

# The effect of caffeine consumption on attention performance in female students at the faculty of health sciences

Effect of  
caffeine  
consumption

Emre Batuhan Kenger and Tugce Ozlu

*Department of Nutrition and Dietetics, Faculty of Health Science,  
Bahcesehir University, Istanbul, Turkey*

Ani Agopyan

*Department of Coaching Education, Faculty of Sport Sciences,  
Marmara University, Istanbul, Turkey, and*

Can Ergun, Aysenur Uslu, Berfin Dinsel,

Dilhan Disli and Nezihe Akdeniz

*Department of Nutrition and Dietetics, Faculty of Health Science,  
Bahcesehir University, Istanbul, Turkey*

Received 15 August 2022  
Revised 14 September 2022  
Accepted 20 September 2022

## Abstract

**Purpose** – There are limited studies on the effects of coffee consumption, which has become part of popular culture and is highly common among young people, on the attention levels of female university students. This paper aims to examine the effects of caffeine consumption given at different doses (0, 100 and 200 mg) to female university students ( $n = 100$ ) studying at the faculty of health sciences on attention performance with the Stroop Color and Word Test (SCWT).

**Design/methodology/approach** – Participants' test completion time, number of errors and corrections were tested. In addition, the frequencies of weekly coffee consumption were also recorded.

**Findings** – It was found that consumption of coffee containing 200 mg of caffeine reduced the time to complete the sections of the SCWT test ( $p < 0.05$ ), as well as the total test completion time ( $55.81 \pm 8.67$  s) compared to no coffee consumption ( $58.25 \pm 9.46$  s) and coffee consumption with 100-mg caffeine ( $57.56 \pm 8.87$  s) ( $p < 0.05$ ; effect size: 0.268). The effect of caffeine on attention level was induced by 200-mg caffeine consumption, but was unapparent at 100-mg dose. In addition, SCWT completion times were reduced in the student group with more weekly coffee consumption ( $=3$  cups/week) at 200-mg caffeine dose.

The authors thank all individuals who devoted their time to conduct this study.

**Funding:** The authors received no financial support for the research, authorship and/or publication of this article.

**Conflict of Interest:** The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

**Author contribution:** EBK: Conceptualization, Methodology, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review and Editing, Visualization; TO: Methodology, Investigation; AA: Methodology, Review and Editing; CE: Resources, Methodology; AU: Data Curation, Methodology; BD: Data Curation, Methodology; DD: Data Curation, Methodology; NE: Data Curation, Methodology.



---

**Originality/value** – In this context, caffeine dose is a factor that should be taken into account in determining the performance of individuals in the SCWT test. It is thought that coffee consumption can increase the concentration of students and have positive effects on academic achievement.

**Keywords** Coffee, Caffeine, Focus, Attention, Stroop test

**Paper type** Research paper

---

## Introduction

Coffee is one of the most consumed beverages in the world, and it has different meanings for each culture (Poole *et al.*, 2017). Coffee consists of various components such as phenols containing caffeine, chlorogenic acid and caffeic acid, diterpenes containing cafestol and kahweol, lactones, niacin and the niacin precursor trigonelline. Caffeine, a psychoactive ingredient in coffee, is rapidly absorbed from the gastrointestinal system and first metabolized in the liver. Plasma caffeine levels reach their highest levels within 15–120 min of caffeine intake (Revelle *et al.*, 2012). Adenosine antagonism is the most accepted mechanism in studies. Adenosine, which is synthesized in the central nervous system (CNS) and prevents the release of CNS regulators, is a modulator closely related to the initiation and maintenance of sleep. Caffeine, on the other hand, binds to adenosine receptors and prevents the function of adenosine by acting as an antagonist (Burke, 2008; Cox *et al.*, 2002).

In recent years, due to the different effects of coffee consumption and its ingredients on the human body, research has intensified in this area. In this context, studies on the effects of coffee consumption on health have shown that it reduces the risk of obesity, type 2 diabetes, nonalcoholic fatty liver disease, breast, colorectal, colon, endometrial and prostate cancers and may be associated with increased blood pressure levels (Grosso *et al.*, 2017). It has also been found that coffee consumption has a stimulating effect on the central nervous system and is associated with cognitive performance, increased attention and concentration and relieving fatigue (Patay *et al.*, 2016; Postuma *et al.*, 2012; Renda *et al.*, 2015). Attention is the process of integration that consists of the ability to store, retain and recall information and experiences (Alharbi *et al.*, 2018). One of the tests used to determine cognitive level is the Stroop Color and Word Test (SCWT), developed by Stroop (1935). SCWT has become a widespread test to measure cognitive flexibility, focused attention, selective attention and ability to change setup (Stroop, 1935). Despite the positive effects of caffeine consumption on cognitive performance (Patay *et al.*, 2016; Postuma *et al.*, 2012; Renda *et al.*, 2015), the number of studies on the effect of caffeine on SCWT is limited, and the results of these studies are conflicting (Foreman *et al.*, 1989; Edwards *et al.*, 1996; Kenemans *et al.*, 1999; Dixit *et al.*, 2012). In some studies in the literature, it has been shown that high doses of caffeine decrease the SCWT reaction time but do not change the error rate (Foreman *et al.*, 1989; Edwards *et al.*, 1996). On the other hand, other studies show that caffeine consumed in different doses (125–250 mg) does not create a significant difference in reaction time, but consumption of coffee containing 250 mg of caffeine reduces the error rate and reaction time (Kenemans *et al.*, 1999; Dixit *et al.*, 2012). The contradictory results of the studies and the positive effects observed increase the necessity for further studies in this direction. In parallel, although attention of students during courses is closely related to levels of academic achievement (Moradi and Amiripour, 2017), the number of studies on this subject is inadequate. Studies on the effects of coffee consumption, which has become part of popular culture and is highly common among young people (Alfawaz *et al.*, 2020), on students' attention levels are limited (Jahrami *et al.*, 2020). Dixit *et al.* (2012) investigated the effect of caffeine on information processing through SCWT and found that caffeine had no effect on the attention levels of male university students. To the best of our knowledge, no

