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