

## Effects of Morning Caffeine' Ingestion on Mood States, Simple Reaction Time, and Short-Term Maximal Performance on Elite Judoists

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Received: Jan 01, 2012

Accepted: Feb 15, 2012

**Key Words:** Caffeine; Anaerobic Performance; Simple Reaction Time; Mood States

### Abstract

**Purpose:** The purpose of the present study was to evaluate the ergogenic effect of caffeine ingestion on mood state, simple reaction time, and muscle power during the Wingate test recorded in the morning on elite Judoists.

**Methods:** Twelve elite judoists (age:  $21.08 \pm 1.16$  years, body mass:  $83.75 \pm 20.2$  kg, height:  $1.76 \pm 6.57$  m) participated in this study. Mood states, simple reaction time, and muscle power during the Wingate test were measured during two test sessions at 07:00 h and after placebo or caffeine ingestion (i.e. 5 mg/kg). Plasma concentrations of caffeine were measured before (T0) and 1-h after caffeine' ingestion (T1) and after the Wingate test (T3).

**Results:** Our results revealed an increase of the anxiety and the vigor ( $P < 0.01$ ), a reduction of the simple reaction time ( $P < 0.001$ ) and an improvement of the peak and mean powers during the Wingate test. However, the fatigue index during this test was unaffected by the caffeine ingestion. In addition, plasma concentration of caffeine was significantly higher at T1 in comparison with T0.

**Conclusions:** In conclusion, the results of this study suggest that morning caffeine ingestion has ergogenic properties with the potential to benefit performance, increase anxiety and vigor, and decrease the simple reaction time.

*Asian Journal of Sports Medicine, Volume 3 (Number 3), September 2012, Pages: 161-168*

## INTRODUCTION

The evidence that caffeine ingestion can improve performance during short-term high-intensity exercise is quite strong [1]. Hence athletes use caffeine in order to increase their performances.

Caffeine's ergogenic effect could be explained by (i) a reduction of the sensation of fatigue induced by exercise [2], (ii) an enhancement of the excitation-contraction coupling [3] and (iii) a stimulation of the central nervous system [4]. In this context, improvements in maximal voluntary contraction after a resistance training program have been associated with improvements in performance during short-term and high-intensity exercise [5], and thus caffeine may have a similar mechanism of action. The means by which a

strength increase might result from caffeine ingestion could be: a direct effect on muscle (e.g. maintaining electrolyte homeostasis or enhancing sarcoplasmic reticulum release) or by an effect on the central nervous system (e.g. increasing motor unit recruitment) [6, 7]. Likewise, previous studies showed that the effect of caffeine essentially appears on the CNS increasing, therefore, the vigilance, the mood, and the attention and reducing the time of reaction [8,9]. However, the literature is unclear on the effect of caffeine ingestion on short-duration high-intensity maximal exercise and it has been the subject of several studies performed over the last three decades. In this context, some previous studies failed to observe substantial performance increments following caffeine ingestion [10,11]. However, other studies revealed that caffeine

ingestion lead to a significant increase in short-term performance [12,13]. In this context, studies examining the effects of caffeine on Wingate performance have typically shown minimal ergogenic effects [14,15].

One of the major reasons of these inconclusive results is the “no-controlled time-of-day” testing. Indeed, to the authors’ knowledge, the existent studies didn’t take into account the effect of time-of-day on their experimental design.

The expression of these rhythms is representative of 24 h variations in both endogenous and exogenous factors. To date, it is well-known that mental performance, including simple and choice reaction times, mood states, vigilance as well as physical outcomes are time-of-day dependent [16-19]. For example, during the Wingate test, peak and mean powers fluctuate with time-of-day, with morning nadirs and afternoon peaks values [20-22].

Thus, it is crucial for athletes interested in maximal performance, as well as coaches and researchers, to determine caffeine’s ergogenic effect on short term exercise in the morning in order to improve their performance at this time-of-day.

In view of the above considerations, the aim of the present study was to investigate caffeine’s effect on the morning short-term maximal exercise, mood state, and simple reaction time on elite judoists.

## METHODS AND SUBJECTS

### *Participants:*

Twelve judokas (age:  $21.08 \pm 1.16$  years; body mass:  $83.75 \pm 20.2$  kg; height:  $1.76 \pm 6.57$  m) volunteered to participate in this study. After receiving a description of the protocol, risks, and benefits of the study, each volunteer provided written informed consent. The study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the University Ethics Committee before the commencement of the assessments. Subjects were selected according to their usual consumption of caffeine and on the basis of their answers to the Horne and Ösberg self-assessment questionnaire [23] to have a group without “extreme type” (i.e. they were selected as “neither type”) This second criterion resulted in a

sample of subjects who shared the same timing in terms of rising times (06:30±00:30 h) and bedtimes (23:00±00:30 h). Subjects reported no sleep disorder, non-smokers, did not consume caffeine or any alcoholic beverages and none of them was taking any medication.

