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Research Article

Caffeine Ingestion among Athletes Based on Safe Dose Daily Allowance in Malaysia

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ABSTRACT

This study aims to investigate the category of caffeinated beverages ingested and caffeine ingestion level among athletes based on safe dose daily allowance. A cross-sectional study was conducted among 236 athletes using validated Caffeine Consumption Questionnaire (CCQ) to estimate the caffeine intake among athletes. The findings revealed a high prevalence (69.1%) of caffeine consumption exceeding the recommended daily allowance was observed among the athletes. Among the various Caffeinated Beverage (CB) categories, Coffee Drink (CD) showed the highest median and interquartile range of caffeine intake 243.0 mg (0–919.5 mg). There was a significant correlation ($p<0.05$) between types of CB Energy Drink (ED) with pre-event ($r=0.280$), during-event ($r=0.447$), post-event ($r=0.291$). Energy Gel (EG) with pre-event ($r=0.139$), during-event ($r=0.498$), post-event ($r=0.170$). Soft Drink (SD) with pre-event ($r=0.328$), during-event ($r=0.228$), post-event ($r=0.304$). CD with pre-event ($r=0.534$), during-event ($r=0.132$), post-event ($r=0.240$). Tea Drink (TD) with pre-event ($r=0.148$), post-event ($r=0.190$). Cocoa Drink (CocD) with pre-event ($r=0.158$), post-event ($r=0.137$). A significant association ($p<0.05$) was observed between the range dose allowance of caffeine intake and the timing of ingestion during sports events. The daily caffeine consumption among athletes in Malaysia exceeds the recommended safe dose. Therefore, it is essential to monitor, track and regulate the intake of caffeine-containing beverages by implementing clear guidelines and promoting awareness of caffeine-related facts. This approach aims to prevent potential adverse health effects while ensuring athletes can still harness its performance-enhancing benefits.

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INTRODUCTION

Caffeine a Central Nervous System (CNS) stimulant alkaloid is most widely consumed and found in coffee and cocoa beans, tea leaves, guarana, berries and kola nut as well as in added ingredients beverages like soda pop and sport and energy drink (Ikram *et al.* 2024). Once consumed, caffeine creates several physiological and neurological impacts including central nervous system stimulation (alertness and arousal), diuresis and insomnia (Samoggia & Rezzaghi 2021). Caffeine is speedily absorbed after ingestion from the gastrointestinal tract into the circulatory system within 45 minutes and is metabolized in the liver (Barcelos *et al.* 2020). After 1 hour ingestion, blood caffeine levels reach the highest level and quickly enters all body tissues also crosses the blood brain. The half-life of caffeine in humans ranges from a minimum

of 2 to a maximum of 12 hours (~3–5 hours on average) and around 3–7 hours in adults (Soós *et al.* 2021).

Sports play a crucial role in promoting physical fitness, mental well-being, and social interaction while fostering discipline, teamwork, and a spirit of competition (Deshmukh *et al.* 2024). Athletes, whether professional or recreational, exemplify dedication, discipline, and a drive for excellence in their respective fields. Through rigorous training, they consistently push their physical and mental limits to enhance their skills, endurance, and overall performance, striving to achieve both personal and team goals (Braunstein-Minkove *et al.* 2022).

Caffeine is the supplements that are commonly consumed by athletes at all levels of sports due to its influence in enhancing the exercise performance and showing ergogenic effects by increasing the buffer capacity and delaying fatigue (Šljivo *et al.* 2020). Given its physiological effects, caffeine has become a popular ergogenic aid among athletes, as it can enhance both physical and mental endurance during training or competitive events (Guest *et al.* 2021). Meanwhile, caffeine has been excluded from the list of prohibited substances in 2004 and has been included under monitoring program until present by the World Anti-Doping Agency (WADA 2020). As a result, recently it is frequently used by sportsmen and women, with research suggesting 75–90% of athletes consume caffeine with timing intake before, during and after sports events (Kennedy & Wightman 2022). The best way to improve performance is to consume caffeine with dose in low to moderate and 30-60 minutes before physical activities (Panayi & Galbraith 2022).

The consumption of caffeine in moderate doses of 3–6 mg/kg body mass or (200−400 mg/day) has been consistently shown to improve exercise performance and harmless (Halldorsson *et al.* 2021). Least effective dose of caffeine might be as low as 2 mg/kg body mass or (<200 mg) depending on an individual (Government of Health Canada 2022). The use of excessive amounts of caffeine regularly (e.g. 6.1 mg/kg and above) or more than daily dose allowance (>400 mg) according to the US Food and Drug Administration (FDA) are associated with a high risks incidence of side-effects and the ergogenic effect seem similar to moderate dose (Guest *et al.* 2021).

