Journal of Science and Medicine in Sport (2008) 11, 139—145

ELSEVIER

Journal of Science and Medicine in Sport

www.elsevier.com/locate/jsams

ORIGINAL PAPER

Body weight changes and voluntary fluid intakes of beach volleyball players during an official tournament

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Received 10 March 2006; received in revised form 19 January 2007; accepted 25 January 2007

KEYWORDS
Dehydration;
Fluid balance;
Beach volleyball

Summary The aim of this study was to calculate sweat rates (measured by weight changes), voluntary fluid intakes, and fluid balance of beach volleyball players during a tournament. Data was collected during the 3 days of the tournament for male players ($n = 47$) age $M = 26.17$ (S.D. = 5.12) years old. Participants were weighed before the warm up and they reweighed immediately after the game. The differences in body weight were calculated in grams. The voluntary fluid intake of players during the game was also recorded by observers, whose inter and intra reliability were evaluated (inter $r = .89$ and intra reliability $r = .93$). Fifty matches took place with a $M = 42.2$ min duration per match. A wide individual variation appeared in fluid intake and sweat loss. The calculated average sweat rate, fluid intake rate and fluid balance of players during each match were $M = 1440$ ml, $M = 731$ ml and $M = -0.8\%$, respectively. Air temperature ranged from 26° to 38 °C ($M = 33.58$ °C, S.D. = 2.8) and humidity from 42% to 75% ($M = 56.04\%$, S.D. = 8.7) and both were measured in each day of tournament, at the beginning and at the end of each game. Although players' dehydration (−0.8%) was of mild level, it was more or less the same as it was reported in other team sports studies. ANOVA did not prove differences between elite and non-elite athletes in sweat loss and fluid intake ($p > .01$). Sweat rate was associated only with humidity ($r = .99$, $p < .01$) and with fluid intake ($r = .315$, $p < .05$). The athletes should be aware of the great significance of fluids and to intake greater quantities in order to prevent weight loss and at the same time loss of vital elements that would cause their performance to decline.

Introduction

The incidents of dehydration-related injuries (including fatigue, cramps, heat exhaustion and heat stroke) are too numerous to be recorded.[1]

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doi:10.1016/j.jsams.2007.01.005

The National Centre for Catastrophic Sports Injuries (NCCSI) also reported 4 deaths among college and high school football players in the year 2000 and it has recorded 20 deaths from heat stroke over the past 7 years. Dehydration was the contributing factor in all of these deaths.[1] Powell and Barber-Foss[2] found that dehydration was the cause behind lost game or practice time for up to 1% of athletes.

A number of organizations (such as the American College of Sport Medicine, ACSM and the Canadian Dietetic Association, CDA) made position statements to warn athletes, coaches and athletic trainers about the dangers associated with dehydration[3,4] and provided guidelines to athletes in order to stay well-hydrated while training and competing. They suggested the appropriate amount and rate of fluid consumption and addressed the palatability composition of dehydration fluids. They also recommend coaches and medical staff to control the athletes' dehydration status by monitoring them and recording their weight changes and fluid intakes in training and competition conditions.[5]

Dehydration among competitive athletes in sports also including Beach Volleyball imposes uncertain effects on athletes' performance, impairments to muscular endurance, cognitive functioning, thermoregulation and gastric emptying.[6–8] Rehydration following the exercise is also particularly important for the recovery and restoration of physical and mental performance.

Beach volleyball is an exciting, spectacular sport which played under demanding environmental conditions. Furthermore, since only two players can participate in beach volleyball, players are forced to perform continuous actions under high temperature and high humidity, for many hours, since the game is structured in such a way that they need to play even three games per day with small intervals between them and for 3 days in a row. The heart rate often reaches very high levels (in official FIVB World Series Tournament max HR = 180.66, S.D. = 8.60 and mean HR = 155.66, S.D. = 13.58).[9]

These characteristics make beach volleyball a sport with increasing demands for anaerobic and aerobic capacity.[10] Beach volleyball, like indoor volleyball, requires activities with short duration and extremely high power output.[11] In addition, moving on sand increases energy utilization compared to moving on solid ground[12,13] and the extended duration of exposure of the players to the sun and to high temperatures are very important factors that increase the risks of dehydration and thermal stress. Dehydration coupled with the loss in body weight due to perspiration, leads to the loss of vital components (potassium, sodium, electrolytes), which are decisive factors and thus, affects the performance of the athletes not only in terms of muscular endurance and cognitive functioning but also of thermoregulation.

