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The Effect of Caffeine Consumption on Reaction Time Among Medical Students of Universitas Tarumanagara Class of 2022–2023

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Abstract: Caffeine is a commonly consumed stimulant known for its ability to enhance alertness and cognitive performance. One of its most extensively studied effects is its potential to reduce reaction time. However, existing research presents inconsistent findings regarding the effectiveness and duration of caffeine's impact on cognitive speed.This study aimed to examine the effect of caffeine consumption on reaction time among medical students from the 2022 and 2023 cohorts at the Faculty of Medicine, Universitas Tarumanagara (FK UNTAR). A quasi-experimental design was employed using a comparative pre-test/post-test approach. The sample was selected through non-random consecutive sampling, without stratification. Inclusion criteria included being an academically active student in good physical and mental health.Reaction time was measured using the Ruler Drop Test before caffeine intake, and again at 15 and 30 minutes post-consumption. Data were analyzed using paired t-tests to assess within-group differences and independent t-tests to compare between groups.The results indicated a statistically significant reduction in reaction time following caffeine consumption ($p < 0.05$). The average reaction time before caffeine intake was 0.202 seconds, decreasing to 0.184 seconds at 15 minutes and 0.163 seconds at 30 minutes post-consumption. These findings suggest that the effect of caffeine on reaction time is most pronounced within 15–30 minutes after ingestion.

Keywords: Caffeine, Reaction Time, Medical Students, Cognitive Performance, Ruler Drop Test, Reflex Response

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1. Introduction

Caffeine is one of the most widely consumed psychoactive substances globally and is commonly found in coffee, tea, energy drinks, and various medications. It acts primarily as a central nervous system stimulant through antagonism of adenosine receptors, leading to increased alertness, improved attention, and enhanced reaction time (McLellan, Caldwell, & Lieberman, 2016). Given its rapid absorption and peak plasma concentration within 30 to 60 minutes after ingestion, caffeine is often utilized to combat fatigue and enhance cognitive and physical performance.

Reaction time—the interval between stimulus presentation and response initiation—is a critical measure of neurocognitive processing speed. Faster reaction times are associated with improved decision-making and psychomotor function, particularly in demanding academic or occupational settings. Evidence from military and occupational research consistently demonstrates that acute caffeine consumption significantly improves reaction time, especially under conditions of fatigue or sleep deprivation (Irwin et al., 2020; Roache et al., 2019). These improvements are linked not only to enhanced alertness but also to modulation of attentional processes in the brain (Smith et al., 2017).

In sports and exercise contexts, caffeine has been shown to positively affect reaction time and performance outcomes, both through its pharmacological action and through placebo effects (Vega-Muñoz et al., 2024; Stellingwerff et al., 2022). However, individual responses vary due to differences in habitual caffeine intake, metabolism, and tolerance. While many studies focus on athletes or military personnel, limited research has examined caffeine's effects on cognitive-motor functions such as reaction time in medical students. —a population frequently exposed to academic stress and irregular sleep schedules.

Medical students are often exposed to long study hours, inadequate sleep, and high academic stress—factors that can impair cognitive function. Anecdotal evidence and surveys indicate that caffeine is commonly used among students to improve focus and maintain alertness (Ibn-Idris et al., 2022). However, despite its widespread use, few studies have specifically investigated caffeine's effect on reaction time among medical students, particularly in Indonesia.

To date, no study has explored the relationship between caffeine consumption and reaction time among medical students at Universitas Tarumanagara especially those in the 2022–2023 academic cohort. The research aimed to examine the effect of caffeine on the reaction time of FK UNTAR students, particularly whether significant differences exist before and after coffee consumption within 15 and 30 minutes.

2. Preliminaries or Related Work or Literature Review

Caffeine is a central nervous system stimulant known to enhance human performance, particularly in tasks requiring rapid psychomotor responses. Its primary mechanism involves antagonism of adenosine receptors (especially A_1 and A_2A subtypes), preventing the suppressive effects of adenosine on neural activity and increasing the release of neurotransmitters such as dopamine and norepinephrine. In the peripheral nervous system, caffeine inhibits phosphodiesterase, leading to increased cyclic AMP (cAMP) levels, enhanced catecholamine release, and greater glycolytic activity in muscles, thereby supplying more energy during physical exertion. This dual central and peripheral action contributes to improved agility and faster reaction times. Studies have demonstrated that moderate doses of caffeine improve both simple and choice reaction times, particularly under conditions of fatigue, stress, or sleep deprivation. Moreover, caffeine enhances alertness, concentration, and decision-making accuracy. However, its effects are dose-dependent and influenced by individual tolerance and habitual intake. Excessive caffeine consumption may lead to side effects such as anxiety, restlessness, tremors, and sleep disturbances, which can impair overall performance. (Spriet,2014), (Kamimori,2015), (Santos,2014)

3. Proposed Method

This quasi-experimental study employed a comparative pre-test/post-test design to evaluate the effect of caffeine consumption on reaction time. A total of 90 medical students from the Faculty of Medicine, Universitas Tarumanagara (academic year 2022–2023), were recruited using consecutive non-random sampling. Inclusion criteria included age between 18–25 years, being in good general health, and willingness to participate. Exclusion criteria encompassed self-reported caffeine intolerance and a history of gastrointestinal complaints (e.g., dyspepsia, nausea, vomiting) following coffee consumption.

