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Title of the article: Effects of carbohydrate, caffeine and guarana on cognitive performance, perceived exertion and shooting performance in high level athletes.

Submission type: Original investigation

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Preferred running head: Exercise, Nutrition and Cognition

Abstract word count: 250

Text-only word count: 4025

Numbers of figures and tables: 6 (5 figures and 1 table)

Abstract

Purpose*:* This study aimed at investigating the effect of carbohydrate (CHO), caffeine (CAF) and a guarana complex (GUAc) ingestion during a running exercise on cognitive performance, ratings of perceived exertion (RPE) and shooting performance in high level Modern Pentathlon athletes. **Methods*:*** Ten athletes completed four counterbalanced sessions within a 2 week-period, corresponding to ingestions of CHO (30 g), GUAc (300 mg), CAF (200 mg) or placebo (PL). The exercise involved a 40-minute run on a treadmill at a steady speed, previously determined as a "somewhat hard" exercise (RPE 13). Shooting and cognitive performances (Simon task) were assessed in three phases: 1) prior to exercise and ingestion, 2) prior to exercise and after half ingestion, and 3) after exercise and full ingestion. Ingestions were consumed 40 minutes (250 ml) and 5 minutes (125 ml) prior to exercise, and after 20 minutes of run (125 ml). RPE was assessed at 10 minutes intervals during exercise. **Results:** Results have shown an interaction between drinks and exercise on mean reaction time ($p = .01$, $\eta p^2 = .41$) and a drinks effect on RPE ($p = .01$, $\eta p^2 = .15$). CHO, CAF and GUAc enhanced the speed of information processing after exercise (respectively $p = .003$, $p = .004$ and $p = .04$) but only CAF and GUAc decreased RPE (respectively $p = .002$, $p = .02$). **Conclusion:** Our results highlight the beneficial effect of nutritional supplements on information processing and RPE. This finding is particularly interesting since decision-making processes are vital in many sports performance.

Introduction

In many sports, successful performance requires filtering relevant information and selecting actions consistent with current goals. Performance is directly linked to the athlete's capacity to simultaneously handle physiological and cognitive loads. Modern Pentathlon is one of these disciplines where athletes are faced with physiological and cognitive requirements, as pentathletes need to provide accurate and appropriate responses under time pressure. This Olympic sport involves five events, all completed in a single day, including swimming, horse riding, fencing, and a combined event of pistol shooting and running. Optimal cognitive functioning stands out as a preponderant factor notably in the fencing event, which is a duelling event involving quick and accurate decision-making. But efficiency of cognitive functioning is also a central component of the combined events since athletes have to complete four pistol shooting series, interspaced by 800 m runs[1]. During this event, irrelevant stimuli such as noise, nearby competitors and lighting represent potential distractions which could affect shooting performances.

Within this framework, it has been well documented that moderate exercise improves cognitive performance whereas heavy or prolonged exercise could lead to a decrease[2]. Recent studies have indicated that nutritional supplements could help limit central fatigue[3] possibly related to brain neurotransmitters disturbances[4], and maintain cognitive abilities during exercise[5,6]. These include carbohydrate (CHO) and caffeine (CAF), which are commonly consumed by athletes for their ergogenic effects on endurance performance and more recently to improve on cognitive functioning due to a modification of cerebral physiological state (for review see[3]). Currently, there is also a growing interest for guarana, commonly consumed in association to multi-mineral complex, and ginseng (GUAc). Guarana ingestion has been reported to enhance cognitive functioning at rest[7,8] and during exercise[9], possibly due to a number of potential stimulants such as caffeine, flavonoids, saponins or tannins[10,11].

