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ACUTE EFFECTS OF A COMPLETE WARM-UP PROGRAM IN HEAT ACCLIMATIZATION ON ANAEROBIC PERFORMANCE AND FATIGUE IN FOOTBALL PLAYERS

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ABSTRACT

The aim of this study was to investigate acute effects of a complete warm-up program in hot weather on anaerobic performance and fatigue index. Twenty-one male football players performed a warm-up session which consists of stretching and a warm-up program in two different conditions. The repeat sprint ability (RSA) was evaluation after a warm-up session with normal temperature (The 11+) or hot temperature (The 11+ HOT) condition a week apart. The statistic data show that the percentage decrement score (%Decre) in The 11^{+} + HOT condition was lower than The 11^{+}. The result was concluded that The 11+ HOT could improve %Decre performance in football players after a complete warm-up program or dynamic stretching under hot temperature.

Keywords: *The 11+, repeat sprint ability, fatigue*

1. Introduction

In intermittent team sports, such as football (soccer), futsal, and rugby, players require highly physical fitness abilities. Football is well known as a popular team sport, often played in outdoor stadiums. There are combinations of anaerobic and aerobic abilities, such as sprinting, acceleration, jumping, and continuous running for extended periods. Heat production while playing football is produced from internal and external factor. An internal factor produces heat through chemical changes involved in muscular activity that is related to the exercise intensity; meanwhile, heat from the hot climate, humidity, and wind velocity (speed) are the external factors. Environment and exercise, especially heat stress, has been widely studied to examine the effects on football performance, with the rationale that football is played in many different environments around the world and heat stress or/and environmental stress affect athletes' performance. Previous studies reported that some competitive matches were played in challenging conditions where the temperature may exceed 30 degrees Celsius with a high relative humidity [36]. The environmental stress affects core and muscle temperatures that were high when compared with normal environment. In line with Nybo et al. [17] who investigated repeated sprint performances (3 x 30-m) with the 43 degrees Celsius (°C) temperature on fatigue parameters in football players. The results showed that sprint performances immediately after the matches and 48 h of post-match were impaired about 2% [17]. On the other hand, hot climate may cause an advantage for improved performances. Guy et al. [18] showed positive data of hot temperature affecting single-sprint performances. The analytical data from the 12 consecutive years with the top six of best running time in 100 m and 200 m competitive event showed that competition in the hot temperature (> 25 °C) had 2% better performance than the cool temperate conditions (< 25 °C). They argued that the hot temperature affects cross-bridge cycle rate as a result of muscle contractile adaptation, and a reinforcement with the fast rate of phosphocreatine (PCr) utilization from a main fiber expresses predominantly myosin heavy chain IIA. These were the mechanisms of muscle physiologic responses with hot temperature as a result of higher pedaling frequencies [19, 20].

A warm-up session is a recommended component before a workout. It affects central and peripheral physiologic responses, such as heart rate and skin temperature elevating. A warm-up session consists of different movements to simulate our human system that involves workout to be ready. An eleven-plus complete warm-up program (11+) is one of the warm-up variations that included jogging, jumping, stretching, strengthening, balancing, speed blend with change direction for improve awareness, and neuromuscular control that made the readiness condition for training or competitive matches [16]. During warm-up and stretching, it stimulates musculo-tendinous unit (MTU) stiffness which influences the transmit force that is generated from internal to the skeletal system [1, 2]. Additionally, dynamic stretching may enhance short-term performances on dynamic concentric external resistance [3], power [4], agility [4], vertical jump [5], electromyographic activity during a maximal voluntary isometric contraction (MVIC) [6], balance, [10] and sprint time [7, 12]. Mostly, dynamic stretching researches focused on dynamic concentric external resistance, power, agility, vertical jump, and sprint time which showed a positive effect. Yamaguchi et al. [3]

showed that dynamic stretching could increase the power output of 5, 30 and 60% of MVIC torque with leg extension greater than the non-stretching group. McMillian et al. [4] studied the effects of dynamic stretching on power (underhand medicine ball throw for distance and 5-step jump) and agility (T-shuttle run). The results showed that dynamic stretching could be significantly difference for control group, the better scores on underhand medicine ball throw for distance, 5-step jump, and T-shuttle run. Turki et al. [7] studied active dynamic stretching with different volumes on 10- and 20-m sprint test in male athletes. The results showed that dynamic stretching affected the reducing of sprint time on 20-m. They recommended that active dynamic stretching should not be performed to exceed three sets because it could induce acute fatigue and impair sprint time performance [7].

