Low doses of caffeine: Enhancement of physical performance in elite adolescent male soccer players

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"Low Doses of Caffeine: Enhancement of Physical Performance in Elite Adolescent Male Soccer Players"
by Ellis M, Noon M, Myers T, Clarke N
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Abstract

Context: Large doses of ~6 mg•kg^{-1} body mass have improved performance during intermittent running, jumping, and agility protocols. However, there are sparse data on low doses of caffeine, especially in elite adolescent soccer players. **Method:** Fifteen elite youth soccer players (177.3±4.8 cm, 66.9±7.9 kg and 16±1 y) participated in the study, consuming 1, 2, or 3 mg•kg^{-1} caffeine in a gelatin capsule or a 2-mg•kg^{-1} placebo in a single-blind, randomized, crossover study design. Testing consisted of a 20-m sprint, arrowhead agility (change of direction [CoD] right or left), countermovement jump (CMJ), and Yo-Yo Intermittent Recovery Test Level-1 (Yo-Yo IR1). Post-exercise CMJ performance was assessed as participants exited the Yo-Yo IR1. Data were analyzed using a Bayesian multilevel regression model to provide explained variance and probabilities of improvement (p=%). **Results:** 3 mg•kg^{-1} caffeine presented the highest probabilities of change compared with placebo across a range of tests (mean ± SD, p= %). Times for 20-m sprint were 3.15±0.10s vs 3.18±0.09s (p=73%), CoD-R times were 8.43±0.24s vs 8.55±0.25s (p=99%), CoD-L times were 8.44±0.22s vs 8.52±0.18s (p=85%), Yo-Yo IR1 distance was 2440±531m vs 2308±540m (p=15%), and preexercise CMJ height was 41.6±7.2cm vs 38±8.5cm (p=96%). Postexercise CMJ was higher with 3 mg•kg^{-1} than with placebo (42.3±8cm vs 36.6±8cm [p=100%]). Doses of 1 or 2 mg•kg^{-1} caffeine also demonstrated the ability to enhance performance but were task dependent. **Conclusion:** Low doses of caffeine improve performance but are dose and task dependent. A dose of 3 mg•kg^{-1} caffeine improved performance across the majority of tests with potential to further improve postexercise CMJ height.

Keywords: ergogenic aid, jump, agility, youth, Bayesian.

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Introduction

Soccer has an intermittent activity profile and yields energy from aerobic and anaerobic pathways[1]. Caffeine is a popular ergogenic and can enhance intermittent[2], endurance[3] and resistance[4] performance. Caffeine non-selectively blocks both adenosine receptors and competitively inhibits the action of adenosine, which increases cell activity[5]. Direct antagonism of adenosine receptors may improve aerobic performance through enhanced excitation-contraction coupling through increased release of Ca^{2+} from the sarcoplasmic reticulum[6]. Similarly, it can reduce pain perception and sustain motor unit firing which can improve anaerobic performance[7].

High doses (≥ 5 mg•kg^{-1}) of caffeine are ergogenic across a variety of sports (e.g. tennis, cycling, rugby and volleyball)[8]. However, ingesting 6 mg•kg^{-1} of caffeine did not increase in match activities (total distance, sprints and accelerations) or fatigue resistance during a soccer simulation match with young soccer players (18±1 y)[9] despite improving reactive agility in elite youth soccer players (14±1 y)[10]. High doses of caffeine have also been reported to increase the susceptibility to negative side effects (increased heart rate, nervousness, insomnia and vomiting)[8]. Lower doses (≤ 3 mg•kg^{-1}) seem to benefit psychological and physical performance in similar magnitudes but vary across individuals and reduce the side effects[8].

Measuring match activity profiles to assess performance may also be a limitation of current research. Match play metrics such as total distance, high speed running and accelerations have demonstrated large variability (CV = 6.4-30.8%) [11]. These variations are potentially the consequence of external factors such as opponents and tactics. Consequently, measuring match profiles may not be optimal to identify changes in performance following the consumption of caffeine. Assessing physical outcomes which can be easily and more accurately assessed may be more appropriate to evaluate the effect of caffeine consumption in

soccer. For instance, the ingestion of 3-3.7 mg•kg^{-1} has been reported to increase jump height, 15m sprint time and repeated sprint ability in soccer players[12,13]. Approximately 2.6 mg•kg^{-1} caffeinated gum has also demonstrated an increase in the distance covered during the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1)[14]. Thus, physical components of soccer performance may be more suitable to evaluate the effect of caffeine in soccer players.