Cognitive functioning represents a huge field of research. In the present study we investigated executive functions, which in a broad sense refer to several processes essential for our adaptability in an ever-changing environment. Among the variety of them, we focused specifically on response inhibition which refers to the efficiency of resolving response conflict.To date, very few studies have investigated the effect of nutritional supplements on response inhibition, even though it is a crucial element in decision-making and crucial in sporting performance. Some research suggest that CAF ingestion could enhance response inhibition at rest possibly through an antagonism action of A_1 and A_{2a} adenosine receptors leading to an indirect increase of dopamine availability in brain regions of interest[12]. But to our knowledge, no study investigated the effect of CAF ingestion on response inhibition at the end of exercise. Similarly, a recent study has shown an improvement of response inhibition, after GUAc ingestion at rest[8]. Lastly, while CHO has been shown to induce beneficial effects on physical performance even during short exercise (< 1 hour) through central mechanisms[13,14], to our knowledge, no study has investigated the effect of CHO intake on response inhibition at the end of the exercise.

The main purpose of the present study was to assess, the effect of CAF, CHO and GUAc ingestion on response inhibition and shooting performance in high level Modern Pentathlon athletes. We also investigated the effect of these three nutritional supplements on ratings of perceived exertion (RPE), which could be defined as “the feeling of how hard, heavy and strenuous a physical task is”[15]. Modification of RPE during exercise is particularly interesting since a decrease in rate could allow participants to produce more power with the same degree of perceived exertion.

Methods

Subjects

Twelve athletes of the Modern Pentathlon National Team took part in the present study (Table 1). All participants were intensely engaged in training (~25 hours per week) and competed at international level. Due to injuries during the experimental period, only ten athletes (6 males and 4 females) were included in the present results. Participants were not currently using nutritional supplements during training or competition and habitually consumed less than 100 mg of caffeine per day. Before inclusion, the experimental procedure was explained to the participants and they signed an informed consent form approved by the Ethics Committee (Ile de France, VII, Saint Germain en Laye, France).

Design

This study used a pseudo counter-balanced design and required participants to visit the laboratory five times.

One week before the experimental sessions, the participants performed a preliminary session in order to collect physiological and anthropometric characteristics. Additionally the participants were required to determine a treadmill running speed which corresponds to a perception of "somewhat hard" exercise. This submaximal speed was identified on the Borg 6-20 category scale[16] by a 13 RPE. Recent studies have provided strong evidence for the efficiency of RPE 13 to self-regulate training over a long period[17]. After a 5-minute warm-up at 8.5 $km.h^{-1}$ for female participants and 10.5 km $.h^{-1}$ for male participants, the running speed was increased by 0.5 $km.h^{-1}$ every 4 minutes and the participants verbally reported the number that reflected how hard they were running, ranging from no exertion at all (6), somewhat hard (13) to maximal effort (20). The running speed was increased until the subjects achieved a level of RPE 13. Additionally, they were excluded from receiving any feedback during the exercise.

The four experimental sessions were performed within two weeks, separated by, at least, 72 hours, and conducted at the same time of the day for each participant. Each session lasted approximately 120 minutes. The participants were required to note their diets with instructions to follow the same diet before each subsequent visit. They were also required to refrain from alcohol, caffeine, pain medication and to control their time and hours of sleep the 48 hours prior to each experimental session. Except water, any ingestion was prohibited in the three hours before the start of the experimental session. Training loads of athletes were replicated in the 48 hours between each session, in order to replicate a similar physiological strain. So as to facilitate digestion processes and to reproduce athlete's consumption habits, ingestion of nutritional supplements was split into three ingestions: two before exercise and one during exercise. Each experimental session started with a short recall of the Simon task, followed by a pistol shooting performance, a first block of the Simon task and the ingestion in a single-blind manner of 250 millilitres (ml) of drink. The participants were then invited to remain calm in a quiet room for 25 minutes. Fifteen minutes before the start of exercise, the participants performed pistol shooting, a second block of Simon task and ingested 125 ml of the same drink. Then, the participants started a constant-workload 40-minute run, at the speed corresponding to RPE 13 as previously determined. Heart rate values were continuously recorded during exercise using Polar RS800 heart rate monitor (Polar Electro, Kempele, Finland). RPE was assessed at 10, 20, 30 and 40 minutes during exercise. A further 125 ml drink was administered after 20 minutes of running and after RPE assessment. Immediately at the end of exercise, subjects performed a pistol shooting followed by a third block of the Simon task. Measurements of lactatemia (lactate Pro II, Arkay, Kyoto, Japan) were taken from a capillary blood of the fingertip before and 2 minutes after exercise (Figure 1).