similar study has been performed on female students to date, and the small sample size in the limited number of studies conducted is noteworthy. With this perspective, the aim of this study was to investigate the acute effect of caffeine consumption at different doses (0, 100 and 200 mg) and weekly coffee consumption frequency on attention level measured by SCWT in female university students. It was hypothesized that coffee consumption would increase the level of attention acutely depending on the dose. With the results of this study, a proposal can be presented to increase the concentration of female university students in health sciences faculty who have to endure a long and tiring curriculum.

## Materials and methods

### *Participants*

This study is a non-drug clinical study conducted to determine the effect of caffeine consumption in different doses on attention level. In total, 100 female university students between the ages of 18 and 25, studying at the health sciences faculty of a private university in a metropolitan city in Turkey, were voluntarily included in the study. Sample size was computed using G\*Power 3.0.10 (Franz Faul, Universitat Kiel, Germany) with parameters of  $\alpha = 0.05$  and Power  $(1 - \beta) = 0.80$ . Those with had cardiovascular disease, acid reflux, gastritis, ulcer or any stomach ailment, color blindness and dyslexia, and individuals who consumed caffeine-containing food or beverage (tea, coffee, energy drink, etc.) up to 24 h before participating in the study were excluded from the study. Individuals who met the inclusion criteria signed a voluntary consent form. A questionnaire containing information such as age and caffeine-containing food or beverage was applied to the participants by face-to-face interview method. The study was prepared according to the ethical standards of the Declaration of Helsinki and approved by the ethics committee of the local university (no: 2019-01/01).

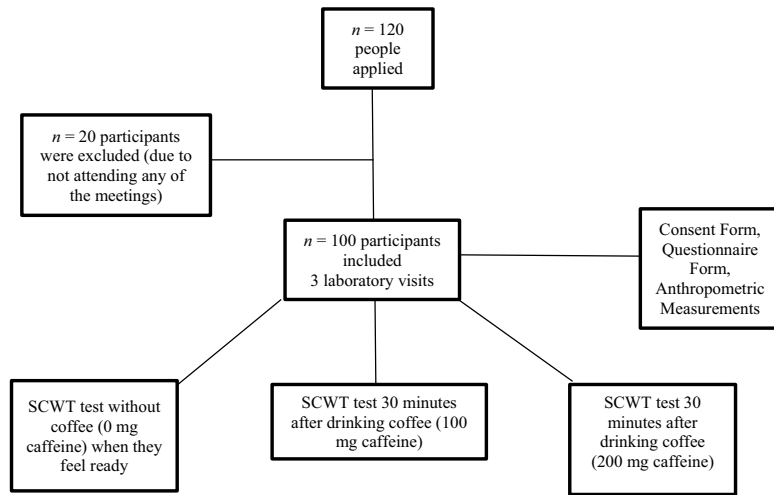
### *Study design*

All participants visited the university's laboratory three times in accordance with the design of the study. All tests were administered between 10:00 a.m. and 12:00 a.m. and while the participants were on a full stomach. All measurements were performed in the same laboratory environment and at room temperature (18–21°C). On the first day that the participants visited the laboratory, their anthropometric measurements and body compositions were determined, and they were subjected to an attention test. The SCWT test was applied to each participant on three different days, after consuming filter coffee containing two different doses of caffeine and one day when no coffee was consumed (Figure 1). The test was conducted in a bright and quiet environment. The tests applied to the participants were randomized and single blinded. Accordingly, each participant took tests after a 30-min wait (when the caffeine level in the brain reached its peak (Latini *et al.*, 1978) after drinking coffee containing 100 or 200 mg of caffeine. The test applied without drinking coffee was started when the participants felt ready. To minimize the acquired habit factor of the test, the participants repeated these tests at least one week apart.

### *Measurements*

Participants' height (cm) was measured with a stadiometer (Leicester Height Measure, Seca 214, UK) with a 0.1 cm sensitivity, while the individual was standing on the Frankfort plane in an upright position (the ear canal and the lower border of the orbital-orbital socket aligned with the gaze parallel to the ground).

Participants' body composition was determined by the bioelectrical impedance analysis method. Body weight (kg), body mass index ( $\text{kg}/\text{m}^2$ ), muscle mass (kg), fat mass (kg) and fat



**Figure 1.**  
Flowchart of the  
study

% ratio of the individuals were measured with Inbody 270 (InBody USA, Cerritos, CA, USA) device. Attention was paid to ensure that participants stopped eating and drinking until 4 h before the measurement, did not do heavy exercise within 12 h, did not drink alcohol within 48 h, did not take diuretics within 7 days prior to the tests and were not in menstruation. Measurements were made in the lightest clothing possible and with bare feet.

#### *The amount and content of coffee*

European Food Safety Authority (EFSA) reported that 200 mL of filter coffee contains 90 mg of caffeine [European Food Safety Authority (EFSA), 2015]. During the study, filter coffee was supplied from the same brand and were given to the participants after being prepared with the machine (Arzum AR3046 Brewtime Filter Coffee Machine) in a laboratory environment. The contents of 250-mL filter coffee given to the participants before SCWT were standardized to contain 8-g coffee (100-mg caffeine) or 16-g coffee (200-mg caffeine). Coffee was prepared without adding sugar, syrup, cream and milk.