In summary, there remains limited evidence regarding the effect of low doses of caffeine in the elite youth soccer players. If a low caffeine dose can acutely improve an aspect of physical performance; prescribing it prior to a training stimulus may improve the training outcome and/or adaptation. Therefore, the aim of the study is to assess a range of low caffeine doses and its effect on performance compared to a placebo.

Methods

Participants

Fifteen male elite youth (category 2 English academy) soccer players (16 ± 1 years, 177.3 ± 4.8 cm and 66.9 ± 7.9 kg) took part in the study. Participants train five times per week with one competitive game at the weekend and are allocated one gym session per week. The players represented all playing positions and included goalkeepers (n=2). The reported habitual mean caffeine intake was 43 mg/day with the majority coming from tea and chocolate sources. All participants were fully informed with parental consent also obtained and were given the right to withdraw at any time. The investigation was approved by the institutional ethics committee.

Experimental design

Participants completed a caffeine consumption questionnaire prior to testing to gauge caffeine usage[15]. Height and body mass were recorded prior to testing. Participants were measured in their shirt and shorts 2-hrs prior to testing. Players were asked to refrain from

consuming caffeine in the 24-hr period prior to 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 prior to testing. A 24-hr dietary recall was completed by each participant during the familiarisation session; it was then photocopied and handed back to the participants in order for them to replicate their diet in subsequent trials. Diet and caffeine compliance was checked verbally 1-hr prior to testing to ensure participants adhered to the same diet and caffeine abstinence.

Using a randomised, crossover, single-blind design participants completed five days of testing over five weeks (once per week). Participants were blinded from each condition and the amount of capsules received were the same irrespective of dose. The first block of testing was to establish baseline values for each test to which participants were already familiarised. Testing consisted of a 20 m sprint, arrowhead agility, countermovement jump (CMJ) and Yo-Yo IR1 on an indoor 3G synthetic surface. Participants completed the CMJ (3 jumps) then went into the 20 m sprints (3 sprints) followed by the arrowhead agility (twice to the right and left) and then completed the Yo-Yo IR1 where 3-mins rest were given between each rep and 5-10 mins between each test. CMJ was completed again immediately following the exit of the Yo-Yo IR1 to see if caffeine could offset fatigue. Participants randomly consumed 1, 2 or 3 $mg{\cdot}kg^{-1}$ caffeine in a gelatin capsule (Bulk powders, Colchester, United Kingdom) or a 2 $mg{\cdot}kg^{-1}$ placebo (maltodextrin, Bulk powders, Colchester, United Kingdom). Caffeine was consumed with water 1-hr prior to testing as previous research has shown that serum caffeine can peak within 1-hr and remain elevated for ~3-hrs[16]. The players were given 1L fluid bottles for ad libitum water consumption throughout testing.

Procedure and performance Variables

Prior to testing participants completed a standardised 10-min warm up which is normally completed on their soccer match day i.e. 4min to raise pulse and activate muscle (kick throughs, cradle stretch and heel flicks) 4min mobilisation (squat, lunge and lateral lunge) and 2min potentiation (jump, land and sprints). The CMJ protocol consisted of participants placing their hands on a dowel (situated on the participants back) and was instructed to jump as high as possible. The GymAware (Kinetic Performance technologies, Canberra, Australia) was attached to the dowel. This system recorded displacement-time data at a sampling rate of 50 Hz, which was transmitted via Bluetooth to a hand held tablet device and downloaded on to a desktop computer for later analysis. The GymAware Version 3.13 (Kinetic Performance Technologies) was used to record jump height, force, velocity and power during the CMJ. An unloaded CMJ has been shown to be sensitive to fatigue measurements during intensified training periods[17]. Maximal 20m-sprint time was recorded using electronic timing gates (Brower Timing Systems, Utah, USA)[18]. The start line was set up 50 cm behind the first set of timing gates. The start was the same for the arrowhead agility and the first cone was positioned 10 m away. Participants would then cut to the left (CoD L) or right (CoD R) where the next cone was 5 m before turning to the top of the arrow and returning through the starting gate positioned 15 m away from the top cone[19]. Participants then completed the Yo-Yo IR1 where a 5 m recovery zone was created and then a 20 m runway for participants to run towards and return to the recovery zone[20].

