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INFLUENCE OF CAFFEINE ADMINISTRATION ON THE ENDURANCE PERFORMANCE OF UNIVERSITY FOOTBALL PLAYERS

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ABSTRACT

The stimulating properties of caffeine can alleviate feelings of tiredness and drowsiness and even enhance sports performance. A study was conducted in South Punjab, Pakistan, with male university football players aged 18 to 25 years. The study was a randomized, placebo-controlled single-blind parallel-group trial with a total of 120 participants divided into four groups of 30 each. Each group was given a different dose of caffeine in capsule form: Group A received 3 mg-kg^{-1}, Group B received 6 mg-kg^{-1}, Group C received 9 mg-kg^{-1} and Group D was given a placebo 0 mg-kg^{-1}. Endurance performance was measured before and after caffeine administration and statistical analyses such as paired sample ''t''-test, ANOVA and Pearson correlation were performed on the data using GraphPad Prism version 6.0 software. The results showed that all three groups that received caffeine in doses of 3, 6, and 9 mg/kg^{-1} experienced significant improvements in their endurance performance. The study concluded that high doses of caffeine (9 mg/kg^{-1}) had the most noticeable effects on the endurance performance of university football players.

INTRODUCTION

Football is a very famous game worldwide because of its different and distinctive aspects like field size, number of players and level of difficulty when compared to other sports (Schulenkorf et al., 2016). Because each position in the game has different tasks, it's important to evaluate the physical and mental demands of every player (Goksu & Yuksek, 2018). Many researchers have looked at how caffeine affects football players' endurance performance in recent years (Ellis et al. 2018; Ranchordas et al. 2018). The word "caffeine" comes from French and German words related to coffee, which shows how coffee spread from Arabia and Turkey to Europe (Shadaia, 2020). Caffeine is the most commonly used drug in the world, with more than 90% of adults using it daily. In elite sports, 75% of athletes have said they have taken drugs before or during competitions. Caffeine has been allowed during competitions even though it was previously prohibited by the World Anti-Doping Agency (WADA) (Wu, 2014).

The International Olympic Committee advises athletes to take 3-6 mg of caffeine per kilogram of their weight before exercising to enhance their performance and athletes often take this amount in competitions (Mielgo-Ayuso et al., 2019). Research has found that taking 9 mg of caffeine per kilogram of body weight doesn't go above the previous IOC limit of 12 mg/L of caffeine in urine after exercising (Magkos & Kavouras, 2005; Beaven et al., 2008).

Caffeine is a strong substance that can enhance both physical and mental performance (Cappelletti et al., 2015). When you consume it, the body absorbs it fast and it reaches its highest level in the blood between 15 to 120 minutes. After 3 to 4 hours, the level of caffeine in the body starts to decrease (Grgic et al., 2019). Caffeine has an impact on all cells in the body, such as those in the central nervous system, muscles, and fat, similar to many other supplements and medications (Sellami et al., 2018). Caffeine can activate the nervous system and brain, leading to more awareness and energy, and less tiredness (Lima-Silva et al., 2021). It can enhance performance by raising the amount of adrenaline, which is the hormone that causes the "fight or flight" response (Barreto et al., 2021). It mostly has to do with the brain's adenosine receptors A1 and A2 being inhibited, which lessens sensations of central fatigue (Lynge & Hellsten, 2000; Barcelos et al., 2020). Adenosine is widely regarded as caffeine's primary ergogenic mechanism because it lowers physiological arousal and neuronal excitability by blocking the production of excitatory neurotransmitters in the brain (Barcelos et al., 2020; Dunwiddie & Masino, 2001). Functional heteromers are created when dopamine D1 and D2 receptors in the CNS connect with adenosine A1 and A2a receptors. In this approach, coffee increases psychomotor activity by inhibiting adenosine A2a receptors and excites the potentiation of D2 receptors (Ballesteros-Yanez et al., 2018). Caffeine may affect performance via peripheral processes such as effort awareness, voluntary motor unit activation, contractile muscle function, calcium release and uptake in the sarcoplasmic reticulum and the activity of sodium/potassium ATPase pumps. Epinephrine circulation, free fatty acid mobilization, reserve glycogen and endorphin release are all increased by coffee (Wan et al., 2017). The evaluation of the player's endurance performance was carried out by administering Yo-Yo Intermittent Recovery Level 1 (YYIR1) test to determine

how effectively football players perform after consuming multiple doses of caffeine.