Thus, cognitive performance and shooting performance were assessed three times during each experimental session: prior to exercise/prior to ingestion, prior to exercise/after half ingestion, and after exercise/after full ingestion.

The experimental sessions differed only by the composition of the drink ingested, prepared by the experimenter, of either: a 6% carbohydrate complex (CHO: fructose (89%) and maltodextrin (11%), ISOXAN® Sport Pro, NHS, Rungis, France), a 200 milligrams (mg) caffeine (CAF: PROLAB® nutrition, Chatswoth, USA) added with orange sugarless syrup, a 3.4 grams (g) guarana complex (GUAc: 300 mg of guarana + 100 mg ginseng + 180 mg vitamins C, Isoxan Actiflash® Booster, NHS, Rungis, France), or a placebo (PL: tap water added with orange sugarless syrup). We decided to use the amount of 6% CHO and 200 mg of caffeine commonly used in nutrition studies. Furthermore, 300 mg guarana was consumed to reach the dose range recommended per day. Tap water was provided ad libitum during the exercise.

Methodology

Cognitive performance

Response inhibition was assessed using the Simon task[18], which provides information about the ability to inhibit prepotent responses. For details about the learning criteria please see[6]. The participants were sitting opposite a computer screen placed at 1 meter away, with two response keys on their right and left hands. They were required to respond, as quickly and accurately as possible, by pressing the appropriate response key (with the right or left thumb finger) according to the shape (square or circle) of a geometric symbol delivered either to the left or to the right of the fixation point. The participants had to select the task-relevant feature of the stimulus (the shape) and inhibit the surrounding task-irrelevant feature (the spatial location). The task included 80 trials divided in two equiprobable trial types randomized: the congruent trials (response side ipsilateral to the stimulus side), and the incongruent trials (response side contralateral to the stimulus side). Performance expressed both in terms of mean reaction time (milliseconds, ms) and error rate (%), is usually reported to be better when the relevant and irrelevant information correspond to the same response than when they are mapped to different responses. This effect is known as the “Simon effect” or “interference effect” in the literature. The emergence of a conflict between the activation of the incorrect response (associated to the irrelevant information) and the activation of the correct response (associated to the relevant information) is thought to be at the origin of the performance impairment[19].

Pistol performance

Pistol shooting was performed in a quiet room, near the experimental room. The participants were required to shoot with their own pistol, held with only one hand, in a standing position behind the firing line located 10 meters away from the electronic targets. The two electronic targets (Hit target, Simpower©) were composed by one black single aim and five green/red lights indicating the success or failure ensuing to the shoot. The participants had to shoot down five targets on the two electronic boxes, as fast as possible. Shooting time (i.e. the delay between the first and the last shoot) and accuracy (i.e. percentage of success in hitting the ten targets during each pistol shooting sessions) were computed.

Statistical analysis

All variables are expressed as mean ± standard deviation (mean ± SD) except for the cognitive tasks which are expressed as mean ± standard errors (mean ± SE). Statistical analysis was performed using a repeated measures ANOVA (Statistica, Statsoft©, version 13). A first analysis was performed to assess the effect of nutritional supplements on shooting performance and on cognitive performance at rest (prior to exercise and ingestion vs prior to exercise and after half ingestion). The shooting performance was assessed using respectively a two-way ANOVA (4 × 2) with factors drinks (PL vs CHO vs GUAc vs CAF) and ingestion (pre vs post ingestion). The cognitive performance was assessed using a three-way ANOVA (4 × 2 × 2)

with factors drinks, ingestion and congruency (congruent vs incongruent).