#### *Stroop Color and Word Test*

SCWT was used to measure the attention levels of the students in the study. SCWT is a neuropsychological test that is used extensively for both experimental and clinical purposes. It evaluates the ability to inhibit the cognitive interference that occurs when the processing of a property of a stimulus affects the simultaneous processing of another property of the same stimulus. The SCWT stages consisting of four cards and five sections, in which word reading and color naming levels are measured, are shown in Table 1. The SCWT TBAG form (Neuropsychological Test Battery for Cognitive Potentials: BILNOT Battery) Turkish version was used in the study. Validity, and reliability study of this form and the scoring method was tested by Karakas *et al.* (1999). Three types of scores are calculated for each of the four cards in the SCWT TBAG Form. These are the time it takes to read/say out loud the last item of the card after giving the subject the “Start” command, the number of errors, and the number of corrections. The conventional color word version task consists of words like “Blue”, “Red”, “Green” and “Yellow” written in another color or are incongruent (e.g. Red is written with blue ink) or symbols like “XXX” in different colors or are neutral. The subject

has to respond to the color. The time taken to perform the task in the two conditions (incongruent and neutral) is recorded and the difference between the two represents interference. Similarly, the time difference between congruent (“Red” written in Red ink) and neutral is an indication of facilitation (Kenemans *et al.*, 1999).

The tasks for all five sections were explained to the participants clearly, and the test was initiated with the “Start” command after making sure that the participants understood the tasks. The stopwatch (iPhone 7, ms 0.01 s) was started from the moment the cards were placed at eye level, from a distance of 50 cm in front of each application. The time elapsed from the start command until the last word said by the participant was calculated. The sections shown in Table 1 are applied respectively, and the participants were asked to tell the color names written on the cards in Sections 1 and 2, and to tell the color of the writing in Sections 3–5. Attention was paid to wait for about 15 s between each section and make sure that participants were ready. Care was taken to ensure that the researcher holding the cards, following the stopwatch, tracking errors and spontaneous corrections and preparing the coffee was the same for each application.

### Evaluation of data

All data were evaluated using SPSS software (version 21, SPSS, Inc., Chicago, IL, USA) package program. Statistical significance was accepted as  $p < 0.05$  in all analyses. Number, percentage, average, min–max value and standard deviation values were presented as part of descriptive statistics. The compliance of the data to normal distribution was checked with the Kolmogorov–Smirnov test. Friedman Test was used to evaluate the difference between repeated measurements for variables without normal distribution, and analysis of variance in repeated measures was used for variables with normal distribution. Independent Samples *t*-test was used for comparison of independent groups for variables with normal distribution, and Mann–Whitney *U* test was used for variables without normal distribution. Effect size (ES) was calculated for each Stroop variable using Cohen’s *d*. (Cohen, 1988). ES values were computed to transform data to a common metric. Effect sizes were computed for studies that provided means and standard deviations. Zakzanis (2001) recommended that Cohen’s *d* be used as a measure of effect size in neuropsychological research. Cohen’s *d* is computed by dividing the difference between group means by the pooled standard deviation weighted by sample size. In interpreting the magnitude of *d*, Cohen’s conventional frame of reference (1988) was used such that an effect size of 0.2 corresponded to a small effect, 0.5 a medium effect and 0.8 a large effect (Zakzanis, 2001).

## Results

### Study population characteristics

Findings regarding the demographic characteristics and body composition of the participants in the study sample are grouped according to weekly coffee consumption frequency (<3 cups; ≥3 cups) and are shown in Table 2. It was determined that there was no

| Sections  | Stimulants | Scope of the stimulus card              | Task                |
|-----------|------------|---|---------------------|
| Section 1 | Card 1     | Color names printed in black            | Reading color names |
| Section 2 | Card 2     | Color names printed in different colors | Reading color names |
| Section 3 | Card 3     | Colored circles                         | Telling the color   |
| Section 4 | Card 4     | Colored neutral words                   | Telling the color   |
| Section 5 | Card 5     | Color names printed in different colors | Telling the color   |

**Table 1.**  
SCWT sections and  
tasks

statistical difference between the two groups in terms of demographic characteristics and body composition components ( $p > 0.05$ ), and the groups were homogeneous.

*Stroop Color and Word test results according to the amount of caffeine consumption*

Table 3 shows the completion times of the SCWT sections, the number of errors and corrections with respect to the amount of caffeine consumed by all participants. Completion time of SCWT Section 1 (ES: 0.30, low;  $p < 0.05$ ), Section 4 (ES: 0.25, low;  $p < 0.05$ ) and Section 5 (ES: 0.31, low;  $p < 0.05$ ) decreased when the participants consumed coffee containing 200 mg of caffeine ( $p < 0.05$ ), compared to the 100-mg caffeine dose and without any coffee consumption. Similar results were also found in the total completion times (ES: 0.27, low;  $p < 0.05$ ). It was determined that the effect sizes of these differences obtained in Sections 1, 4 and 5 and total completion times were low. When the participants were evaluated according to the number of errors, no statistically significant difference was found in sections and total error numbers ( $p > 0.05$ ). When the number of corrections was evaluated, it was determined that the number of corrections decreased only in Section 3 with consumption of coffee containing 200 mg compared to the results without consuming coffee and the effect size was moderate (ES: 0.50, moderate;  $p < 0.05$ ).