Data analysis

Different regression models were run ranging from standard linear regression to multilevel models where individual intercepts and slopes were allowed to vary. Model fit was evaluated using Watanabe–Akaike information criterion (WAIC) to determine expected out-

of-sample-prediction error[21]. The best fitting models with both the lowest out-of-sample-prediction error (WAIC) and the highest variance explained (R^2) were multilevel models allowing intercepts to vary for each participant. Bayesian multilevel model were fitted with post-score as the dependent variable and group as the independent variable using weakly informative priors to regularize the models and avoid unreasonable parameter estimates. The models were fitted using R (R Core Team, Vienna, Austria) using the brms package which uses Stan (Stan development team, Helsinki) to implement a Hamiltonian Markov Chain Monte Carlo (MCMC) with a No-U-Turn Sampler[22]. All models were checked for convergence ($\hat{r} = 1$) and graphical posterior predictive checks were used using bayesplot (Gabry, Mahr and Buerkner, bayesplot, version 1.5.0, 2018). 15 participants were included in the multilevel model but only 10 were used for individual comparisons due to dropout. There are several advantages of using multilevel models in general and Bayesian multilevel models in particular. Multilevel models are able to handle missing data, use different numbers of observations for each individual, allow inference about between-individual differences and allow observations for individuals to be collected across different time points[23]. Bayesian analysis is more suitable for small scale athlete studies than traditional statistics, allows direct probability statements to be made about the parameters (population level effects), and gives more accurate estimates of uncertainty that are more intuitively interpretable. For example, 95% credible intervals (Bayesian equivalent to a traditional confidence interval) suggest that there is a 0.95 probability that the true parameter lies within this interval. The estimated differences displayed represent mean of the posterior distribution of the group differences, the probabilities associated with these differences are interpreted as the probability of the difference. This is because, unlike traditional statistics, Bayesian analysis allow probabilities to be assigned to parameters and the research hypothesis.

A Bayesian formulation for quantifying and interpreting the magnitude of effect and 'Smallest Worthwhile Change' (SWC) was employed[24,25]. The SWC used was a standardised change of 0.2 based on previous recommendations (Hopkins, 2009). All analyses were conducted using R (R Core Team (2016) using brms pack[22].

Results

Descriptive statistics and individual data for each caffeine dose and placebo are presented in figure 1. CV% for 20m sprint, CoD R, CoD L and CMJ were 1.3%, 0.9%, 1.13% and 8.98% respectively. The results show that overall caffeine had an effect on 20m sprint, CoD R, CoD L and YoYo IR1 (Table 1). Caffeine explained 64% of the variance in change in 20m sprint performance with 3 $mg{\cdot}kg^{-1}$ of caffeine providing a 73% probability that it would improve. Overall caffeine explained between 61% and 72% of the variance in changes in CoD R ($R^2 = 0.72$), CoD L ($R^2 = 0.61$) and Yo-Yo IR1 ($R^2 = 0.66$) performance. There is a 99% probability that a 2 $mg{\cdot}kg^{-1}$ caffeine improves performance over placebo in CoD left and right. There is more uncertainty around caffeine having a positive performance effect than placebo in Yo-Yo IR1 performance (Table 1).

Table 1 also identifies the probability of each dose improving physical attributes greater than the SWC. The SWC for 20m sprint, CoD R, CoD L and Yo-Yo IR1 were 0.012 s, 0.026 s, 0.03 s and 57.65m respectively.