A second analysis was performed to assess the interaction between exercise and nutritional supplements (prior to exercise and after half ingestion vs after exercise and full ingestion). A two-way ANOVA (4 × 4) was conducted on mean heart rate and perceived exertion with factors drinks and exercise duration (10 min vs 20 min vs 30 min vs 40 min). The shooting performance and lactatemia were assessed using a two-way ANOVA (4 × 2) with factors drinks and exercise (pre vs post exercise).The cognitive performance was assessed using a three-way ANOVA (4 × 2 × 2) with factors drinks, exercise and congruency. Post-hoc

Newman-Keuls tests were conducted for all significant effects. Effect sizes were calculated using partial eta square (ηp^2). Values of: 0.01, 0.06 and over 0.14 were respectively considered as small, medium and large effect[20]. For univariate repeated-measure ANOVA tests involving more than one degree of freedom, the Greenhouse-Geisser correction was conducted. In this case, the corrected degrees of freedom and p-value were reported. The level of significance was set at $p < .05$.

Results

Nutritional supplements at rest

Shooting performance

Results did not reveal any effect of ingestion or interaction between drinks and ingestion on shooting time (respectively $F(1.00, 9.00) = .063$, $p = .807$, $\eta p^2 = .007$ and $F(2.68, 24,1) = .854$, $p = .467$, $\eta p^2 = .087$) and on shooting accuracy (respectively $F(1.00, 9.00) = .159$, $p = .700$, $\eta p^2 = .017$ and $F(2.43, 21.9) = 1.45$, $p = .256$, $\eta p^2 = .139$).

Cognitive performance

Results showed a large effect of congruency on mean reaction time, $F(1.00, 9.00) = 86.5$, $p < .001$, $\eta p^2 = .91$ (congruent = 334 ± 7 ms vs incongruent = 356 ± 7 ms) and on error rates, $F(1.00, 9.00) = 15.5$, $p = .003$, $\eta p^2 = .633$ (congruent = 2 ± 0.4% vs incongruent = 4 ± 0.4%). No interaction between drinks and ingestion was found on mean reaction time and on error rates (respectively $F(2.11, 19.0) = .842$, $p = .452$, $\eta p^2 = .0856$ and $F(2.27, 20.4) = .274$, $p = .789$, $\eta p^2 = .030$). Additionally, no interaction between drinks, ingestion and congruency was found on mean reaction time and error rates suggesting no influence on response inhibition (respectively $F(2.78, 25.0) = .517$, $p = .661$, $\eta p^2 = .054$ and $F(2.06, 18.5) = 2.76$, $p = .088$, $\eta p^2 = .234$).

Interaction between exercise and nutritional supplements

Physiological parameters

The treadmill running velocity for the 40-minute exercise was 12.1 ± 1 $km.h^{-1}$ (female : 10.7 ± 1; male: 13.3 ± 1) and the mean heart rate was 162 ± 1 bpm corresponding to 83 ± 5% of the theoretical maximal heart rate[21]. Results highlight a large exercise effect on the mean heart rate, $F(1.06, 9.52) = 45.8$, $p < .001$, $\eta p^2 = .836$. The interaction between drinks and exercise duration showed a trend and suggests that the evolution of the mean heart rate during exercise could differ between drinks, $F(2.07, 18.7) = 2.93$, $p = .077$, $\eta p^2 = .245$ (Figure 2). No effect of exercise or an interaction between drinks and exercise was found on lactatemia, respectively $F(1.00, 8.00) = .198$, $p = .770$ $\eta p^2 = .011$ and $F(2.77, 22.1) = .540$, $p = .663$, $\eta p^2 = .063$.

Perceived exertion

A large effect of exercise was found on RPE, $F(1.13, 10.2) = 21.9$, $p < .001$, $\eta p^2 = .708$ suggesting an increase of RPE between 10 and 40 minutes of exercise. Additionally, a drink effect was observed, $F(2.40, 21.6) = 4.87$, $p = .014$, $\eta p^2 = .147$. Newman-Keuls test highlighted a lower mean of RPE during exercise with CAF and GUAc compared to PL (respectively Δ = 1, p = .002 and Δ = 1, p = .019) (Figure 3). No interaction between drinks and exercise duration

has been found, $F(3.06, 27.5) = 1.55$, $p = 0.14$, $\eta p^2 = .144$.

