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Original article

The acute effects of caffeine ingestion on reactive agility performance in soccer players

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Abstract. *Study Objectives:* Caffeine has been shown to provide ergogenic benefits to sports performance. However, limited research is available on the effects of caffeine on agility performance. The study aimed to evaluate the acute effects of caffeine ingestion on reactive agility performance in soccer players. *Methods:* A total of forty-eight healthy male (age = 16.5 ± 0.5 years, height = 172.3 ± 4.5 cm, body mass = 64.5 ± 5.6 kg, training age: 6.77 ± 1.56 years) youth soccer players volunteered to participate in this study. Participants ingested 6 mg·kg^{-1} caffeinated coffee (caffeine group) or 6 mg·kg^{-1} decaffeinated coffee (placebo group) or no coffee (baseline group) with randomized, counter-balanced, single-blind, and repeated-measures experimental design. Movement time (MT), sprint time (ST), total agility time (TAT), and decision time (DT) were analyzed using by one-way repeated-measures ANOVA. *Results:* There were statistically significant differences among the baseline, caffeine, and placebo conditions on MT (p=0.005), ST (p=0.000), TAT (p=0.000), DT (p=0.000). There were significant differences in MT with caffeine compared with the placebo group (p=0.005). It is seen that the ST value has a significant difference in baseline condition compared to caffeine and placebo group (p=0.000 and p=0.002). There were statistically significant differences between caffeine and baseline status on TAT (p=0.000). There were statistically significant differences between caffeine and baseline condition (p=0.000) and placebo (p=0.000) condition on DT. *Conclusion:* It can be said that caffeine intake has a positive effect on ST, TAT, and DT components compared to baseline and placebo. Considering the MT values, it is seen that the mean of MT with caffeine is lower than the placebo but higher than the baseline. Caffeine ingestion may supply ergogenic benefit on the reactive agility performance of the soccer players.

Keywords: Caffeine Ingestion, Athlete, Performance, Reactive Agility

Introduction

Soccer is a team sport and achievement in this discipline depends on some factors including physical fitness, technique, and tactics. Soccer is defined by the continuous combination of short sprints, fast accelerations/decelerations, and changes of direction dabbled with jumping, kicking, tackling. Also, these physical fitness factors, techniques, tactics, cognitive ability, and psychological factors may affect on soccer performance (1,2). The investigation of the effects of ergogenic supplementation on athletic performance has become a major topic for players and trainers associated with soccer because it can enhance achievement during the play (2).

Caffeine is a drug that is commonly consumed in the world. It has an important effect on many activities of people. They who use this drug can feel better themselves and have more energy and quality of life (3). Caffeine is also mostly used by athletes, and there are many studies about caffeine's ergogenic or "work enhancing" effects in sport fields (4). Related studies determined that caffeine at doses of 6-9 mg/kg/body mass, or ~3-4 cups of coffee, was effective at improvement of endurance in sport fields (4-7). Foskett, Ali, and Gant (2009) evaluated that the ingestion of 6 mg/

kg of caffeine before exercise developed passing accuracy and accrued considerably less penalty time during the test (8). Jordan et al. (2014) reported that the consumption of 6 mg/kg of caffeine 1 hour before the test remarkably developed the reaction time of the soccer players (9). Apostolidis et al. (2018) observed that the intake of 6 mg/kg of caffeine 1 hour before the test developed neuromuscular performance and aerobic endurance in well-trained athletes (10). According to the results of the research, the intake of the caffeine may be efficient to increase performance in athlete' abilities and soccer-specific skills.

Agility can be described as "a rapid whole-body movement with change of velocity or direction in response to a stimulus" (11). In the literature agility and change of direction are used interchangeably. In some sports, during the game a change of direction is often executed in response to un-predictable visual stimuli, and the maneuvers are related agility might not be pre-planned (12). That's why, the real-sport-agility depends on fast and accurate responses to stimuli specific to sport environments. As you can see while a change of direction is used in planned movements, the reactive agility is used to explain unplanned movements in sports (13,14). Many traditional tests of agility only assess change-of-direction speed; they do not incorporate a decision-making component (11). These tests include the planned movements and could not be representative of the agility needed during the game. Because they do not have a cognitive component in which a player reacts to an opponent's movements. In addition planned agility has also been found to not differentiate between players of different athletic skills (15).