Increasing muscles core body temperature is essential to enhance performance because it affects the speed of nerve impulses, the sensitivity of nerve receptors, and the speed of a contraction allowing rapid and forceful muscle contractions [11]. There were studies of muscles core body temperature, and it was found that it was especially important with intermittent sport performance and our body responses according to Fletcher and Jones [8]. They investigated the different warm-up stretch protocols to 20-m sprint test. The results showed that dynamic stretch could reduce the duration on 20-m sprint test about 0.03-0.06 seconds, but static stretching showed the opposite extreme. They suggested that rehearsal of specific movement patterns that enhance the coordination of subsequent movement by pre-activated. It affects the switch from eccentric to concentric contraction rapidly as a result of producing power and decreasing sprint time [8].

The effects of warm-up and dynamic stretching were reported continuously, such as they can increase muscle core body temperature and the rehearsal of movement in a more specific pattern and affect anaerobic performance in training or match competition. However, fatigue during repeating anaerobic activity, anaerobic performance, and a complete warm-up program for dynamic stretching that could increase core muscle temperature [11] may positively affect the repeat sprint performance in Thailand with hot-humid climate that is in accord with Girard et al. 25], who suggested that the increase in core and/or muscle temperature may improve sprint or decrease fatigue performance via increased anaerobic metabolism. In addition, an increase in nerve conduction rates has been infrequently investigated. On the other hand, repeated sprint performance and static stretching program were studied.

2. Materials and Methods

2.1 Experimental Approach to the Problem

A randomized repeated measured experimental was designed to test the hypothesis that acute effects of a complete warm-up program with normal temperature (The 11+) or hot temperature (The 11+ HOT) condition affects repeat sprint ability (RSA) and percentage decrement score (%Decre) differently.

2.2 Subjects

Twenty-one male football players of the Sports Science and Technology, Bangkok Thonburi University, Bangkok, Thailand, age 19.2 ± 0.7 years, resting heart rate 65.3 ± 3.6 beats.min^{-1}, height 174.1 ± 5.5 cm, weight 64.8 ± 6.7 kg, body mass index 21.3 ± 1.7 kg.m^{-1}, football experience 8.9 ± 2.6 years, VO_2max 45.1 ± 4.1 ml/min/kg, regular training five times per week, no injury throughout three months priory to this study, participated in the study. A physical activity readiness questionnaire (PAR-Q) was used as a general health checkup tool.

2.3 Testing Procedures

Subjects were divided into two groups (Group-A and Group-B) of 10 and 11 persons, respectively, by drawing lots. Group-A and Group-B performed two different stretching protocols on two nonconsecutive days (a week apart). Two different stretching protocols included The 11+ warm-up program with hot temperature protocol (35-38 degrees Celsius, The 11+ HOT) and The 11+ warm-up program with normal temperature protocol (25 degrees Celsius, The 11+). Stretching protocols for each group were randomized five minutes before the first testing. The 11+ HOT was performed in the main stadium that was outdoor in hot environment with, 35-38 degrees Celsius and The 11+ was performed at room temperature with 25 degrees Celsius. In 11+ HOT conditions, if the outdoor temperature was not in the range of 35-38 degrees Celsius, the experiment was set the next date. Repeat sprint ability test (RSA) was performed after warm-up at a laboratory room. There were three testing days (Day 1-3) for this experiment. Day 1st was used for subjects to be familiarized with the testing procedures, such as performing a minimum of trial and maximum oxygen consumption

(VO_2Max). Day 2nd and Day 3th were set to test the effect of warm-up protocols. For example, on Day 2nd, Group-A was tested with The 11+ HOT, and Group-B was tested with The 11+, and then Day 3 was alternate. Before RSA, subjects were jogging with four minutes and resting with two minutes followed by The 11+ HOT or The 11+. Collected data were stretching protocols format (The 11+ HOT and The 11+) from Group-A and Group-B. For example, RSA result of The 11+ HOT was collected from Group-A and Group-B.

