermia may occur in slow runners who run long distances, especially in wet and windy conditions. Core body temperatures as low as 92°F have been observed in 65°F conditions (74).

Section Six

REFERENCES AND WEB SITES

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American College of Sport Medicine (ACSM)
www.acsm.org

American Sport Education Program
www.asep.com

Gatorade Sport Science Institute (GSSI)
www.gssiweb.com

Human Kinetics
www.humankinetics.com

National Athletic Trainers Association (NATA)
www.nata.org

National Strength and Conditioning Association (NSCA)
www.nsca-lift.org

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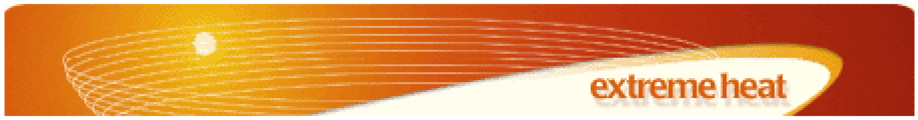

Heat Stroke

Heat stroke occurs when the body is unable to regulate its temperature. The body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. Body temperature may rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not provided.

Recognizing Heat Stroke

Warning signs of heat stroke vary but may include the following:

- An extremely high body temperature (above 103°F, orally)
- Red, hot, and dry skin (no sweating)
- Rapid, strong pulse
- Throbbing headache
- Dizziness
- Nausea
- Confusion
- Unconsciousness

What to Do

If you see any of these signs, you may be dealing with a life-threatening emergency. Have someone call for immediate medical assistance while you begin cooling the victim. Do the following:

- Get the victim to a shady area.
- **Cool the victim rapidly using whatever methods you can.** For example, immerse the victim in a tub of cool water; place the person in a cool shower; spray the victim with cool water from a garden hose; sponge the person with cool water; or if the humidity is low, wrap the victim in a cool, wet sheet and fan him or her vigorously.
- Monitor body temperature, and continue cooling efforts until the body temperature drops to 101-102°F.
- If emergency medical personnel are delayed, call the hospital emergency room for further instructions.
- Do not give the victim alcohol to drink.

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- Get medical assistance as soon as possible.

Sometimes a victim's muscles will begin to twitch uncontrollably as a result of heat stroke. If this happens, keep the victim from injuring himself, but do not place any object in the mouth and do not give fluids. If there is vomiting, make sure the airway remains open by turning the victim on his or her side.

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Heat Rash

Heat rash is a skin irritation caused by excessive sweating during hot, humid weather. It can occur at any age but is most common in young children.

Recognizing Heat Rash

Heat rash looks like a red cluster of pimples or small blisters. It is more likely to occur on the neck and upper chest, in the groin, under the breasts, and in elbow creases.

What to Do

The best treatment for heat rash is to provide a cooler, less humid environment. Keep the affected area dry. Dusting powder may be used to increase comfort, but avoid using ointments or creams -- they keep the skin warm and moist and may make the condition worse.

Treating heat rash is simple and usually does not require medical assistance. Other heat-related problems can be much more severe.

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Heat Cramps

Heat cramps usually affect people who sweat a lot during strenuous activity. This sweating depletes the body's salt and moisture. The low salt level in the muscles causes painful cramps. Heat cramps may also be a symptom of heat exhaustion.

Recognizing Heat Cramps

Heat cramps are muscle pains or spasms -- usually in the abdomen, arms, or legs -- that may occur in association with strenuous activity. If you have heart problems or are on a low-sodium diet, get medical attention for heat cramps.

What to Do

If medical attention is not necessary, take these steps:

- Stop all activity, and sit quietly in a cool place.
- Drink clear juice or a sports beverage.
- Do not return to strenuous activity for a few hours after the cramps subside, because further exertion may lead to heat exhaustion or heat stroke.
- Seek medical attention for heat cramps if they do not subside in 1 hour.

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Sunburn

Sunburn should be avoided because it damages the skin. Although the discomfort is usually minor and healing often occurs in about a week, a more severe sunburn may require medical attention.

Recognizing Sunburn

Symptoms of sunburn are well known: skin becomes red, painful, and abnormally warm after sun exposure.

What to Do

Consult a doctor if the sunburn affects an infant younger than 1 year of age or if these symptoms are present:

- Fever
- Fluid-filled blisters
- Severe pain

Also, remember these tips when treating sunburn:

- Avoid repeated sun exposure.
- Apply cold compresses or immerse the sunburned area in cool water.
- Apply moisturizing lotion to affected areas. Do not use salve, butter, or ointment.
- Do not break blisters.

Click here for more information about skin cancer prevention.

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Heat Exhaustion

Heat exhaustion is a milder form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids. Those most prone to heat exhaustion are elderly people, people with high blood pressure, and people working or exercising in a hot environment.

Recognizing Heat Exhaustion

Warning signs of heat exhaustion include the following:

- Heavy sweating
- Paleness
- Muscle cramps
- Tiredness
- Weakness
- Dizziness
- Headache
- Nausea or vomiting
- Fainting

The skin may be cool and moist. The victim's pulse rate will be fast and weak, and breathing will be fast and shallow. If heat exhaustion is untreated, it may progress to heat stroke. Seek medical attention immediately if any of the following occurs:

- Symptoms are severe.
- The victim has heart problems or high blood pressure.

Otherwise, help the victim to cool off, and seek medical attention if symptoms worsen or last longer than 1 hour.

What to Do

Cooling measures that may be effective include the following:

- Cool, nonalcoholic beverages, as directed by your physician
- Rest
- Cool shower, bath, or sponge bath

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Tips on Preventing and Managing Heat

The best defense is prevention. Here are some prevention tips:

- Drink more fluids (nonalcoholic), regardless of your activity level. Don't wait until you're thirsty to drink. Warning: If your doctor generally limits the amount of fluid you drink or has you on water pills, ask him how much you should drink while the weather is hot.
- Don't drink liquids that contain caffeine, alcohol, or large amounts of sugar–these actually cause you to lose more body fluid. Also, avoid very cold drinks, because they can cause stomach cramps.
- Stay indoors and, if at all possible, stay in an air-conditioned place. If your home does not have air conditioning, go to the shopping mall or public library–even a few hours spent in air conditioning can help your body stay cooler when you go back into the heat. Call your local health department to see if there are any heat-relief shelters in your area.
- Electric fans may provide comfort, but when the temperature is in the high 90s, fans will not prevent heat-related illness. Taking a cool shower or bath, or moving to an air-conditioned place is a much better way to cool off.
- Wear lightweight, light-colored, loose-fitting clothing.
- NEVER leave anyone in a closed, parked vehicle.
- Although any one at any time can suffer from heat-related illness, some people are at greater risk than others. Check regularly on:
  - Infants and young children
  - People aged 65 or older
  - People who have a mental illness
  - Those who are physically ill, especially with heart disease or high blood pressure
- Visit adults at risk at least twice a day and closely watch

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them for signs of heat exhaustion or heat stroke. Infants and young children, of course, need much more frequent watching.

If you must be out in the heat:

- Limit your outdoor activity to morning and evening hours.
- Cut down on exercise. If you must exercise, drink two to four glasses of cool, nonalcoholic fluids each hour. A sports beverage can replace the salt and minerals you lose in sweat. Warning: If you are on a low-salt diet, talk with your doctor before drinking a sports beverage. Remember the warning in the first "tip" (above), too.
- Try to rest often in shady areas.
- Protect yourself from the sun by wearing a wide-brimmed hat (also keeps you cooler) and sunglasses and by putting on sunscreen of SPF 15 or higher (the most effective products say "broad spectrum" or "UVA/UVB protection" on their labels).

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Outdoor Action Guide to Heat-Related Illnesses& Fluid Balance

by Rick Curtis

Heat injuries can be immediately life-threatening. Be aware of the temperature conditions and your hydration levels. The information provided here is designed for educational use only and is not a substitute for specific training or experience. Princeton University and the author assume no liability for any individual's use of or reliance upon any material contained or referenced herein. This article is prepared to provide basic information about heat related illnesses for the lay person. Medical research is always expanding our knowledge of the causes and treatment. It is your responsibility to learn the latest information. The material contained in this article may **not** be the most current.

Fluid Balance

All the body's fluids make up one large body fluid pool. Losses of fluid from any one source is reflected in the levels of all the body's other fluids: e.g. profuse sweating will ultimately result in decreased blood volume. If a patient loses enough fluid through any manner-bleeding, sweating, vomiting, or diarrhea-the end result is the same: dehydration and, potentially, volume shock. Adequate fluid is also critically important in hot environments to help our body thermoregulate (see Heat Illnesses page 00). Remember, dehydration can kill!

If someone is chronically losing fluid (from diarrhea or vomiting), then you have a real emergency on your hands. Treat the cause of the fluid lose as best you can (see Shock page 00, Bleeding page 00, Heat Illnesses page 00, Abdominal Infections page 00) and rehydrate the patient. **Be prepared to evacuate your patient.**

Dehydration is always easier to prevent than it is to treat. So it is important to ensure that all members of your group replace their regular fluid losses by drinking adequate amounts of water (see below). Your body absorbs fluids best when you drink frequently and in small amounts rather than drinking large amounts at one time. It also helps with fluid absorption if you drink while eating. A pinch of salt and sugar in the water will do if no food is available. Very dilute mixtures of sports drinks like Gatorade® (add just enough to taste) work well for this purpose.

Don't depend on feeling thirsty to tell you when to drink. Thirst is a late response of the body to fluid depletion. Once you feel thirsty, you are already low on fluids. The best indicator of proper fluid levels is urine output and color. You, and all the people in your group should strive to be "copious and clear." Ample urine that is light colored to clear shows that the body has plenty of fluid. Dark urine means that the body is low on water, and is trying to conserve its supply by hoarding fluid which means that urine becomes more concentrated (thereby darker).