### *Experimental Design:*

During the week before the experiment, all subjects came to the laboratory several times and at different hours of the day to become fully familiarized with the procedure and tests involved so as to minimize learning effects during the experiment. Then, the subjects performed two experimental trials in the morning between 06:00–07:00 h in a randomized order over two days with a minimum recovery period of 48 h in-between: after either a placebo or caffeine ingestion.

After 10 min of rest in sitting position, subjects ingested caffeine dose or placebo; then, they remained in sitting position for 60 min. Immediately after the 60 min of resting, the test session was performed as follows: simple reaction time, mood states measurements, warm-up of 5 min, and then the 30-s Wingate test. The quantity of coffee to give the desired amount of caffeine needed (i.e.,  $5 \text{ mg.kg}^{-1}$ ) was measured using electronic weighing machine BOECOTE.

Blood samples were obtained from the antecubital vein before caffeine or placebo ingestion, 1-h after ingestion and immediately after the Wingate test for the determination of plasma caffeine.

### *Simple reaction Time:*

The reaction time was used as an index of individuals’ motor performance. The assessment of the simple reaction time has been achieved by the slant of the software “React”. The test consisted to answer, as quickly as possible, to a visual stimulus while pushing on a key of a microcomputer.

### *Profile of Mood States (POMS):*

The POMS consists of 65 adjectival items (e.g. tense, scared) developed to measure 7 aspects of mood (anxiety/tension, depression/dejection, anger/hostility, confusion/ bewilderment, vigor/activity, fatigue/inertia, and friendship). Factor analyses by the developers failed to confirm the friendship domain, and although guidelines for administration that were followed in this

trial continue to include the seven friendship items, they are no longer reported as a POMS subscale or included in the total mood D (TMD) score. McNair et al. [24] responses to each item range from 0 to 4, with higher scores indicating more negative mood (0 indicates “Not at all,” regarding the presence of an adverse mood [e.g. anger] over the past week, and 4 indicates “extremely”).

To generate the POMS TMD score, the vigor subscale score, created from responses to positively worded items (e.g. lively, active), is subtracted from the sum of the 5 other subscale scores to yield a TMD score ranging from 32 (best possible TMD score) to 200 (worst possible TMD score) [24].

#### **Wingate test:**

As previously described by Chtourou et al [25], the Wingate test involved a 30-s maximal sprint against constant resistance. For each participant, the load was determined according to body mass:  $0.087 \text{ kg} \cdot \text{kg}^{-1}$  body mass. Participants were given vigorous verbal encouragement during the test. Seat height was adjusted to each participant's satisfaction and toe-clips were used to prevent the participant's feet from slipping off the pedals. Seat height was recorded and kept the same for each participant throughout the trials. Peak power (PP) was taken as the highest mechanical power elicited during the test. Mean power (PM) was the average power sustained throughout the 30-s period. The fatigue index (FI) was calculated as follows:  $\text{FI} (\%) = [(\text{PP}-\text{PL})/\text{PP}] \times 100$ , with PL: lowest power during the 30-s.

#### **Blood Sampling and Analysis:**

Blood samples were drawn from an antecubital vein into 10 mL serum vacutainer tubes. Then, serum tubes were centrifuged at 3000 rpm for 10 min at room temperature. Serum was separated from blood cells and stored at  $-20 \text{ }^{\circ}\text{C}$  until analyzed. Plasma caffeine was measured using automated HPLC (SHIMADZU, Japan).

150  $\mu\text{l}$  of plasma was added to 40 mg ammonium sulphate and 50  $\mu\text{l}$  (0.05%) acetic acid. After addition of 25  $\mu\text{l}$  of an internal standard solution (7- $\beta$ -hydroxypropyl theophylline) and 3 ml chloroform-isopropyl alcohol (85:15, vol/vol) extracting solvent, the mixture was vortexed for 30 s and centrifuged for 10 min at 3000 rpm. The organic phase was transferred

and dried under oxygen-free  $\text{N}_2$  and resuspended in HPLC mobile-phase solvent (3% isopropanol, 0.05% acetic acid and 0.5% methanol), and 100  $\mu\text{l}$  was injected into a Beckman, Ultrasphere, IP, C18, 5- $\mu\text{l}$  column. Methylxanthines were measured at 282-nm wavelength. Reagents for standards were obtained from Sigma Chemical (St. Louis, MO).