2.4 Warm-up protocols

The 11+ warm up program consisted of 3 parts. Part one was jogging combined with active stretching and controlled after contacts with a partner. The running course included six to ten pairs of cones (depending on the number of players) about 30-40 meters. Part two consisted of six different exercises that included strength, balance, and jumping, each with three levels of increasing difficulty. For this study, level 1 to stretch was used. Final part was speed running combined with football specific movements with sudden changes in directions [16].

2.5 Repeat sprint ability test

The purpose of RSA was to assess reduction in the maximal speed or fatigue. The RSA consisted of seven 30-m sprints (7 x 30m) separated by a 25-second active recovery period behind starting line and a wait for the next sprint. A hand-held stopwatch measured the time for the 25-second recovery. The sprint times were recorded by a hand-held stopwatch. Subjects stood 0.5m behind the start line before they started each sprint, starting from a standing position. Subjects were given strong verbal encouragement throughout all trials to ensure maximal effort. RSA was analyzed by four methods: a) the fastest sprint time (FST) among the sprints, b) average sprint time (AST) among sprints, c) total sprint time (TST), and d) percentage decrement score (%Decre) or fatigue which was calculated by TST that was divided from FST multiply with number of sprints. Then, the result was taken by obliterate 1 and multiply 100 [21].

Statistical analysis

Before using parametric tests, the condition of normal variation was verified using the Shapiro–Wilk W-test. Acute effects of a complete warm-up program in heat acclimatization on RSA performance in football players were determined by using pair *t*-test. All data were expressed as means ± SD. Significance was accepted at $p< 0.05$.

3. Results

Results from RSA test were shown in Table 3.1. The data showed that there were no significant differences between the two conditions in FST, AST, and TST. However, the %Decre with The 11+ HOT was lower when compared with the 11+ condition. Additionally, Figure 3.1 showed the magnitude of %Decre in the bar graph display.

Table 3.1 Repeat sprint ability test (RSA). The data were mean ± SD.

Repeat sprint ability test	The 11+	The 11+ HOT
Fastest sprint time, FST (s.)	4.26 ± 0.18	4.27 ± 0.22
Average sprint time, AST (s.)	4.60 ± 0.20	4.54 ± 0.22
Total sprint time, TST (s.)	32.21 ± 1.39	31.82 ± 1.54
Percentage decrement score (%Decre)	8.08 ± 3.25	6.51 ± 2.76*

*$p < 0.05$ significant between The 11+ HOT vs The 11+

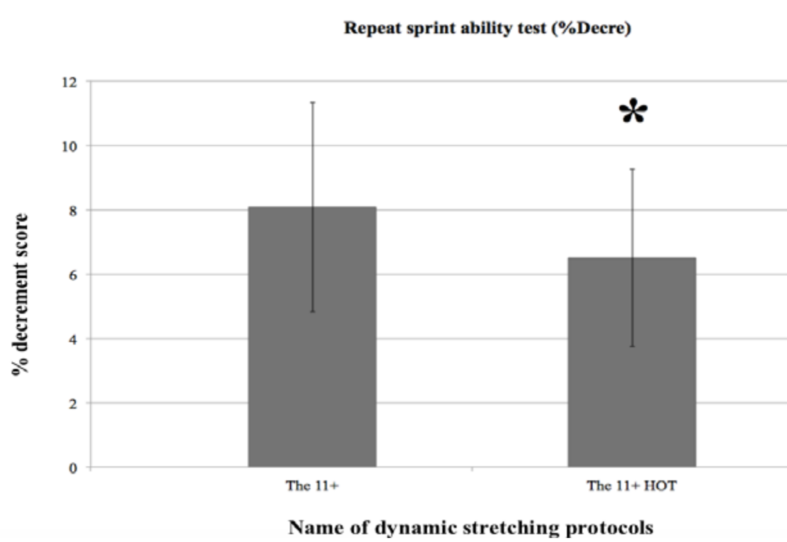

Figure 3.1 The %Decre, $p < 0.05$ was significant between The 11+ HOT vs. The 11+. The data were mean ± SD.