Basic Fluid Recommendations

Season/Weather	**Quarts/day**	**Explanation**
Fall & Spring Backpacking*<B/	2-3 quarts 1.8-2.8 liters	This is what an average person will need on a daily basis in general temperate conditions.
Hot Weather Backpacking*	3-4 quarts 2.8-3.7 liters	In hot and humid weather you are losing additional fluid through sweating which must be replaced.
Winter Backpacking*	3-4 quarts 2.8-3.7 liters	In the winter time you are losing moisture through evaporation to the dry air and especially through respiration. Dry air entering the lungs heats up and is exhaled saturated with moisture.
***All Seasons**	Add 1quart 1.8 liters	At high altitude the body looses more fluid. Increase your fluid intake if you are traveling at high altitudes (over 8,000 feet/2,438 meters)

Table 9.1

Fluids & Salts:

Another factor in overall fluid balance is the replacement of salts lost to sweat. In most cases the salts found in normal food consumption is adequate for salt replacement. In the event of severe dehydration, a solution of ½ teaspoon salt and ½ teaspoon of baking soda per quart/liter of water can be used to replace lost fluid and salt. Use lukewarm fluids. Discontinue the fluids if the person becomes nauseated or vomits. Restart fluids as soon as the person can tolerate it.

Thermoregulation

The body has a number of mechanisms to properly maintain its optimal core temperature of 98.6° F (37° C). Above 105° F (40° C) many body enzymes become denatured and chemical reactions cannot take place leading to death. Below 98.6° F (37° C) chemical reactions slow down with various complications which can lead to death. Understanding thermoregulation is important to understanding Heat Illnesses and Cold Injuries.

How Your Body Regulates Core Temperature:

- **Vasodilation** - increases surface blood flow which increases heat loss (when ambient temperature is less that body temperature).
- **Vasoconstriction** - decreases blood flow to periphery, decreases heat loss.
- **Sweating** - cools body through evaporative cooling
- **Shivering** - generates heat through increase in chemical reactions required for muscle activity. Visible shivering can maximally increase surface heat production by 500%. However, this is limited to a few hours because of depletion of muscle glucose and the onset of fatigue.

- **Increasing/Decreasing Activity** will cause corresponding increases in heat production and decreases in heat production.
- **Behavioral Responses** - putting on or taking off layers of clothing will result in thermoregulation

Cold Challenge

Whenever you go into an environment that is less than your body temperature, you are exposed to a Cold Challenge. As long as your levels of Heat Production and Heat Retention are greater than the Cold Challenge, then you will be thermoregulating properly. If the Cold Challenge is greater than your combined Heat Production and Heat Retention, then you susceptible to a cold illness such as hypothermia or frostbite (see Table 9.3).

Cold Challenge - (negative factors)

- Temperature
- Wet (rain, sweat, water)
- Wind (see Table 9.3 Wind Chill Table)

Heat Retention - (positive factors)

- Body Size/shape - your surface to volume ratio effects how quickly you lose heat.
- Insulation - type of clothing layers
- Body Fat - amount of body fat also effects how quickly you lose heat.
- Shell/Core Response - allows the body shell to act as a thermal barrier

Heat Production - (positive factors)

- Exercise
- Shivering

Heat Retention	+	**Heat Production**	<	**Cold Challenge**	=	**Cold Injury**
Body Size/shape Insulation Body Fat Body shunting blood to the core		Exercise Shivering		Temperature Wetness Wind		Hypothermia Frostbite

Table 9.2

Wind Chill

Wind Chill can have a major impact on heat loss through convection (see Chapter 2 - Equipment: Regulating Your Body Temperature). As air heated by your body is replaced with cooler air pushed by the wind, the amount of heat you can lose in a given period of time increases. This increase is comparable to the amount of heat you would lose at a colder temperature with no wind. The Wind Chill factor is a scale that shows the equivalent temperature given a particular wind speed.

Heat Challenge

In hot weather, especially with and humidity, you can lose a great deal of body fluid through exercise. This can lead to a variety of heat related illnesses including Heat Exhaustion and Heat Stroke. Heat Challenge is a combination of a number of external heat factors. Balanced against this Heat Challenge is your body's methods of Heat Loss (passive and active). When Heat Challenge is greater than Heat Loss, you are at risk for a heat-related injury (see Table 9.4). In order to reduce the risk you need to either decrease the Heat Challenge or increase your Heat Loss. Fluids are a central part of exercising in a Heat Challenge (see Fluids above).

Heat Challenge - (negative factors)

- Temperature
- Exercise
- Humidity (see Table 9.5 Heat Index Table)
- Body Wetness from sweating
- Wind (see Table 9.3 Wind Chill Table)

Passive Heat Loss - (positive factors)

- Body Size/shape - your surface to volume ratio effects how quickly you lose heat.
- Insulation - type of clothing layers
- Body Fat - amount of body fat also effects how quickly you lose heat.
- Shell/Core Response - allows the body shell to act as a thermal barrier
-

Active Heat Loss - (positive factors)

- Radiant Heat from the body.
- Sweating which causes heat loss through evaporation. Amount of sweating is limited by:
    - Fluid Levels
    - Level of Fitness

Passive Heat Loss	+	**Active Heat Loss**	<	**Heat Challenge**	=	**Heat Injury**
Body Size/shape Insulation Body Fat Body shunting blood to the core		Radiant Heat Sweating		Temperature Exercise Humidity Body Wetness Wind		Heat Syncope Heat Exhaustion Heat Stroke

Table 9.4

The Heat Index:

Ambient temperature is not the only factor that plays a role in creating the potential for heat injuries, humidity is also important. Since our bodies rely on the evaporation of sweat as a major method of cooling, high humidity reduces our ability to cool the body, increasing the risk of heat illnesses. The Heat Index shows the relative effects of temperature and humidity (see Table 9.5).

The Heat Index											
	Environmental Temperature Fº (Cº)										
	70&ord m; (21)	75&ord m;(24)	80&ord m;(27)	85&ord m;(29)	90&ord m;(32)	95&ord m;(35)	100&ord m;(38)	105&ord m;(41)	110&ord m;(43)	115&ord m;(46)	120&ord m;(49)
Relative Humidity	**Apparent Temperature Fº (Cº)**										
0%	64&ord	69&ord	73&ord	78&ord	83&ord	87&ord	91&ord	95&ord	99&ord	103&ord	107&ord

	m;(18)	m;(20)	m;(23)	m;(26)	m;(28)	m;(31)	m;(33)	m;(35)	m;(37)	m;(39)	m;(42)
10%	65º(18)	70º(21)	75º(24)	80º(27)	85º(29)	90º(33)	95º(35)	100º(38)	105º(41)	111º(44)	116º(47)
20%	66º(19)	72º(22)	77º(25)	82º(28)	87º(30)	93º(33)	99º(37)	105º(41)	112º(44)	120º(49)	130º(54)
30%	67º(19)	73º(23)	78º(26)	84º(29)	90º(33)	96º(36)	104º(40)	113º(45)	123º(51)	135º(57)	148º(64)
40%	68º(20)	74º(23)	79º(26)	86º(30)	93º(34)	101º(38)	110º(43)	123º(56)	137º(58)	151º(66)	
50%	69º(20)	75º(24)	81º(27)	88º(31)	96º(36)	107º(42)	120º(49)	135º(57)	150º(66)		
60%	70º(21)	76º(24)	82º(28)	90º(33)	100º(38)	114º(46)	132º(56)	149º(65)			
70%	70º(21)	77º(25)	85º(29)	93º(34)	106º(41)	124º(51)	144º(62)				
80%	71º(22)	78º(26)	86º(30)	97º(36)	113º(45)	136º(58)					
90%	71º(22)	79º(26)	88º(31)	102º(39)	122º(50)						
100%	72º(22)	80º(27)	91º(33)	108º(42)							

Apparent Temperature	**Heat-stress risk with physical activity and/or prolonged exposure.**
90º-104º (32-40)	Heat cramps or Heat Exhaustion possible
105º-130º (31-54)	Heat cramps or Heat Exhaustion likely. Heat Stroke possible.
130º and up (54 and up)	Heat Stroke very likely.

Caution: This chart provides guidelines for assessing the potential severity of heat stress. Individual reactions to heat will vary. Heat illnesses can occur at lower temperature than indicated on this chart. Exposure to full sunshine can increase values up to 15º F.

Table 9.5

Heat Illnesses

Heat illnesses are the result of elevated body temperatures due to an inability to dissipate the body's heat and/or a decreased fluid level. Always remember that mild heat illnesses have the potential of becoming severe life threatening emergencies if not treated properly (See Fluid Balance above).

<u>Heat Cramps</u>

Heat cramps are a form of muscle cramp brought on by exertion and insufficient salt.

<u>Heat Cramps Treatment</u>

Replace salt and fluid (see Fluid Balance) and stretch the muscle (See Chapter 6 - Wilderness Travel & Camping: Stretching). Kneading and pounding the muscle is less effective than stretching and probably contributes to residual soreness.

<u>Heat Syncope</u>

Heat Syncope (fainting) is a mild form of heat illness which results from physical exertion in a hot environment. In an effort to increase heat loss, the skin blood vessels dilate to such an extent that blood flow to the brain is reduced, resulting in symptoms of faintness, dizziness, headache, increased pulse rate, restlessness, nausea, vomiting, and possibly even a brief loss of consciousness. Inadequate fluid replacement which leads to dehydration contributes significantly to this problem.

<u>Heat Syncope Treatment</u>

Heat Syncope should be treated as fainting (See Fainting). The person should lie or sit down, preferably in the shade or in a cool environment. Elevate the feet and give fluids, particularly those containing salt (commercial "rehydration" mix or ½ teaspoon salt and ½ teaspoon baking soda per quart/0.9 liter) (see Fluid Balance page 00). **The patient should not engage in vigorous activity for at least the rest of that day.** Only after s/he has completely restored his/her body fluids and salt and has a normal urinary output should exercise in a hot environment be resumed (and then cautiously).

<u>Heat Exhaustion</u>

This occurs when fluid losses from sweating and respiration are greater than internal fluid reserves (volume depletion). Heat Exhaustion is really a form of volume shock. The lack of fluid causes the body to constrict blood vessels especially in the periphery (arms and legs). To understand Heat Exhaustion think of a car with a radiator leak pulling a trailer up a mountain pass. There is not enough fluid in the system to cool off the engine so the car overheats. Adding fluid solves the problem.