#### **Statistical Analysis:**

All statistical tests were processed using Statistica Software (StatSoft, Paris, France). Data are reported as the mean  $\pm$  SD (standard deviation) in the text, and is displayed as the mean  $\pm$  SE (standard error) in the figures. The Kolmogorov-Smirnov test of normality revealed that the data were normally distributed. Once the assumption of normality was confirmed, parametric tests were performed. A comparison of mean data between without and following the ingestion of caffeine was achieved by paired Student's t tests. Plasma caffeine concentrations were analyzed using one-Way analysis of variance ANOVA [3 (point)]. When a significant difference was determined in the above analyses, pair-wise comparisons were made using Bonferroni's adjustment to control the Type-1 error rate. Effect sizes were calculated as partial eta-squared  $\eta_p^2$  to assess the practical significance of our findings. All statistical tests were performed using STATISTICA Software (StatSoft, France). The level of statistical significance was set at  $P < 0.05$ .

## **RESULTS**

#### **Profile of Mood State:**

POMS subscale and TMD scores and t-test results after the administration of caffeine or placebo are presented in the table 1. The anxiety and the vigor were significantly higher after the caffeine than the placebo ingestion ( $p < 0.05$ ). However, depression, anger, tiredness, confusion; and the TMD were not significantly affected by the caffeine ingestion.

#### **The simple reaction time:**

Data of the simple reaction times recorded after the ingestion of caffeine or the placebo are presented in the table 1. The simple reaction time was significantly

**Table 1:** The POMS subscale and TMD scores and the simple reaction time' results after caffeine or placebo ingestion (n=12)

Subscale of Mode	Placebo	Caffeine	P Value
Depression	0.56 (0.3)	0.55 (0.48)	NS
Confusion	1.45 (0.37)	01.42 (0.91)	NS
Anger	0.82 (0.89)	0.80 (0.62)	NS
Fatigue	0.48 (0.18)	0.40 (0.22)	NS
Vigor	1.05 (0.24)	2.24 (0.37)	<0.05
Anxiety	0.42 (0.16)	1.45 (0.24)	<0.05
TMD	3.73 (0.37)	4.62 (0.43)	NS
Simple reaction time (ms)	0.34 (0.03)	0.3 (0.04)	<0.001

POMS: Profile of Mood States; TMD: total mood D; NS: no-significant difference

lower after the caffeine than the placebo ingestion ( $P<0.001$ ).

#### Wingate test:

The results of the Wingate test after the administration of caffeine or the placebo are presented in table 2.

The statistical analysis revealed a significant caffeine affect on PP ( $P<0.05$ ) and MP ( $P<0.01$ ) with higher values after the caffeine test session. However, the FI was unaffected by the caffeine ingestion.

#### Plasma Caffeine:

The statistical analysis revealed a significant increase of plasma caffeine after 60 min of the ingestion ( $P<0.01$ ,  $\eta_p^2=0.73$ ). In addition, plasma caffeine was significantly higher after the Wingate test in comparison with before the ingestion of caffeine (i.e. 3.45 mg/l vs. 0.28mg/l).

## DISCUSSION

The aim of this study was to determine the effect of caffeine ingestion on simple reaction time, mood states, and maximal anaerobic power measured in the morning

on elite judoists. Our results showed a decrease in simple reaction time, changes in mood states caused by the increase of the anxiety and the vigor, and a significant increase of PP and MP. However, FI is unaffected by caffeine ingestion.

Although, Ruijter et al [26] showed no-significant caffeine effect, the present study' results are consistent with previous studies that showed a significant decrease in the simple reaction time 60 min after ingestion of caffeine [8,9,27]. Latini et al [28] explain the decrease of the simple reaction time induced by the ingestion of caffeine by its role as a molecule necessary for the transfer of messages from one neuron to another.

Concerning the effect of caffeine on mood states, previous studies suggest that the dose of caffeine is a determinant factor [29,30]. Indeed, Hasenfratz et al [29] showed that low doses of caffeine improve positive mood, while higher doses result in the creation of negative mood. Likewise, Griffiths et al [30] showed that 300 mg of caffeine was able to create a positive mood states. For the present study's caffeine dose, our results are on line with those of Kawachi et al [31] who revealed that ingestion of caffeine contributes to a higher negative mood in the morning. This higher negative mood state could be explained by the caffeine dose (i.e. 5 mg/kg).