*Stroop Color and Word Test results according to coffee consumption frequency*

According to the weekly coffee consumption frequency of the participants (<3 cups vs  $\geq 3$  cups), it was determined that the completion time of SCWT sections, the number of errors and corrections did not differ when no coffee was consumed (Table 4). It was found that the time to complete the test was lower in students who consumed three cups or more coffee per week only with a dose of 200 mg of caffeine compared to those who consumed less than three cups of coffee per week ( $p < 0.05$ ). It was determined that there was no difference between the groups in the other components of SCWT (number of errors and corrections) for 100- and 200-mg caffeine consumption ( $p > 0.05$ ).

## Discussion

In this study, it was aimed to investigate the acute effect of caffeine consumption in different doses (0, 100, 200 mg) on attention level measured by SCWT in female university students who go through a long and tiring curriculum. In addition, the attention levels of the

**Table 2.** Characteristics of the study population according to coffee consumption frequency

| Quantitative variables *             | Weekly coffee consumption frequency |                         |                               | $p^a$ |
|--------------------------------------|-------------------------------------|-------------------------|-------------------------------|-------|
|                                      | All participants<br>( $n = 100$ )   | <3 cups<br>( $n = 60$ ) | $\geq 3$ cups<br>( $n = 40$ ) |       |
| Demographics                         |                                     |                         |                               |       |
| Age (years)                          | 20.9 $\pm$ 1.6                      | 20.7 $\pm$ 1.5          | 21.4 $\pm$ 1.6                | 0.262 |
| Body weight (kg)                     | 57.9 $\pm$ 10.0                     | 57.9 $\pm$ 11.9         | 57.6 $\pm$ 6.3                | 0.880 |
| Height (cm)                          | 165.1 $\pm$ 6.1                     | 164.5 $\pm$ 6.2         | 165.9 $\pm$ 6.1               | 0.303 |
| Body composition                     |                                     |                         |                               |       |
| Body mass index (kg/m <sup>2</sup> ) | 21.2 $\pm$ 3.5                      | 21.3 $\pm$ 4.3          | 21.0 $\pm$ 2.1                | 0.682 |
| Body fat weight (kg)                 | 16.4 $\pm$ 7.2                      | 17.0 $\pm$ 8.5          | 15.6 $\pm$ 4.5                | 0.395 |
| Skeletal muscle weight (kg)          | 22.6 $\pm$ 2.8                      | 22.4 $\pm$ 2.9          | 23.0 $\pm$ 2.5                | 0.317 |
| Body fat (%)                         | 27.3 $\pm$ 7.2                      | 27.85 $\pm$ 8.0         | 26.7 $\pm$ 5.7                | 0.468 |

Notes: \*Mean  $\pm$  SD; <sup>a</sup>Independent samples  $t$  test was used

| SCWT sections*   | Completion time           | <i>p</i>           | No. of errors | <i>p</i>           | No. of corrections      | <i>p</i>           |
|------------------|---------------------------|--------------------|---------------|--------------------|-------------------------|--------------------|
| <b>Section 1</b> |                           |                    |               |                    |                         |                    |
| 0 mg             | 8.04 ± 1.39               | 0.011 <sup>a</sup> | –             | –                  | 0.01 ± 0.1              | 1.00 <sup>c</sup>  |
| 100 mg           | 7.97 ± 1.28               | ES:0.30 small      | –             |                    | 0.01 ± 0.1              |                    |
| 200 mg           | 7.64 ± 1.24 <sup>¶</sup>  |                    | –             |                    | 0.01 ± 0.1              |                    |
| <b>Section 2</b> |                           |                    |               |                    |                         |                    |
| 0 mg             | 8.76 ± 1.98               | 0.281 <sup>b</sup> | 0.04 ± 0.40   | 0.178 <sup>c</sup> | 0.04 ± 0.19             | 0.282 <sup>c</sup> |
| 100 mg           | 8.65 ± 1.68               |                    | 0.13 ± 0.86   |                    | 0.06 ± 0.24             |                    |
| 200 mg           | 9.02 ± 2.68               |                    | 0.15 ± 0.73   |                    | 0.13 ± 0.52             |                    |
| <b>Section 3</b> |                           |                    |               |                    |                         |                    |
| 0 mg             | 10.99 ± 2.28              | 0.073 <sup>b</sup> | 0.02 ± 0.14   | 0.444 <sup>c</sup> | 0.23 ± 0.5              | 0.000 <sup>d</sup> |
| 100 mg           | 10.79 ± 2.05              |                    | 0.04 ± 0.24   |                    | 0.10 ± 0.33             | ES:0.50 medium     |
| 200 mg           | 10.50 ± 1.89              |                    | 0.03 ± 0.3    |                    | 0.03 ± 0.3 <sup>¶</sup> |                    |
| <b>Section 4</b> |                           |                    |               |                    |                         |                    |
| 0 mg             | 12.43 ± 2.38              | 0.018 <sup>a</sup> | 0.05 ± 0.41   | 0.717 <sup>c</sup> | 0.08 ± 0.3              | 0.191 <sup>c</sup> |
| 100 mg           | 12.53 ± 2.31              | ES:0.249 small     | 0.03 ± 0.17   |                    | 0.03 ± 0.17             |                    |
| 200 mg           | 11.85 ± 2.27 <sup>¶</sup> |                    | 0.04 ± 0.19   |                    | 0.12 ± 0.4              |                    |
| <b>Section 5</b> |                           |                    |               |                    |                         |                    |
| 0 mg             | 18.01 ± 4.36              | 0.022 <sup>a</sup> | 0.3 ± 0.97    | 0.066 <sup>c</sup> | 0.44 ± 0.71             | 0.561 <sup>c</sup> |
| 100 mg           | 17.61 ± 3.87              | ES:0.310 small     | 0.07 ± 0.35   |                    | 0.37 ± 0.67             |                    |
| 200 mg           | 16.79 ± 3.49 <sup>¶</sup> |                    | 0.16 ± 0.76   |                    | 0.39 ± 0.72             |                    |
| <b>Total</b>     |                           |                    |               |                    |                         |                    |
| 0 mg             | 58.25 ± 9.46              | 0.011 <sup>a</sup> | 0.41 ± 1.17   | 0.823 <sup>c</sup> | 0.80 ± 1.08             | 0.497 <sup>c</sup> |
| 100 mg           | 57.56 ± 8.87              | ES:0.268 small     | 0.27 ± 0.96   |                    | 0.66 ± 0.91             |                    |
| 200 mg           | 55.81 ± 8.67 <sup>¶</sup> |                    | 0.38 ± 1.15   |                    | 0.80 ± 1.13             |                    |