The signs and symptoms of Heat Exhaustion are:

- Sweating
- Skin - Pale, clammy (from peripheral vasoconstriction)
- Pulse - Increased
- Respirations - Increased
- Temperature - normal or slightly elevated
- Urine Output - Decreased
- Patient feels weak, dizzy, thirsty, "sick," anxious
- Nausea and vomiting (from decreased circulation in the stomach)

<u>Heat Exhaustion Treatment</u>

Victims of Heat Exhaustion must be properly re-hydrated and must be very careful about resuming physical activity (it is best to see a physician before doing so). Treatment is as described above for Heat Syncope, but the person should be **more** conservative about resuming physical activity to give the body a chance to recover. Have the person rest (lying down) in the shade. Replace fluid with a water/salt solution (commercial "rehydration" mix or ½ teaspoon salt and ½ teaspoon baking soda per quart/0.9 liter) (see Fluid Balance page 00). Drink slowly, drinking too much, too fast very often causes nausea and vomiting.

Evacuation usually is not necessary. Heat Exhaustion can become Heat Stroke if not properly treated (see Heat Stroke below). **A victim of Heat Exhaustion should have be closely monitored to make sure that their temperature does not go above 103° F (39° C) If it does so, treat the person for Heat Stroke as described below.**

<u>Heat Stroke - Hyperthermia</u>

Heat Stroke is one of the few life threatening medical emergencies. A victim can die within minutes if not properly treated. Heat Stroke is caused by an increase in the body's core temperature. Core temperatures over 105° (41° C) can lead to death. The rate of onset of Heat Stroke depends on the individual's fluid status. To understand Heat Stroke think of that same car pulling a trailer up a mountain pass on a hot day. This time the radiator has plenty of fluid, but the heat challenge of the engine combined with the external temperature is too much. The engine can't great rid of the heat fast enough and the engine overheats. There are two types of Heat Stroke-fluid depleted (slow onset) and fluid intact (fast onset).

- **<u>Fluid depleted</u>** - The person has Heat Exhaustion due to fluid loss from sweating and/or inadequate fluid replacement, but continues to function in a heat challenge situation. Ultimately, the lack of fluid has minimized the body's active heat loss capabilities to such an extent that the internal core temperature begins to rise. Example: a cyclist on a hot day with limited water.

- **<u>Fluid intact (fast onset)</u>** - The person is under an extreme heat challenge. The heat challenge overwhelms the body's active heat loss mechanisms even though the fluid level is sufficient. Example: a cyclist pushing hard on a 104° F day (40° C).

<u>Signs & Symptoms of Heat Stroke</u>

- **The key to identifying Heat Stroke is hot skin**. Some victims may have hot, dry skin, others may have hot, wet skin because they have just moved from Heat Exhaustion to Heat Stroke.

- Peripheral vasoconstriction (skin gets pale)

- Pulse Rate - increased

- Respiratory Rate - increased

- Urine Output - decreased

- Temperature - increased (may be over 105° F/41° C)

- Skin - may be wet or dry, flushed

- AVPU - Severe changes in mental status and motor/sensory changes, then the person may become comatose, possibility of seizures.

- Pupils - may be dilated and unresponsive to light

<u>Heat Stroke Treatment</u>

- **Efforts to reduce body temperature must begin immediately!** Move the patient (gently) to a cooler spot or shade the victim. Remove clothing. Pour water on the extremities and fan the person to increase air circulation and evaporation. Or cover the extremities with cool wet cloths and fan the patient. Immersion in cool **(not cold)** water is also useful. During cooling the extremities should be massaged vigorously to help propel the cooled blood back into the core.

- After the temperature has been reduce to 102° F (39° C), active cooling should be reduced to avoid hypothermia (shivering produces more heat). The patient must be monitored closely to make sure that temperature does not begin to go up again.

- Volume replacement - the victim will probably need fluid regardless of the type of onset.
- Basic life support, CPR if needed.
- Afterwards there can be serious medical problems. **Prepare to evacuate your patient.**
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IMMDA ADVISORY STATEMENT ON GUIDELINES FOR FLUID REPLACEMENT DURING MARATHON RUNNING

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SUMMARY

During endurance exercise about 75% of the energy produced from metabolism is in the form of heat, which cannot accumulate. The remaining 25% of energy available can be used for movement. As running pace increases, the rate of heat production increases. Also, the larger one's body mass, the greater the heat production at a particular pace. Sweat evaporation provides the primary cooling mechanism for the body, and for this reason athletes are encouraged to drink fluids to ensure continued fluid availability for both evaporation and circulatory flow to the tissues. Elite level runners could be in danger of heat illness if they race too quickly in hot/humid conditions, and may collapse at the end of their event. Most marathon races, however, are scheduled at cooler times of the year or day, so that heat loss to the environment is adequate. Typically however, this post-race collapse is due simply to postural hypotension from decreased skeletal muscle massage of the venous return circulation to the heart upon stopping. Elite athletes manage adequate hydration by ingesting about 200 – 800 ml per hour, and such collapse is rare. Athletes "back in the pack," however, are moving at a much slower pace, with heat accumulation unlikely and drinking much easier to manage. They are often urged to drink "as much as possible," ostensibly to prevent dehydration from their hours out on the race course. Excessive drinking among these participants can lead to hyponatraemia severe enough to cause fatalities. Thus, a more reasonable approach is to urge these participants not to drink as much as possible but to drink *ad libitum* no more than 400 – 800 ml per hour.

HISTORICAL BACKGROUND: IMMDA AND AIMS

The International Marathon Medical Directors Association (IMMDA) was formed as the Consulting Medical Committee of the Association of International Marathons (AIMS). AIMS is a global organization of marathons and other road races, formed in May, 1982. The purpose of AIMS is to i) foster and promote marathon running throughout the world, ii) recognize and work with the International Association of Athletics Federations (IAAF) as the sport's world governing body on all matters relating to international marathons, and iii) exchange information, knowledge, and expertise among its member events. Starting with scarcely a dozen members, AIMS' current roster numbers approximately 150 events which are conducted on all 7 continents and which includes the world's largest and most prestigious marathons.

The purpose of IMMDA is to i) promote and study the health of long distance runners, ii) promote research into the cause and treatment of running injuries, iii) prevent the occurrence of injuries during mass participation runs, iv) offer guidelines for the provision of uniform marathon medical services throughout the world, and v) promote a close working relationship between race and medical directors in achieving the above four goals. This Advisory Statement on Guidelines for Fluid Replacement During Marathon Running continues a series of periodic informational and advisory pieces prepared occasionally by IMMDA to provide timely, needed, and practical information for the health and safety of runners participating in AIMS events in particular, but applicable to other distance running races as well.

THE CHANGING NATURE OF PARTICIPATION IN MARATHON RACES

During the 1970s a major development in the worldwide fitness movement saw the creation of so-called "Big City Marathons," in which thousands of fitness enthusiasts joined elite athletes in the grueling challenge of completing a 42.195 km (26.22 mi) trip on foot through city streets. The first of these occurred in 1976 when the New York City Marathon changed its course from several loops around its Central Park to become a tour of the town covering all 5 of its boroughs. Prior to the early 1970s, relatively few marathons were staged around the world on an annual basis, and they were small, with participation numbering from the dozens into the hundreds. The competitors entered were talented athletes, well-trained and dedicated, including some hoping to earn berths on national traveling teams to major regional or world competitions such as the Olympic, Pan American, and Commonwealth Games, European Championships, and the like. The Boston Marathon was the largest of these, and as shown in Table 1, so talented was the field that the race was finished by 3 ½ hours. Women seldom participated until the mid-1970's.

The 1976 New York City Marathon thus added the element of a giant physical fitness participation spectacle to what previously was a purely athletic event, and its popularity gave it steady growth. Table 1 shows the numbers of finishers sorted by 30-minute time groupings for the 1978 and 2001 editions of this race as a means for comparing its changing participatory dynamics over time. Notice first the enormous size that can be attained by today's marathons; the New York City Marathon is often among the one or two world's largest such events. Second, notice the longer time required by the bulk of the runners in 2001 to complete the distance as compared with that in 1978 - at least 60 minutes or more. Just the opposite might have been expected, i.e. the increasing popularity of marathon racing over the years ought to have produced faster times for participants rather than slower. Indeed, this has occurred among the several dozen invited elite-level runners up front, but it appears that the "back-in-the-pack" marathon runners are delivering slower performances. They either have less inherent talent, or are doing less training, or both. Study of the race demographics does show among today's participants a large percentage who are engaging in "running tourism" or who are "running for a charitable cause," and thus for whom simply finishing is satisfaction enough.

This increased event size has of necessity resulted in an enormous expansion of medical support services for participants, especially during and immediately following these races. Much of this medical support has consisted of fluids (water plus electrolyte and energy-containing beverages) at so-called "aid stations" along the course. This is because the current approach to drinking, especially during the race has become quite the opposite to that advocated in the 1960's and early 1970's. The current paradigm is that athletes should drink "as much as possible" during lengthy endurance exercise such as marathon running (3-6).

The purpose of this IMMDA Advisory Statement is to provide a caution against this paradigm, due to the recent realization that athletes – particularly the slower ones - can drink so much during prolonged exercise that potentially fatal consequences can result (7-14). The previously accepted guidelines for fluid replacement during more prolonged exercise thus require timely and meaningful revision. This Advisory Statement covers both social recreational running/racing as well as the more disciplined training done by elite-level athletes and also essentially sedentary people becoming military basic training recruits (12,13). Perusal of the several revisions of published guidelines by the American College of Sports Medicine (ACSM) for fluid replacement during exercise (3-6) indicates that they are more laboratory-evidence-based than clinical-evidence-based (15,16). Although they indeed promote the wise doctrine that athletes do need to drink generously during exercise, a substantial and increasing body of evidence shows that harm can occur (7-9) from excessive drinking by endurance fitness enthusiasts requiring 4 or more hours to complete events such as a marathon footrace. This Advisory Statement briefly reviews the literature on this topic, describing how the interpretation of experimental data by itself has failed to adequately explain physiological adjustments occurring in the body during exercise that causes heat gains and fluid losses.

LABORATORY VERSUS CLINICAL OBSERVATIONS REGARDING ENDURANCE EXERCISE PERFORMANCE

Laboratory Studies

The logic for suggesting that athletes should drink copious amounts of fluids during prolonged exercise such as marathon running likely stems from publication of laboratory research as early as 1969, which showed a relationship between the extent of dehydration that developed during exercise and the rise in rectal (core body) temperature (17-21). The sensible conclusion was that dehydration was the single greatest risk to the health of marathon runners because it would cause the body temperature to rise, leading to heat illness, including heatstroke (4-6,16-18). A related conclusion was that marathon runners who collapsed during or after races were suffering from dehydration-induced heat illness, the urgent treatment for which logically would include rapid intravenous fluid therapy (22). Further laboratory studies showed that the complete repletion of fluid losses during exercise maintained more normal cardiovascular function and lower rectal temperatures than did lesser levels of fluid replacement during exercise (20-21). Hence it was concluded that *complete* replacement of fluid losses during exercise was desirable. Thus, all athletes should be encouraged to drink “as much as possible” during long-lasting endurance exercise (4-6).