Compared to placebo, all caffeine doses improved jump performance pre-exercise as explained by the variance: jump height ($R^2 = 0.62$), peak power ($R^2 = 0.51$), mean power ($R^2 = 0.62$), peak force ($R^2 = 0.70$) and peak velocity ($R^2 = 0.43$). A 2 $mg{\cdot}kg^{-1}$caffeine dose demonstrated an 84-96% probability that all CMJ variables would improve over placebo (Table 2). Interestingly, 3 $mg{\cdot}kg^{-1}$ caffeine demonstrates a larger increase in estimated difference for jump height with a 96% probability of improvement compared to placebo. All caffeine doses

improved post-exercise jump performance (Table 2) when compared to placebo as explained by the variance: jump height (R^2 = 0.59), peak power (R^2 = 0.55), mean power (R^2 = 0.68), peak force (R^2 = 0.70) and peak velocity (R^2 = 0.43). However, a 3 mg·kg^{-1} caffeine dose has the potential to improve CMJ height beyond pre-exercise jump height as seen in figure 2. Moreover, 3 mg·kg^{-1} produces a larger estimated difference for peak force and peak velocity compared to 2 mg·kg^{-1} following exercise.

Table 2 also presents the probability of each dose improving jump data greater than or equal to the SWC. The SWC for jump height, peak power, mean power, peak velocity and peak force were 0.94 cm, 260 W, 105 W, 0.06 m·s^{-1} and 59 N respectively.

Discussion

The aim of the present study was to establish if low doses of caffeine could improve physical performance in elite adolescent soccer players. The results of this study identified that improvements in performance were dose and task dependent. However, 3 mg·kg^{-1} caffeine improved performance across a broader range of tasks; 20m sprint, CMJ height (pre and post exercise), CoD R and CoD L. The probability of improvement (1-16%) compared with the placebo across all caffeine doses in the Yo-Yo IR1 test was the smallest magnitude of change across all tests.

Responses to caffeine appear to be dose and task dependent. For example, when compared to placebo, the largest improvement in 20m sprint was in the 3 mg·kg^{-1} group (73% probability of improvement, estimated effect of -0.01s and 43% probability that the change is greater than the SWC). Jump height also increased in the 3 mg·kg^{-1} caffeine group (p=0.96) compared to placebo as the estimated effect was 2.05cm with a 94% probability the change will be greater than the SWC. CoD R and CoD L improve with a 3 mg·kg^{-1} and 2 mg·kg^{-1} caffeine dose compared to placebo respectively; with a 99% probability of improvement and a

-0.10s to -0.11s estimated difference. When compared to placebo, 2 mg·kg^{-1} caffeine improves peak power (164-518 W), mean power (115-174 W) and peak velocity (0.01-0.09 m·s^{-1}) with an 86-96% probability of improving these variables. 1 mg·kg^{-1} caffeine improved peak force compared to placebo, with a 94% probability of improvement and an estimated difference of 121N. Thus, each caffeine dose seems to affect each task and jump metric differently, however, consuming 3 mg·kg^{-1} caffeine still improves performance across all performance tests.

Furthermore, caffeine improved all jump metrics compared to placebo following the exit of the Yo-Yo IR1 (fatigued). Consequently, 3 mg·kg^{-1} caffeine produced larger estimated differences and higher probabilities of a positive effect across all jump variables. As seen in figure 2, caffeine also has the potential to improve jump height (estimated difference 5.47cm) even under fatigued conditions. Therefore, 3 mg·kg^{-1} of caffeine improves jump performance which is a similar finding to that of Del Coso et al.[12]. Moreover, Foskett, Ali and Gant[13] established that 3.7 mg·kg^{-1} caffeine improved 15m sprint time and also maintained sprint performance as participants fatigued. The present study also established that 3 mg·kg^{-1} caffeine could improve sprint speed and participants ability to perform maximal anaerobic tasks following exercise (post-exercise CMJ). The present study fatigued participants via the Yo-Yo IR1 which differs to the Loughborough Intermittent Shuttle Test (LIST) used by Gant, Ali and Foskett[13]. The LIST protocol used by Gant, Ali and Foskett simulated a 90min soccer match with self-pacing and no volitional fatigue, whereas, the Yo-Yo IR1 requires participants to run until exhaustion. By inducing volitional fatigue the present study provides evidence that caffeine can still improve anaerobic performance when acutely fatigued; potentially through sustaining motor unit performance[7].