The reactive agility tests (RAT) in which the ability of players to read and react to a stimulus were developed by researchers to have a correct evaluation of the agility (12,15). These tests are valid and reliable and could find out the differences between the high level and low level of athletes in the sports of netball (15), rugby league (12), and Australian football (13). In the literature there is much research about the effect of caffeine on athletic performance in adults (16,17). But there is a lack of literature evaluating caffeine's effect on the athletic performance of young athletes. The first research was conducted by Pontifex et al. (2010) to test caffeine's effects on a RAT in adults. They reported that a caffeine supplement did not have a significant development on the RAT when compared with the placebo (18). Hovewer, Young and Farrow (2013), Lorino et al. (2006), and Duvnjak-Zaknich et al. (2011) detected that caffeine intake increased reactive agility performance in male athletes in their studies (19-21). Much research is necessary to measure the effect of caffeine on reactive agility where the performance requires both a cognitive and a physical response. Therefore, the present study aimed to evaluate the acute effects of caffeine ingestion on reactive agility performance in soccer players.

Material and Methods

Participants

Forty-eight healthy male, youth soccer players volunteered to participate in this study (mean ± *SD*: age = 16.5 ± 0.5 years, height = 172.3 ± 4.5 cm, body mass = 64.5 ± 5.6 kg, training age: 6.77 ± 1.56 years). All subjects were elite status. They had similar conditioning levels and expertise participating in 4 training sessions and 1 match per week. The participants were limited to the players of the same team so that the training effect did not affect the test results. The subjects were informed about the possible risks and benefits of the study and gave their informed consent to participate in this study, which was approved by the Clinical Research Ethical Committee of Pamukkale University (60116787-020/28623).

Experimental design

On the first day, anthropometric measurements were taken and players were adapted to the RAT. Each subject's height and body mass were recorded before completing any testing. Participants ingested 6 $mg \cdot kg^{-1}$ caffeinated coffee (caffeine group), 6 $mg \cdot kg^{-1}$ decaffeinated coffee (placebo group), and no coffee (baseline group) with randomized, counter-balanced, single-blind, and repeated-measures experimental design. There were 48 hours between each testing session for the recovery. Players were asked to refrain from consuming caffeine in the 24-hr period before testing and were given a list of foods and beverages that contain caffeine. Participants were also asked to refrain from food and beverages 1-hr before testing. All subjects were tested at the same time of the day (between 09:00-12:00). It was requested to be consumed their coffees which dissolved in 300 ml of hot water 10 minutes by the participants. One hour later RAT test was carried out. As the literature indicates caffeine's peak blood serum levels are reached in this time frame, a 1-hour wash-in period was considered (17). Before testing, players completed standard team warm-up which consisted of a 10-minute possession game interspersed with squat jumps and concluded with 5 to 10 near maximum sprints of no more than 10 m in distance.

Reactive agility test (RAT)

Reactive agility test was completed on a regulation indoor soccer court surface. Four dual beam timing gates (Swift Technologies) were placed on the court surface to allow the collection of movement time, sprint time, total agility time and decision time resulting from completion of a soccer specific agility pattern (Figure 1).

Four parameters were measured from a combination of the timing gates and the video record. All times are reported in milliseconds. *Movement time (MT)* was defined as from the start of the test until the completion of the side-stepping component and the first meter of forward movement (or from the start gate to gate 2). *Sprint time (ST)* was the time it took subjects to complete the final 8.1 m sprint (or from gate 2 to gate 3 or 4). *Total agility time (TAT)* was the time it took from the start to finish of the test. *Decision time (DT)* of the subjects was recorded through the post-hoc inspection of the video-footage (50 Hz). DT was the difference in time between ball release by the passing player (on the video projection) and the first definitive foot contact of the participant that initiated her final direction of travel in an attempt to intercept the pass. This was considered to reflect the subject's assessment of the perceptual display and time to decide as to which direction to respond (15). Participants were given 60 seconds of rest between each trial. 3 measurements were taken and the best score was recorded.

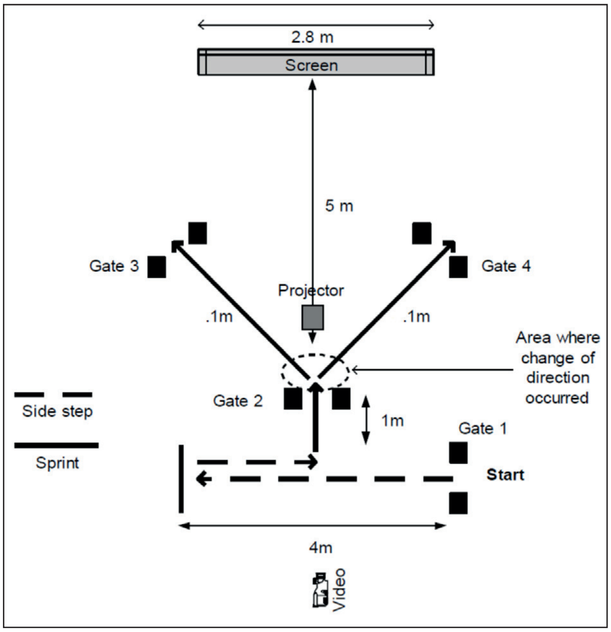

Figure 1. Reactive agility test set-up (15).