However, many of these studies lack practical relevance for advising such copious drinking because they were performed in laboratory temperature/humidity environmental conditions that exceeded the typically cool-to-temperate spring or fall season climate under which most of today’s city marathons are conducted (18-21). During these seasons, days with excessive heat production, and with it, the risk of heat illness, are minimal. (Those races contested in regions where the climate is consistently tropical – notably Pacific Rim locations - are held very early in the morning.) Some experimental temperature conditions even exceeded the guidelines for safe exercise proposed by the ACSM in attempting to quantify the thermal challenge.

In addition, many of these studies were performed without adequate convective cooling (16) (facing wind speed), which is another important difference when exercise is performed in the laboratory as opposed to out-of-doors (28). Inadequate convective cooling might explain why the high incidence of dehydration and elevated body temperature, reported in laboratory studies performed under these very warm environmental conditions, has never been confirmed in out-of-doors competitive sport (26,27,29,30). Indeed, the logical conclusion from those studies is that when athlete subjects are allowed to choose their own pacing strategies as they do when participating in out-of-doors competitive sport, then their level of dehydration, as well as their drinking behavioral patterns, becomes a relatively unimportant determinant of the rectal temperature during exercise. A brief review of the physiological relationships between heat production and the development of heat injury is appropriate here.

Physiological Basis for Heat Stress and Heat Illness

The crucial factors that determine the risk of heatstroke are not the levels of dehydration reached during exercise but rather the rate at which the athlete produces heat and the capacity of the environment to absorb that heat. Perhaps the main reason why an incorrect doctrine (that dehydration *alone* causes heatstroke) has been allowed to achieve universal credence is because of the widespread ignorance of the multi-factorial aetiology of heatstroke and, especially, the relative importance of the different aetiological factors.

Several factors more important than dehydration combine their influence to determine when the rate of heat production exceeds the rate of heat loss. The rate of heat production is determined by the athlete's rate of energy expenditure (metabolic rate), which is a function of the athlete's mass and intensity of effort (running speed). Using this logic, the risk of heatstroke will likely be greater in athletes who run 10 km races (42) than when they run marathons, because 10 km race pace is faster than 42.195 km race pace. Heavier athletes will also be at greater risk than lighter athletes when both run at the same speed (41), since they generate more heat when running at the same speed, which cannot accumulate. *The reality is that heatstroke can only occur when the athlete's rate of heat production exceeds the rate at which the excess heat produced during exercise can be dissipated into the environment.*

The capacity of the environment to absorb the heat generated by the athlete during exercise is determined by the environmental temperature and humidity, and by the rate at which the surrounding air courses over the athlete's body, producing cooling by convective heat losses. Thus, in summary, the risk of developing heat stroke is increased:

i) when the exercise intensity is highest, for example in shorter distance races (such as 10 km) rather than in longer distance races including the marathon;

ii) in athletes with greater body mass, who thereby generate more heat than lighter athletes who are running at the same pace;

iii) when the environmental temperature, and most especially the humidity of the air, are increased; and

iv) when the potential for convective cooling is low as occurs under still wind conditions or in laboratory experiments in which there is inadequate convective cooling (16,28).

Practical Clinical Experience

Three compelling sets of clinical and field observations provide evidence against the recommended need for as much fluid replacement as possible during marathon competition. One set of data involves the marked rise in the number of athletes "back in the pack" suffering from fluid overload in marathon and ultramarathon races (Table 2). More than 70 cases of this condition have been described (7-9) since it was first recognized in 1985 (23). The majority of these cases have occurred in athletes in the United States and many of the victims report that they followed the prevailing advice of drinking "as much as possible" during exercise (9). During the same time period, it has been difficult to find any studies in which dehydration has been identified as the sole important causative factor for even a single case of exercise-related heatstroke.

Hence, it appears that the advice to drink copious amounts of fluid during prolonged exercise has generated an iatrogenic disease, the incidence of which has increased sharply in the past 15 years during the same period that this advice has been propagated with increasing enthusiasm. Furthermore, it appears that the medical risks associated with this novel iatrogenic condition exceed the risks associated with the condition for the prevention of which this (harmful) advice was originally formulated. This is particularly unfortunate since there is no credible evidence that high rates of fluid ingestion can influence the risk of heatstroke (22,24,25).

A second body of evidence mitigating against the need for drinking large volumes of fluids during marathon races comes from the observation that this behavior does not appear to have reduced the number of people seeking medical care after marathon and ultramarathon races. Some medical directors have found that advocating a *conservative* rather than an aggressive drinking policy is associated with fewer than expected admissions to the race day medical facilities, if for no other reason than because the incidence of water intoxication is substantially reduced (26,27).

A third set of observations combines physiologic estimates of dehydration with practical experience in working with elite athletes. It is well-known that the level of dehydration that develops during prolonged exercise like marathon running cannot be measured with certainty because it is not determined simply by the amount of weight loss during exercise. This is because the weight lost during exercise includes up to 1 kg of metabolic fuel that is irreversibly oxidized during exercise plus a variable amount of fluid that is stored with glycogen and released during exercise as the stored liver and muscle glycogen stores are oxidized. It has been calculated that an athlete who loses 2 kg of weight during a marathon race would, in fact, be dehydrated by only ~200 g (34) when allowance is made for the weight lost from those other sources.

Interestingly, the average weight loss during marathon races in which athletes drink *ad libitum* and not "as much as possible," is between 2-3 kg, suggesting that these athletes intuitively (and accurately) assess their needs for fluid replacement during exercise. This contrasts to the currently popular dogma which holds that thirst is an inadequate index of the fluid requirements during exercise, and thus athletes who drink only in response to their thirst will become sufficiently dehydrated during exercise that their performances will be impaired and their health placed at risk. Hence they are urged to override their natural inclination and rather to drink "as much as possible". This dogma may in fact not represent what competitive athletes ought to follow.

Athlete interview evidence suggests that world-class runners ingest minimal fluid volume during their competitive races, primarily because of the difficulty of such ingestion when racing at the high exercise intensities (~85% of maximum oxygen consumption) and fast running speeds necessary to achieve success in top-level races. As examples, for the men, a 2:06:00 marathon represents a pace of 2:59 per km (4:48 per mile) or a velocity of 20.1 km per hour (12.5 miles per hour). For the women, a 2:23:00 marathon represents a pace of 3:23 per km (5:27 per mile), or a velocity of 17.7 km/hr (11.0 miles per hour). Personal discussions with elite-level marathon runners suggest that they ingest about 200 ml per hour during marathon races. This value is similar to drinking amounts reported in the 1960's in slightly less talented athletes (17,35,36), but substantially less than the volume of 1.2 - 2 liters per hour that the ACSM guidelines recommend for elite athletes in competition. This practical information alone questions the dogma that only by drinking large volumes of fluids are athletes able to perform at a high level of competency.

Based upon the above review of literature, practical information available from competing athletes, and experience in clinical settings at finish lines of endurance races, several guidelines can be offered to assist medical personnel better manage their population of patients presenting with symptoms during or after their race.

GUIDELINE # 1: *Be very careful to make accurate diagnoses, so that the treatment plan can be optimally effective rather than inappropriate.*

Perspective: As an example, encouraging the slower runners/walkers in marathon races to drink "as much as possible" is the incorrect treatment for the wrong group of athletes, since it is precisely this group of athletes who are at essentially no risk of developing heatstroke due to their low rate of heat production during exercise. It is the elite athletes who experience the greatest risk of heatstroke due to their much larger *rate* of heat production. Even they tend not to develop heat stroke despite drinking very little during such races, because they vary their pace according to existing conditions, delivering extraordinarily quick performance times in cooler weather and slowing the pace appropriately during hot summertime competitions such as occurs with major world championships.

GUIDELINE # 2: *Considerable individual difference in responsiveness exists for tolerable fluid ingestion during exercise. The optimum rates of fluid ingestion during exercise depend on a number of individual and environmental factors. Hence it is neither correct nor safe to provide a blanket recommendation for all athletes during exercise.*

Perspective: Several factors determine the rate of sweat loss and hence the necessary rate of fluid ingestion during exercise. These have been mentioned already, and include i) the rate of energy expenditure (metabolic rate), which is a function of the athlete's size and running speed, and ii) the environmental conditions, particularly the humidity and the presence or absence of convective cooling (facing wind speed).

In general, it is found that the fastest running athletes lose between 1 –1.5 kg of mass per hour during competitive marathon running. However, for reasons described earlier, this does not mean that this is the rate at which fluid must be replaced. This is because a portion of that weight loss is from oxidized metabolic fuels and another portion is from the release of water stored with muscle glycogen. Furthermore, there is no evidence that, during competition, elite athletes can drink at rates that even approach these rates of weight loss.

GUIDELINE # 3: *A diagnosis of heat illness should be reserved only for those patients who have clear evidence of heatstroke, the diagnostic symptoms of which are described above, and* ***the successful treatment of which requires active whole body cooling.*** *If the rectal temperature is not elevated above 40 – 41 degrees C so that the patient recovers fully without the need for whole body cooling, then a diagnosis of "heat illness" cannot be sustained and an alternate diagnosis must be entertained (25,32,33).*

Perspective: Much of the confusion of the role of fluid balance in the prevention of heat illness indeed arises because of the adoption of incorrect diagnostic categories for the classification of "heat illnesses" (16,25,32). True heatstroke is diagnosed as a rectal temperature in excess of 40-41 degrees C in an athlete who shows an altered level of consciousness without other cause, and who recovers only after a period of active cooling; this appears to be an extremely uncommon complication of marathon running since there are so few documented case reports in the medical literature. Even the boldly titled review article, "Heatstroke and Hyperthermia in Marathon Runners," (36) presented at the New York Academy of Sciences Conference on the Marathon that preceded the first 5-boroughs New York City Marathon in 1976, described anecdotal evidence of only one well-known case of heatstroke in a world class marathon runner. It is for this reason that these well-remembered anecdotes – Jim Peters in the 1954 Empire Games Marathon (36); Alberto Salazar in the 1982 Boston Marathon; Gabrielle Andersen-Schiess in the 1984 Olympic Games Marathon - are frequently used to project the danger of heatstroke during marathon running and hence the need to drink adequately to prevent this condition in marathon races. In fact these anecdotes really only prove how extremely rare is this condition in modern marathon races run in reasonable environmental conditions.