Similarly, anaerobic tasks such as CoD R and L may have improved through direct antagonism of adenosine receptors which can enhance excitation-contraction coupling through increased release of calcium from the sarcoplasmic reticulum[6]. Moreover, CoD tasks require

cognitive focus (i.e. where to plant, cut and how to accelerate during each turn) to which low doses (3 mg.kg^{-1}) of caffeine may also improve[26]. Consequently, the present study provides a different context to the work of Pettersen et al.[9] where participants consumed 6 mg.kg^{-1} caffeine during a simulated soccer match. Given that training is the primary stimulus to improve physical and football performance (technical and tactical); improving the training stimulus itself rather than an overall match activity profile may be more beneficial. For example, 3 mg.kg^{-1} could be prescribed prior to speed sessions, on-field CoD drills or a plyometric jump session in the gym. Therefore, consuming caffeine prior to these training sessions may enhance the training stimulus and consequently overall match performance.

Low doses of caffeine improved Yo-Yo IR1 performance as 1-3 mg.kg^{-1} provide a 90-135m estimated improvement from placebo; which was greater than the SWC 58m. One possible explanation for a trivial improvement could be a ceiling effect response and no further improvements are possible between 1 and 3 mg.kg^{-1} caffeine. Similar findings have been observed in basketball players[27] and university trained soccer players[14] with only trivial improvements observed. Graham[16] suggested that Caffeine does not improve maximal oxygen capacity directly, but could permit the athlete to train at a greater power output and/or to train longer. However, increasing the dose to 6 mg.kg^{-1} caffeine seems to stimulate catecholamine release, reduce muscle interstitial potassium accumulation, increase plasma ammonia, increase blood glucose but not increase blood lactate[2]. These peripheral mechanisms may be essential to further improving Yo-Yo IR1 (intermittent aerobic) performance and further work is required to elucidate this. Therefore, whilst caffeine has a trivial effect on Yo-Yo IR1 performance, this study identified that caffeine does improves players ability to execute explosive anaerobic performance after a Yo-Yo IR1.

Potential limitations of the present study were that participants completed a 24-hr recall food diary and replicated diet before each subsequent testing session for 5 weeks. Compliance

to consume the same food prior to each testing may have slightly differed for each participant and we cannot be certain the same diet was adhered too despite being advised to. In addition, caffeine abstinence was not checked via enzyme linked immunoassay kit to check for compliance. Thus, participants may have consumed caffeine prior to testing. However, the caffeine consumption questionnaire does indicate an average intake of only 43 mg·day. To address these potential limitations, future research should include caffeine abstinence checks and potentially provide a standardised diet 24-hr prior to testing. For practical reasons, the study was single-blinded, leaving potential for experimenter bias. However, as no participants could correctly guess the capsules, this would seem unlikely.

Practical Application

Practical implications for the present study come from a Bayesian analysis approach which allows raw data to be interpreted and used in an applied context. For example, probabilities and estimated differences provide the practitioner with information which they can determine whether it is a useful intervention or not. Moreover, the present study provides data to support that low doses of caffeine can improve a range of physical performance tests. Interestingly, it appears to improve performance even when participants are fatigued during anaerobic tasks. Thus, consumption of caffeine prior to training (technical, tactical or physical) may enhance the training outcome and consequently soccer performance.

Moreover, a practical application would also be that improvements in performance were dose and task dependent. Thus, if a practitioner was looking to improve peak force during a jump program, they may consider only prescribing 1 $mg \cdot kg^{-1}$ caffeine. However, if they were trying to improve sprint speed, then 3 $mg \cdot kg^{-1}$ caffeine would be more appropriate. Conversely, 2 $mg \cdot kg^{-1}$ caffeine improved CoD tasks, power outputs and increased velocity of the CMJ.

Therefore, practitioners may want to consider different caffeine doses prior to a training task in order to improve the physical output of the training demand.