**Notes:** \* Mean ± SD; ES: effect size; <sup>a</sup>analysis of variance in repeated measurements,  $p < 0.05$ ; <sup>b</sup>analysis of variance in repeated measurements,  $p > 0.05$ ; <sup>c</sup>friedman analysis,  $p > 0.016$ ; <sup>d</sup>friedman analysis,  $p < 0.016$ ; <sup>¶</sup>significant difference between 0 and 200 mg groups,  $p < 0.05$ ; <sup>§</sup>significant difference between 100 and 200 mg groups,  $p < 0.05$

**Table 3.**  
Evaluation of SCWT  
results according to  
caffeine doses

Effect of  
caffeine  
consumption

| SCWT results *                     | Weekly coffee consumption frequency |                             | <i>p</i>           |
|------------------------------------|-------------------------------------|-----------------------------|--------------------|
|                                    | <3 cups<br>( <i>n</i> = 60)         | ≥3 cups<br>( <i>n</i> = 40) |                    |
| <i>Total completion time</i>       |                                     |                             |                    |
| 0 mg                               | 59.2 ± 9.60                         | 56.8 ± 9.1                  | 0.218 <sup>b</sup> |
| 100 mg                             | 58.1 ± 8.33                         | 56.6 ± 9.67                 | 0.401 <sup>b</sup> |
| 200 mg                             | 57.4 ± 8.58                         | 53.4 ± 8.34                 | 0.024 <sup>a</sup> |
| <i>ES: 0.47 small</i>              |                                     |                             |                    |
| <i>Total number of errors</i>      |                                     |                             |                    |
| 0 mg                               | 0.48 ± 1.33                         | 0.31 ± 0.89                 | 0.589 <sup>c</sup> |
| 100 mg                             | 0.23 ± 1.27                         | 0.27 ± 0.96                 | 0.144 <sup>c</sup> |
| 200 mg                             | 0.43 ± 1.19                         | 0.31 ± 1.10                 | 0.391 <sup>c</sup> |
| <i>Total number of corrections</i> |                                     |                             |                    |
| 0 mg                               | 0.80 ± 1.17                         | 0.77 ± 1.09                 | 0.629 <sup>c</sup> |
| 100 mg                             | 0.61 ± 0.83                         | 0.72 ± 1.02                 | 0.606 <sup>c</sup> |
| 200 mg                             | 0.90 ± 1.14                         | 0.67 ± 1.13                 | 0.195 <sup>c</sup> |

**Table 4.** Comparison of SCWT results with respect to weekly coffee consumption frequency of students

**Notes:** \*Mean ± SD; ES: effect size; <sup>a</sup>independent samples *t* test, *p* < 0.05; <sup>b</sup>independent samples *t* test, *p* > 0.05; <sup>c</sup>Mann–Whitney U test, *p* > 0.05

participants were evaluated according to their weekly coffee consumption frequency. The main finding of this study was that the consumption of filter coffee containing 200 mg of caffeine increased the attention level of female university students studying at the faculty of health sciences, although the effect size was small, and this effect differed according to the sections of SCWT. This positive effect was observed at the beginning and end of the test and in total completion times. It was demonstrated that different amounts of caffeine consumed did not make a significant difference in the number of errors in the SCWT test. It was determined that 200 mg of caffeine consumption was moderately effective in reducing the number of corrections in only Section 3 of the SCWT test compared to those who did not consume any coffee. Participants with three or more cups of coffee consumed per week completed the test faster when they consumed 200 mg of caffeine. It was shown that the attention level of the person may vary depending on the effect of different doses of caffeine consumed. In this context, the consumption of filter coffee with a minimum of 200-mg caffeine can be more effective in increasing attention level.

There are some studies in the literature in which the effect of caffeine on the SCWT test is investigated on male students (Dixit *et al.*, 2012), or compared between genders, but the sample size is small (Foreman *et al.*, 1989; Edwards *et al.*, 1996; Kenemans *et al.*, 1999; Arieputri *et al.*, 2018). In this context, to the best of our knowledge, this is the first study to reveal the effect of caffeine on the attention levels of female university students studying at the Faculty of Health Sciences.