4. Discussions

This study investigated the acute effects of a complete warm-up program, applied to dynamic stretching, in a heat environment conditions on repeat sprint ability test (RSA) in football players. This investigation showed that a complete warm-up program in heat environment could significantly improve the %Decre of RSA performance at room temperature test (about 25.13 ± 0.12 °C, 34% humidity). Furthermore, results of a complete warm-up program in heat environment demonstrated that dynamic stretching could have a tendency to improve the FST, AST and TST of RSA performance.

According to previous research, the study found insignificant effect of a complete warm-up program in heat environmental on the FST of RSA performance. Bishop and Maxwell [23] and Backx et al. [24] reported similarly to our results and concluded that short sprint performance was not unduly affected by an active warm-up in heat environmental conditions. In contrast, some previous studies showed significant increases in peak power or short sprint following warm-up program [28]. So, previous investigations manipulated peak power or short sprint performance tests of 10s. to 20s. This is unlikely to explain the contradictory results as peak power or short sprint performance should occur in the 5s as this study. The most important thing in sprinting is from previous studies that investigated the effects of active warm-up or dynamic stretching on single sprint performance, rather than multiple sprint performance [23]. Possibly, a subconscious pacing strategy by participants during RSA determines the overall pacing strategy use during exercise by matching the rate of energy expenditure and the current energy reserves with the predicted energy cost of the exercise [34] to possibly affect multiple sprints interfering with the expected ergogenic effects of dynamic stretching on the FST of RSA performance. According to this study, it showed that the FST of RSA performance in The 11+ (25.13 ± 0.12 °C) and The 11+ HOT (38.88 ± 0.76 °C) were not different; therefore, subjects who were in The 11+ HOT might manage energy to be average peak power to seven sprints test, and dynamic stretching in heat environment did not fully affect to the FST of RSA performance in this study. Furthermore, Girard et al. [33] suggested that the FST of RSA performance or single sprint was failed reports because of the myriad of confounding external and internal factors, which was a lone or combination to influence the FST of RSA performance or single sprint.

An interesting observation in this study is the AST and TST of RSA performance that showed an improvement following a complete warm-up program in heat environment (not significant) in The 11+ HOT when compared with The 11+, agreeable with the results of previous that have significant increases in mean sprint performance [28, 30]. Falk et al. [28] investigated that heat (35 °C) could develop mean power in sprint performance. They explained that temperature elevations could improve the faster rate of phosphocreatine (PCr) utilization and greater anaerobic adenosine (ATP) turnover to affect a contractile adaptations of the muscles [19, 20] which would improve the AST and TST of RSA performance. Gray et al. [20] found that PCr and ATP content decreased significantly in all fiber types, with a greater decrease during the elevated condition (37.3 °C) in type IIA fibers than in the normal trial, which contributed to the higher maximal power output (20). Sargeant [26] reported that for every 1 °C increase in muscle temperature was a concomitant 4% increase in power output. According to this investigation, environment temperature while this study (38.88 ± 0.76 °C) might cause to elevate body temperature and improve average running speed trivially in The 11+ HOT. The potential of heat acclamation might affect a little improvement of the FST, AST and TST of RSA performance in The 11+ HOT because subjects were football players of the Faculty of Sports Science and Technology who trained four to six times/week at noon and late noon (35-39 °C). Therefore, subjects may get acclimated to the heat before this study. Castle et al. [27] investigated the 10-day acclimation period to reduce resting rectal temperature about 0.4 °C, increasing 2% in peak power output during sprint protocol in the heat. They concluded that heat acclimate could increase peak and mean power output [27].