Shooting performance

A large negative effect of exercise on the shooting performance was observed on time (Δ = +7 s) and accuracy (Δ = -10%), respectively, $F(1.00, 9.00) = 6.93$, $p = .027$, $\eta p^2 = .435$ and $F(1.00, 9.00) = 10.6$, $p = .010$, $\eta p^2 = .541$. No significant interaction between drinks and exercise was observed on the shooting time (F1.68, 15.1) = 2.11, $p = .160$, $\eta p^2 = .190$) or accuracy ($F(1.71, 15.4) = 1.62$, $p = .231$, $\eta p^2 = .15$) suggesting that nutrition does not negate the detrimental effect of exercise (Figures 4A and 4B).

Cognitive performance

Mean reaction time

Analysis revealed a large effect of congruency, $F(1.00, 8.00) = 188$, $p < .001$, $\eta p^2 = .959$ (congruent = 327 ± 7 ms vs incongruent = 353 ± 7 ms) and an interaction between drinks and exercise, $F(2.07, 16.5) = 5.59$, $p = .014$, $\eta p^2 = .407$ on mean reaction time. Newman-Keuls test did not reveal a significant change of mean reaction time after exercise compared to before exercise with PL ingestion (p = .848), whereas a significant improvement of reaction time after exercise was observed with CHO (Δ = -20 ms, p = .003), GUAc (Δ = -11 ms, p = .048) and CAF (Δ = -20 ms, p = .004) ingestions (Figure 5A).

No significant interaction between exercise and congruency ($F(1.00, 8.00) = .344$, $p = .573$, $\eta p^2 = .041$) or between drinks, exercise and congruency ($F(2.10, 16.8) = .929$, $p = .419$, $\eta p^2 = .104$) was observed on mean reaction time, suggesting that neither exercise nor nutritional supplements modified the magnitude of the interference effect.

Error rates

A large effect of congruency, $F(1.00, 9.00) = 33.4$, $p < .001$, $\eta p^2 = .787$ (congruent = 2.5 ± 0.4% vs incongruent = 3.9 ± 0.4%) and an interaction between drinks and exercise, $F(2.58, 23.3) = 3.41$, $p = .040$, $\eta p^2 = .274$ were observed on error rates. Newman-Keuls test did not reveal a significant difference in error rates for each drink before and after exercise: CAF (p = .300), CHO (p = 1.00), PL (p = .098) and GUAc (p = .060). Nonetheless a larger decrease of error rates with GUAc compared to PL was found after exercise, $F(1.00, 9.00) = 8.15$, $p = .019$ (Figure 5B).

No significant interaction between exercise and congruency ($F(1.00, 9.00) = .148$, $p = .709$, $\eta p^2 = .016$) or between drinks, exercise and congruency ($F(2.66, 24.0) = 2.91$, $p = .060$, $\eta p^2 = .244$) was observed on error rates.

Discussion

The present study was conducted to assess the influence of nutritional strategies on cognitive performance, shooting performance and perceived exertion. To this aim, ten high level Modern Pentathlon athletes were required to ingest CHO, CAF and GUAc drinks before and during a submaximal run of 40 minutes. The response inhibition and shooting performance have been assessed prior and after exercise and RPE was measured every 10 minutes while exercising. The most important findings were: (i) CAF and GUA ingestion led to a decrease in perceived exertion compared to PL; (ii) CHO, CAF and GUAc enhanced information processing in terms of speed compared to PL; (iii) nutritional supplements did not modify the magnitude of the interference effect and did not improve shooting performances.