In the field of sport medicine, the level of dehydration is quantified by the amount of weight lost (usually by exercise) during a diurnal cycle (a day practice session). An athlete who loses 3% of his/her body weight is considered as being ''3% dehydrated''.[5] Wyndham and Strydom[14] reported that any loss of mass in excess of 3% of the body weight can seriously disrupt temperature regulation and physical performance. Similarly, Convertino et al.[15] support that a 1% loss of body weight can result in mild symptoms of dehydration that are evident at a 3% weight loss. Therefore, there is a need to maintain a balance between the intake and loss of fluids so that the performance of players will not be adversely affected.

Fluid losses and fluid intakes practices of athletes have been reported for a number of sports and appear to differ between sports and sporting events.[16,17] Although a number of articles have outlined the optimal body loss and fluid intakes for swimmers,[18–20] for weight-training males,[21] for rugby players,[22] for marathon runners,[23] for squash players,[24] for tennis players[25]; no research has specifically investigated fluid balance in beach volleyball.

Beach volleyball is a physically demanding sport, involving prolonged, high intensity exercise under high temperatures and humid environmental conditions. The purpose of this study was to estimate sweat losses (measured by body weight changes) and voluntary fluid intakes during a tournament, for beach volleyball players.

Method

Participants

Participants were 47 beach volleyball players who competed in an official tournament, with average values regarding: age $M = 26.17$ years old (S.D. = 5.12), weight $M = 83.10$ kg (S.D. = 6.9), and $M = 1.89$ m (S.D. = 5.79) height. Participants were divided into elite ($n = 21$) and non-elite athletes ($n = 26$). Elite athletes were the players who competed in international tournaments and non-elite those who competed in national tournaments. The median time of players training in course period was 1.97 h/day (S.D. = 0.77), and in preparation period was 3.27 h/day (S.D. = 1.27). All participants provided written consent prior to their participation and were free to withdraw from the study at any

time. The study was approved by the Ethics Committee of the Greek Sports Commission.

Procedure

Participants were weighed before the warm up (players were towel-dried prior to their post-match weight) and were reweighed immediately after the game (before they visited the toilet). Researchers recommend to all participants do not drink any drink before they weighed. All participants were weighed wearing only their short pants (they took off their t-shirts).[5] The differences in body weight were calculated in grams.

Cool drinks were readily available to the players. However, players were responsible for their own drinks during the match (only in time-outs and court changes between sets). The voluntary fluid intakes of players were recorded by observers, who also further recorded whether the fluid was water or a solution (Gatorade, Lucozate).

Apparatus

Participants were weighed on a portable digital scale—Soehnle 7307, which was manufactured in Germany and provided accuracy of ± 50 g. For recording the temperature and humidity, a thermometer and a hygrometer (Vaisala HM 34, Humidity and Temperature Meter, Finland) were used.

Observers

Observers were students belonging to the Beach Volleyball Faculty of the Physical Education Department of the Aristotle University and were trained in the observation and recording of fluids intake. They had spent time observing a previous tournament and they were both taught and trained accordingly based on the same recording code. Furthermore, their internal reliability was examined (inter and intra reliability), which displayed a high correlation. (Inter $r = .89$ and intra reliability $r = .93$).

Protocol

Data was collected from beach volleyball players over the 3-day tournament, in each day. A total of 141 observations regarding the fluid balance of players took place (3 times for each player). The mean corresponding to the pre- and post-weight for each player was calculated.

Over the 3-day tournament, changes in body weight and recorded levels of fluid consumed were used to calculate sweat loss for each player using the following formula: sweat loss (g) = {pre-match body weight (g) − post-match body weight (g)} + fluid intake (g). No correlation was made for respiratory water loss or metabolic fluid changes. Mean percent change in fluid balance = {(post-match body weight (g) − pre-match body weight (g))/pre-match body weight (g)} × 100.[20] Air temperature and humidity (Vaisala HM34, Humidity and Temperature Meter, Finland) were measured in each day of the tournament, at the beginning and at the end of every game. The duration of the sets were also recorded, as well as the number of sets per game and whether the players had won or lost the game. Playing action time began when referee blew his whistle for the first service and ended when the referee whistled the end of game. Time spent on time outs and while changing courts was also included in the count of the total match duration. Sweat loss and fluid intake have been expressed as ml per hour of total match time with taking into account time spent on substitutions and time outs. Therefore, fluid intake per hour represents the actual intake during time outs and at the very end of each match.

Statistical analysis

The linear association of body weight with factors such as fluid intake rate, sweat rate, temperature and humidity was assessed using a Pearson correlation coefficient (SPSS for Windows release 10.0.05). ANOVA (Tukey's HSD test) was used to compare means for calculated sweat loss and fluid intakes by elite and non-elite players. The criterion used to determine significance was $p < .05$.

Results

A summary of the duration of matches and environmental conditions are presented in Table 1.

Table 2 presents the differences in weight, fluid intake, calculated sweat loss, and changes in fluid balance for beach volleyball players. The mean voluntary fluid intake rate during the tournament was 1039 ml/h and sweat loss was 1996 ml/h. The mean percent change in fluid balance for players was −0.8% and −1.14% ml/h.

