J. Sci. Math. Lett. UPSI Volume 4 (2016) 56 - 62
ISSN 2462-2052

The Effects of Different Doses of Caffeine on Attention and Cognitive Reaction Time among Universiti Pendidikan Sultan Idris (UPSI) Students

Kesan Dos Kafein Berbeza terhadap Tumpuan dan Masa Reaksi Kognitif dalam kalangan pelajar Universiti Pendidikan Sultan Idris (UPSI)

Normah Jusoh[1] & Niza Anira Mohd Zanani[1]
[1]Faculty of Sports Science and Coaching, Sultan Idris Education University,
35900 Tanjung Malim, Perak, Malaysia
normah@fsskj.upsi.edu.my

Abstract

This study aimed to examine the effects of different doses of caffeine on attention and cognitive reaction time among UPSI students. Thirty habitual drinkers of caffeine were voluntarily participated in this study. They were assigned into three groups namely one control group (water) and two treatment groups (65 mg caffeine and 130 mg caffeine). Every group was instructed to complete the Eriksen Flanker Task after 20 minutes of drink consumption to measure attention and reaction time. The results showed that there were significant differences observed for attention (P=0.003), congruent reaction time (P=0.001) and incongruent reaction time (P=0.049) between control and treatment groups. To conclude, this study proved that caffeine could increase attention and cognitive reaction time among habitual caffeine users.

Keywords Caffeine consumers, attention, reaction time

Abstrak

Kajian ini bertujuan menguji kesan dos yang berbeza terhadap tumpuan dan masa reaksi kognitif di kalangan pelajar UPSI. Seramai tiga puluh peserta pengguna kafein terlibat secara sukarela dalam kajian ini. Mereka dibahagikan kepada tiga kumpula iaitu satu kumpulan kawalan (air) dan dua kumpulan rawatan (65 mg dan 130 mg kafein). Setiap peserta diarahkan untuk menjawab ujian *Eriksen Flanker* selepas 20 minit pengambilan minuman untuk mengukur tumpuan dan fungsi kognitif. Dapatan kajian menunjukkan terdapat perbezaan yang signifikan bagi tumpuan (P=0.003), masa reaksi kongruen (P=0.001) dan masa reaksi tidak kongruen (P=0.049) antara kumpulan kawalan dan rawatan. Sebagai kesimpulan, kajian ini membuktikan bahawa kafein dapat meningkatkan tumpuan dan masa reaksi kognitif dalam kalangan pengguna kafein.

Kata kunci Pengguna kafein, tumpuan, masa reaksi

INTRODUCTION

Caffeine is a bitter substance found mainly in foods such as coffee, tea, chocolate, colas and others. Caffeine has been used widely since 1400 years ago (Roberts & Baron, 1983). For instance, the term coffee culture has been coined to show the deep impact of coffee consumption among society in most part of the world.

Caffeine is primarily used as food ingredients, food supplements and added in some medications. In sports, caffeine is known as one of nutritional supplements taken by some athletes to increase sports performance. Many studies have been conducted to investigate the potential ergogenic effect of caffeine in psychomotor response (Hogervost et al., 2008; Stevenson, Hayes & Allison, 2009; Van Gelder et al., 2007), aerobic endurance performance (Del Coso et al., 2014; Schubert, Astorino & Azevedo, 2013) and muscular strength and endurance (Davis & Green, 2009; Warren, Park, Maresca, McKibans & Millard-Stafford, 2010) among athletes. These studies however produced mixed results due to different methodology applied, status of the caffeine users and dosage of caffeine used in the studies.

Most athletes usually face difficulties in retaining their focus and cognitive abilities during games due to the behavior of audiences, pressure from the opponents and other environmental cues that may affect the performance (Shahruddin, 2001). There are psychological techniques available such as self-talk, imagery and others, but the use of caffeine as an ergogenic aid in sports has becoming more common to overcome such problems. Caffeine consumption stimulates the central nervous system and may affect psychomotor responses such as mental alertness and cognitive function. A study by Hogervost and colleagues (2008) showed that 100 mg caffeine could improve cognitive function during and after exercise among the well-trained cyclists. On the other hand, Hespel, Maughan and Greenhaff (2006) concluded that where a low dose of caffeine (2-5 mg/kg body mass) could potentially improve performance, however caffeine overdose should be avoided because it may impair the visual information processing in sports that require rapid visual stimuli such as soccer.

Since there is no conclusive evidence about the appropriate doses of caffeine that enhances sports performance, thus this study aims to examine whether different doses of caffeine has an effect on attention and reaction time among recreationally active UPSI students. We hypothesized that the students who were given different doses of caffeine scored significantly better in attention and cognition than the control group.