METHODOLOGY

The aim of this research was to examine how caffeine intake affects the endurance performance of male university football players in the Multan zone, south Punjab, Pakistan. To achieve this goal, a randomized, placebo-controlled, single-blind parallel groups trial was conducted, involving 120 participants who were selected after undergoing pre-study screening procedures, including filling out a Pre-participation Screening Questionnaire adopted by AHA/ACSM Health/Fitness Facility (Balady et al., 1998). Only participants who met the exclusion criteria were included in the study. The selected participants, aged between 18 and 25 years, had a mean age of 22.39 ± 1.69 years, a mean height of 172.9 ± 5.85 cm, a mean body mass of 70.12 ± 5.03 kg, and a mean body mass index of 23.45 ± 1.43 kg/m^2. The participants were divided into four groups, each group consisting of 30 players, to evaluate the impact of caffeine intake on endurance performance. On average, participants consumed 150.1 ± 39.6 mg of caffeine daily as part of their regular routine. To ensure accurate testing, the football players refrained from intense physical activity and followed a regular diet for 48 hours prior to testing. They were instructed not to consume caffeine until 24 hours before the experiment. The endurance test was conducted under specific environmental conditions (Temperature +79°^{F}, Real Feel +79°^{F}, Atmospheric pressure 30$_{hg}$, Wind speed 1.6 mph (N), Humidity 50%) at the same time of day. Endurance performance time was measured before taking caffeine and then three different doses of caffeine were given to three groups (A, B and C) in capsule form. Group A received a low dose of 3 mg-kg^{-1}, Group B received a medium dose of 6 mg-kg^{-1}, and Group C received a high dose of 9 mg-kg^{-1}. Group D served as a placebo control group and received no caffeine. After taking an oral dose of caffeine, the players were directed to remain motionless for an hour. The doses mentioned have been documented in earlier research studies (Beaven et al., 2008; Wu, 2014), and it's important to note that the maximum level of caffeine in the blood is typically reached an hour after consumption (Graham, 2001). The study aimed to investigate the effect of caffeine intake on endurance performance by conducting an endurance test on the experimental and placebo groups after 60 minutes of caffeine intake. To assess the impact of caffeine on endurance performance, the Yo-Yo Intermittent Recovery Level 1 (YYIR1) test, commonly used in football-specific testing, was administered. Before the test, participants completed a 15-minute standard warm-up routine to engage their muscles and increase their heart rate. Endurance performance was measured both before and after caffeine consumption. Previous studies have also employed the YYIR1 test in football-related research (Ranchordas et al., 2018; Ellis et al., 2018). The researcher utilized the Yo-Yo Intermittent Recovery Level 1 (YYIR1) (Bangsbo, Iaia, & Krustrup, 2008) was then carried out, requiring 2 x 20 m shuttle runs that were incrementally accelerated by auditory signals. Participants ran around a cone that was placed five meters beyond the starting line during the 10 seconds of active recovery that followed each run. Before the audio indicator signaled the end of the test, there were two consecutive failures to cross the finish line. To establish consistency, the researcher verbally encouraged all tests and this was repeated on the second

visit. The effects of different caffeine doses on endurance performance were analyzed using statistical methods in GraphPad Prism version 6.0 software. The researchers used paired sample t-tests, ANOVA and Pearson correlation to investigate the relationship between caffeine dosage and endurance performance.

RESULTS

Table 4.1: Participants of the research

Game	Groups	No. of Players	Percentage
Football	A	30	25%
	B	30	25%
	C	30	25%
	D	30	25%
Total		120	100%

The number of participants in the study was provided in Table 4.1, which showed that a total of 120 football players from a university participated in the study. These players were grouped into four different groups, each group comprising 30 university-level football players.

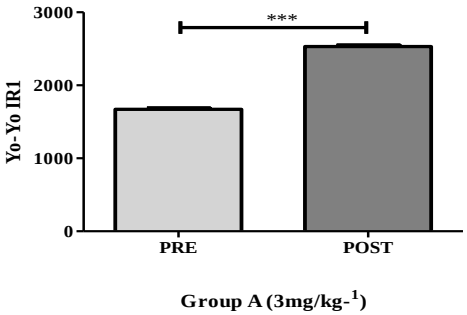

Figure 4.1: Presenting pre vs post-test score of Yo-Yo IR1 in Group A Dose (3mg/kg-^{1})

The average distance (m) of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 1671± 15.18 m before administering a 3mg/kg dose of caffeine, which increased significantly by 52 percent 60 minutes after dose administration. Whereas, the average score of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 2532± 15.60 m in football players in post-dose administered condition.