Recent research has focused on the acute effects of caffeine on improving cognitive functions, particularly attention and concentration (Kahathuduwa *et al.*, 2017). Kahathuduwa *et al.* (2017) showed that high doses of caffeine (160 mg) had a significant effect in increasing attention, and a similar study showed that a 60-mg single oral dose of caffeine significantly increased continuous attention and alertness compared to the placebo group (Wilhelmus *et al.*, 2017). SCWT is one of the tests frequently used to measure attention levels. There are conflicting results in previous studies regarding the effect of caffeine/coffee consumption on SCWT performance. In the literature, there are studies reporting that high dose caffeine

---

decreases the SCWT reaction time but does not change the error rate (Foreman *et al.*, 1989), caffeine at different doses does not make a significant difference in reaction time (Edwards *et al.*, 1996) or caffeine is associated with a decrease in error rates (Edwards *et al.*, 1996). In the study of Foreman *et al.* (1989), it was determined that individuals consuming coffee containing 250 mg of caffeine had a lower SCWT reaction time compared to individuals consuming coffee without caffeine and 125 mg of caffeine, but there was no significant difference in error rates between the groups. In another study, it was determined that there was no significant difference in SCWT performances in individuals consuming coffee containing 125 and 250 mg of caffeine (Edwards *et al.*, 1996). Kenemans *et al.* (1999) found that 250-mg caffeine dose was associated with a decrease in SCWT reaction time and a decrease in error rate.

In some studies, it has been emphasized that the reaction time, the number of correct answers and the number of errors may vary depending on 50–250-mg dose (Kenemans *et al.*, 1999; Dixit *et al.*, 2012; Soar *et al.*, 2016; Dodd *et al.*, 2015; Hasenfratz and Bättig, 1992). On the other hand, it has been stated in different studies that caffeine consumption has no effect and adversely affects performance at the cognitive level (Foreman *et al.*, 1989; Deslandes *et al.*, 2005; Schmitt *et al.*, 2003). Furthermore, it has also been determined that low-medium dose caffeine consumption (40–100 mg) has an effect on cognitive functions such as attention, alertness, reaction time, fatigue perception and mood (Irwin *et al.*, 2018). In our study, 100 mg of caffeine consumption had no effect on attention levels of female college students, consistent with the results of Irwin *et al.* (2018). However, our results show that 200 mg of caffeine, which is accepted as a high dose in the literature (Smit and Rogers, 2000) can increase attention levels. Our results are in line with studies demonstrating the positive effect of high dose caffeine consumption on the attention level determined by SCWT (Kenemans *et al.*, 1999; Dixit *et al.*, 2012). According to these results, it can be said that consumption of coffee containing 200 mg of caffeine can be a factor decreasing total completion time and section completion time in SCWT. This positive effect of caffeine on the attention of individuals can be attributed to the inhibition of adenosine receptors that increase dopaminergic and cholinergic transmission in the brain (Kahathuduwa *et al.*, 2017). On the other hand, we think that the limited acute effect of caffeine on the number of errors and corrections may be due to the small number of errors and corrections made. To the best of our knowledge, SCWT error and correction numbers were not examined separately in other studies in the literature; therefore, our results could not be compared (Dixit *et al.*, 2012). Conflicting results between studies may arise from differences in the application of the test (e.g. word-color vs numerical versions, practice effects) (Irwin *et al.*, 2018). The mental state of the participants during the test can be considered as a factor that will affect the study results (Rahadian and Scovani, 2014). To prevent this situation, the test was started when the participants felt ready. On the days when coffee containing 100 and 200 mg caffeine was consumed, the tests were applied 30 min after the coffee was consumed. Considering that plasma caffeine levels reach their highest levels within 30 to 90 min after caffeine intake, waiting for this time is one of the strengths of the present study. EFSA reported that a single dose of 200-mg caffeine is a safe intake level for healthy adults under normal conditions [European Food Safety Authority (EFSA), 2015]. Therefore, this study was conducted with filter coffee containing a maximum dose of 200-mg caffeine.

Another purpose of this study was to examine SCWT results of female college students according to their weekly coffee consumption frequency. It was determined that female university students in the same age group had a homogeneous structure in terms of demographic characteristics (age, height) and body composition (body weight, body mass index, body fat weight, skeletal muscle weight and body fat ratio) despite different coffee

---

consumption frequencies. In this context, it is noteworthy that SCWT completion times were lower in students who consumed more coffee ( $\geq 3$  cups/week) per week when they consumed 200 mg of caffeine. The field of health is a special area that is difficult to work in, both physically and mentally. In this mentally challenging field, long-term concentration and focus or continuous processing of many complex tasks are required and this can lead to mental exhaustion (Xavier *et al.*, 2020). Therefore, caffeine consumption may be recommended for students of the Faculty of Health Sciences, especially during periods that require concentration. However, considering the potential side effects of caffeine consumption (anxiety, insomnia), attention should be paid to daily caffeine consumption without exceeding the intake levels recommended by EFSA (400-mg caffeine/day) [European Food Safety Authority (EFSA), 2015; Babwah *et al.*, 2018].

Despite the important results of our study, there are some limitations. First of all, as the effects of the SCWT test on attention are frequently evaluated in male students in the literature, the inclusion of female university students in the present study may be considered as a limitation. Second, the participants take part in different academic periods, which may affect their stress levels. Another limitation is that the effect sizes for the majority of the findings are small to moderate.