**Table 2:** Values of peak and mean power, and the fatigue index recorded during the Wingate test after the ingestion of caffeine or placebo (n=12)

Parameter	Placebo	Caffeine	P Value
Values of Peak (W. kg-1)	10.21 (2.61)	11.01 (2.46)	<0.001
Mean Power (W. Kg-1)	7.36 (1.25)	7.88 (0.9)	<0.05
Fatigue Index (%)	49.5 (12.1)	52.28 (9.91)	No Significant

The effect of caffeine on anxiety has been the subject of several studies [32,33]. Loke et al. [34] revealed that the increase in anxiety is in relation with the high doses of caffeine (3 or 6 mg / kg). In with our findings, Sicard et al [35] observed an increase in anxiety after the ingestion of 600 mg of caffeine. In the same way, Green and Suls [36] found an increase in anxiety following the consumption of 125 mg of caffeine. Likewise, consistent with previous works, the present study's results showed an increase of vigor after caffeine ingestion [37,38].

For lower-limb muscle power, the present study's results showed an increase in PP and PM in the morning after ingestion of caffeine in trained subjects. However, the FI was unaffected by caffeine ingestion.

These results are in line with those of Kang et al [39] that revealed a significant increase in PP and PM during a Wingate test in trained subjects following the ingestion of 5mg/kg [12,40,41]. Anselm et al [40] found a 7% increase in maximal anaerobic power with untrained subjects during a single 6-s sprint following consumption of 250 mg of caffeine. However, Williams et al [15] found no benefit from caffeine (7 mg/kg) during maximal exercise (15-s) for peak power, total power, and fatigue index with untrained subjects. Although Williams et al [15] failed to find improved performance during a 15-s Wingate test; results indicate that caffeine is beneficial for trained and untrained subjects when bouts are 4–6 seconds in duration, which may more closely mimic the time frame associated with high-intensity sports [13]. However, other studies showed no effect of caffeine on anaerobic performance in untrained subjects [42]. They found that caffeine had no effect on electromyogram (EMG) activity. Moreover, Williams et al [15] failed to find an effect of caffeine ingestion on EMG signalling during maximal and submaximal isometric hand grip contraction indicating that neuromuscular properties of the muscle are not affected by the caffeine ingestion. Nevertheless, the present study's results cannot be compared with those studies because our participants are trained subjects. Alternatively, differences in training status could explain these discrepancies, as it has been speculated that caffeine may provide a greater ergogenic benefit in trained subjects [4].

In support of these possible mechanistic effects of caffeine, Lopes et al [3] reported that caffeine had a direct effect on skeletal muscle contractile properties. Similarly, Tarnopolsky [43] reported that caffeine delayed the fatigue in human muscle during low-frequency stimulation, demonstrating an impact of caffeine on excitation-contraction coupling.

Of the mechanisms purported to explain the beneficial effects of caffeine ingestion, recent findings support a CNS response mediated by antagonism of adenosine receptors leading to increases in neurotransmitter release, motor unit firing rates, and dopaminergic transmission [7]. Although further research is required to clarify the relative contribution made by each of these processes to various activities and to confirm or refute the possibility of an intramuscular mechanism of action [44], Kalmar and Cafarelli [45] reported higher maximal voluntary contraction and greater ability to activate the vastus lateralis motor unit pool with caffeine compared to placebo.

Consistent with Graham et al [46] our results showed an ergogenic effect of caffeine. Numerous factors can explain the ergogenic effect of caffeine. Caffeine ingestion has been shown to reduce the sensation of pain induced by exercise [2], enhance excitation-contraction coupling [3], and stimulate the CNS [4] by altering motor unit recruitment and perceptions of fatigue via antagonism of the adenosine receptor. These mechanisms seem to offer sparse insight into the influence of caffeine on anaerobic performance.

## CONCLUSION

The purpose of this study was to evaluate the effect of caffeine on the psychological state (i.e. mood states), the simple reaction time, and anaerobic performance in the morning. Our results revealed an increase in anxiety and vigor, a decrease in the simple reaction time, and an improvement in PP and PM measured during a Wingate test after morning caffeine ingestion.



This study's findings provide justification for future research. First, experimental studies should be conducted to determine the effect of time-of-day of caffeine ingestion on short-term maximal exercise. Second, studies are needed to measure changes in catecholamine or methylxanthine concentrations in response to acute caffeine intake.

## ACKNOWLEDGMENTS

This study was supported by the Ministry of Higher Teaching and Scientific Research, Tunisia. We are grateful to all of the players who participated so willingly in the study. The protocol of the study was approved by the Clinical Research Ethics Committee of the National Centre of Medicine and Science of Sports of Tunis (CNMSS).

**Conflict of interests:** None

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