Conclusion

In conclusion, low doses of caffeine (1-3 $mg{\cdot}kg^{-1}$) improve aspects of physical performance in elite adolescent soccer players. Improvements in performance are dose and task dependent but 3 $mg{\cdot}kg^{-1}$ seems to positively affect the majority of performance tests. However, higher doses of caffeine may be required to improve Yo-Yo IR1 performance. Overall, consuming 3 $mg{\cdot}kg^{-1}$ 45 mins prior to a training stimulus may further enhance the physical capacity to undertake that training stimulus.

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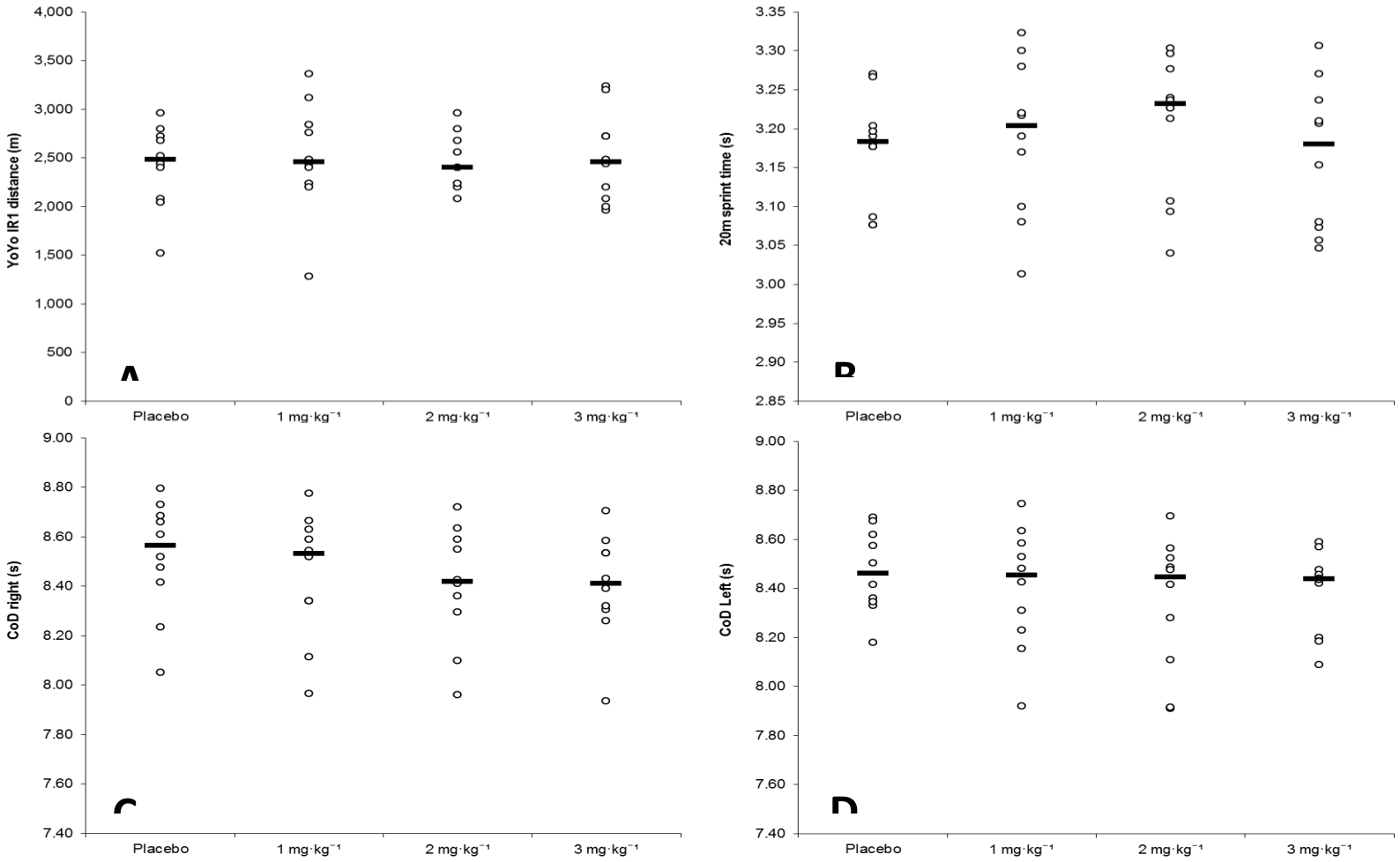

