Materials : Football (Soccer)

Monitoring Heat Stress during Female Football Competition and Training in Hot Conditions

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Since the football (soccer) season of the National Sports Festival in Japan changed from fall to summer in 2002, the competition, local elimination round and daily training were expected to be carried out in an extremely hot environment. We therefore applied a type of intervention strategy to cope with hot weather competition and training for the female prefectural football team. Environmental conditions and body weight of players before and after activities were monitored for 3 months. We have also done the guidance in appropriate water intake during exercise, management of the players' injuries and brief leg cooling for accelerating recovery from fatigue. The mean ambient temperature during the whole training period at evening was 32.0 ± 3.0 ˚C, and mean wet bulb globe temperature (WBGT) during the competition was 28.1 ± 2.3 ˚C. The mean body weight loss during the whole training period and games was 0.57 ± 0.2 kg, the percentage of dehydration was 1.15 ± 0.3 %. These results suggest that, even when environmental condition is severe, the players keep a good condition for a long training period. Consequently the team won the local area elimination round and placed fifth in the 2002 National Sports Festival under the hot conditions.

Keywords: hot environment, conditioning, body weight, cooling

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1. Introduction

Many major sport events are held in extreme hot conditions. It is well accepted that the human is able to thermoregulate efficiently during exercise in a range of cool to moderate ambient conditions. However, this has been shown to be more difficult during exercise in warm conditions (Marino, 2004). In fact, it has been reported that exercise performance was greatly influenced by environmental temperatures (Galloway and Maughan, 1997; Parkin *et al*., 1999), and the percent number of finishers in the Olympic Marathon from 1896-2000 is highly correlated with the ambient temperature (Martin and Gynn, 2000). Therefore, several strategies including heat acclimatization (Cheung and McLellan, 1998; Nielsen *et al*., 1993), pre-cooling (Booth *et al*., 1997; Cotter *et al*. 2001), fluid ingestion (McConell *et al.*, 1997; Kay and Marino, 2000) and a combination of two of these methods (Hasegawa *et al.,* 2006) have been applied. It is also important to prevent players from increasing the body temperature and from dehydrating during exercise in order to maintain a high level of athletic performance or conditioning even in a hot environment condition (Marino, 2002; Maughan and Shirreffs, 2004). However, numerous cases of heat-related illness have still occurred during training or competitive events in summer (Armstrong, 2003). Indeed, as heat illness is the third leading cause of death in US high school athletes, heat illness is a significant concern for everyone exercising in the heat (Coris *et al.*, 2004). Monitoring and maintaining hydration status, educating athletes regarding fluid replacement, increased awareness and early intervention will help to reduce the risk of heat illness (Binkley *et al*., 2002; Casa *et al*. 2000; Casa and Yeargin, 2005).

Some studies focused on environmental conditions have reported heat stress and physical stress to athletes during the training and athletic competitions

Table 1 Schedule and results

Date	Interventional supports
29 June 2002	・The 1st physical test ・Selection of final seventeen members preparing the competition
28-29 July 2002	・Training camp ・Practice matches versus Japan Ladies league team ・Measurements of heart rate during games
17-19 August 2002	・Chugoku Area Elimination Round in Okayama (Three won games and one drawn game, and then advanced next tournament)
3 September 2002	・The 2nd physical test
20-23 September 200	・2002 National Sports Festival in Kochi (One won game and one lost game, the 5th prize)

(Elias *et al*., 1991; Elias, 2001). According to the report of Elias *et al*. (1991), 18 of the 4,000 participants in the USA Cup Soccer 1988, which was held under hot and humid conditions, developed symptoms of collapse within the first 2 days of the event. Since the officials of the event took compensatory measures such as shortening the duration of games, prolonging time-outs for the water intake, and abolishing restrictions of substitution, the athletes who suffered heat illness decreased although abnormally high temperatures persisted for the rest of the tournament. As indicated by this example, event officials must make sufficient preparations for heat in their organizing event, and also, managerial staffs, coaches, and players must make sufficient preparations to participate in athletic events under a hot environment condition (Binkley *et al*., 2002).