Picture 1. Reactive Agility Test View

Statistical analysis

In the statistical analysis of the data, descriptive analyzes of test measurements of soccer players were calculated as mean and standard deviation. Dependent variables (MT, ST, TAT, and DT) were analyzed using by one-way repeated-measures ANOVA. Bonferroni post hoc analysis was applied to determine the condition under which the difference originated. The obtained data were evaluated with SPSS 23.0 program and the statistical significance was set at $p<0.05$.

Results

There were statistically significant differences among the baseline, caffeine, and placebo conditions on movement time (WilksLambda = 0.795; F = 4.589;

p=0.005; $\Delta\eta^2$=0.205) (Table 1). A post hoc test using a Bonferroni adjustment revealed a significantly different MT with caffeine compared with the placebo condition (p=0.005). We can explain that caffeine has a positive effect on MT compared to the placebo condition.

There were statistically significant differences among the baseline, caffeine, and placebo conditions on sprint time (WilksLambda = 0.520; F = 13.084; p=0.000; $\Delta\eta^2$=0.480) (Table 1). According to the Bonferroni test results, it is seen that the baseline status creates a significant difference with both caffeine and placebo status (p=0.000 and p=0.002). When we look at the sprint time values, it is seen that the sprint time is 1,936s in the case of caffeine condition and 1,965s in the placebo case. It is seen that the ST value has a significant difference in baseline condition compared to caffeine and placebo condition.

There were statistically significant differences among the baseline, caffeine, and placebo conditions on total agility time (WilksLambda = 0.201; F = 4.349; p=0.000; $\Delta\eta^2$=0.799) (Table 1). According to the Bonferroni test results, there were statistically significant differences between caffeine and baseline status (p=0.000). It can be said that caffeine intake caused a significant decrease in total agility time.

There were statistically significant differences among the baseline, caffeine, and placebo conditions on decision time (WilksLambda = 0.132; F = 1.419; p=0.000; $\Delta\eta^2$=0.868) (Table 1). According to the Bonferroni test results, there were statistically significant differences between caffeine and baseline condition (p=0.000) and placebo (p=0.000) condition. It can be said that caffeine intake has a positive effect on decision time. When the decision periods in all three conditions are analyzed, it is seen that the decision time is faster in caffeine intake.

Table 1. Repeated-measures ANOVA results

	Mean ± SD	N	df	F	p	$\Delta\eta^2$
Movement Time (sec)						
Baseline	2,71 ± ,13					
Caffeine	2,73 ± ,11*	48	2	4,58	0,005	,205
Placebo	2,75 ± ,11					
Sprint Time (sec)						
Baseline	2,06 ± ,19**					
Caffeine	1,93 ± ,12	48	1	13,08	0,000	,480
Placebo	1,96 ± ,18					
Total Agility Time (sec)						
Baseline	4,78 ± ,22#					
Caffeine	4,69 ± ,20	48	1	4,34	0,000	,799
Placebo	4,73 ± ,25					
Decision Time (sec)						
Baseline	0,84 ± ,11					
Caffeine	0,77 ± ,09&	48	1	1,41	0,000	,868
Placebo	0,83 ± ,10					

** significant difference with placebo (p=0,005); ** significant difference with caffeine (p=0,000) and placebo (p=0,002); # significant difference with caffeine (p=0,000); & significant difference with baseline (p=0,000) and placebo (p=0,000)*

Discussion and Conclusion

The present study aimed to evaluate the acute effects of caffeine ingestion on reactive agility performance in soccer players. By using a reactive agility test, caffeine's effect on agility performance was evaluated based on cognitive and physical components of agility. There were significant differences among the baseline, caffeine, and placebo conditions on MT, ST, TAT, DT (p<0.05). We can explain that caffeine has a positive effect on MT compared to the placebo condition. Also, it is seen that the ST value has a significant difference in baseline condition compared to caffeine and placebo condition. It can be said that caffeine intake caused a significant decrease in TAT and caffeine intake has a positive effect on DT. We can see from the table 2, DT value with caffeine was lower in all conditions.