Figure 1 – Individual responses with median score for Yo-Yo IR1 (A), 20m sprint (B), CoD R (C) and CoD L (D)

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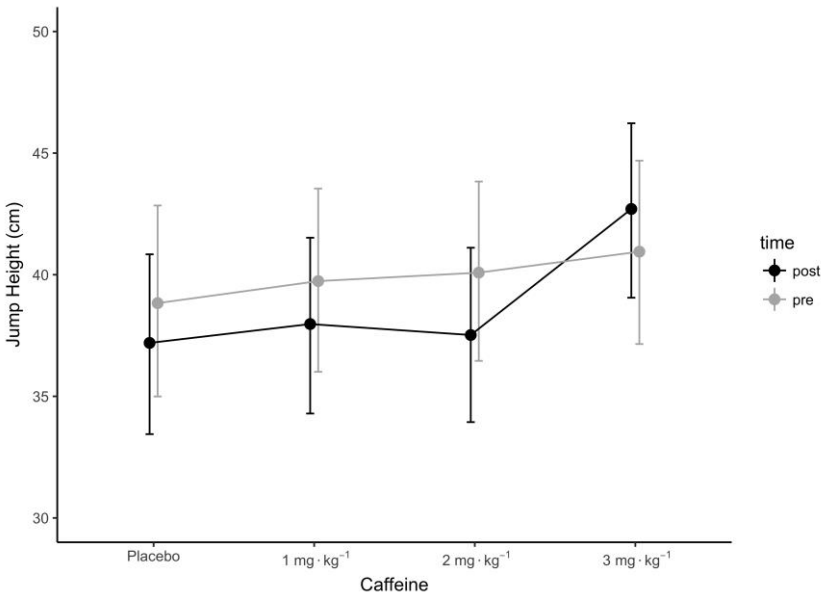

Figure 2 - Posterior estimates and 95% credible intervals showing the potential of a 3 mg.kg^{-1} dose of caffeine to improve CMJ height performance following completion of a YoYo IR1.

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Table 1- The effect of each caffeine dose compared to placebo for 20m sprint, CoD R, CoD L and Yo-Yo IR1

	Placebo	**1 mg•kg^{-1}**	**2 mg•kg^{-1}**	**3 mg•kg^{-1}**
20m sprint				
mean ± SD (s)	3.18 ± 0.09	3.18 ± 0.09	3.18 ± 0.10	3.15 ± 0.10
estimated difference (s)		0.00	0.03	-0.01
95% CI [LB – UB]		[-0.03 to 0.04]	[-0.01 to 0.06]	[-0.04 to 0.02]
p<0		0.43	0.05	0.73
pSWC		0.17	0.01	0.43
Right CoD				
mean ± SD (s)	8.55 ± 0.25	8.47 ± 0.25	8.43 ± 0.23	8.43 ± 0.24
estimated difference (s)		-0.08	-0.10	-0.11
95% CI [LB – UB]		[-0.16 to 0.00]	[-0.17 to -0.01]	[-0.19 to -0.03]
p<0		0.98	0.99	0.99
pSWC		0.91	0.96	0.98
Left CoD				
mean ± SD (s)	8.52 ± 0.18	8.44 ± 0.26	8.34 ± 0.25	8.44 ± 0.22
estimated difference (s)		-0.04	-0.11	-0.04
95% CI [LB – UB]		[-0.13 to 0.04]	[-0.20 to -0.03]	[-0.13 to 0.04]
p<0		0.84	0.99	0.85
Yo-Yo IR1				
mean ± SD (m)	2308 ± 540	2470 ± 569	2456 ± 265	2440 ± 531
estimated difference (m)		135	41	90
95% CI [LB – UB]		[-104 to 371]	[-204 to 292]	[-145 to 330]
p>0		0.16	0.01	0.15
pSWC		1.00	1.00	1.00

95% CI = 95% Credible intervals with LB-UB (lower bound to upper bound), *p*<0 = probability that the change is less (<) or greater (>) than 0 from population estimate, *pSWC* = probability of improvement being greater than the smallest worthwhile change

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Table 2 – The effect of each caffeine dose compared to placebo for pre and post exercise CMJ parameters.