Participants were randomly assigned into two groups: an experimental group (n = 45) and a control group (n = 45). Baseline reaction times were measured in both groups. The experimental group received a standard dose of coffee, while the control group received mineral water. Reaction times were re-assessed at 15 and 30 minutes post-intervention in both groups. Reaction time was assessed using the Ruler Drop Test (RDT), a simple and validated psychomotor test. Participants were seated with their dominant hand positioned over a table edge, fingers held in a pincer-like grip. A 30-cm plastic ruler was suspended vertically between the thumb and index finger, with the zero mark aligned to the top of the thumb. Upon unannounced release by the examiner, participants attempted to catch the ruler as quickly as possible.

The distance (in meters) from the point of release to the point of catch was recorded and used to calculate reaction time (t) using the formula:

t=2dgt = \sqrt{\frac{2d}{g}}t=g2d

where *d* is the drop distance (m) and *g* is the acceleration due to gravity (9.8 m/s²). Each participant completed three trials, and the mean value was used for further analysis [5].

Data were assessed for normal distribution. Paired sample t-tests were used to analyze within-group differences, while independent sample t-tests were applied for between-group comparisons. Statistical significance was set at $p < 0.05$.

4. Results and Discussion

This study involved 90 respondents from the Faculty of Medicine, Universitas Tarumanagara, academic year 2022–2023, with an average age of 21 years (range: 20–22 years). The gender distribution consisted of 30 male students (33.3%) and 60 female students (66.7%).

Reaction time was assessed at three time points: baseline (pre-intervention), 15 minutes post-intervention, and 30 minutes post-intervention. The experimental group (coffee intake) had a baseline mean reaction time of 0.201 ± 0.020 seconds. This decreased to 0.184 ± 0.018 seconds at 15 minutes and further to 0.163 ± 0.015 seconds at 30 minutes post-intervention. In contrast, the control group (mineral water) recorded a baseline mean reaction time of 0.199 ± 0.019 seconds, which decreased slightly to 0.190 ± 0.018 seconds at 15 minutes and 0.174 ± 0.016 seconds at 30 minutes post-intervention (see Table 1).

Table1 Respondent Characteristics (N = 90)

Characteristics	Frequency (%)	Mean ± SD	Median (min-max)
Age (years)		20,69 ± 0,647	21 (20 - 22)
20	37 (41,1)		
21	44 (48,9)		
22	9 (10)		
Gender			
Male	30 (33,3)		
Female	60 (66,7)		
Mean Reaction Time (seconds)			
Control Group (n=45)			
Pre intervention		0.199 ± 0,019	0.200 (0.152 - 0.236)
15 minutes post intervention		0.190 ± 0,018	0.192 (0.145 - 0.226)
30 minutes post intervention		0,174 ± 0,016	0,171 (0,147 - 0.215)
Intervention Group (n=45)			
Pre intervention		0.201 ± 0.020	0.204 (0.159 - 0.233)
15 minutes post intervention		0.184 ± 0.018	0.184 (0.145 - 0.235)
30 minutes post intervention		0.163 ± 0.146	0.165 (0.135 - 0.195)

Statistical analysis using the independent sample t-test showed no significant difference in baseline reaction times between the experimental and control groups ($p = 0.628$). At 15 minutes post-intervention, the experimental group exhibited faster reaction times compared to the control group (0.184s vs. 0.191s), though the difference was not statistically significant ($p = 0.083$). However, a significant difference was observed at 30 minutes post-intervention, with the experimental group showing a shorter reaction time (0.163s) than the control group (0.174s) ($p = 0.005$), indicating a measurable effect of caffeine.

Within-group comparisons using the paired sample t-test showed significant reductions in reaction time at both 15 and 30 minutes post-intervention for both groups. In the experimental group, the mean difference from baseline to 15 minutes was −0.018 ± 0.016 seconds ($p < 0.001$), and from baseline to 30 minutes was −0.038 ± 0.019 seconds ($p < 0.001$). The control group also demonstrated statistically significant but smaller reductions in reaction time (−0.009 ± 0.009 at 15 minutes, −0.025 ± 0.018 at 30 minutes; $p < 0.001$ for both) (see Table 2).

