The Effects of Caffeine on Rugby Passing Accuracy while Performing the Reactive Agility Test

Abstract:

Caffeine has been observed to improve performance of high-intensity and endurance exercise, but its effects on passing accuracy and reactive agility seen in intermittent high intensity team sports such as rugby and hockey are unclear. The purpose of this investigation was to determine the effect of ingesting caffeine on passing accuracy and agility speed before and after a simulated rugby protocol (SRP). Nine male amateur rugby union players volunteered to participate in the study. The first visit participants undertook the multistage fitness test to determine estimated maximal oxygen consumption levels. On the second and third visits, a passing accuracy test (PAT) was undertaken which involved a modified reactive agility speed test that pressured the participants to pass into a target at the end of each run pre and post the 40 minute SRP. Participants ingested either 6mg.kg.bw^{-1} of caffeine (CAF) or a placebo (PL) 60 minutes prior to the start of the SRP. CAF maintained sprint speed after the SRP whereas it decreased during PL trial. However, there were no effect of CAF on PAT scores (p >0.05) nor was there an effect on RPE (p >0.05). The results of the study lend some support to findings illustrating beneficial effect of caffeine ingestion before a simulated rugby protocol.

La caféine à été observée d'améliorer les performances de l'exercice intermittent haute intensité, mais ses effets sur la précision de passer et l'agilité réactive dans les sports de l'équipe (rugby) ne sont pas claires. Le but de cette enquête était de déterminer l'effet de l'ingestion de caféine sur cette précision et agilité avant et après un simulation de rugby (SR). Neuf joueurs amateurs ont participé à l'étude. Pour la première visite ils ont fait un test de forme de plusieurs étapes afin de faire une estimation des niveaux de consommation de d'oxygène maximale. Pour les visites suivantes ils ont fait un test de précision de passer (PP) qui a impliqué un test de vitesse d'agilité réactive modifié (VARM); Ils devaient passer dans une cible avant et après la SR de 40 minutes. Ils ont ingéré soit 6mg.kg.bw-1 caféine (CAF) ou un placebo (PL) 60 minutes avant le début de la SR. Cependant il n'y avait aucun effet sur les scores de PP (p>0,05) ni sur le RPE (p>0,05). Les résultats apportent un certain soutien à l'effet bénéfique de l'ingestion de caféine avant une SR.

Keywords: Caffeine, Rugby, Reactive Agility Test

1. Introduction:

The importance of caffeine's use as an ergogenic aid has increased dramatically since the World Anti-Doping Authority (WADA) removed it from the list of banned substances in January 2004. As a result, research on its ergogenic benefits in relation to athletic performance has increased [1-3]. Caffeine has been unequivocally demonstrated to improve time to exhaustion and other indicators of endurance in several different physical activities including rowing, swimming, cycling, and running as well as rugby and football [1,4-6]. Moreover, the daily use of caffeine to provide added mental alertness and better focus in relation to its low cost and simplicity of consumption has made it a popular choice for improving athletic performance [2,7].

The mechanism of action of caffeine has been shown to be linked with the blocking of adenosine receptor sites that produce a stimulatory effect on the central nervous system (CNS) [8], which in turn may explain its ergogenic effects. In addition research has reported enhanced neural firing rates, reduction in feelings of fatigue, improved concentration and alertness, accuracy, and reactive time in trained athletes both in a lab and field-testing [6,9-12]. All these responses to caffeine would suggest that caffeine would improve performance in high intensity intermittent team sports such as rugby. Although caffeine's potential ergogenic effects on endurance performance have been thoroughly studied [3,13,14] research is still low in comparison when investigating the benefits of caffeine on team sports performance, such as football or rugby.