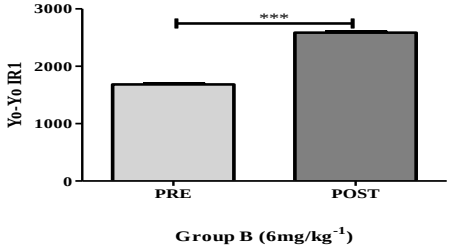

Figure 4.2: Presenting pre vs post-test score of Yo-Yo IR1 in Group B Dose (6mg/kg-^{1})

The average distance (m) of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 1683 ± 16.38 m before administering a 6mg/kg dose of caffeine, which increased significantly by 54 percent 60 minutes after dose administration. Whereas, the average score of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 2587 ± 18.03m in a football player in a post-dose administered condition.

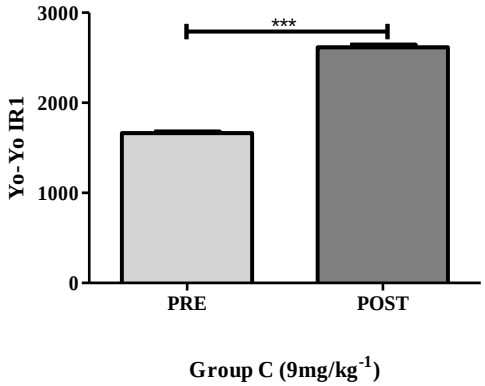

Figure 4.3: Presenting pre-test vs post-test Score of Yo-Yo IR1 in Group C Dose (9mg/kg-^{1})

The average distance (m) of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 1663 ± 16.90m before administering a 9mg/kg dose of caffeine, which increased significantly by 57 percent 60 minutes after dose administration. Whereas, the average score of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 2617 ± 27.24m in football players in post-dose administered condition.

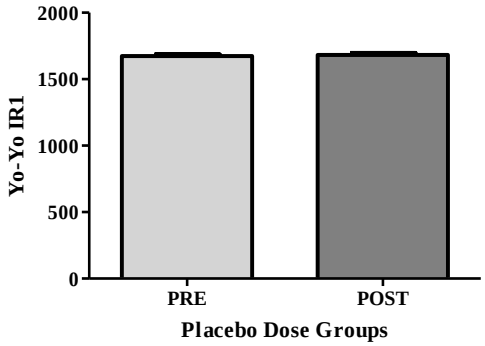

Figure 4.4: Presenting pre vs post-test score of Yo-Yo IR1 in placebo dose Group

The average distance (m) of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 1675± 11.94 m before administering the placebo dose. which increased non-significantly 60 minutes after dose administration. Whereas, the average score of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was found to be 1683± 14.34 m in football players in post-dose administered condition.

Table 4.2: Indicating mean score of Yo-Yo IR1 in football players in pre vs post-test conditions.

Game	Group	*n*	Dose	Test type	Yo-Yo IR1 Mean ± SEM	%age Difference	*P-Value*
Football *n*=120	A	30	Low Dose (LD) CAF: 3mg /kg^{-1}	Pre Post	1671± 15.18 2532± 15.60	51↑***	< 0.0001
	B		Medium Dose (MD) CAF: 6mg /kg^{-1}	Pre Post	1683± 16.38 2587± 18.03	54↑***	< 0.0001
	C		High Dose (HD) CAF: 9mg /kg^{-1}	Pre Post	1663 ± 16.90 2617 ± 27.24	57↑***	< 0.0001
	D		Placebo Control (PC)CAF: 0mg /kg^{-1}	Pre Post	1675± 11.94 1683± 14.34	-	0.6300