Indeed the evidence from the 1996 Centennial Olympic Games held in "Hotlanta" was that "heat illness" was the most common diagnosis amongst spectators, accounting for 22% of medical visits, but was the least common diagnosis among the competitors, accounting for only 5% of medical consultations (37). Furthermore of 10,715 persons treated by physicians during those Games, not one was treated for heatstroke (37).

On the other hand, the number of athletes requiring medical care especially after marathon races has increased precipitously in the past 25 years, as evidenced by the growth in the provision of medical services at those races. However there is no evidence that the vast majority (> 99%) of the athletes treated in those medical facilities are suffering from heat-related illnesses since (i) they recover without active cooling and (ii) their rectal temperatures are not higher than are those of control runners who do not require medical care after those races (37-40).

As a result, the prevention of heatstroke in distance running requires that attention first be paid to those factors that really do contribute to the condition in a meaningful way.

The true incidence of the real heat illnesses in marathon runners is unknown but appears to be extremely low. There are no studies showing that dehydration or its prevention plays any role in the cause or prevention of the so-called "heat illnesses" that are frequently diagnosed, on questionable grounds, in athletes seeking medical care after endurance events (22,24,25). Rather it has been suggested that postural hypotension, reversible by nursing the collapsed athlete in the head-down position (25,31-33), is the most appropriate and only necessary form of treatment for these incorrectly diagnosed as cases of "heat illnesses".

GUIDELINE # 4: *Athletes who collapse and require medical attention **after** completing long distance running events are probably suffering more from the sudden onset of postural hypotension (31,32) than from dehydration.*

Perspective: A crucial recent finding was that the majority (~ 75%) of athletes seeking medical care at marathon or ultra marathon races collapse only **after** they cross the finishing line (32,40). It is difficult to believe that a condition insufficiently serious to prevent the athlete from finishing a marathon, for example, suddenly becomes life-threatening only **after** the athlete has completed the race, at the very time when the athlete's physiology is returning to a state of rest. Rather, the evidence is that athletes who collapse **before** the race finish are likely to be suffering from a serious medical condition for which they require urgent and expert medical care (32,40).

The hypotension is likely due to the persistence of a state of low peripheral vascular resistance into the recovery period, compounded by an absence of the rhythmic action of the skeletal muscles contracting in the legs (that earlier had been aiding blood return to the heart) as soon as the athlete completes the race and stops moving. Thus, there is a sudden fall in right atrial pressure which begins the moment the athlete stops exercising.

There is no published evidence that this postural hypotension is due to dehydration. Nor does logic suggest this as a likely explanation, since dehydration should cause collapse when the cardiovascular system is under the greatest stress, for example, **during** rather than immediately upon cessation of prolonged exercise. This has important implications for treatment of the common condition of post-exercise collapse in marathon runners.

Diagnosing this condition as a "heat illness" is intellectually risky not least because it leads to the false doctrine that "if only these athletes had drunk 'as much as possible' during the marathon, they would not have required medical care after the race". In addition, there is evidence that a sudden fall in right atrial pressure can produce a paradoxical and sudden increase in skeletal muscle vasodilation. This leads to a sudden fall in peripheral vascular resistance, thereby inducing fainting. This was first identified by Barcroft et al. (43) in research undertaken during the Second World War (1944).

The assumption that athletes collapse after exercise because they are suffering from a dehydration-related heat illness has led to the widespread use of intravenous fluids as the first line of treatment for this condition of exercise-associated collapse. There are no clinical trials to show that intravenous fluid therapy is either beneficial or even necessary for the optimum treatment of those athletes who collapse **after completing marathon races** and who seek medical care as a result.

If, however, the condition is really due to a sustained vasodilatation, perhaps in response to a dramatic reduction in right atrial pressure (43) that begins at the cessation of exercise, then the most appropriate treatment is to increase the right atrial pressure. The most effective method to achieve this to nurse the collapsed athlete in the head down position, according to the method depicted in Figure 1. Since adopting this technique in the two races under our jurisdiction in Cape Town, South Africa, we have not used a single intravenous drip in the past 2 years. These are very long races with large numbers of participants. The 56 km Two Oceans Marathon had a total of ~ 16,000 runners in the last 2 years, and the 224 km Cape Town Ironman Triathlon had ~ 1,000 finishers in the last 2 years (26,27). We found no evidence that the management of these athletes was compromised in any way as a result of the adoption of this novel treatment method.

GUIDELINE # 5: *Runners should aim to drink ad libitum between 400 – 800 ml per hour, with the higher rates for the faster, heavier runners competing in warm environmental conditions and the lower rates for the slower runners/walkers completing marathon races in cooler environmental conditions***.**

Perspective: Published evidence indicates that rates of fluid intake during running races vary from 400 – 800 ml per hour (1, 29). Among those who develop the hyponatraemia of exercise, the rates of fluid ingestion during exercise are very much higher and may be as high as 1.5 liters per hour (7-9,44).

One can observe consistently that athletes who run fast in the present-day marathons with temperate environmental conditions appear to cope quite adequately despite what appear to be quite low levels of fluid intake during those races. Thus there does not appear to be any reason why elite athletes should be encouraged to increase their rates of fluid intake during marathon racing by drinking "as much as possible" (26, 27). But perhaps the even more cardinal point is that athletes who run/walk marathon races in 4 or more hours will have lower rates of both heat production and fluid loss, and must therefore be advised **not** to drink more than a maximum of 800 ml per hour during such races. They must be warned that higher rates of fluid intake can be fatal if sustained for 4 or more hours.

Several recent studies show that drinking *ad libitum* is as effective a drinking strategy during exercise as is drinking at the much higher rates proposed in the ACSM guidelines (45-47). Accordingly perhaps the wisest advice that can be provided to athletes in marathon races is that they should drink *ad libitum* and aim for ingestion rates that never exceed about 800 ml per hour.

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The International Marathon Medical Directors Association (IMMDA) was formed as the Consulting Medical Committee of the Association of International Marathons (AIMS). AIMS is a global organization of marathons and other road races, formed in May, 1982. The purpose of AIMS is to i) foster and promote marathon running throughout the world, ii) recognize and work with the International Association of Athletics Federations (IAAF) as the sport's world governing body on all matters relating to international marathons, and iii) exchange information, knowledge, and expertise among its member events. AIMS' current roster numbers approximately 150 events which are conducted on all 7 continents and which includes the world's largest and most prestigious marathons.

The purpose of IMMDA is to i) promote and study the health of long distance runners, ii) promote research into the cause and treatment of running injuries, iii) prevent the occurrence of injuries during mass participation runs, iv) offer guidelines for the provision of uniform marathon medical services throughout the world, and v) promote a close working relationship between race and medical directors in achieving the above four goals.

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TABLE 1. Difference in Finish Time Distribution Among Marathons 'Then' and 'Now'

	Boston, 1975	New York City, 1978	New York City, 2001
Men's Winning Time	2:09:55	2:12:11	2:07:43
Total # Finishers	1,818	8,588	23,651
#, % under 3 hours	887, 48.8%	806, 9.4%	570, 2.4%
#, % 3 to 3 1/2 hours	931, 51.2%	1,810, 21.1%	1,996, 8.4%
#, % 3 1/2 to 4 hours		2,513, 29.3%	4,595, 19.4%
#, % 4 to 4 1/2 hours		1,807, 21.0%	5,770, 24.4%
#, % 4 1/2 to 5 hours		1,047, 12.2%	5,302, 22.4%
#, % 5 to 5 1/2 hours		437, 5.1%	2,818, 11.9%
#, % 5 1/2 to 6 hours		126, 1.5%	1,434, 6.1%
#, % 6 to 6 1/2 hours		35, 0.4%	609, 2.6%
#, % 6 1/2 to 7 hours		3, 0.03%	324, 1.4%
#, % 7 to 7 1/2 hours		4, 0.05%	137, 0.6%
#, % 7 1/2 to 8 hours			66, 0.3%
#, % 8 to 8 1/2 hours			30, 0.1%

TABLE 2.* Reported Cases of Exercise-related Hyponatraemia: 1985-2001

Main Presenting Symptoms	Number & %	Mean Serum Na+#	Serum Na+ Range#
Disorientation	34 (49%)	125	117 - 131
Pulmonary oedema	13 (19%)	121	115 - 127
Respiratory arrest	2 (3%)	118	113 - 123
Seizure	22(31%)	117	108 - 124
Coma	6 (9%)	113	107 - 117

*: 70 Non-fatal cases with significant illness
#: Na+ values in mEq per L

Proper Hydration for Distance Running-Identifying Individual Fluid Needs

A USA TRACK & FIELD Advisory

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INTRODUCTION

Any time a runner hits the road, track, or trail to perform in a race or training session, the need to properly hydrate becomes an issue that will influence the quality of the effort. The evaporation of sweat from the skin's surface is a powerful cooling mechanism to allow you to release the heat that is being produced by working muscles. The replenishment of fluid being lost as sweat is an important consideration during any effort. It has long been preached to runners (and all athletes) that you should consume "as much fluid as possible" to ward off the demons of dehydration. More recently, runners and medical staff have been told to limit hydration due to the potential dangers associated with overhydrating that can occur when running for an extended period of time.

Thus, we have a double-edged sword situation: drink enough fluids during activity to prevent dehydration - which could be detrimental to health and performance - but do not consume too much fluid - which could cause the potentially dangerous problem of hyponatremia.

So, what does the competitive runner do to address the issues related to hydration in order to minimize the likelihood of dehydration and hyponatremia? The answer lies in the process of determining individual fluid needs and then developing a hydration protocol based on those individual needs. This is a simple process that can maximize performance and minimize any potential hazards that may be associated with inappropriate hydration practices. The ensuing pages will provide an overview of dehydration and hyponatremia and provide USATF guidelines for distance runners and other athletes that can be utilized to determine individual fluid needs.

Dehydration

What is dehydration?

Dehydration is caused by two distinct factors that may occur during exercise.