Stuart *et al*.[6] investigated caffeine's effect ($6mg.kg.bw^{-1}$) on rugby performance while including an accuracy skill test which was included as part of the simulated rugby test protocol. However, in his study the passing skill was performed in a static and closed skill manner that does not reflect the rugby game situation, so although they found an improvement in passing accuracy this may not be reflected in real rugby play. However, a more realistic accuracy skill test was performed in football by Fosket, Ali, and Gant [15] who examined the effects of caffeine ingestion ($6mg.kg.bw^{-1}$) on cognitive and skill performance during simulated football activity. The authors used an open skill test to investigate passing accuracy where random audible cues were used as well as target identification which is more reflective of real play and they found an improvement in passing accuracy with caffeine. To further the support of use of caffeine on high intensity intermittent sports Schneiker et al.[16] observed improvements in intermittent sprint ability in team sports players following the ingestion of $6mg.kg.bw^{-1}$ of caffeine. Positive performance benefits of caffeine have been found with concentrations as low as $1.9mg.kg^{-1}$ [17]. However, the majority of research which has found positive performance enhancing effects on rugby related performances have used higher doses ($6mg.kg.bw^{-1}$) without any negative side effects [6,15,16].

To better determine whether caffeine has an effect on rugby performance the present study used the reactive agility speed test with an open skill test to examine the effects of caffeine ingestion ($6mg.kg.bw^{-1}$) on rugby passing performance. The same passing accuracy test has been used as a valid and reliable test to measure an athlete's reaction agility time, decision-making and movement time [10,18]. The purpose of this investigation was to determine the effect of caffeine ingestion on rugby passing skill execution and the reaction agility time before and at the end of simulated 40-minute rugby half.

2. Methods:

2.1 Participants:

Nine male amateur rugby union players who competed in the British Universities and Colleges Sport league and trained for rugby at least four times a week participated in the study. All participants were right hand dominant (mean ±SD age 22.4 ±1.8 yrs, mass 81.7 ±9.0 kg, height 1.8 ±0.1m and estimated VO_{2max} 51.5 ±2.1 $ml.Kg.min^{-1}$). Their daily caffeine intake was estimated from a 3-day dietary recall and was below 300 $mg.day^{-1}$. All participants were given written information concerning the nature and purpose of the study, completed a pre-participation medical screening questionnaire and gave written consent prior to participation. A post hoc statistical power analysis was conducted using the Hopkins method using G*Power software, and it was found that the sample size was sufficient to provide more than 80% statistical power. University Ethics Committee approval for the study's experimental procedures was obtained and followed the principles outlined in the Declaration of Helsinki.

2.2 Design:

The current investigation incorporated a double blind randomized cross over design; with all participants performing a multistage fitness test to estimate maximal oxygen uptake (VO_{2max}) prior to data collection. This allowed for estimation of the participants VO_{2max} and their maximum heart rate in order to determine relative intensity during the experimental trials. The participants then completed two experimental trials separated by a week, where they either consumed 500ml of sugar free fruit juice with $6mg.kg.bw^{-1}$ of caffeine (MyProtein anhydrous powder; CAF) or

500ml of the same fruit juice (PL). This dose of CAF was selected as it has been shown to previously improve performance without negative side effects [6,15,16].

2.3 Preliminary Trial:

Mass and height were measured using weighing scales (Seca Sauna 761, Seca, USA) and estimated VO_{2max} was assessed using the multistage fitness test (MSFT)[19]. The test was terminated when participants were unable to complete 20m in the dedicated time twice in a row. Estimated VO_{2max} was determined from the MSFT chart [20] that equates the VO_2 cost associated with the work rate as determined by stage and level.

On the same visit, participants were familiarized with the rugby passing accuracy test as well as the simulated rugby protocol (SRP). Participants were then asked to avoid caffeinated products and alcohol 24 hours prior to each trial and to avoid physical activity 48 hours before each trial. Moreover, they were asked to maintain similar diets 24 hours before each trial which was established from the food diary.

2.4 Experimental Trials:

Each participant undertook two experimental trials performed at a temperature of 16 ±2ºC at a local outdoor rugby pitch at the end of the rugby union season. Each trial consisted of a passing accuracy test pre and post SRP. On both trials participants arrived one hour after ingesting 500 ml of water to try to ensure euhydration. Participants performed a structured 10-minute staged warm up which included two practice full trials for each of the participant's left and right hand of the rugby passing accuracy test (PAT). Once completed, participants performed the passing accuracy test (Pre-PAT) on the rugby pitch. At the completion of Pre-PAT, participants ingested either CAF or PL and passively rested for 60 minutes. The participants following ingestion were asked if they could identify which solution they had been given on each trial.