As expected, prolonged exercise leads to an increase in RPE. However, our results indicate that both CAF and GUAc ingestion attenuate perceived exertion rising during exercise, and may be associated with a lower mean of heart rate, as reported by a trend effect. This result

is particularly interesting since RPE has been used to explain changes in pace and pacing strategy[17]. Beneficial effects of CAF on RPE have already been shown[22] and expounded through central nervous system involvement. A possible explanation for the caffeine-induced reduction in RPE for unchanged muscle activation is the attenuation of premotor and motor areas activities reflected by the decrease in the amplitude of the motor-related cortical potential[23]. It has been proposed that dopamine and adenosine system could interact in the brain, possibly in the nucleus accumbens, creating a greater dopaminergic drive involved in regulating behavioural activation and motivation[24]. Similarly, we observed that GUAc ingestion also has a positive effect on RPE increase when compared to PL, which is in line with a recent study[9] investigating the effect of a similar GUAc ingestion on RPE during a 30-minute run. The possible mechanism of guarana on RPE remains unknown, but previous authors suggest that the psychoactive properties of guarana may be attributable to higher content of other psychoactive components than caffeine, including both saponins and tannins[10]. Lastly, we failed to report any beneficial effect of CHO on RPE during exercise. Several studies had previously highlighted the beneficial effect of CHO ingestion during prolonged exercise[25,26] but effects appeared to be significant only from 75 minutes of a 2 hours cycling exercise. If RPE enhancement in prolonged exercise suggests an increase of substrate
availability with CHO consumption, to date, mechanisms and effects on shorter exercise (~1 hour) are more equivocal.

Another interesting result is that the mean reaction time is shorter after CHO, GUAc and CAF ingestions compared to PL which suggests a speed information processing enhancement. Several studies have shown a beneficial effect of CHO ingestion on cognitive functions during a prolonged exercise (> 2 hours) leading to fatigue[3] but results on shorter exercise (<1 hour) are less conclusive. One hypothesis raised by recent mouth rinsing studies indicates that the beneficial effect of CHO during exercise < 1 hour may be mediated by central neural response from an oral CHO stimulus which can influence activation of different brain areas and influence emotion and behaviour[6,27]. Concerning CAF ingestion, our results highlighted an enhancement of speed of information processing, but no effect was found on response inhibition. In the literature, some studies suggest that CAF could have positive influence on response inhibition at rest and reduces interference costs[13,28], whereas another investigation do not support a beneficial effect of caffeine on a variety of inhibitory tasks [29]. To date, effect during exercise is even more uncertain. Using the Stroop task, Hogervorst et al.[30] found an improvement of information processing in terms of speed, with CAF bars ingestion compared to both CHO and PL from 70 minutes of exercise. However, effects on response inhibition require to be further investigated. Likewise, our results highlight the beneficial effect of GUAc on information processing after exercise but no effect was found on response inhibition. Up to the present time, very few studies have investigated the interaction effect of GUAc ingestion and exercise on cognitive function. In a recent study, Veasey et al.[9] highlighted an increase in accuracy of numeric working memory and in speed of picture recognition after exercise when compared to PL. Even if mechanisms explaining guarana effects remain unclear, taken together, these results suggest that GUAc ingestion could be an interesting nutritional strategy to enhance cognitive functioning even if effects on response inhibition at the end of exercise remains limited.

Lastly, in this study we failed to observe any improvement or effect on shooting performances. In our well trained participants, 40 minutes of exercise leads to a decrease in shooting performance but no effect of CHO, CAF and GUAc ingestions was found. Like for all fine motor coordination, shooting performance is extremely sensitive to various factors. A large variability in the shooting performance was observed for athletes throughout baselines sessions, which possibly affected the magnitude effect. It could have been interesting to also assess the effect of nutritional supplements on some selective components of a successful shooting performance such as postural balance and pistol stability, which may be predictive of performance enhancement[31]. Furthermore, the low sample size, in line with this specific population, the low-dose range of drinks or the low physiological disturbances compared to those of competition, could be insufficient to highlight these effects. It is important to note that the administration of drinks in a single-blind manner and the lack of the participant's efficiency

measurement to distinguish drinks may present a main limitation in this study.