- **The loss of fluids from sweat, urine, and respiratory losses.** Dehydration is the acute change of fluid stores from that of a steady-state condition of normal body water to that being something less than normal body water. If the decreased body water stores remain for an extended period of time, the individual is said to be in a "state of hypohydration", which is a steady-state condition of decreased body water. Since the human body is approximately 65% water, a significant decrease in body water stores will alter normal physiological function. For instance, cardiovascular function (i.e. heart rate), thermoregulatory capacity (i.e. sweating) and muscle function (i.e. endurance capacity) can be detrimentally altered if the amount of dehydration reaches critical thresholds to alter the physiological function of these processes.
- **Fluid intake does not match up to fluid losses.** When fluid consumption is less than fluid losses, dehydration will ensue. The magnitude in which these two factors are out of balance will determine the degree of dehydration. Fluid can be lost in sweat, urine, feces, and during respiration (breathing). The great majority of the loss is that in sweat. Fluid losses can be replaced by that consumed orally or intravenously and that which is produced during metabolism [a small amount of water is actually formed during the metabolic pathways that allow muscles to contract]. The great majority of fluid intake occurs from the oral consumption of fluids (including fluids in food products). So, generally speaking, during exercise, when sweat losses exceed fluid intake via oral consumption, a condition of dehydration will ensue. Mild dehydration, about 1-2% of total body weight, is quite likely and is not a great concern. But, losses beyond this should be avoided if at all possible.

Dehydration occurs:

- During moderate and intense activity- As the intensity of an activity increases, the sweat rate increases. Additionally, as intensity reaches high levels (e.g. >75% VO_2max), the rate at which fluid can be processed and comfortably handled by the stomach and intestines and emptied into the bloodstream is decreased. Also, increasing intensity will likely decrease the amount of time the individual can focus on rehydration.
- During activity in warm and hot conditions- As the temperature increases the sweat rate increases.
- In those with high sweat rates- Those individuals with high sweat rates (and great differences can exist between individuals) will have the need to replenish more fluids for a certain time.
- When proper hydration is not attained at the start- When individuals begin an exercise session not properly hydrated, they may reach a dangerous dehydration level more rapidly.
- During multiple practices the same day- As the number of exercise sessions in a day increases this will increase the amount of fluid needed during the course of the day.
- When there is improper access to meals- A majority of fluid consumption occurs during meal times, so a disturbance in normal meals may alter the ability to maintain proper hydration.
- When there is improper access to fluids- When fluids are not readily accessible during races or training sessions, the likelihood will increase for dehydration.
- When there is poor vigilance- Athletes who are not educated about the needs to properly hydrate will not actively pursue a proactive hydration protocol to address individual fluid needs.

- In larger individuals- A person's size influences sweat rate, so those who are larger will generally have a higher sweat rate.
- Due to personal preferences- If the temperature of the rehydration fluid is extremely hot or extremely cold or if it is a flavor the individual dislikes or is made of non-ideal compounds then this may alter the degree of voluntary rehydration.
- Due to individual differences in fluid tolerance- Some individuals cannot comfortably handle the amounts of fluid to approximate fluid losses during activity. A possible solution to this may be gradually drinking over time and not having one large amount after a period of time. Also, people may be able to alter the amount when the hydration protocol is practiced during training sessions.
- Due to illness.

<u>How do you recognize dehydration?</u>

It is important to remember that while dehydration is an important factor that contributes to hyperthermia associated with exercise, other factors are also very important. For example, intensity of activity, environmental conditions (humidity, temperature, shade/cloud cover), level of fitness, degree of heat acclimatization, amount of clothing/equipment, illness, etc. all contribute to the rate of rise in body temperature and athletes should consider these when looking to decrease the risk associated with exercise in the warm and hot conditions.

Runners, coaches, and medical staff must be adept at recognizing that a problem with hyperthermia exists and treating that first. If it is mild, then the runner needs to slow down or stop depending on the symptoms observed. If the symptoms are more severe, an immediate effort must to made to reduce core body temperature. Runners should be able to recognize the basic signs and symptoms of the onset of heat illness for which dehydration may be a cause: irritability, and general discomfort, then headache, weakness, dizziness, cramps, chills, vomiting, nausea, head or neck heat sensations (e.g. pulsating sensation in the brain), disorientation and decreased performance. Runners have been instilled with the concept that adequate hydration will negate the adverse effect of high heat and humidity. Runners need to learn that core body temperature can rise to dangerous levels despite a proper level of hydration.

In the absence of guidelines for optimum hydration, thirst can be a guiding factor. Runners have been instilled with the concept that hydration must be ahead of thirst and that the presence of thirst indicates dehydration. However, staying ahead of thirst can lead to overhydration as thirst is no longer available as a natural signal to know individual fluid needs. The sensation of thirst is a general indicator of dehydration. It is a clear signal to drink. If the signal of thirst is not used for rehydration, there is greater danger of dehydration and heat illness.

Symptoms that complicate the diagnosis are the feeling of dizziness or weakness and collapsing. When this happens at a point when the runner has stopped either along the course or at the finish line, rather than while in motion, the likely cause is postural hypotension which is a pooling of blood in the legs and inadequate blood supply to the upper body. This can be avoided by walking or flexing the legs when standing in place. When a runner collapses from postural hypotension, the legs should be raised above the head and held there for 3-4 minutes. That should relieve the symptoms.

How do you treat dehydration?

A conscious, cognizant, dehydrated runner without gastrointestinal distress can aggressively rehydrate orally, while one with mental compromise or gastrointestinal distress should be transported to a medical facility for intravenous rehydration. If an exertional heat illness beyond dehydration is suspected then medical treatment would be necessary. Additionally, dehydration itself, if severe, may require medical assistance. See the citation for the Exertional Heat Illness Position Statement at the end of this paper for specifics regarding the prevention, recognition, and treatment of the common exertional heat illnesses.

Exertional Hyponatremia

What is hyponatremia?

Exertional hyponatremia (EH), or low blood sodium (generally defined by sodium levels less than 130mmol/L), is caused by two distinct but often additive conditions that may arise during prolonged exercise, most often 4 hours or more. They include:

- **The excessive intake of fluid**. In this scenario, athletes ingest significantly more fluid than they lose in sweat and urine over a given period of time. Doing so causes them to become hyper-hydrated and blood sodium falls. This is the most critical contributory factor to the onset of EH.
- **The ingestion of low-sodium fluids.** In this scenario, athletes drink fluids that are low in sodium. In doing so, they dilute their blood sodium and fail to replace what they're naturally losing in sweat during exercise. Sports drinks have low-sodium levels in order to be appetizing to the general public. EH results when plasma sodium levels go below approximately 130 mmol/L. The more pronounced the drop, the greater the risk of medical consequences. Runners can still be at risk with higher sodium intake when overhydrating. Excessive fluids are the crux of the problem, but having fluids with sodium is better than without it, excessive drinking or not.

Runners, coaches, and medical staff must be adept at recognizing this condition because rehydration could cause further problems. Severe cases of EH may involve grand mal seizures, increased intracranial pressure, pulmonary edema, and respiratory arrest. The fact is EH can and has led to death—and not just in running, but in a variety of athletic, military, and recreational settings.

When does EH occur?

EH occurs most frequently:

- **In sports that last for longer than four hours-** This gives athletes more time to drink and to lose large amounts of sodium through prolonged sweating.
- **During lower-intensity endurance activities**-where athletes have the opportunity to ingest large volumes of fluid.
- **When athletes drink large volumes of water without adequate sodium intake-**Blood sodium levels fall quickly whenever excess water is ingested, particularly during or after exercise in which large amounts of sweat and salt are lost. This can even happen during exercise or at rest when athletes drink lots of water in a misguided attempt to ward off cramping.

How do you recognize EH?

Unfortunately, EH may mimic many of the signs and symptoms of exertional heat stroke, such as nausea, vomiting, extreme fatigue, respiratory distress, and central nervous system disturbances (i.e. dizziness, confusion, disorientation, coma, seizures).

EH also has unique characteristics that distinguish it from other like conditions such as low plasma sodium levels (< 130 mmol/L). Other symptoms may include:

- A progressively worsening headache.
- Normal exercise core temperature (generally not > 104^{o}F)
- Swelling of the hands and feet (which may be noted with tight wedding bands, watches, shoes, etc.).

How do you treat EH?

If you suspect this condition it is important to be sure of the following:

- Make sure runner is not dangerously hyperthermic. If an immediate measure of rectal temperature reveals extreme hyperthermia (>104^{o}F), begin ice/cold water immersion therapy.
- If hyponatremia is suspected, have the athlete transported immediately to an emergency room where a physician can monitor care and if necessary administer an IV of a hypertonic sodium replacement, diuretic (if hyperhydrated), and/or anti-convulsive drug (if still having seizures).

Rapid and prudent response, along with that of on-site medical personnel, can assure a healthy outcome.

How do you prevent EH?

The most important aspect of preventing EH lies in your having an appropriate hydration protocol for the event or task being performed. This process was discussed in the dehydration section. A few key points include:

- Education regarding replacing fluids in appropriate amounts, not to exceed sweat rates.
- Assuring easy access to a sports drink containing an adequate amount of sodium.
- Monitoring body weights when feasible to identify those who have gained weight from overdrinking.

Additional steps to consider:

- Encourage athletes to be well-acclimatized to the heat because this is an effective way to decrease sweat sodium losses.
- Maintain normal meal patterns and don't restrict dietary sodium intake, so sodium levels are normal prior to the start of an event.
- Consume a little extra sodium with meals and snacks during continuous days of exercise in hot weather to help maintain blood sodium levels.

  There is a great performance benefit associated with proper hydration during exercise, but overdrinking must be avoided. Athletes who lose and replace fluids at equal rates greatly diminish the risk of EH—especially if they drink fluids that contain adequate sodium.

How do you prevent dehydration without overhydrating?