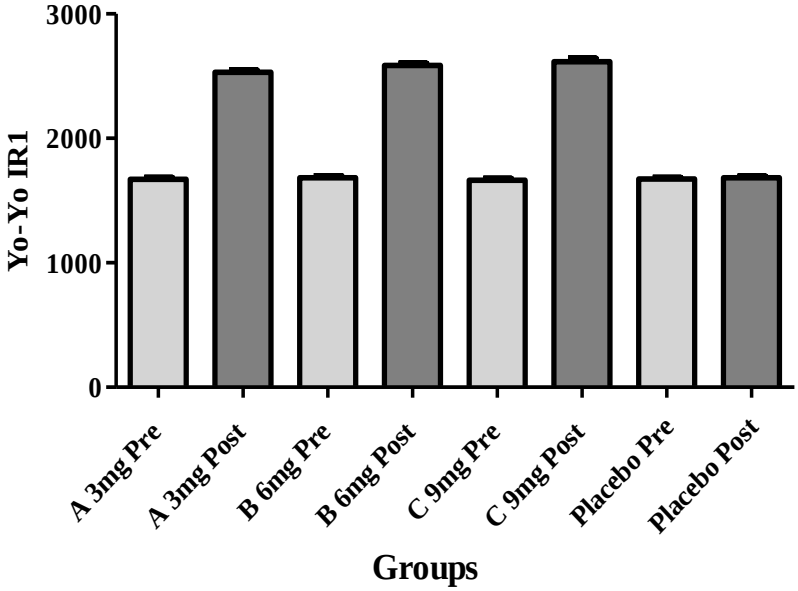

Figure 4.5: Presenting overall comparison of Yo-Yo Intermittent Recovery Level 1 (YYIR1) analyzed by ANOVA in different dose groups

In Table 4.3: A comprehensive presentation of different Yo-Yo Intermittent Recovery Level 1 (YYIR1) analyzed by ANOVA is presented.

Group Comparison	Yo-Yo IR1 Means ± SEM		Percentage Difference
A 3mg Pre vs A 3mg Post	1671± 15.18	2532±15.60	**51↑*** **
A 3mg Pre vs B 6mg Post	1671± 15.18	2587±18.03	**54↑*** **

A 3mg Pre vs C 9mg Post	1671± 15.18	2617±27.24	**56↑***
A 3mg Post vs B 6mg Pre	2532±15.60	1683±16.38	**56↑***
A 3mg Post vs C 9mg Pre	2532±15.60	1663±16.90	**52↑***
A 3mg Post vs C 9mg Post	2532±15.60	2617±27.24	**3↑***
A 3mg Post vs Placebo Pre	2532±15.60	1675±11.94	**51↑***
A 3mg Post vs Placebo Post	2532±15.60	1683±14.34	**50↑***
B 6mg Pre vs B 6mg Post	1683±16.38	2587±18.03	**53↑***
B 6mg Pre vs C 9mg Post	1683±16.38	2617±27.24	**55↑***
B 6mg Post vs C 9mg Pre	2587±18.03	1663±16.90	**55↑***
B 6mg Post vs Placebo Pre	2587±18.03	1675±11.94	**54↑***
B 6mg Post vs Placebo Post	2587±18.03	1683±14.34	**53↑***
C 9mg Pre vs C 9mg Post	1663±16.90	2617±27.24	**57↑***
C 9mg Post vs Placebo Pre	2617±27.24	1675±11.94	**56↑***
C 9mg Post vs Placebo Post	2617±27.24	1683±14.34	**55↑***

****** indicate significance at P ≤0.001***

Significant elevation ($P < 0.001$) was documented in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 3mg post-test caffeine administered condition vs 3mg pre-test caffeine administered condition. Moreover, 51% elevation was found in the 3mg post-caffeine administered group as compared to the 3mg pre-test administered group.

Prominent elevation ($P< 0.001$) of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was evidenced in the 6mg post-test caffeine-administered conditions when compared with the 3 mg pre-test administered condition. Moreover, 54% elevation was found in the 6mg post-caffeine administered group as compared to the 3mg pre-test administered group.

Marked elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 9mg post-test caffeine administered conditions when compared with 3 mg pre-test caffeine administered conditions. Moreover, 56% elevation was found in the 9mg post-test caffeine-administered group as compared to the 3mg pre-test administered group.

In a comparison of the 3mg post-test caffeine administered condition vs 6mg pre-test caffeine administered condition, there was a marked ($P < 0.001$) increase of Yo-Yo Intermittent Recovery Level 1 (YYIR1) distance in the 6mg pre-test. Moreover, 56% elevation was found in the 6mg pre-test caffeine-administered group as compared to the 3mg post-test administered group.

Prominent elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 3mg post-test caffeine administered condition vs 9mg pre-test caffeine administered condition. Moreover, 52% elevation was found in the 3mg post-caffeine administered group as compared to the 9mg pre-test administered group.