After the passive rest, participants performed the same warm up routine followed by the SRP based on Stuart *et al.* [6] simulated rugby test that consisted of eight circuits. At the end of each circuit, ratings of perceived exertion (RPE) using Borg scale that ranged from 6- 20 [21] was recorded. Heart rate (HR) was monitored (Hosand TM200, Hosand Technologies Srl, Italy) throughout the SRP and average HR was determined during both conditions. Following the SRP the participants completed the post- PAT for both left and right hands.

2.5 Passing Accuracy Test (PAT):

The participants started half a meter behind the first time gate that allowed natural sprinting position to take place while carrying a rugby ball, then as the subject passed the trigger gate the last two gates flashed and buzzed randomly based on the reactive agility speed test built in to the smart speed PDA unit (Smart Speed Gate System, Fusion Sport, Australia) that transmitted the signals to the gates. As soon as the participants past the last gate they had to pass the rugby ball to hit a circular target (75 cm in diameter) placed five meter away from the final gates while avoiding a pole placed one meter in front of the gates that acted as pressure and forced the participants to pass quickly. If the participants passed beyond this pole the pass was given as a miss. Each participant had 3 attempts with each hand. If they successfully hit the target they scored two points, if they clipped the target they scored one point and if they missed they scored zero. They could score a maximum of 6 with each hand.

2.6 Simulated Rugby Protocol (SRP):

The SRP consisted of eight circuits with 10 stations that took in total 40-minutes to complete. The participants started at station 1 and proceeded through the 10 stations at 30-s intervals. Once the task at each station was complete, the subject had the remainder of the 30-s to recover and move to the next station. Each circuit was made up of 10 stations for activities that included sprinting (straight-line and change of direction sprints), tackling bags and flipping tires, but also allowed for rest periods of walking and standing (Table 1). For sprint tasks, the straight-line sprint was a forward straight run, while the offensive sprint involved a forward run with swerving in and out of cones. The defensive sprint involved running 33 arcs starting forward then backward. The tackle sprint involved making a tackle on a tackle bag, picking up a ball and running backward, placing the ball, making another tackle, and then running forward. For simulating rucking and mauling, a wheel tyre (50 Kg) was used and flipped five times. Total distance covered during the SRP with sprinting over the test was 1088m.

Table 1 near here

2.7 Statistical Analyses:

The Shapiro-Wilk statistic confirmed that the normal distribution assumption was met for all variables. Therefore data were analysed using a repeated measures two-way (Treatment X Time) analysis of variance (ANOVA; SPSS v20). Appropriate post-hoc analyses were conducted using a Bonferroni correction to control for type I error. Partial effect sizes were calculated using an η^2. A paired t-test was performed on the HR data. Data are presented as mean ± standard deviation in tables and figures. Significance was set at $p<0.05$.

3. Results:

Only one of the participants was able to identify which condition they had received during the testing session.

3.1 Passing Accuracy Test (PAT):

Table 2 shows the mean ± SD performance values for the total scores, left hand scores and right hand scores of the skill test.

Table 2 near here

3.2 Total Score

Although there was no significant interaction between time and condition for total score ($F_{1,8}$=1.631, *p*=.237, η^2=.111) there was an effect of condition which was a result of consistently higher scores in the CAF trial for both pre and post tests ($F_{1,8}$=18.391, *p*=.003, η^2=.617; Table 2). There was also a significant main effect for time ($F_{1,8}$=12.903, *p*=.007, η^2=.680), with a greater total score post SRP for both CAF (9 ±1) and PL (8 ± 1) compared to pre (6 ± 2 and 5 ± 2 for CAF and PL respectively).

3.3 Left Hand

There was a significant main effect for time on the left hand PAT score ($F_{1,8}$=10.89, *p*=.013, η^2=.558), with skill score greatest post SRP in both trials (4 ±1 and 5 ±1 for PL and CAF respectively) compared to pre (2 ±1 and 3 ±2 for PL and CAF respectively; Table 2). There was also a main effect for condition ($F_{1,8}$= 11.256, *p*=.010, η^2=.585) with CAF producing greater PAT scores (Table 2). However, there was no interaction between time and condition ($F_{1,8}$= 0.78, *p*=.43, η^2=.089).