Table 2. Comparison of Mean Reaction Time Between Coffee and Water Groups (N = 90)

Mean Reaction Time (s)	Control Group	Intervention Group	Difference (Pre–Post)
Pre-intervention (baseline)	0.200 ± 0.020	0.202 ± 0.021	–
15 min post-intervention	0.191 ± 0.018	0.184 ± 0.019	-0.009 ± 0.009 **
			-0.018 ± 0.016 **
30 min post-intervention	0.174 ± 0.017 *	0.163 ± 0.015 *	-0.025 ± 0.018 **
			-0.038 ± 0.019 **

Notes: *p-value < 0.05, **p-value < 0.001

These results suggest that caffeine intake results in a significantly faster reaction time, particularly noticeable at 30 minutes post-consumption. This study aimed to examine the effect of caffeine consumption on the reaction time of medical students at Universitas Tarumanagara, class of 2022–2023. The results showed a statistically significant reduction in reaction time at both 15 and 30 minutes following caffeine ingestion, suggesting that caffeine has a positive effect on psychomotor performance in young adults.

These findings align with those reported by McLellan, Caldwell, and Lieberman (2016), who concluded that caffeine enhances alertness, cognitive performance, and motor responses through its antagonistic action on adenosine receptors. By blocking adenosine's inhibitory effects, caffeine promotes increased neuronal firing and the release of excitatory neurotransmitters such as dopamine and norepinephrine, thereby improving vigilance and reaction speed.

Furthermore, Salomone et al. (2019) found that caffeine significantly enhances reaction time, particularly under conditions of cognitive fatigue or sleep deprivation. Although the present study did not control for participants' sleep quality, it is reasonable to assume that medical students experience academic-related fatigue, which may have amplified caffeine's impact.

Smith et al. (2017) suggested that caffeine's effect on reaction time is predominantly mediated by attentional processes rather than motor function. This finding supports our observation that improved reaction time was likely due to enhanced cognitive alertness rather than increased muscular response.

The most pronounced improvement in reaction time was observed at 15 minutes post-ingestion, with sustained effects seen at 30 minutes. This corresponds well with the known pharmacokinetics of caffeine, which reaches peak plasma concentrations within 30–60 minutes after consumption (McLellan et al., 2016), supporting the timing of performance enhancement seen in this study.

In comparison to a similar study conducted by Smit and Rogers (2000), which evaluated the cognitive and psychomotor effects of varying doses of caffeine in university students, this study reports comparable results—showing that even a moderate dose of caffeine (as typically found in coffee) is sufficient to enhance reaction time. Likewise, Brunye et al. (2010) found that caffeine improved both simple and complex reaction time tasks in healthy young adults, especially under pressure or time-constrained conditions, which aligns with the academic stress faced by medical students in our sample.

In the context of physical and exercise performance, caffeine has also been found to enhance reaction time and performance outcomes, with both pharmacological and placebo effects contributing to these improvements (Vega-Muñoz et al., 2024; Stellingwerff et al., 2022). While our participants were not athletes, the improvement in cognitive-motor response is consistent with these findings, indicating similar underlying mechanisms.

Nonetheless, individual variability in response to caffeine should be acknowledged. Factors such as habitual caffeine intake, genetic variations in caffeine metabolism (e.g., CYP1A2 polymorphisms), tolerance, and body composition may influence outcomes (Roache et al., 2019). These were not accounted for in the current study and constitute a potential confounding factor.

Finally, Ibn-Idris et al. (2022) noted that caffeine is frequently consumed by medical students to enhance alertness and cognitive performance, often without a full understanding of its neurophysiological effects. Our findings provide empirical evidence to support caffeine's short-term benefits for psychomotor function in this specific academic population.

6. Conclusions

This study demonstrated that caffeine consumption significantly improves reaction time among medical students at Universitas Tarumanagara. A notable reduction in reaction time was observed at 15 and 30 minutes after caffeine intake, indicating that caffeine positively influences cognitive-motor performance, particularly under academic stress conditions. These findings are consistent with previous research suggesting that caffeine enhances psychomotor vigilance by blocking adenosine receptors and stimulating central nervous system activity.

Given that reaction time is a critical component of academic and clinical performance, especially in decision-making and task execution under pressure, caffeine may serve as a practical aid for temporarily enhancing mental alertness in students. However, variability in individual responses, potential side effects, and dependency risks must be considered before advocating routine caffeine use.

Recommendations

Caffeine may be used strategically to enhance alertness and reaction speed during exams or prolonged study sessions. However, students should avoid excessive or habitual intake, monitor their tolerance, and remain mindful of potential side effects such as insomnia, jitteriness, or dependency and future studies should incorporate more precise computerized reaction time assessments and account for confounding variables such as habitual caffeine use, sleep quality, genetic factors (e.g., CYP1A2 polymorphism), and dietary habits. Including a larger and more diverse population would also enhance generalizability.

References

References must follow the IEEE style. We recommend preparing references with a bibliography software package like Mendeley, EndNote, or Zotero to avoid typos and duplicate references. **Digital object identifiers (DOIs) must be included for all available references. It is important to do a lookup-based DOI (if any) on the reference manager, see Figure 5.**

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