### Conclusion

The findings of the present study strengthen existing knowledge on the effect of caffeine consumption on attention levels (Kenemans *et al.*, 1999; Dixit *et al.*, 2012). In this study, it was revealed that the greatest effect of caffeine was on the section completion times and total completion times of SCWT. It was determined that the effect of caffeine on attention became apparent at 200 mg compared to 100-mg caffeine dose. In this context, caffeine dose is a factor that should be taken into account in determining the SCWT performance of individuals. It was also found that female university students who consumed more coffee ( $\geq 3$  cups) per week had lower SCWT completion times when they consumed 200 mg of caffeine. Considering these results, it can be recommended that female university students of the Faculty of Health Sciences pay attention to the caffeine dose to increase attention levels. Analyzing different regions of the brain with imaging techniques to determine the basic mechanisms leading to these results may be the subject of future studies.

### References

- Alfawaz, H.A., Khan, N., Yakout, S.M., Khattak, M.N., Alsaikhan, A.A., Almousa, A.A., Alsuwailam, A.T., Almjlad, T.M., Alamri, N.A., Alshammari, S.G. and Al-Daghri, N.M. (2020), "Prevalence, predictors, and awareness of coffee consumption and its trend among Saudi female students", *International Journal of Environmental Research and Public Health*, Vol. 17 No. 19, pp. 1-17.
- Alharbi, W.D., Azmat, A. and Ahmed, M. (2018), "Comparative effect of coffee Robusta and coffee Arabica (Qahwa) on memory and attention", *Metabolic Brain Disease*, Vol. 33 No. 4, pp. 1203-1210.
- Arieputri, V., Hanny, V., Kenji, N. and Permana, D. (2018), "The effect of caffeine consumption on attention: an experiment conducted on psychology students in Indonesia", *Universitas Indonesia International Psychology Symposium for Undergraduate Research (UIPSUR 2017)*, pp. 15-20.
- Babwah, T.J., Ramcharan, C., Ramgoolam, C., Sookoo, N., Creese, W., Pamassar, M., Kassie, P. and Ramdin, R. (2018), "Most major side effects of caffeine experienced by young adults are acute effects and are related to their weekly dosage ingested", *Journal of Caffeine and Adenosine Research*, Vol. 8 No. 1, pp. 18-26.

- Burke, L.M. (2008), "Caffeine and sports performance", *Applied Physiology, Nutrition, and Metabolism*, Vol. 33 No. 6, pp. 1319-1334.
- Cohen, J. (1988), *Statistical Power Analysis for the Behavioral Sciences*, Lawrence Erlbaum Assoc., Hillsdale, NJ.
- Cox, G.R., Desbrow, B., Montgomery, P.G., Anderson, M.E., Bruce, C.R., Macrides, T.A., Martin, D.T., Moquin, A., Roberts, A., Hawley, J.A. and Burke, L.M. (2002), "Effect of different protocols of caffeine intake on metabolism and endurance performance", *Journal of Applied Physiology*, Vol. 93 No. 3, pp. 990-999.
- Deslandes, A.C., Veiga, H., Cagy, M., Piedade, R., Pompeu, F. and Ribeiro, P. (2005), "Effects of caffeine on the electrophysiological, cognitive and motor responses of the central nervous system", *Brazilian Journal of Medical and Biological Research*, Vol. 38 No. 7, pp. 1077-1086.
- Dixit, A., Goyal, A., Thawani, R. and Vaney, N. (2012), "Effect of caffeine on information processing: evidence from stroop task", *Indian Journal of Psychological Medicine*, Vol. 34 No. 3, pp. 218-222.
- Dodd, F.L., Kennedy, D.O., Riby, L.M. and Haskell-Ramsay, C.F. (2015), "A double-blind, placebo-controlled study evaluating the effects of caffeine and l-theanine both alone and in combination on cerebral blood flow, cognition and mood", *Psychopharmacology*, Vol. 232 No. 14, pp. 2563-2576.
- Edwards, S., Brice, C., Craig, C. and Penri-Jones, R. (1996), "Effects of caffeine, practice, and mode of presentation on stroop task performance", *Pharmacology Biochemistry and Behavior*, Vol. 54 No. 2, pp. 309-315.
- European Food Safety Authority (EFSA) (2015), "Scientific opinion on the safety of caffeine", *Efsa J*, Vol. 13 No. 5, pp. 4102-4122.
- Foreman, N., Barraclough, S., Moore, C., Mehta, A. and Madon, M. (1989), "High doses of caffeine impair performance of a numerical version of the stroop task in men", *Pharmacology Biochemistry and Behavior*, Vol. 32 No. 2, pp. 399-403.
- Grosso, G., Godos, J., Galvano, F. and Giovannucci, E.L. (2017), "Coffee, caffeine, and health outcomes: an umbrella", *Annual Review of Nutrition*, Vol. 37 No. 1, pp. 131-156.
- Hasenfratz, M. and Bättig, K. (1992), "Action profiles of smoking and caffeine: stroop effect, EEG, and peripheral physiology", *Pharmacology Biochemistry and Behavior*, Vol. 42 No. 1, pp. 155-161.
- Irwin, C., McCartney, D., Khalesi, S. and Desbrow, B. (2018), "Caffeine content and perceived sensory characteristics of pod coffee: effects on mood and cognitive performance", *Current Research in Nutrition and Food Science Journal*, Vol. 6 No. 2, pp. 329-345.
- Jahrami, H., Al-Mutarid, M., Penson, P.E., Al-Islam Faris, M.E., Saif, Z. and Hammad, L. (2020), "Intake of caffeine and its association with physical and mental health status among university students in Bahrain", *Foods*, Vol. 9 No. 4, pp. 1-12.
- Kahathuduwa, C.N., Dassanayake, T.L., Amarakoon, A.T. and Weerasinghe, V.S. (2017), "Acute effects of theanine, caffeine and theanine – caffeine combination on attention", *Nutritional Neuroscience*, Vol. 20 No. 6, pp. 369-377.
- Karakas, S., Erdogan, E., Soysal, S., Ulusoy, T., Yuceyurt, I. and Alkan, S. (1999), "Stroop test TBAG form: standardization studies for Turkish culture, reliability and validity", *Clinical Psychiatry*, Vol. 2, pp. 75-88.
- Kenemans, J.L., Wieleman, J.S., Zeegers, M. and Verbaten, M.N. (1999), "Caffeine and stroop interference", *Pharmacology Biochemistry and Behavior*, Vol. 63 No. 4, pp. 589-598.
- Latini, R., Bonati, M., Castelli, D. and Garattini, S. (1978), "Dose-dependent kinetics of caffeine in rats", *Toxicology Letters*, Vol. 2 No. 5, pp. 267-270.
- Moradi, F. and Amiripour, P. (2017), "The prediction of the students' academic underachievement in mathematics using the DEA model: a developing country case study", *European Journal of Contemporary Education*, Vol. 6 No. 3, pp. 432-447.