Optimum hydration is geared around the general premise that fluid intake should match fluid losses and that these processes are extremely individualized. It is an individual process because rehydration practices vary based on a wide-variety of issues (discussed earlier). The crux of this process is trying, to the best of your ability, to match fluid intake with fluid losses. If this can be done relatively closely, then all of the hazards of under or overhydrating are avoided and the likelihood of a safe and productive exercise session is maximized. The following guidelines should assist in establishing a hydration protocol:

USATF Self-testing Program for Optimum Hydration

Establish a hydration strategy that considers the sweat rate, sport dynamics (rest breaks, fluid access), environmental factors, acclimatization state, exercise duration, exercise intensity, and individual preferences. To correctly assess rehydration needs for each individual, it is of great importance to calculate the individual's sweat rate. For this process, we recommend the following program:

Calculate sweat rate (Sweat Rate = body weight pre-run – body weight post-run + fluid intake – urine volume/exercise time in hours) for a representative range of environmental conditions, practices, and competitions (Table 1 provides a sample worksheet). This calculation is the most fundamental consideration when establishing a hydration protocol. Average sweat rates from the scientific literature or other athletes can vary from .5 l/h to over 2.5 l/h (1.1 lb/hr to 5.5 lb/hr) and should not be used.

When establishing an individual sweat rate that will be applicable during a long race, try to run at race intensity (for races of 1 hour or more) in a 1-hour training session. Try to establish a sweat rate in similar climatic conditions expected for a targeted race or for long training runs leading up to the race, whichever are in a higher temperature. Follow this procedure:

- Do a warm-up run to the point where perspiration is generated.
- Urinate if necessary.
- Weigh yourself naked on an accurate scale.
- Run for one hour at intensity similar to the targeted race.
- Drink a measured amount of a beverage of your choice during the run.
- Do not urinate during the run (unless you choose to measure the amount of urine).
- Weigh yourself in the buff again on the same scale after the run.
- Enter data into table 1.

You now know your approximate fluid needs per hour.

Clubs may want to organize hydration-testing clinics at which they provide an accurate scale and a means of privacy for disrobing to get weighed along with supporting information about the subject of hydration and supervision of the USATF testing program.

It should be noted that metabolism of carbohydrates, fats, and protein during exercise accounts for a very small amount of the weight lost during activity. The effect of fuel oxidation on weight loss during high sweat efforts is a small enough amount that weight changes that occur following an activity can largely be attributed to sweat losses. However, it should be calculated in when measuring a low-sweat effort at about 15% of the total weight loss.

Heat acclimatization induces physiologic changes that may alter individual fluid replacement considerations.

First, sweat rate generally increases after 10 to 14 days of heat exposure, requiring a greater fluid intake for a similar bout of exercise. An athlete's sweat rate should be reassessed after acclimatization.

Second, moving from a cool environment to a warm environment increases the overall sweat rate for a bout of exercise. Athletes must closely monitor hydration status for the first week of exercise in a warm environment.

Third, increased sodium intake may be warranted during the first 3 to 5 days of heat exposure, since the increased thermal strain and associated increased sweat rate increase the sodium lost in sweat. Adequate sodium intake optimizes fluid palatability and absorption during the first few days and may decrease exercise-associated muscle cramping. After 5 to 10 days, sweat sodium concentration decreases, but the overall sweat rate is higher so the athlete should still be cognizant of sodium ingestion.

Consider the event/training session and how you can approximate your calculated fluid needs. Things to consider are the location of hydration stations, what fluids you want to use, and when and how you can refill fluid containers if you choose to carry your own fluids with you.

Fluid replacement beverages should be easily accessible in individual fluid containers and flavored to the athlete’s preference. Individual containers permit easier monitoring of fluid intake. Clear water bottles marked in 100-ml (3.4 fl oz) increments provide visual reminders to help runners gauge proper amounts. Carrying water bottles or other hydration systems during running encourages greater fluid volume ingestion. Hydration systems, in contrast to water bottles, will keep fluids cooler which optimizes the hydration process.

Individual differences will exist with regards to tolerance of amount of fluids that can be comfortably consumed, gastric emptying and intestinal absorption rates, and availability of fluids during the workout or event. Each individual's rehydration procedures should be tested in practice and modified regularly if necessary to optimize hydration while maximizing performance in competition. Individuals should be encouraged to retest themselves during different seasons depending on their training/racing schedule to know their hydration needs during those seasons.

Hydration

Pre-Event Hydration

Runners should begin all exercise sessions well hydrated. Hydration status can be approximated by runners in several ways (Table 2). Assuming proper hydration, pre-exercise body weight should be relatively consistent across exercise sessions. Remember that body weight is dynamic. Frequent exercise sessions can induce nonfluid-related weight loss influenced by timing of meals and defecation, time of day, and calories expended in exercise. The simplest method is comparison of urine color (from a sample in a container) with a urine color chart (Figure 1). A urine color of 1-3 indicates a good hydration status while 6-8 indicates some degree of dehydration. Note that urine color can be offset by recent, excessive supplemental vitamin intake. Urine volume is another general indicator of hydration status. A runner should frequently have the need to urinate during the course of the day. Remember that body weight changes during exercise give the best indication of hydration needs.

To ensure proper pre-exercise hydration, the athlete should consume approximately 500 to 600 ml (17 to 20 fl oz) of water or a sports drink 2 to 3 hours before exercise and 300 to 360 ml (10 to 12 fl oz) of water or a sports drink 0 to 10 minutes before exercise.

Post-Event Hydration

Post-exercise hydration should aim to correct any fluid loss accumulated during the practice or event. Ideally completed within 2 hours, rehydration should contain water to restore hydration status, carbohydrates to replenish glycogen stores, and electrolytes to speed rehydration. The primary goal is the immediate return of physiologic function (especially if an exercise bout will follow). When rehydration must be rapid, the athlete should compensate for obligatory urine losses incurred during the rehydration process and drink about 25% more than sweat losses to assure optimal hydration 4 to 6 hours after the event.

Fluid temperature influences the amount consumed. While individual differences exist, a cool beverage of 10^{o} to $15^{o}C$ (50^{o} to $59^{o}F$) is recommended.

The Role and Use of Carbohydrates

In many situations, athletes benefit from including carbohydrates (CHO) and electrolytes (especially sodium) in their rehydration beverages. Include CHO in the rehydration beverage during exercise if the session lasts longer than 45 to 50 minutes or is intense. An ingestion rate of about $1\ g \cdot min^{-1}$ (.04 oz/min) maintains optimal carbohydrate metabolism: for example, 1 liter of a 6% carbohydrate drink per hour of exercise. CHO concentrations >8% increase the rate of CHO delivery to the body, but compromise the rate of fluid emptying from the stomach and absorbed from the intestine. Fruit juices, CHO gels, sodas, and some sports drinks have CHO concentrations >8% and are not recommended DURING an exercise session as the sole beverage. Athletes should consume CHO at least 30 minutes before the normal onset of fatigue and earlier if the environmental conditions are unusually extreme, although this may not apply for very intense short-term exercise which may require earlier intake of CHO. Most CHO forms (i.e., glucose, sucrose, maltodextrins) are suitable, and the absorption rate is maximized when multiple forms are consumed simultaneously. Substances to be limited include fructose (may cause gastrointestinal distress), and those that should be avoided include alcohol or high amounts of caffeine (may increase urine output and reduce fluid retention), and carbonated beverages (may decrease voluntary fluid intake due to stomach fullness).

Electrolyte Considerations

A modest amount of sodium (0.5 to $0.7\ g \cdot l^{-1}$) would be an acceptable addition to all hydration beverages since it stimulates thirst, increases voluntary fluid intake, may decrease the risk of hyponatremia, and causes no harm. Inclusion of sodium chloride in fluid replacement beverages should be considered under the following conditions: There is inadequate access to meals or meals are not eaten; when the physical activity exceeds 4h in duration; and/or during the initial days of hot weather. Under the above conditions, addition of modest amounts of sodium (0.5 to $0.7\ g \cdot l^{-1}$) can offset sodium lost in sweat and may minimize medical events associated with electrolyte imbalances (e.g. muscle cramps, hyponatremia).

Potassium levels lost in sweat can be a concern for people in general and especially for people taking diuretics for high blood pressure. Diuretics cause excessive excretion of potassium, and running could result in hypokalemia. Also, plain water intake or hyperhydration will exacerbate losses of potassium by sending the excess fluid to the kidneys for excretion at the expense of potassium.

For more information on hydration, exertional hyponatremia and exertional heat illnesses please see:

Binkley HM, J Beckett, DJ Casa, D Kleiner, P Plummer. National Athletic Trainers Association position statement: Exertional heat illnesses. *Journal of Athletic Training*. 37(3):329-343, 2002. (can be found at www.nata.org/members1/jat/37.3/attr_37_03_0329.pdf)

Casa DJ, LE Armstrong, SK Hillman, SJ Montain, RV Reiff, B Rich, WO Roberts, JA Stone. National Athletic Trainers' Association position statement: Fluid replacement for athletes. *Journal of Athletic Training*. 35(2):212-224, 2000.
(can be found at www.nata.org/members1/jat/jt0200/jt020000212p.pdf)

Noakes, T., Martin, D.E. IMMDA-AIMS Advisory statement on guidelines for fluid replacement during marathon running. *New Studies in Athletics* 17 (1): 15-24, 2002.

Table 1: Sample Sweat Rate Calculation

Table 3. Sample Sweat Rate Calculation*

A	B	C	D	E	F	G	H	I	J
		Body Weight							
Name	Date	Before Exercise	After Exercise	ΔBW (C-D)	Drink Volume	Urine Volume†	Sweat Loss (E+F−G)	Exercise Time	Sweat Rate (H/I)
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
Kelly K.‡	9/15	61.7 kg	60.3 kg	1400 g	420 mL	90 mL	1730 mL	90 min	19 mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	1.5 h	1153 mL/h

*Reprinted with permission from Murray R. Determining sweat rate. *Sports Sci Exch*. 1996;9(Suppl 63).
†Weight of urine should be subtracted *if urine was excreted prior to postexercise body weight*.
‡In the example, Kelly K. should drink about 1 L (32 oz) of fluid during each hour of activity to remain well hydrated.