METHODOLOGY

Participants

Thirty students comprised of 15 males (aged 27±2 years; height 170±3 cm; body mass 71±9 kg) and 15 females (aged 25±1 year; height 153±8 cm; body mass 54±8 kg) were voluntarily participated in the study (Table 1). The participants were randomly selected among the recreationally active sports science students.

All participants were healthy and free from chronic diseases and were habitual caffeine users. All participants received both written and verbal details of the study prior to the start of the trials. Once they agreed to proceed with the trial, written informed consent was obtained from them. This study was conducted according to the Declaration of Helsinki.

J. Sci. Math. Lett. UPSI Volume 4 (2016) 56 - 62
ISSN 2462-2052

Instruments and Procedures

Before the trial, all participants were asked to fill in a form containing demographic information such as gender, age, weight, stature and frequency of caffeine intake per week. An Eriksen Flanker Task (Eriksen & Eriksen, 1974) was utilized to measure attention and cognitive function of the participants. Cognitive function was further divided into congruent and incongruent reaction time. Reliability index for the instrument was 0.80 (Miller, 1987).

Thirty participants were randomly assigned to three different groups with equal numbers of both gender into the control group with no caffeine (N=5 males, 5 females), 65 mg caffeine group (N=5 males, 5 females) and 130 mg caffeine (N=5 males, 5 females). The participants were instructed not to take foods and beverages containing caffeine 30 hours before commencing the test.

When the participants arrived at the laboratory, they were informed about the steps and how to answer the test. Flanker Test is represented by arrows which calculated the percentage of correct responses to measure attention. To measure cognitive function, stimuli in the form of arrows was presented one at time to the participants and the time taken to respond to the stimuli was recorded. For congruent reaction time, the participants were showed the arrows pointing in the same direction as the target stimulus (e.g. >>>>>) , meanwhile incongruent reaction time was registered when the participants were presented with the arrows pointing the opposite direction to the target stimulus (e.g. << ><<).

They were explained about the usage of keyboard as an instrument to response for reaction time test. The ‘z’ or the ‘/’ key was pressed to respond to the left or right arrow, respectively. The task consists of 36 pairs of trials with all possible combinations of stimuli. After the briefing, all participants were asked to consume their respective drink based on the experimental groups and sat quietly for 20 minutes. After that, they were instructed to answer the test. Attention score and time taken to answer the test were recorded.

Data analysis

All data sets were checked for normative distribution using the Kolmogorov-Smirnov test. As the data was parametric, MANOVA was used to evaluate the effect of independent variable (control, 65 mg caffeine and 130 mg caffeine) on the outcome variables (attention, congruent reaction time and incongruent reaction time). A Post hoc test was utilized following the significant results of the variables. The level of significant was set at $P<0.05$. Statistical analysis was performed using SPSS version 16.0. for Windows (SPSS inc., Chicago, IL, USA).

RESULTS

Table 1 shows the demographic data of the participants reported in frequency, percentage and mean ± standard deviation. In terms of frequency of caffeine intake, male participants (3.8±2.5 times per week) took caffeine more frequent compared to females (3.0±1.4 times per week).

Table 1 Demographic Data of the Participants (N=30)

Variables	Frequency (N)	Percentage (%)	Mean±SD
Gender			
Male	15	50	
Female	15	50	
Age (years)			
Male			27±2
Female			25±1
Body mass (kg)			
Male			71± 9
Female			54 ± 8
Stature (cm)			
Male			170 ± 3
Female			153 ± 8
Frequency of caffeine intake (time/wk)			
Male			3.8±2.5
Female			3.0±1.4

The findings for attention and reaction time among the three experimental groups with different doses of caffeine is shown in Table 2. There were significant differences for attention (P=0.003), congruent reaction time (P=0.001) and incongruent reaction time (P=0.049) among the participants.

Table 2 Attention, Congruent and Incongruent Reaction Time among the Experimental Groups (N=30). Values in Mean±SD.

Variables	Control group (N=10)	65 mg caffeine (N=10)	130 mg caffeine (N=10)	P value
Attention score (%)	92.3±5.5**	97.5±4.9	99.5±1.6	0.003*
Congruent reaction time (ms)	857.7±330.8#	541.7±87.6	478.5±89.5	0.001*
Incongruent reaction time (ms)	999.7±757.2##	626.1±88.3	506.5±87.4	0.049*

*Significant at P<0.05

**Significant at P<0.05 (Bonferoni Post Hoc Test, control vs 65 mg caffeine; control vs 130 mg caffeine)

#Significant at P<0.05 (Bonferoni Post Hoc Test, control vs 65 mg caffeine; control vs 130 mg caffeine)

##Significant at P<0.05 (Bonferoni Post Hoc Test, control vs 130 mg caffeine)

Bonferoni Post Hoc shows that the mean attention score was significantly higher both in 130 mg caffeine group and 65 mg caffeine group compared to the control group. Likewise, both the treatment groups had significantly faster congruent reaction time than the control group. For the incongruent time reaction, 130 mg caffeine group was the fastest among the groups. The 130 mg group was two-fold faster than the control group but was not significantly different than the 65 mg group.