3.4 Right Hand

Although there was a main effect for time ($F_{1,8}$= 24.123, *p*= .001, η^2=.751) for right hand PAT scores with scores greatest post SRP for both PL and CAF compared to pre (Table 2), there was no interaction for time and condition (F1,8= 0.229, *p*=0.645, η^2=.028). Also there was no main effect for condition therefore CAF had no effect on right hand PAT scores ($F_{1,8}$=0.113, p=.746, η^2=.014).

3.5 Time to complete

There was a tendency for a significant interaction between time and condition for mean PAT sprint times (F1,8=5.052, *p=.06*,η^2 = *.387).* Sprint speed was slower post PAT compared to PRE during the PL trial, whereas it remained the same post PAT during the CAF trial (Figure 1).

Figure 1 near here

3.6 Rate of Perceived Exertion and Heart Rate

There was no significant interaction between condition and time for RPE ($F_{7,56}$=0.154, *p*=.993, η^2= .019) and no main effect for condition ($F_{1,8}$= 0.188, *p*= .676, η^2= .023). However, there was a significant main effect for time for RPE ($F_{7,56}$= 29.335; *p*=0.000, η^2= .786), reflecting an increased perception of effort as exercise time progressed (Figure 2). A paired t-test was undertaken on the mean HR during the SRP for both CAF (135.4 ± 9.19 beats.min^{-1}) and PL (132.5 ± 6.9 beats.min^{-1}) and no differences were found between trials (t_8= -1.573, *p*= .154).

Figure 2 near here

4. Discussion:

The purpose of this study was to investigate the effect of pre-match ingestion of caffeine (6-mg.kg.bw^{-1}) on rugby passing accuracy pre and post a simulated rugby protocol. A secondary aim was to examine whether the effects of caffeine could improve reactive agility time while performing the passing accuracy test. Such effects were observed for PAT (time to complete) as there was a slowing of sprint speed during the PL trial, whereas there was no change during the CAF trial. PAT scores increased post SRP in both conditions with no differences between CAF and PL suggesting caffeine had no effect on passing accuracy.

The maintenance of sprint speed shown in the agility performance after caffeine ingestion in this study were most likely due to the blocking of adenosine receptors in different tissues in the body, resulting in a stimulatory effect on the central nervous system [11,22]. As a result, caffeine-induced adenosine inhibition causes increased neural firing, arousal and alertness as well showing to attenuate feelings of perceived exertion and leading to an improvement in performance when fatigued [8,11,22]. Moreover, it has been suggested that a direct stimulation of the central nervous system while athletes are fresh could improve neural firing rates and the release of neurotransmitters, thus improving agility performance [10]. However, this remains unclear and further research must be conducted in regards to the potential mechanisms behind reactive agility improved performance after caffeine ingestion.

Surprisingly, there was no effect of caffeine on passing accuracy as shown by the results of the PAT. The results of this study conflict with those of Stuart *et al.*[6] who found an improvement of 10% after caffeine ingestion. The different outcome may be due to the fact that Stuart *et al.* [6] performed a static closed skill accuracy test whereas the present study performed an open skill test. The static nature of the test does not reflect the true nature of a rugby game where players pass when they are in dynamic motion [23,24]. Fatigue seemed to improve PAT in the present study, demonstrating that accuracy improved as the players became fatigued. However, speed may have been subconsciously modified during the post PAT to compensate for accuracy during the PL trial.

The complexity of the skill test demands were essential in this protocol as it required more complex cognitive functioning while hitting the target as well as being a simulation of open skills observed in rugby match play. Gillingham, Keefe and Tikuisis [25] reported improved marksmanship after caffeine ingestion in target shooting engagement whereas in a task of friend-foe identification, there was no difference in the complex cognitive process. May be caffeine has less effect when the skill involved uses complex cognitive processes such as those in the PAT during the present study.