A total of 50 games took place, 36 of which ended with a score of 2-0 and only 14 of them with a score of 2-1. The average duration of the games was 42.2 min (S.D. = 9.8) each. On average the athletes played three games per day and lost −673 g (S.D. = 593.3) of weight per game, while receiving per game on average an

Table 1 Duration and environmental conditions of beach volleyball matches

	N	Mean	Min	Max	S.D.
Duration of matches (min)	50	42.2	27	62	9.8
Duration of 2-0 matches (min)	36	36.9	27	53	5.6
Duration of 2-1 matches (min)	14	55.2	48	62	4
Temperature (°C)	50	33.6	26	38	2.8
Humidity (%)	50	56.0	42	75	8.7

Time-outs, court changes, pause between sets.

Table 2 Means in, fluid, sweat loss, and percent change in fluid balance for beach volleyball players during a tournament

	N	Mean	Min	Max	S.D.
Differences in weight (g) (pre—post-weighing)	47	673	2000	1800	593
Fluid intake (ml) (42.2 min match duration)	47	731	0	1500	393
Fluid intake (ml/h)	47	1039	0	2616	686
Sweat loss (ml) (42.2 min match duration)	47	1404	1200	2700	642
Sweat loss (ml/h)	47	1996	872	4709	1120
Change in fluid balance (%) (42.2 min)	47	−.8	−2.21	1.98	.68
Change in fluid balance per hour (%)	47	−1.14	3.86	3.45	1.19

intake of 731 g (S.D. = 393.29) of fluids, water in preference, [except seven persons who consumed solutions *M* = 164 g (S.D. = 236.13) (Gatorade, Lucozate κ.α.)].

The temperature during the games ranged from 26 to 38 °C (*M* = 33.6) (S.D. = 2.8) and the relative humidity from 42 to 75% (*M* = 56%) (S.D. = 8.7).

The analysis of variance did not display differences between the elite and non-elite athletes regarding sweat loss and fluid intake ($p > .01$). Sweat rate was associated with fluid intake ($r = .99$, $p < .01$) but not with the players' body weight. Humidity was also associated with fluid intake ($r = .315$, $p < .05$), but not with sweat loss and temperature.

Discussion

Adequate hydration is essential for optimum performance[26] and to ensure that athletes do not incur heat-related illness.[27] In more stark terms, Galloway[28] has noted that ''an effective rehydration strategy can mean the difference between life and death'' (p. 188). With the exception of unusual circumstances, the hydration status can be perceived as a function that is largely based upon voluntary fluid intake. However, the amount of fluid consumed by athletes frequently does not adequately match sweat loss.[29,16,24] This failure to adequately replace lost fluid levels was described as ''voluntary dehydration'' by Rothstein et al.,[30] and has been well documented.

The advantage of the present study lies on the fact that it was carried out in real time conditions during an official tournament. The results derived from this study provided information on body mass changes and on the practices of beach volleyball athletes regarding fluid intakes during a tournament under demanding environmental conditions.

The findings of this study showed that beach volleyball players during competition experienced greater sweat loss (1996 ml/h) but also received a greater intake of fluid (1039 ml/h), when compared to other studies, which used the same protocol and were carried out on other team sports. Cox et al.[20] found that calculated mean sweat rate of male water polo players in training and competition was 287 and 786 ml/h respectively. The same group of researchers investigated body weight changes in athletes from a variety of team sports during training and competition by using the same protocol.[17] Calculated sweat rates appear to be considerably higher in ''land based'' team sports, regardless of environmental conditions. The mean sweat rate of elite male basketball players was 1371 and 1601 ml/h during training and competition, respectively. For elite male soccer players it was 985 ml/h during training and 1209 ml/h during competition. Woolford and Angove[31,32] also found that more time was spent in high intensity activity in netball matches (like beach volleyball) than during training sessions.

The findings of the present study can be justified by the fact that beach volleyball is played on open air courts, under demanding environmental situa-

tions (temperature ranging from 26 to 38 °C and humidity from 42 to 75%) with these factors being directly related to respiration, fluid loss and fluid intake. During the course of this study, the temperature reached up to 38 °C, a level that would logically lead to greater perspiration and loss in body weight. Unfortunately, there are no similar studies in the field of beach volleyball in order to compare the findings of the present study, neither applicable to training conditions nor to real time game conditions.

The results of this study show that the mean sweat loss of beach volleyball players was 1404 ml or 1.4 l. These results almost agree with Leatt[33] who had reported a body weight loss of 1.0 kg (1.4% of body weight) occurring to eight international level athletes playing under high temperature conditions. Much larger losses were reported by Mustafa and Mahmoud[34] in international soccer players.