The National Sports Festival in Japan is one of the largest sports events held annually including various sport competitions in which prefectural representatives compete in tournaments. Football games of the competition had been held in the fall, but the season was changed to summer as from the 2002 Meet. Since then the competition, local elimination round to qualify teams for the tournament and daily training must be carried out in a hot environment. These were expected to cause heat stress to the players. We therefore applied a type of intervention strategy to cope with hot weather competition and training for the female prefectural football team. Primary contents of our supports were environmental monitoring, measurement of the body weight before and after activities, guidance in appropriate water intake, cooling for accelerating of recovery from fatigue, and management of player's injuries and first aid treatment.

2. Material and Methods

2.1. Participants

The participants were 17 female football players (Age 22 ± 3.4 years; Height 159 ± 4.2 cm; Body weight 52.6 ± 2.7 kg; Football experience 9.3 ± 4.2 years). All players were of amateur level and members of a team playing for the prefecture. They had usually trained three to five times a week. All players were fully informed about procedures to be performed and the purpose of the study prior to the experiments.

2.2. Schedule and results of games

Table 1 shows the schedule and results of games during the period in which we provided support. Full-member training was normally carried out once or twice a week from 19:00 to 21:00 from July to September.

2.3. Measuring environmental conditions

2.3.1. Training conditions

The temperature and humidity were measured at the beginning and at the end of each training session

using a simple thermo-hygrometer.

2.3.2. Game conditions

In the Chugoku Area Elimination Round and the National Sports Festival, the wet bulb globe temperature (WBGT), a standard index of environmental heat stress (Binkley *et al*., 2002), was measured approximately every 30 minutes in games played by the team. It was calculated from the indications of the wet bulb thermometer (T_{wb}), black globe thermometer (T_{bg}), and dry bulb thermometer (T_{db}) by the following formula (Binkley *et al*., 2002).

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

2.4. Management of body weight

The players were weighted to the nearest 50 g (UC-321, A&D, Japan) before and after every training and game in 3 months. The percentage of dehydration was calculated by the following formula:

Dehydration (%) = (body weight before exercise – body weight after exercise) / body weight before exercise × 100

2.5. Cooling to promote recovery from fatigue

We performed a brief leg cooling, promoting recovery from fatigue using ice baths after each training session and each game. Ice and water were placed in a tank that was as deep as the femoral region of the players (Yamamoto and Yoshinaga, 2001). The water temperature was maintained at about 12°C, and the players immersed their legs for 3 minutes.

2.6. Special treatments during competitions

During the competition, tents were set up to avoid the sun shine, water intake was encouraged as from warm-up, and icing of the head and active muscles was applied during half time.

2.7. Management of injuries

Injuries of the players were checked before, during, and after training. Taping, stretching, massage, and re-conditioning were performed by athletics trainers if necessary. During the competition, massage and physiotherapy were given at the lodging, if necessary.

2.8. Questionnaire survey about the supports

The players and coaches were requested to assess our interventional supports by a questionnaire method after the training period. Each question was scored on a continuous scale from 0 to 5, where 0 was rated as ineffective, 5 rated as effective.

2.9. Data analysis

Data are presented as mean ± standard deviation (SD) unless otherwise stated.

3. Results

3.1. Environmental conditions during activities

3.1.1. Training conditions

The average temperature and humidity during 3 month training period were 32.0 ± 3.0 ˚C and 57 ± 7 %, respectively (33.0 ± 3.4 ˚C and 56 ± 8 % in daytime training; 32.2 ± 1.7 ˚C and 59 ± 5 % in evening training).

3.1.2. Game conditions

During the Chugoku Area Elimination Round, the average temperature, average humidity, and the mean WBGT were 33.0 ± 2.5 ˚C, 50 ± 7 %, and 28.0 ± 2.5 ˚C, respectively. During the National Sports Festival, the average temperature, average humidity, and the mean WBGT were 34.0 ± 2.0 ˚C, 42 ± 8 %, and 28.6 ± 0.7 ˚C, respectively (**Table 2b**).