Practical Applications

For athletes who have to simultaneously perform decision-making processes with a high physiological load, CHO or more specifically GUAc and CAF ingestion would be useful to enhance cognitive abilities during competition. It is appropriate to consider that a large variability in the magnitude of response ingestion has already been shown, and it is clearly necessary to previously test any nutritional supplement in order to determine the athlete's response. Furthermore, while some benefits on cognitive functioning have been established with moderate amounts of caffeine (~ 3 $mg.kg^{-1}$ body mass)[32], some side effects like dizziness, headache, nervousness, insomnia, and gastrointestinal distress have also been noticed by the participants presenting caffeine intolerance (for review see[33]) and/or with consumption of higher doses than that advocated of 200 mg. These potential health effects should be taken into

account in the development of individual nutritional supplements strategies.

Conclusion

In addition to the beneficial effect of nutritional supplements on physical performance previously highlighted in the literature[34], our results come through the possible ergogenic effects of CHO on information processing and of CAF and GUAc on both, perceived exertion and information processing. This finding is particularly interesting since decision-making processes are fully involved in many sports performances, including multi-events competition.

Acknowledgements

The authors wish to thank the CREPS PACA, the French Squash Federation and the French Federation of Modern Pentathlon for supporting the project, and especially coach Cédric Maillard and all the young pentathlon athletes who participated in this study. We also thank Laurence Casini for helping with the data analysis.

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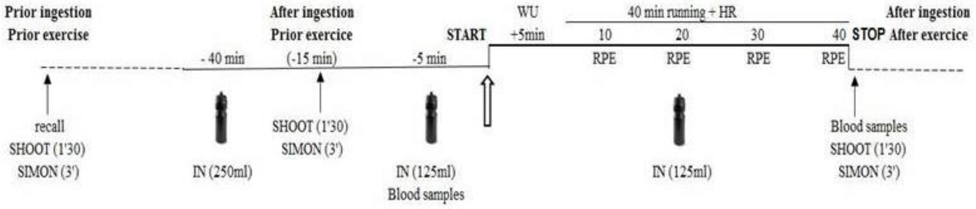

Figure 1: General procedure of each experimental session (recall = recall of the Simon task; SHOOT = pistol shooting; SIMON = Simon task; IN = ingestion of drink; WU = warm up; HR = heart rate record; RPE = ratings of perceived exertion).

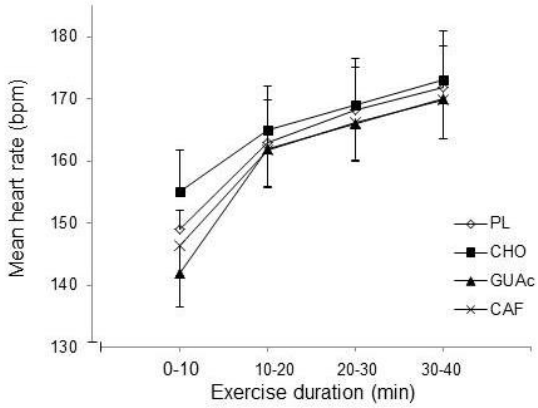

Figure 2: Effect of exercise duration on mean heart rate in function of nutritional supplements. Errors bars represent standard deviation of the mean divided per two.

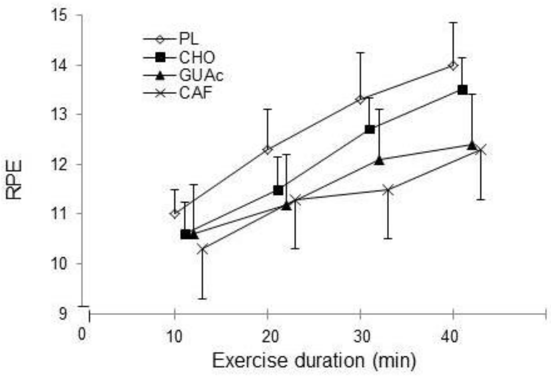

Figure 3: Effect of exercise duration on ratings of perceived exertion (RPE) in function of nutritional supplements. Errors bars represent standard deviation of the mean divided per two. Mean running speed at RPE13 was 12.2 ± km.h-1.