The findings from our study show similarity with the finding by Duvnjak-ZaZaknich et al. of improvements from caffeine intake in total time, reactive agility time, movement time, and decision time measurements of a RAT (21). But, they failed to document a level of statistical significance, potentially due to the small sample size (n=10). This result shows that there is potential for caffeine to develop the reactive agility performance in elite youth athletes. However, Jordan et al. (2014) reported that caffeine intake did not have a significant effect on sprint performance including RT and MT in their studies. Caffeine may affect TAT performance through improvements in RT and so could be important during the game (9). The results of this study are an incoherent result with the results of our and other researches assessing caffeine's effect on MT (23-25).

Most experimental studies evaluating the potential for caffeine to enhance athletic performance has been done in laboratory conditions with firmly controlled trials. Some studies have evaluated the effects of caffeine on repeated sprinting tasks (26), reactive agility tests (21), and sport situations including tennis, soccer, rugby, volleyball, basketball, and field hockey (6,27,28). These studies have shown documents that caffeine develops athletic performance and skill performing in intermittent type sports.

Caffeine is a potent drug that produces a wide range of metabolic, hormonal, and physiologic effects on the organism (29,30). These effects can support an improvement in sports performance. It has been detected that caffeine intake enhances the perceived muscle power during simulated competitions of athletes in several sports activities (31). For instance, the acute ingestion of caffeine increased the rate of technical elements qualified as positive for the game in male (32) and female volleyball players (28). In basketball players, caffeine was found to increase the number of rebounds, assists, and the performance parameters (33). Foskett, Ali, and Gant (2009) detected that 6mg per kilogram of body mass increased both passing accuracy and jumping performance (3.9% better than placebo), in 12 male footballers during a 90-min football-specific intermittent running trial (8).

A lot of studies have examined the effects of caffeine on cognitive function and perception during the game in team sports. Hogervorst et al. (2008) suggest that a low dose of caffeine enhances cognitive performance during and after vigorous exercise. In that study, the athletes completed the tests considerably faster and took longer to finish the time to exhaustion test after taking caffeine compared to the placebo (34). Therefore, caffeine intake can remarkably improve endurance performance and cognitive ability during and after extensive exercise. Caffein's effects may be considered for athletic performance in sports activities in which concentration and decision making play a major role. In addition Stevenson, Hayes, and Allison (2009) demonstrated how caffeine intake not only improved the performance of golf players, but also managed to increase their alertness and positively affect their mood compared to the placebo (35).

Much data recommend that caffeine also increases the physical and technical elements of performance in athletes during the game in sport fields. For instance, caffeine can improve repeated sprint and reactive agility (21,36) during intermittent-type sports. Some studies have evaluated the effects of caffeine on repeat sprint performance in team sports (21,26,36-38). Paton and Vollebregt (2001), and Woolf, Bidwell, and Carlson (2009) all detected that there was no difference in sprint performance when caffeine intake was compared to placebo (37,38). And also, Astorino and Robertson (2012) reported no effect of caffeine on sprint times in soccer players (39). But caffeine has been evaluated to increase sprint performance in team sport players following intaking of anhydrous caffeine (23) and a caffeinated beverage (40) compared to placebo.

Although high-speed actions which include agility only contribute to; 11% of the total distance covered during the game, they constitute the more crucial moments of the game and contribute directly to winning possession of the ball and to scoring or to conceding of goals (22). So, the ingestion of caffeine may be useful for developing the athlete's sprint performance and so may influence the results of soccer matches.

Caffeine's effect on the central nervous system (CNS) may be the reason for the improvements in reaction time. Because caffeine can function as an adenosine receptor antagonist, which lowers the threshold for motor unit recruitment (41). The caffeine could reduce the effect of unrelated visual information and support decision-making accuracy, especially as athletes become fatigued during the game. When the athletes are not tired, a direct stimulation of the CNS, developing neural firing rates, and the release of stimulatory neurotransmitters may clarify the progression in the agility performance of the athletes (21). According to the findings of this study, significant improvements were found on ST, TAT, and DT parameters with caffeine intake. The reason for this may be the blocking of adenosine receptors in various tissues in the body, producing a stimulatory effect on the CNS. However, for more realistic results, more research with the caffeine intake and youth sports performance is needed.

As a result, it can be said that caffeine intake has a positive effect on ST, TAT, and DT components compared to baseline and placebo. Considering the MT values, it is seen that the mean of MT with caffeine is lower than the placebo but higher than the baseline. Caffeine ingestion may supply ergogenic benefit on the reactive agility performance of the soccer players.

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Conflicts of interest

The authors declare that there is no conflict of interest about this manuscript.

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