- 
- Patay, É.B., Bencsik, T. and Papp, N. (2016), "Phytochemical overview and medicinal importance of coffee species from the past until now", *Asian Pacific Journal of Tropical Medicine*, Vol. 9 No. 12, pp. 1127-1135.
- Poole, R., Kennedy, O.J., Roderick, P., Fallowfield, J.A., Hayes, P.C. and Parkes, J. (2017), "Coffee consumption and health: umbrella review of meta-analyses of multiple health outcomes", *BMJ*, Vol. 359, pp. 1-18.
- Postuma, R.B., Lang, A.E., Munhoz, R.P., Charland, K., Pelletier, A., Moscovich, M., Filla, L., Zanatta, D., Romenets, S.R., Altman, R., Chuang, R. and Shah, B. (2012), "Caffeine for treatment of Parkinson disease: a randomized controlled trial", *Neurology*, Vol. 79 No. 7, pp. 651-658.
- Rahadian, J. and Scovani, L. (2014), "Pengaruh pemberian dosis minimal kafein terhadap peningkatan atensi mahasiswa fakultas kedokteran universitas katolik Indonesia atma jaya", *Damianus Journal of Medicine*, Vol. 13 No. 3, pp. 183-190.
- Renda, G., Committeri, G., Zimarino, M., Di Nicola, M., Tatasciore, A., Ruggieri, B., Ambrosini, E., Viola, V., Antonucci, I., Stuppia, L. and De Caterina, R. (2015), "Genetic determinants of cognitive responses to caffeine drinking identified from a double-blind, randomized, controlled trial", *European Neuropsychopharmacology*, Vol. 25 No. 6, pp. 798-807.
- Revelle, W.R., Condon, D.M. and Wilt, J. (2012), "Caffeine. of: ramachandran VS", editor. *Encyclopedia of Human Behavior: Second Edition*, Elsevier. pp. 423-429.
- Schmitt, J.A., Hogervorst, E., Vuurman, E.F., Jolles, J. and Riedel, W.J. (2003), "Memory functions and focussed attention in middle-aged and elderly subjects are unaffected by a low, acute dose of caffeine", *J Nutr Health Aging*, Vol. 7 No. 5, pp. 301-303.
- Smit, H.J. and Rogers, P.J. (2000), "Effects of low doses of caffeine on cognitive performance, mood and thirst in low and higher caffeine consumers", *Psychopharmacology*, Vol. 152 No. 2, pp. 167-173.
- Soar, K., Chapman, E., Lavan, N., Jansari, A.S. and Turner, J.J.D. (2016), "Investigating the effects of caffeine on executive functions using traditional Stroop and a new ecologically-valid virtual reality task, the jansari assessment of executive functions (JEF©)", *Appetite*, Vol. 105, pp. 156-163.
- Stroop, J.R. (1935), "Studies of interference in serial verbal reactions", *Journal of Experimental Psychology*, Vol. 18 No. 6, pp. 643-662.
- Wilhelmus, M.M., Hay, J.L., Zuiker, R.G., Okkerse, P., Perdrieu, C., Sauser, J., Beaumont, M., Schmitt, J., Van Gerven, J.M.A. and Silber, B.Y. (2017), "Effects of a single, oral 60 mg caffeine dose on attention in healthy adult subjects", *Journal of Psychopharmacology*, Vol. 31 No. 2, pp. 222-232.
- Xavier, G., Ting, A.S. and Fauzan, N. (2020), "Exploratory study of brain waves and corresponding brain regions of fatigue on-call doctors using quantitative electroencephalogram", *Journal of Occupational Health*, Vol. 62 No. 1, pp. 1-8.
- Zakzanis, K.K. (2001), "Statistics to tell the truth, the whole truth, and nothing but the truth formulae, illustrative numerical examples, and heuristic interpretation of effect size analyses for neuropsychological researchers", *Archives of Clinical Neuropsychology*, Vol. 16 No. 7, pp. 653-667.

### Corresponding author

Emre Batuhan Kenger can be contacted at: [emrebatuhan.kenger@hes.bau.edu.tr](mailto:emrebatuhan.kenger@hes.bau.edu.tr)

---

For instructions on how to order reprints of this article, please visit our website:

[www.emeraldgroupublishing.com/licensing/reprints.htm](http://www.emeraldgroupublishing.com/licensing/reprints.htm)

Or contact us for further details: [permissions@emeraldinsight.com](mailto:permissions@emeraldinsight.com)