The %Decre of RSA performance is a considerable performance in football which can identify a fatigue during match or race which reduces the maximal power output or speed developed rapidly after the first sprint and presented a significant enhancement (6.51 ± 2.76% vs 8.08 ± 3.25%) after a complete warm-up program in a heat environment conditions (The 11+ HOT, 38.88 ± 0.76 °C) when comparing with a complete warm-up program in room temperature (The 11+). A complete warm-up program may affect Post-activation potentiation (PAP) which is the important role of dynamic stretching. PAP is defined as an increase of the efficient muscles to product sub-maximal force after voluntary contraction that is produced by regulatory light chain (RLC) phosphorylation and increases the number of force-producing crossbridge under conditions of suboptimal Ca2 activation. It may potentially increase the rate constant of crossbridge attachment. Needham et al. (12) reported dynamic stretching and dynamic stretching followed by eight front squats plus 20% body mass (DSR) to positively affect 20-m sprint test immediately, and three and six minutes after stretching protocol. They suggested that one of the possible mechanisms behind the enhanced sprint performance after dynamic stretching is PAP (12). An improvement in the %Decre of RSA performance was observed by Falk et al. [28], Lacerda et al. [35], and Girard et al. [25]. These investigators studied the effects of heat exposure on anaerobic or RSA performance to show that subjects who were tested in heat could increase 6-8% of power output higher in 35 °C compared with 22 °C and peak power output decreased 19.7 and 16.5% from sprint one to sprint 10 in 24 °C compared with 35 °C, respectively [25, 28, 35]. Girard et al. [25] suggested that the increase in core and/or muscle temperature has been proposed to improve sprint or RSA performance via decreased resistance muscle and joint, increased anaerobic metabolism, as well as an increase in nerve conduction rates. Nevertheless, a core temperature is not collected in this investigation. Although Fritzsche et al. [14] suggested that dynamic stretching can increase core temperature and heart rates during cardiovascular drift were strongly correlated. Generally, much research reported that the %Decre of repeat sprint (RS) performance (5x15s sprints with 15s of rest) in heat condition (40 °C) was impaired when core (~ 39.5 °C), and muscle (~ 40.2 °C) temperatures was simultaneously elevated as a result of 40 mins of intermittent cycling in heat [22]. Nybo et al. [17] studied competitive intermittent exercise in the heat effect to recovery and aggravating markers of muscle fiber damage during 48 h of recovery from a match played (90 mins.) in 43 °C and control match (90 mins.) in 21 °C. They found that RS performance was impaired by ~2% immediately after the matches because muscle glycogen levels were still depressed [17]. Girard et al. [33] suggested that high core temperature seemed to be a primary factor limiting RS performance in the heat by negatively influence the central nervous system function, which also negates the beneficial effect of a higher muscle temperature. However, this study showed that the %Decre of RSA performance in The 11+ HOT is better than The 11+ because of The 11+ HOT is warm-up in heat environment about 20-30 minutes to may cause core temperature elevations lower than 38.5 °C and enable the improvement of the %Decre of RSA performance in The 11+ HOT that across from Nybo et al. [17] and Girard et al. [9], who had a 90-109 minutes of active activity to induce declines in the %Decre of RSA performance.

Heat acclimation may be positive affected The %Decre of RSA performance of The 11+ HOT of the football players of the Faculty of Sports Science and Technology to practice at noon and late noon (35-39 °C) about four to six times/week, 10 weeks, more than The 11+. According to Sawka et al. [32], it was suggested that heat acclimation requires a minimum daily heat exposure of two hours combined with aerobic exercise, completing after 10 to 14 days of exposure. Moreover, chronic heat exposure increases high-intensity and endurance performance in the heat in team-sport populations [31, 32]. Heat acclimation may improve aerobic performance [32], a faster rate of PCr utilization [19], reducing H+ accumulation affecting to decrease The %Decre of RSA performance in The 11+ HOT than The 11+. In contrast, Ball et al. [19] studied power output in normal and heat environment. They found that a faster rate of fatigue when exercise was performed in the heat compared to the normal environment [19].

5. Conclusions

The data obtained supported the hypothesis that a complete warm-up program under hot temperature in football players can improve anaerobic performance which is different from under room temperature.

A complete warm-up program under hot temperature can improve anaerobic performance distinctly in football players by elevating muscle temperature, and reducing the viscous resistance of muscle may be linked to the rehearsal of specific movement patterns.

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