	Placebo		**1 mg•kg^{-1}**		**2 mg•kg^{-1}**		**3 mg•kg^{-1}**	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Jump Height								
mean ± SD (cm)	38.07 ± 8.49	36.6 ± 8.00	39.36 ± 7.23	36.6 ± 7.17	40.96 ± 6.11	37.47 ± 8.21	41.61 ± 7.18	42.25 ± 7.90
estimated difference (cm)			0.85	0.75	1.19	0.27	2.05	5.47
95% CI [LB – UB]			[-1.55 to 3.16]	[-1.75 to 3.20]	[-1.27 to 3.53]	[-2.41 to 2.90]	[-0.27 to 4.34]	[2.7 to 7.98]
p>0			0.77	0.72	0.84	0.58	0.96	1.00
pSWC			0.48	0.43	0.60	0.30	0.94	0.99
Peak Power								
mean ± SD (W)	4382 ± 1607	4300 ± 1676	4961 ± 2598	4902 ± 1565	5339 ± 2037	5613 ± 2390	4764 ± 1357	5157 ± 1642
estimated difference (W)			470	476	518	976	164	657
95% CI [LB – UB]			[-94 to 1040]	[-106 to 1035]	[-65 to 1102]	[350 to 1564]	[-382 to 724]	[86 to 1227]
p>0			0.95	0.95	0.96	0.99	0.72	0.99
pSWC			0.75	0.75	0.80	0.99	0.37	0.91
Mean Power								
mean ± SD (W)	2486 ± 797	2212 ± 791	2618 ± 1099	2619 ± 980	2759 ± 958	2866 ± 1060	2656 ± 779]	2781 ± 862
estimated difference (W)			123	443	174	601	115	569
95% CI [LB – UB]			[-137 to 377]	[199 to 701]	[-89 to 440]	[337 to 873]	[-130 to 369]	[325 to 822]

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	Placebo		1 mg·kg^{-1}		2 mg·kg^{-1}		3 mg·kg^{-1}	
p>0			0.83	1.00	0.90	1.00	0.82	1.00
pSWC			0.57	0.99	0.70	1.00	0.54	0.99
Peak Velocity								
mean ± SD (m.s^{-1})	3.26 ± 0.48	3.15 ± 0.33	3.27 ± 0.50	3.22 ± 0.40	3.38 ± 0.52	3.33 ± 0.50	3.34 ± 0.35	3.33 ± 0.43
estimated difference (m.s^{-1})			0.01	0.11	0.09	0.16	0.05	0.18
95% CI [LB – UB]			[-0.15 to 0.18]	[-0.04 to 0.25]	[-0.08 to 0.26]	[0 to 0.32]	[-0.11 to 0.21]	[0.03 to 0.32]
p>0			0.56	0.92	0.86	0.97	0.74	0.99
pSWC			0.75	0.74	0.40	0.91	0.59	0.95
Peak force								
mean ± SD (N)	1976 ± 541	1918 ± 528	2101 ± 629	2148 ± 573	2133 ± 538	2156 ± 682	2049 ± 528	2149 ± 583
estimated difference (N)			121	233	93	212	65	231
95% CI [LB – UB]			[-27 to 267]	[78 to 389]	[-62 to 246]	[49 to 378]	[-79 to 213]	[70 to 390]
p>0			0.94	0.99	0.88	0.99	0.81	0.99
pSWC			0.81	0.99	0.69	0.97	0.55	0.98

95% CI = 95% Credible intervals with LB-UB (lower bound to upper bound), *p*<0 = probability that the change is less (<) or greater (>) than 0 from population estimate, *pSWC* = probability of improvement being greater than the smallest worthwhile change.