Meanwhile, the same significantly ($P < 0.001$) increasing distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was evidenced in the 9mg post-test caffeine administered condition vs the 3mg post-test caffeine administered condition. Moreover, a 3% elevation was found in the 9mg post-caffeine administered group as compared to the 3mg post-test administered group.

Marked elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 3mg post-test administered vs Placebo pre-test caffeine administered condition. Moreover, 51% elevation was found in the 3mg post-test caffeine-administered group as compared to the Placebo pre-test administered group.

In a comparison of 3mg post-test caffeine administered condition vs placebo post-test caffeine administered condition, there was a marked ($P < 0.001$) increase of Yo-Yo Intermittent Recovery Level 1 (YYIR1) distance in 3mg post conditions. Moreover, 50% elevation was found in the 3mg post-test caffeine-administered group as compared to the placebo post-test administered group.

Prominent elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 6mg post-test caffeine administered condition vs 6mg pre-test caffeine administered condition. Moreover, 53% elevation was found in the 6mg post-test caffeine-administered group as compared to the 6mg pre-test administered group.

Meanwhile, the same significantly ($P < 0.001$) increasing distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) was evidenced in the 9mg post-test caffeine administered condition vs 6mg pre-test caffeine administered condition. Moreover, 55% elevation was found in the 9mg post-test caffeine-administered group as compared to the 6mg pre-test administered group.

Significant elevation ($P < 0.001$) was documented in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 6mg post-test caffeine administered condition vs 9mg pre-test caffeine administered condition. Moreover, 55% elevation was found in the 6mg post-test caffeine-administered group as compared to the 9mg pre-test administered group.

In the comparison of 6mg post-test caffeine administered condition vs placebo pre-caffeine administered condition, there was a marked ($P < 0.001$) increase of

Yo-Yo Intermittent Recovery Level 1 (YYIR1) distance in 6mg post-test conditions. Moreover, 54% elevation was found in the 6mg post-test caffeine-administered group as compared to the placebo pre-test administered group.

Prominent elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 6mg post-test caffeine administered condition vs placebo post-test caffeine administered condition. Moreover, 53% elevation was found in the 6mg post-test caffeine-administered group as compared to the placebo post-test administered group.

Marked elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 9mg post administered vs 9mg pre-caffeine administered condition. Moreover, 57% elevation was found in the 9mg post-test caffeine-administered group as compared to the 9mg pre-test caffeine-administered group.

Significant elevation ($P < 0.001$) was documented in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 9mg post-test caffeine administered condition vs placebo pre-test caffeine administered condition. Moreover, 56% elevation was found in the 9mg post-test caffeine-administered group as compared to the placebo pre-test administered group.

Prominent elevation ($P < 0.001$) was noticed in the distance of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in 9mg post-test caffeine administered condition vs placebo post-test caffeine administered condition. Moreover, 55% elevation was found in the 9mg post-test caffeine-administered group as compared to the placebo post-test administered group.

Table 4.4: Presenting Coefficient of correlation of Yo-Yo Intermittent Recovery Level 1 (YYIR1) in different dose groups

	Group A 3mg Pre	**Group A 3mg Post**	**Group B 6mg Pre**	**Group B 6mg Post**	**Group C 9mg Pre**	**Group C 9mg Post**	**Placebo Pre**	**Placebo Post**
G A 3mg Pre	1	.172	-.300	.119	-.136	-.351	.122	.097
GA 3mg Post		1	-.127	.262	-.008	-.398*	-.176	.184
G B 6mg Pre			1	.029	.318	.198	-.299	-.142
G B 6mg Post				1	-.014	-.089	-.097	.289
G C 9mg Pre					1	.294	-.262	-.062
G C 9mg Post						1	.032	.156
Placebo Pre							1	.228
Placebo Post								1

*** indicate significant at *P* ≤0.05 (2-tailed).**

Correlation coefficients of Yo-Yo Intermittent Recovery Level 1 in different dose groups were shown in Table 4.4. The table represented that There was a not positive significant correlation ($p>0.05$) among all variables, However, it was noted that there was a negative significant correlation ($p<0.05$) between Group A 3mg Post and Group C 9mg Post.