Ekblom[35] also reported a weight loss of 1.0—2.5 kg during games played in temperature climates, with the loss being greater in games of international level and lesser in players performing at a lower quality level. In games played under high temperatures, losses of almost 4 l were recorded, although the mean loss was 2.0—2.5 l. When players performed in cooler (13 °C) conditions, a much smaller mean of sweat loss of 0.85 l was reported. Large sweat losses of up to 4.5 l in some individuals were also reported by Bangsbo,[36] but details of the conditions under which the experiment took place were not provided.

The mean fluid intake by the players during matches in the present study was 731 ml in real time activity and 1039 ml/h. These values are greater than those found by Cox, et al.,[20] for water polo players (142 ml/h for training and 380 ml/h for competition, respectively) and for male basketball players (797 ml/h for summer training and 1097 ml/h for competition, respectively) and in soccer players (429 ml/h).[17]

This may reflect a number of different factors. Firstly, during the games when the measurements were recorded it was warmer than usual ($M = 33.58$ °C), so thirst forced many players to consume more fluids and a number of them to consume fluids after the game had ended. Another important factor that favored the flow of fluid intakes was the time spent in time outs and intervals in between sets, during which the players could drink as much water or other fluids as they wanted to.

Regarding the mean percent change in fluid balance for beach volleyball players it had a value of −0.8% for each game and −1.14%/h, which was more than Cox et al.[20] had found for water polo players (−0.26% for training and −0.35% for competition, respectively) and almost equal to male basketball players values (−1.0% for summer training and −0.9% for competition, respectively).[17]

According to Oppliger and Bartok,[5] an athlete who loses 3% of his/her body weight is considered to be ''3% dehydrated''. Wyndham and Strydom[14] claimed that any loss of mass in excess of 3% of body weight can seriously disrupt temperature regulation and physical performance. Similarly, Convertino et al.[15] supports that a 1% loss of body weight can result in mild symptoms of dehydration which are evident at a 3% weight loss.

Opportunities for fluid intake during the game are limited and this coupled with the fact that the ingested fluid from the stomach may not be readily absorbed in the small intestine, makes it appropriate for players to ensure they are fully hydrated before beginning their match play. These players were due to play again in the same day after a recovery time period of only 2 or 3 h, so it seems unlikely that those who had experienced the largest fluid deficits would have fully replaced them before resuming playing. The possible cumulative effects of playing a number of matches under hot weather with incomplete restoration of fluid balance must give rise to some concerns.

The non-finding of differences between elite and non-elite athletes is justified by the fact that the common practice of both teams as regards to the intake of fluids was almost identical. The only difference observed concerned the intake of other fluid solutions, which represented a small proportion (7 out of the 21 elite athletes) and for this reason, it is not mentioned.

Due to the fact that this study is based on observation has all the disadvantages and/or limitations (subjectivity). Also the design of the study is taken place in real life situations thus rules of the game and time pressure are also factors that affect objectivity of the study. In order for researchers to derive accurate conclusions about dehydration more studies should take place in real life situation and in laboratory so as to correlate the results.

It is suggested that future research also measures the elements lost due to perspiration such as sodium or electrolytes, which can significantly influence the performance of the players. Furthermore, it is suggested that the percentage of dehydration is correlated to the performance (win or loss) of the players since poor performance could be caused by the effects of dehydration.

Conclusion

As the findings of the present study display, beach volleyball players managed to keep dehydration in low levels and did not face the risk of dehydration and its subsequent symptoms (thermal stress or decline in performance). Even though the environmental conditions were demanding and the risk of dehydration was great, the athletes managed to receive an adequate intake of fluids and to stay in a mild dehydrated level. Although players succeeded to minimize dehydration on an average level, there are obviously some players who have incurred significant dehydration. Perhaps in future studies each case should be tested individually.

The results of the present study indicate that fluid loss and fluid intake incurred during prolonged high intensity exercise in a hot environment (as measured by body weight deficit) obtained greater values than those typically reported in other sports. However, beach volley players displayed wide individual variation in fluid intake and sweat loss. The most important of all is that players are informed of the dehydration risks and to intake an adequate quantity of fluids beforehand, meaning to begin by being sufficiently hydrated during and immediately after the games. In addition, they should be aware of the ways in which they can control the fluid balance of their bodies.

Practical implications

- Beach volleyball athletes should receive enough fluid (water) so as to have the proper hydration and electrolytes balance, to avoid dehydration and thus affect their performance negatively.
- The time that they receive fluids (water) as well as the quantity of them, should be in relation to the training and game time, along with the temperature and the humidity of the environment.
- The balance between sweat loss and weight loss should remain stable during the games by adjusting the quantity of the fluids received.
- Athletes should ask advice from specialists about appropriate food or fluid supplements and ergogenic aids.

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