J. Sci. Math. Lett. UPSI Volume 4 (2016) 56 - 62
ISSN 2462-2052

DISCUSSION

Our study documents showed that attention and cognitive function response to the different doses of caffeine given to the participants.

For attention score, it was found that with the two different doses of caffeine resulted in higher percentage of focus as compared to the participants with no caffeine. The result in the present study is in agreement with the study by Rees, Allen and Lader (1999). They conducted the study on the effect of 250 mg caffeine on attention in young (20-25 years old) and elderly (50-65 years old) and found that both young and old groups who took caffeine had significantly higher attention score compared to the groups who did not take caffeine. Recent studies by Brunye, Mahoney, Lieberman and Taylor (2010) and De Bruin, Rowson, Van Buren, Rycroft and Owen (2011) also revealed the consumption of caffeine in an appropriate dose did enhance attention due to hypothetical assumption that caffeine may interact with adenosine and dopamine in the brain which stimulates the visual attention in human.

In terms of cognitive function, the findings in the present study also showed that the participants who had caffeine performed better than those who did not have caffeine. Both groups who received 65 mg and 130 mg had faster congruent and incongruent reaction time than the control group. This study supports the findings by Smit and Rogers (2000) who concluded that caffeine acts as a stimulant psychologically and physically. They found that caffeine doses at 12.5 mg until 100 mg had a positive effect on reaction time, with higher doses resulted in faster reaction time. Besides, a study by Mihai, Gernot and Mihaela (2011) also showed that the university students who took caffeine in Nescafe and energy drink had better cognitive function than those who did not. Indeed, Smith, Christopher and Sunderland (2013) showed that the caffeine consumers who were withdrawn from caffeine for few days still had faster reaction time and better cognitive function than those who were non-consumer of caffeine.

Even though many studies have proven the positive effect of caffeine on attention and cognitive function, there are other studies which showed otherwise. For example, Yeomans, Javaherian, Thovey and Stafford (2005) examined the effect of caffeine on cognitive function in caffeine drinkers versus non-consumer. The results revealed that the non-consumers had faster reaction time than the caffeine consumers who had overnight caffeine abstinence. In the study, the authors hypothesized that the degradation of cognition following caffeine withdrawal was due to the fall in caffeine concentration below the threshold level of cognitive response. In our study, all participants were habitual caffeine drinkers who were asked not to take caffeine the day before the trials. This may explain the findings in our study which showed that the participants who were not given any caffeine (control group) had a significantly two-fold decrease in incongruent reaction time compared to the 130 mg experimental group.

Our study also demonstrated that there was no significant difference in attention score and reaction time between the doses of 65 mg and 130 mg caffeine. In the present study, all participants were tested 20 minutes after ingesting the drinks, which is the average time taken for caffeine to produce effects on cognitive function (Mumford et al., 1994). We could not find the difference between two doses of caffeine probably because the dose may produce an effect at a different time after consumption. According to Smit and Rogers

(2000), low caffeine dose started to show its effect on cognitive performance after 40 minutes of consumption. Similarly, Heatherly, Hayward, Seers and Rogers (2005) proved that the longer the absorption rates of caffeine, the stronger the effect on the cognitive function. In their study, no difference was found at the 4 hours, but the significant different on cognitive performance was observed at the 6 hours and 8 hours between the control group and the treatment group who received 1.2 mg/kg body mass.

CONCLUSION

The doses of 65 mg and 130 mg caffeine produced significant effects on attention and cognitive reaction time among habitual caffeine users. The doses are equivalent to one and two glasses of coffee intake, respectively.

Given the fact that caffeine is a diuretic which induces body fluid loss, however, our study concluded that an appropriate dose may confer some benefits in term of improving mental alertness and cognitive function. Further studies are warranted to look into the effect of higher dose of caffeine on physiological and psychological changes in all populations because caffeine intake particularly coffee consumption worldwide is on the hike every year.

ACKNOWLEDGEMENT

We are grateful to the staff at the Faculty of Sport Science and Coaching for helping with the data collection. We also thank the Faculty for allowing us to use the computers to run the Flanker Task.