DISCUSSION

Endurance in football players refers to their ability to sustain physical activity, such as running, jumping, and changing direction, for a prolonged period without experiencing fatigue or exhaustion. In football, endurance is crucial as the players are required to engage in a variety of high-intensity activities throughout the game, which may include repeated sprints, jumps, tackles and other movements.

Our research findings indicated that the three groups of participants who received caffeine in different doses of 3mg/kg-^{1}, 6mg/kg-^{1}, and 9mg/kg-^{1} all displayed a significant enhancement in their performance during the Yo-Yo Intermittent Recovery Level 1 (YYIR1) test. Of these groups, the university football players showed the substantial improvement when they were administered the highest caffeine dose of 9mg/kg-^{1}.

Our findings are in accordance with the finding of Ellis et al. (2018) and Ranchordas et al. (2018). The findings of our investigation validate the outcome presented by different previous researchers. One such study was conducted by Ellis et al. (2018), who found that consuming 3 mg/kg of caffeine capsules of caffeine resulted in a significant enhancement in endurance performance compared to a placebo. Overall, the study suggests that caffeine can improve endurance performance in male elite youth players. Similarly, a study by Ranchordas et al (2018) found that consuming 200 mg of caffeine resulted in improved endurance performance. Endurance performance is a key factor in football, and it refers to the ability of an individual to sustain physical activity for extended periods. Caffeine has been widely studied as an ergogenic aid, and its effects on endurance performance have been of particular interest to researchers. Caffeine can stimulate the central nervous system, increasing alertness, reducing fatigue, and improving cognitive function. This stimulation can enhance motivation and make exercise feel easier, allowing athletes to push harder and longer (Guest et al., 2021). Caffeine also blocks the adenosine receptors in the brain, which can prevent adenosine from binding to these receptors and causing feelings of drowsiness and fatigue. This can help athletes maintain their focus and energy levels during exercise (Martin et al., 2018). Caffeine can also help spare glycogen, which is the stored form of glucose in the body that is used for energy during exercise. By sparing glycogen, caffeine allows the body to use more fat for fuel, which can increase endurance and delay the onset of fatigue (Ivy et al., 1979; Spriet et al., 1992). Caffeine can increase the oxidation of fat, which means the body is better able to use fat as an energy source during exercise. This can help athletes maintain their endurance for longer periods (Burke, 2021).

Overall, caffeine can improve endurance performance by enhancing the central nervous system, blocking adenosine receptors, sparing glycogen, and increasing fat oxidation. However, the effects of caffeine can vary depending on the individual and the dosage consumed, the current investigation recommends that 9mg /kg^{-1} is more beneficial for football players. Previous hypoxia investigations indicated that enhanced endurance performance following caffeine use, which may, in turn, be explained in part by caffeine's ability to alleviate neuromuscular fatigue (Berglund and Hemmingsson 1982; Fulco et al. 1994; Stadheim et al. 2015).

There is a lot of previous evidences that central motor command, which is the activity of the premotor and motor areas of the cortex causes voluntary muscle contractions is linked to a feeling of effort (Marcora 2009; Smirmaul 2012; De Morree et al. 2012, 2014; Zenon et al. 2015). Marcora et al. (2008) and De Morree et al. (2012) documented that when the neuromuscular system wears out, you have to increase central motor command to keep exercising at the same absolute force or power output. This causes you to get tired faster and feel like you're working harder. de Morree et al. (2014) found that caffeine's positive effects on the neuromuscular system may partially counteract the negative effects of neuromuscular fatigue by reducing the activity of premotor and motor areas of the cortex required for a given level of submaximal force production, which makes it feel like less work.

CONCLUSION

These current research findings indicated that the three groups of participants who received caffeine in doses of 3, 6, and 9 mg/kg-^{1} all displayed a significant enhancement in their performance during the Yo-Yo Intermittent Recovery Level 1 (YYIR1) test. Overall results of this study showed that high doses (9 mg/kg^{-1}) had prominent effects on the endurance performance of university football players. Pearson correlation coefficient results showed that there was a not positive significant correlation ($p>0.05$) among all variables, However, it was noted that there was a negative significant correlation ($p<0.05$) between Group A 3mg Post and Group C 9mg Post.

Practical Application

Caffeine capsules can be taken by football players 15 minutes before a game, but it takes between 15-120 minutes for caffeine to be fully absorbed in the body and take effect. However, FIFA regulations state that halftime breaks cannot exceed 15 minutes. Taking caffeine in this manner may improve the player's performance.

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