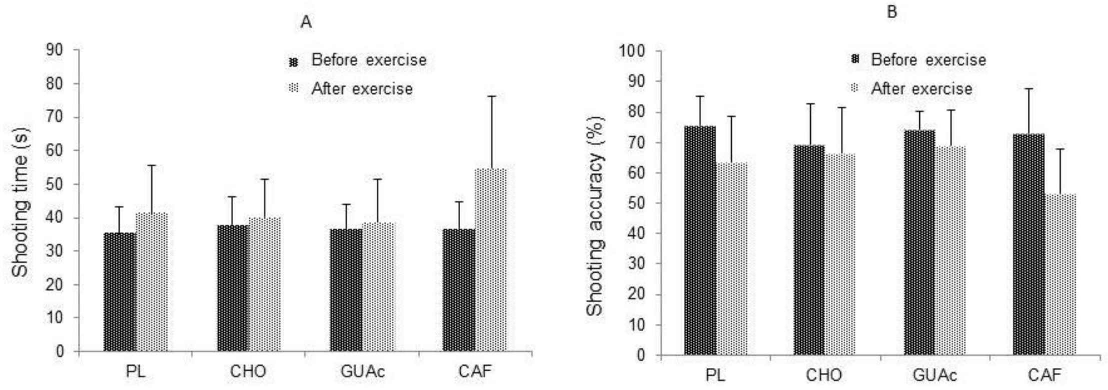

Figure 4: Effect of nutritional supplements on A) shooting time and B) shooting accuracy before exercise and after exercise. Participants were required to shoot down 10 targets as fast as possible. Errors bars represent standard deviation of the mean.

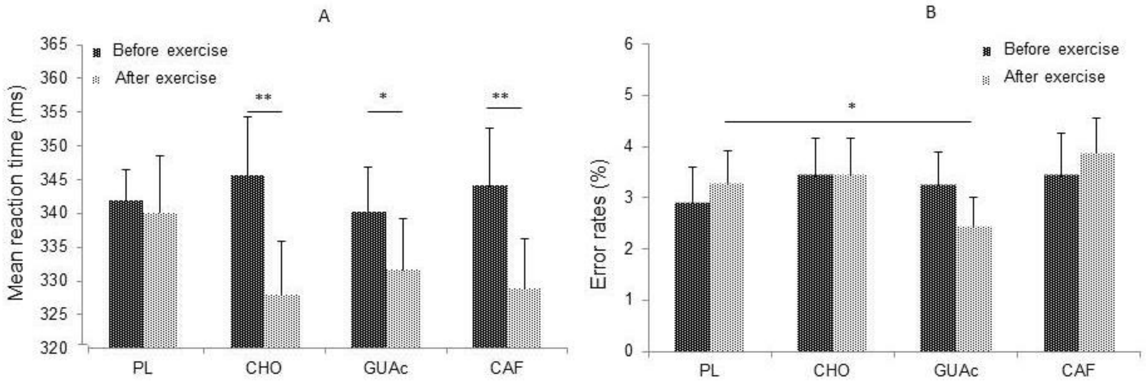

Figure 5: Effect of nutritional supplements on A) mean reaction time (RT) and B) error rates for the Simon task, before exercise and after exercise. Errors bars represent standard errors of the mean *p < .05, ** p < .01.

Table 1: Anthropometric and physiological characteristics of participants.

Mean (Standard deviation)			
Variables	**All**	**Female**	**Male**
Sample size	10	4	6
Age (years)	18.6 (2)	18.9 (2)	18.5 (3)
Height (cm)	173 (11)	168 (12)	176 (11)
Body mass (kg)	60.9 (9)	56.5 (9)	63.8 (11)
Fat mass (%)	13.3 (5)	19.5 (6)	9.20 (5)
Heart rate max (bpm)	195 (2)	195 (2)	195 (2)
Running speed RPE 13	12.2 (1)	10.7 (1)	13.3 (1)