Table 2: Indices of Hydration Status (general guidelines)

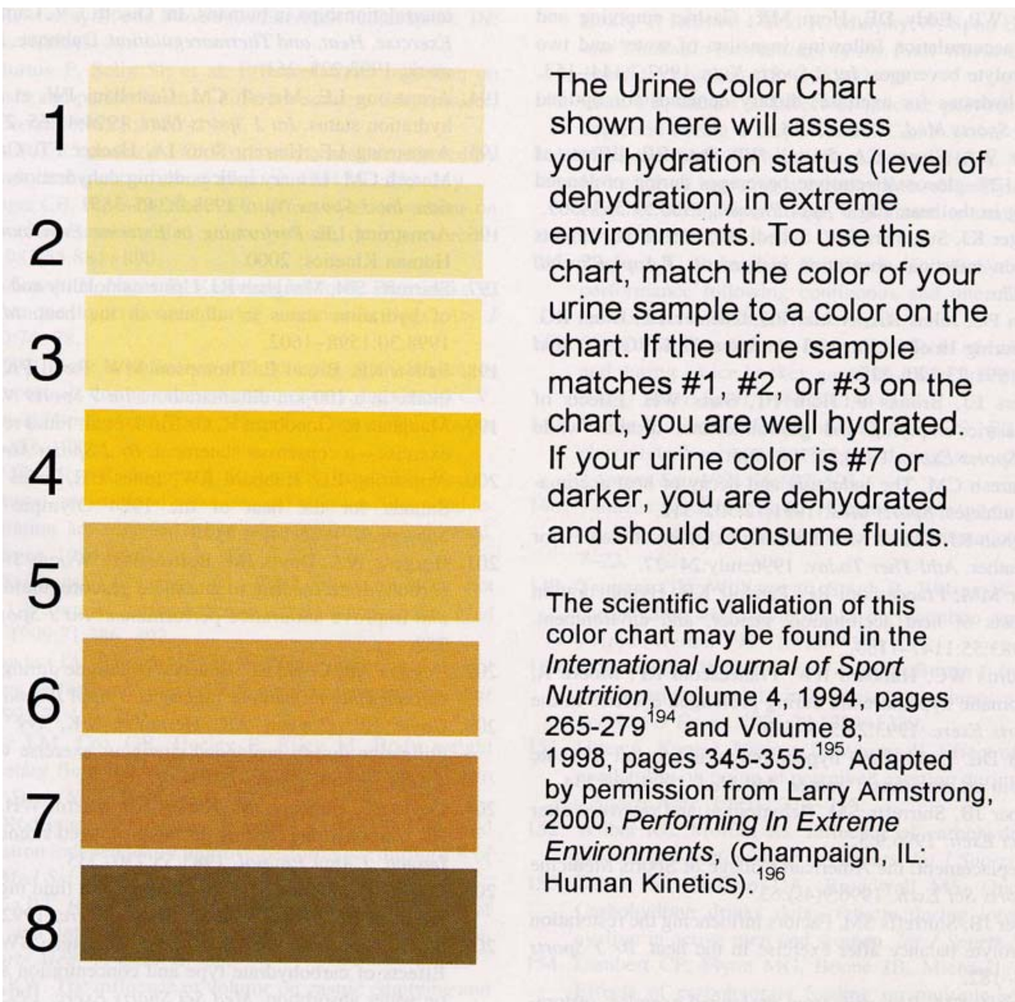
	% Body Weight Change	Urine Color
Well-Hydrated	+1 to -1 %	1 or 2
Minimal Dehydration	-1 to -3 %	3 or 4
Significant Dehydration	-3 to -5 %	5 or 6
Serious Dehydration	> 5 %	> 6

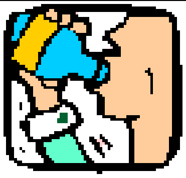
$$\% \text{ Body Weight Change} = \frac{\text{Pre Body Weight} - \text{Post Body Weight}}{\text{Pre Body Weight}} \times 100$$

See Figure 1 for Urine Color Chart and appropriate reference. Please note that a urine sample may not be possible during serious dehydration.

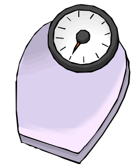
Also, these are physiologically independent entities and the numbers provided are only general guidelines.

<u>Figure 1: Urine Color Chart</u>





Self-Testing Program for Optimal Hydration



from *Proper Hydration for Distance Running – Identifying Individual Fluid Needs,* by Douglas J. Casa, PhD, ATC, FACSM.

Any time a runner hits the road, track, or trail to perform in a race or training session, the need to properly hydrate becomes an issue. It has long been preached to runners (and all athletes) that you should consume "as much fluid as possible" to ward off the demons of dehydration. More recently, runners and medical staff have been told to limit hydration due to the potential dangers associated with overhydrating that can occur when running for an extended period of time. So what does the runner do to address the issues related to hydration?

In USATF's new hydration guidelines, long-distance runners are instructed to consume 1 liter of fluid for every liter lost during a race. Runners should determine their fluid needs well before any race longer than an hour, by using the following procedure during a 1-hour training run. If possible, do this session in climatic conditions similar to those at the race.

1. Make sure you are properly hydrated BEFORE the workout – your urine should be clear.
2. Do a warm-up run to the point where perspiration is generated, then stop. Urinate if necessary
3. Weigh yourself naked on an accurate scale
4. Run for one hour at an intensity similar to your targeted race.
5. Drink a measured amount of a beverage of your choice during the run if and when you are thirsty. It is important that you keep track of exactly how much fluid you take in during the run.
6. Do not urinate during the run.
7. Weigh yourself naked again on the same scale you used in Step 3.
8. You may now urinate and drink more fluids as needed. Calculate your fluid needs using the following formula:

A. Enter your body weight from Step 3 in Kilograms* *(To convert from pounds to kilograms, divide pounds by 2.2)*	–	____________
B. Enter your body weight from Step 7 in Kilograms* *(To convert from pounds to kilograms, divide pounds by 2.2)*		____________
C. Subtract B from A	=	____________
	x	1000
D. Convert your total in C to grams by multiplying by 1000	=	____________
E. Enter the amount of fluid you consumed during the run in milliliters *(To convert from ounces to milliliters, multiply ounces by 30)*	+	____________
F. Add E to D	=	____________

This final figure is the number of milliliters (ml) that you need to consume per hour to remain well-hydrated. If you want to convert milliliters back to ounces, simply divide by 30.

Now you know how much you need to drink per hour in order to stay properly hydrated during a race or a long hard training run. Keep in mind that as you get in better shape over time, you may need to perform this test again to make sure that your fluid needs have not changed. By the same token, if you reduce or change your training significantly, you may also need to perform the test again.

If the expected climatic conditions for your race or long training runs change, you will also need to perform the test again in as close to the new climatic conditions as possible. Keep in mind that we now know that when conditions get hot, drinking sufficient water will not be enough to prevent heat-related illness. As the temperature rises, you simply have to slow down.

Of additional importance is determining the type of fluids to drink. In many situations, athletes can benefit from including carbohydrates and electrolytes (especially sodium) in their rehydration beverages. However, just as individual differences exist in sweat lost during exercise, individuals also can differ in the types of beverages that are most suitable. Once you have determined how much fluid you need to consume, you should begin incorporating this fluid consumption into your training runs. It is during these practice sessions that you can find out what type(s) of beverage will work best for you.

More information on hydration, including the full paper by Dr. Douglas Casa and other important information on fluid intake from Dr. Lewis Maharam, can be found at www.usatf.org.

Fluids On Race Day

Water and sports drinks provide you with fluid. Follow these recommendations and you will remain healthy! BUT DON'T OVER-DRINK! Remember, too much is as bad as too little. Use your urine color as a guide (see below):

- Drink at least 16 ounces of fluid 1-2 hours before the race.
- Drink another 16 ounces of fluid in the hour before the race.
- Check your urine 1/2 hour before the race…if clear to dark yellow…you are well pre-hydrated…if dark and concentrated…drink more fluids!
- ***During the race drink no more than 1 cup (8-10 ounces)*** of fluid every 15-20 minutes along the way - that does not mean a cup at EVERY water station! Water/Sports Drink stations are usually located throughout the course much closer than the 15-20 minute rule..
- **DO NOT** take any product with ephedra in it. Ephedra increases your risk of "heat illness." It should not be used while training or on race day!

Too Much Fluid Can Be Harmful

Most athletes understand the importance of drinking fluids, but some don't understand that drinking too much can be harmful as well. Over-hydrating can lead to a dangerous condition known as hyponatremia (low blood sodium). Runners or walkers out on the course for long periods, losing lots of sodium in sweat, are at risk. Overzealous drinkers who drink lots of water in the days prior to the race and then stop at every fluid station along the course, and /or drink quarts after finishing also may risk hyponatremia. This condition can lead to nausea, fatigue, vomiting, weakness, sleepiness, changes in sensorium and in the most severe instances, seizures, coma and death.

To avoid hyponatremia follow these easy guidelines:

- Follow the fluid recommendations.
- Try not to drink more than you sweat.
- Include pretzels or a salted bagel in your pre-race meal.
- Favor a sports drink that has some sodium in it over water, which has none.
- In the days before the race, add salt to your foods (provided that you don't have high blood pressure or your doctor has restricted your salt intake).
- Eat salted pretzels during the last half of the race.
- Carry a small salt packet with you, and during the last half of the race, if you feel that you have been sweating a lot or that it's a warm/hot day, consume that single packet.

- After the race, drink a sports drink that has sodium in it and eat some pretzels or a salted bagel.
- Stop taking non-steroidal anti-inflammatories 24 hours before your race and do not start again until a minimum of 6 hours after finishing the race.

Weigh In Daily during the hot months of summer

Step out of bed every morning and onto the scale.

- If you're anywhere from 1% to 3% lighter than yesterday, re-hydrate by drinking 8 ounces of fluid for each pound lost before training again.
- Between 3% and 6% lighter, re-hydrate and back off that day's training intensity.
- Over 7%, get to the doctor.

Drink During Workouts

Two hours before your workout, drink about half a quart. Drink again as early as 15 minutes into the session, but keep the doses small - 4 to 7 ounces.

And After Workouts?

Weigh yourself right before and after workouts. For every pound you lost, drink a pint of electrolyte replacement fluid watered down to whatever strength you like.

Pain Relievers

Recent medical research has shown that non-steroidal anti-inflammatories (NSAIDs) like Advil, Motrin, Aleve, ibuprofen, naproxen, etc. may be harmful to runners' kidney function if taken within 24 hours of running; acetaminophen (Tylenol®) has been shown to be safe. These NSAIDs are thought to increase the possibility of hyponatremia while running long distances due to their decreasing blood flow to the kidneys and interfering with a hormone that helps the body retain salt. Therefore it is recommended that on race day (specifically beginning midnight before you run) you do not use anything but acetaminophen (Tylenol®) if needed until 6 hours after you have finished the race, are able to drink without any nausea or vomiting, have urinated once, and feel physically and mentally back to normal. Then, an NSAID would be of benefit in preventing post-event muscle soreness.