REFERENCES

Brunyé, T. T., Mahoney, C. R., Lieberman, H. R., & Taylor, H. A. (2010). Caffeine modulates attention network function. *Brain and Cognition*, 72, 181-188.

Davis, J. K and Green, J. M. (2009). Caffeine and anaerobic performance: ergogenic value and mechanisms of action. *Sports Medicine*, 39(10), 813-832.

De Bruin, E. A., Rowson, M. J., Van Buren, L., Rycroft, J. A., & Owen, G. N. (2011). Black tea improves attention and self-reported alertness. *Appetite*, 56, 235-240.

Del Coso, J., Perez-Lopez, A., Abian-Vicen, J., Salinero, J. J., Lara, B and Valades, D. (2014). Enhancing physical performance in male volleyball players with a caffeine- containing energy drink. *International Journal of Sports Physiology and Performance*, 9(6), 1013-1018.

Eriksen, B. A and Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception and Psychophysics*, 16, 143-149.

Heatherly, V. S., Hayward, C. R., Seers, E. H and Rogers, J. P. (2005). Cognitive and psychomotor performance, mood, and pressor effects on caffeine after 4, 6, and 8 h caffeine abstinence. *Psychopharmacology (Berl)*, 178(4), 461-470.

Hespel, P., Maughan, R. J and Greenhaff, P. L. (2006). Dietary supplements for football. *Journal of Sports Science*, 24(7), 749-761.

Hogervost, E., Bandelow, S., Schmitt, J., Jentjens, R., Oliveira, M., Carter, J and Gleeson, M. (2008). Caffeine improves physical and cognitive performance during exhaustive exercise. *Medicine and Science in Sports and Exercise*, 40(10), 1841-1851.

Mihai, A., Gernot, S and Mihaela, C. (2011). The influence of energy drinks and caffeine on reaction time and cognitive processes in young Romanian students. *Procedia Social and Behavioral Sciences*, 30, 662-670.

Miller, J. (1987). Priming is not necessary for selective-attention failures: semantic effects of unattended, unprimed letters. *Perception and Psychophysics*, 41, 419-434.

Mumford, G. K., Benowitz, N. L., Evans, S. M., Kamisnki, B. J., Preston, K. L., Sannerud, C. A., & Griffins, R. R. (1994). Absorption rate of methylxanthines following capsules, cola and chocolate. *European Journal of Clinical Pharmacology*, 51, 319-325.

Rees, K., Allen, D and Lader, M. (1999). The influence of age on psychomotor and cognitive function. *Psychopharmacology(Berl)*, 145(2), 181-188.

Roberts, H. R and Baron, J. J. (1983). Biological effect of caffeine: History and Use. *Journal of Food Technology*, 37, 32-39.

Schubert, M. M., Astorino, T. A and Azevedo, J. L. (2013). The effects of caffeinated 'energy shots' on time trial performance. *Nutrients*, 6, 2062-2075.

Shahruddin, Abd Aziz (2001). *Mengaplikasi teori psikologi dalam sukan*. Kuala Lumpur: Utusan Publication & Distribution Sdn. Bhd.

Smit, H. J and Rogers, P. J. (2000). Effect of low doses of caffeine on cognitive performance, mood and thirst in low and higher caffeine consumers. *Psychopharmacology (Berl)*, 152, 167-173.

Smith, A. P., Christopher, G and Sunderland, D. (2013). Acute effects of caffeine on attention: a comparison of non-consumers and withdrawn consumers. *Journal of Psychopharmacology*, 27(1), 77-83.

Stevenson, E. J., Hayes, P. R and Allison, S. J. (2009). The effect of a carbohydrate-caffeine sports drink on simulated golf performance. *Applied Physiology, Nutrition and Metabolism*, 34(4), 681-688.

Van Gelder, B. M., Buijsse, B., Tijhuis, M., Kalmijn, S., Giampaoli, S., Nissinen, A and Kromhout, D. (2007). Coffee consumption is inversely associated with cognitive decline in elderly European men: the FINE study. *European Journal of Clinical Nutrition*, 61, 226-232.

Warren, G. L., Park, N. D., Maresca, R. D., McKibans, K. I and Millard-Stafford, M. L.(2010). Effect of caffeine ingestion on muscular strength and endurance: a meta-analysis. *Medicine and Science in Sports and Exercise*, 42(7), 1375-1387.

Yeomans, M. R., Javaherian, S., Thovey, M. H and Stafford, D. L. (2005). Attentional bias for caffeine-related stimuli in high but not moderate or non-caffeine consumers. *Psychopharmacology (Berl)*, 181(3), 477-485.