Overall, maintaining sprint speed during the post PAT suggests that caffeine ingestion of 6-mg.kg.bw^{-1} of caffeine does not result in over-arousal and diminished rugby performance as suggested by Hespel, Maughan and Greenhaff [26]. Previous research has shown that fine motor skills have been negatively affected by caffeine tremor [27]. In contrast, this is not observed in rugby passing skill and cognitive processing of significant stimuli. It is more likely that any beneficial effect of caffeine ingestion is due to the participants' enhanced cognitive processing to interpret and respond to the visual and audible stimuli [15]. As mentioned previously, caffeine’s ability to decrease the impact of unrelated visual and audible information [28] could have helped in finishing the post PAT in a faster time compared to placebo as seen in the current study.

There appears to be conflicting research with regards to the effect of caffeine on RPE with some reporting a reduction in RPE after caffeine ingestion [13,29-33] and others demonstrating no effect [10,16,30,34-38]. There are many differences in the testing protocols which could have resulted in these conflicting results. In the present study there was no difference in RPE between conditions, and this may due to the RPE scale not being sensitive enough to detect changes in perceived exertion while participants work at high-intensity exercise during the fatiguing protocol. Also it has been reported by Schneiker *et al*.[16] and Woolf, Bidwell and Carlson [38] that subjects had achieved more work despite similar perceived exertion with placebo group after caffeine ingestion. This is in agreement with the present study since the subjects performed better after ingesting caffeine, while there was no difference in RPE during the fatiguing protocol. This could be due to the caffeine’s effect to dampen perceived exertion during high-intensity exercise protocol [1]. In addition there were no differences in HR during the SRP between trials which along with the RPE data suggests that the differences in PAT performance was not due to differences in fatigue from the SRP. Finally, the mean HR in the present study was 135.4 ± 9.19 beats.min^{-1} for CAF and 132.5 ± 6.9 beats.min^{-1} for PL which are similar values to those determined by Morton [39] during a rugby match. This suggests that the SRP simulated the intensity of a rugby match and the intensity was similar in both trials.

In conclusion, caffeine can be a valuable performance enhancer that exhibited effects on simulated intermittent-high-intensity team sport performance; where ingesting 6-mg.kg.bw^{-1} of caffeine before 60 minutes of a 40-minute simulated rugby fatiguing exercise protocol prevented a decrease in reactive agility speed test but had no effect of passing accuracy. This observed improvement in reactive agility speed after the SRP is an indicator that rugby athletes will most likely be more aroused, alert and attentive in the 2nd half of the rugby match. This may be a helpful indicator for athletes who play rugby, football, hockey, basketball and tennis to ingest caffeine. However, it must be noted that there are inter-individual responses to caffeine with some individuals being responders and others being non responders which may affect whether it is ergogenic in its effect. In addition, there are potential negative side effects such as tachycardia which can negatively impact on performance. As with any ergogeinc aid, an athlete is best to try it in training before competition. Caffeine's mechanisms are still vague, the suggested advantages of caffeine are that it can affect several processes in the central nervous system in order to reduce fatigue with reactive agility speed sprints and enhancing the cognitive –complex processing for high motor skill execution such as passing rugby balls, hitting balls, or shooting for goals with accuracy during a match play.

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Tables:

Table 1. Performance tasks at each station in the simulated rugby protocol.

Station	**Task**	**Description**
1	20-m sprint	Straight line
2	Offensive sprint	22m- change of direction
3	Walk	Walk to next station
4	Drive	Flipping a wheel 5 times
5	Walk	Walk to next station
6	Defensive sprint	33-m change of direction
7	Walk	Walk to next station
8	Tackle sprint	31-m change of direction
9	Walk	Walk to next station
10	30-m sprint	30-m straight line

Table 2. Mean ±SD for caffeine (CAF) and placebo (PL) for Total Scores, Left and Right Hand Scores.

	PL Mean ± SD		CAF Mean ± SD	
	Pre	**Post**	**Pre**	**Post**
Total Scores	5 ± 2	8 ± 1	6 ±2	9 ± 1
Left Hand Scores	2 ± 1	4 ± 1	3 ± 2	5 ± 1
Right Hand Scores	3 ± 1	4 ± 1	3 ± 1	4 ± 1

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