3.2. Management of body weight

Figure 1 shows the changes in the mean body weight and the dehydration of each training session and game for 3 months. The mean body weight loss after training or a game was 0.57 ± 0.2 kg, the mean dehydration was 1.15 ± 0.3 %.

3.3. Management of injuries

Table 3 shows the number of injuries until the end of the competitions.

3.4. Questionnaire survey about the supports

The results of questionnaires for our support were as follows (from 0; ineffective to 5; effective). The

Table 2 Schedule and results

a. Chugoku Area Elimination Round in Okayama

Date	Results	Weather	Time		Twb (℃)	Tbg (℃)	Tdb (℃)	WBGT (℃)
8.17	vs Tottori	fine	11:30	1st half start	27.0	44.0	36.0	31.3
	2-0		12:00		27.0	43.5	36.5	31.3
			12:30		27.0	43.5	36.5	31.3
				mean	27.0	43.7	36.3	31.3
8.18	vs Shimane	fine	10:00	1st half start	25.0	38.5	32.0	28.4
	9-0		10:30		21.0	40.0	33.0	26.0
			11:00		26.5	44.5	35.5	31.0
				mean	24.2	41.0	33.5	28.5
	vs Okayama	cloudy	15:30	1st half start	25.0	34.5	32.0	27.6
	1-1		16:00		24.0	33.0	31.0	26.5
			16:30		23.0	31.5	30.0	25.4
				mean	24.0	33.0	31.0	26.5
8.19	vs Yamaguchi	fine	15:30	1st half start	22.0	35.0	30.5	25.5
	13-0		16:00		22.0	35.5	30.5	25.6
			16:30		23.0	35.5	32.0	26.4
				mean	22.3	35.3	31.0	25.8
				mean total	24.6	38.4	32.8	28.2
				SD	2.2	4.7	2.5	2.5

b. 2002 National Sports Festival in Japan in Kochi

Date	Results	Weather	Time		Twb (℃)	Tbg (℃)	Tdb (℃)	WBGT (℃)
9.20	vs Kochi	fine			not measure			
	2-0							
9.21	vs Hyogo	fine	13:30	1st half start	24.0	42.0	32.0	28.4
	0-5		14:00		23.0	42.5	34.0	28.0
			14:30		24.0	44.5	36.0	29.3
				mean	23.7	43.0	34.0	28.6
					0.6	1.3	2.0	0.7

Twb = wet bulb temperature, Tbg = black globe temperature, Tdb = dry blub temperature, WBGT = wet bulb globe temperature

management of body weight: 4.5 ± 0.6, brief leg cooling using ice baths after training: 4.7 ± 0.5, brief leg cooling after game: 4.9 ± 0.4, environmental monitoring: 3.3 ± 0.6. Both brief leg cooling after training and games were very effective for them.

4. Discussion

There are few studies focused on the physical condition of female football players during training or competition until now. We applied a type of intervention strategy to keep a good conditioning of female football players under hot weather competition and training for a long period. Our main supports were environmental measuring during training and competition, measurement of the body weight before and after activities, guidance in appropriate water intake, cooling for accelerating of recovery from fatigue, and management of player's injuries and first aid treatment.

Since the risk of heat illness becomes high when WBGT exceeds 28°C, it is recommended to avoid exercise with a large heat burden such as vigorous exercise and endurance running, and to frequently take time-outs and drink water (American College of Sports Medicine, 1996; Gleeson, 1998). In addition, according to the guideline of NATA, if the WBGT is greater than 28˚C an athletic event should be delayed or rescheduled (Binkley *et al*., 2002). In the present study, the mean WBGT during the local elimination round was 28.0 ± 2.5 ˚C. Particularly, the first game was carried out under severe conditions with WBGT

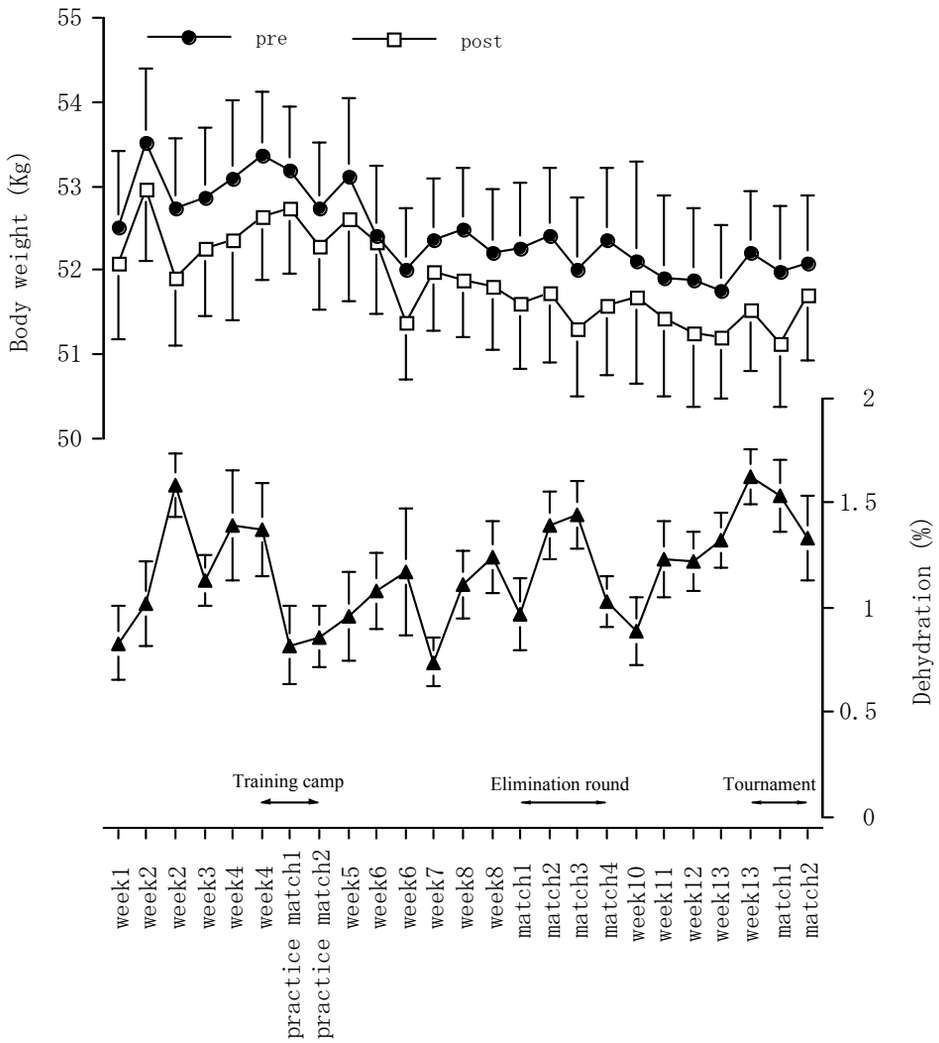

Figure 1 Changes in body weight and dehydration. Values are expressed mean ± SEM.

Table 3 Injury sites, varites and numbers

		total numbers
Injury sites	lumbus	20
	thigh	24
	knee	3
	leg	8
	foot	12
Injury varieties	sprain	19
	contusion	2
	strain	15
	others	34

being 31.3°C (**Table 2a**). One "drinking time" was taken in each half of the game in the local elimination round. The "drinking time" is a ruled time-out taken for rehydration during the game, and players are required to drink water quickly during the limited period. It has been introduced and executed since 1997 in Japan for youth and female football players. On the other hand, the mean WBGT during the National Sports Festival was 28.6 ± 0.7 ˚C, which was even higher than during the local elimination round (**Table 2b**). However, the games were carried out on schedule in severe heat condition without "drinking time". These results suggest that severe environmental conditions stressed the players during the competitions.

Body water lost during exercise-induced sweating can lead to dehydration. Even a small amount of dehydration can increase cardiovascular strain, 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 (American College of Sports Medicine,1996). Therefore, the consequences of body water deficit can increase

the probability for impairing exercise performance, and it is thus important to minimize dehydration during exercise in hot conditions. By measuring the body weight, it can be evaluated whether the water intake has been appropriate for the loss of water during the exercise (Binkley *et al*., 2002; Casa and Yeargin, 2005). We weighed the players before and after training and games during a long period (3 months). The goal should be to lose no more than 2 % body weight during the training or competitions, because dehydration over 2 % of the body weight increases stress to the body (American College of Sports Medicine, 1996; Binkley *et al*., 2002; Sawka *et al*., 2001). In the present study, despite the severe environmental conditions, the mean body weight loss after training or games was 0.57 ± 0.2 kg, the average dehydration for the whole training period was 1.15 ± 0.3 %. Thus, the percentage of dehydration was less than 2 % during all training sessions and games, fulfilling the goal as a result of encouraging frequent water intake. These results suggest that the players could keep good conditioning during the long training period even in severe environmental condition. The support, in which individual data of the players were fed back to them, also led to marked improvements in the players' awareness, which were manifested by their greater ability and eagerness for self-management.

Trainings and games in a hot environment cause a marked stress to the body, and accumulation of fatigue due to the tight schedule of the tournament also affects conditioning of the players. Fatigue accumulates not only due to games but also because of training. The way to promote recovery from fatigue is important in order to perform better in such a severe situation. We established a method of recovery from fatigue throughout the season and performed a brief leg cooling using ice bath after each training session and game. Brief leg cooling using an ice bath is expected to produce various effects such as preventing secondary hypoxic injury, alleviation of muscle spasms, reducing thermal strain and acceleration of recovery from fatigue by reducing the energy consumption (Cross *et al*., 1996; Hayashi *et al*., 2004; Knight, 1995). Although the brief leg cooling has already been introduced to various athletic events and has attracted attention (Yamamoto and Yoshinaga, 2001), its effects on exercise performance or physiological responses are not clear until now. There are some evidences that the brief leg cooling after exercise reduced thermal and cardiovascular strain during subsequent exercise in the heat (Hayashi *et al*. 2004), and it improved the second bout of exercise performance (Yamamoto, 1998). While the other study reported that the brief leg cooling during half time intervals did not affect on the subsequent bout of exercise performance (Ishiyama *et al*. 2001). The different results might be due to the difference of exercise protocol or difference of temperatures of cooling or difference of muscle and skin temperatures. Therefore, further research is necessary to elucidate the effectiveness of brief leg cooling on the recovery from exercise-induced fatigue.

In addition, during the weekly evening training, sufficient cooling down by running and stretching was occasionally impossible because of the limitation of the time allowed for the use of the field, but the brief leg cooling performed after each training was markedly effective for promoting recovery from fatigue. The conditions in the local area elimination round were more demanding: games were played on 3 consecutive days in severe heat environments (**Table 2a**). Especially, two games were played on the second day, and recovery from fatigue between the games was expected to be an important key for a good performance of the players. Because of the brief leg cooling, the team performed excellently, with few players suffering from cramps, even in the second game in the heat. We also evaluated the effectiveness of brief leg cooling for the players by a questionnaire method after termination of our supports period. The results showed that players really felt positive about this treatment, both after trainings and during competitions.

5. Summary

We provided support for maintaining and promoting the physical condition of a female football team to ensure better performance in the heat training and the 2002 National Sports Festival in Japan. The environmental conditions of the competition, the local elimination round and each training were extremely severe, and physiological stress to the players was large. However, the players kept low dehydration and good conditioning for a long training period. Our support included environmental measures, measuring body weight during activities, brief leg cooling are considered to

have been effective, because fewer players failed in conditioning or sustaining injury, and the team ranked high in the tournament.

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