While several investigators have examined the caffeine intake among working consumers and university students (Ghozayel *et al.* 2020) and there also lack of study on caffeine intake a day in an event basis during sports day among athletes (Martyn *et al.* 2018). In Malaysia, there has not been much research about the caffeine consumption on sports event a day in relation with the daily safe dose allowance of caffeine intake among athletes. Habitually, athletes often tend to consume caffeine-containing beverages before, during and after competition due to energy booster for their physical and overall performance. However, how much caffeine are they consuming? Hence, the current study aims to investigate the caffeine ingestion among athletes based on safe dose daily allowance in Malaysia. Thus, by conducting this study, it can show the overall intake of caffeine a day among athletes associated with safe dose daily recommendation.

METHODS

Design, location, and time

A quantitative, cross-sectional study was conducted. As the study was carried out during COVID-19 pandemic in 2021, and offline data collection was not possible due to lockdown condition as the limitation, therefore, a questionnaire was prepared and emailed via online Google form and the participants were randomly recruited by phone and social media to participate the study with consent. This study was obtained ethical approval on December 2020 from *Jawatankuasa Etika Penyelidikan* Universiti Kebangsaan Malaysia with approval number JEP-2020-729.

Sampling

A total of 388 athletes from 20 government universities in Malaysia were initially selected based on a sample frame derived from the list of registered names under Majlis Sukan University Malaysia (MASUM) Sports 2020/2021. The study employed a stratified simple random sampling technique which falls under probability sampling, to ensure representation across various sports categories. However, after distributing the survey, only 10 universities participated, with a total of 236 respondents completing the study. These athletes were chosen as the target population, since caffeine consumption among them was very popular to enhance their sporting

performance (Šljivo *et al.* 2020). The inclusion criteria of the participants were university athletes registered under (MASUM), aged 20–25 years old, active participating in competitions and habitually or consistently consumed caffeinated beverages as part of their daily routine or several times a week.

Data collection

The questionnaire used in the current study was extracted from revalidated instruments employed in previous studies with internal consistency (α=0.95) and Intraclass Correlation Coefficient (ICC=0.90) (Irons *et al.* 2016; Ágoston *et al.* 2018; Rowe *et al.* 2020) to achieve the research objectives. The level and content of the questions in the questionnaire were deemed to be suitable for completion by the athletes. The validated questionnaire consisted of 2 sections (Section A and B). The first section consisted of 6 questions to assess the socio-demographic information of the participants and the last section comprised of 6 questions to identify the caffeine consumption towards caffeinated beverages among athletes. The estimated time for completion of the questionnaire was 5–10 minutes.

Data collection was performed for six months, from June to November 2021. The questionnaire items were created as an online survey using Google Forms and emails. A probability simple random sampling technique was adapted, which is a technique that includes all subjects having an equal chance of being selected by the researcher. This sampling technique was chosen in order to recruit a representative sample of the entire targeted population. An official invitation for participation was sent using messaging applications such as WhatsApp® and Telegram®, as well as through the email used to disseminate the survey link. Basic information about the study and the letter seeking participants' consent was contained on the introductory page of the online form. All the data collected were kept private and confidential and used only for academic purposes. Follow-up messages were sent to participants weekly to remind them to complete the survey.

Data analysis

Responses collected from the questionnaires were encoded and analysed using IBM Statistical Package for the Social Sciences (SPSS) software version 26.0. Incomplete responses were filtered using an extracted Microsoft Excel file from the Google form. Data analyses were performed using descriptive and inferential statistics. Descriptive data such as central tendency, frequency and percentage were used to describe the participants' characteristics. The Kruskal-Wallis test was performed to determine the statistically significant association between the ingestion time of caffeinated beverages and dose of caffeine intake, while Spearman's rho test was executed to determine the correlation between the preferences types of caffeinated beverages intake and ingestion time in sports event. Data with $p<0.05$ were considered significant.

RESULTS AND DISCUSSION

The demographic characteristics of all participants are presented in Table 1. A total 236 of athletes responded to the survey. The participants' median age was 23 (22–24) years old and the most of them were male athletes (57.2%) compared to female athletes (42.8%). In addition, all participants were categorised as having a normal range of Body Mass Index (BMI) according to National Institute of Health (NIH) (2023).

Male athletes frequently outnumber female athletes in terms of involvement in sports (Paul *et al.* 2023). In terms of BMI, most of the athletes in the present study had a normal range of BMI according to the NIH (2023) which is consistent with the reports in a recent study Hermawan *et al.* (2021). Specifically, the average value of body weight, height and BMI were at normal values for all the athletes recruited in this study.

The favourable types of caffeinated beverages among athletes

The most chosen categories of caffeinated beverages among athletes by category were analysed based on Table 2. The higher Median (IQR) consumption for overall caffeinated beverages was observed in coffee drink 243.0 mg (0.0−919.5), followed by tea drink 152.5 mg (0.0−436), energy drink 43.0 (0.0−165.8), cocoa drink 3.5 mg (0.0−24.0), soft drink 0.0 mg (0.0−62.0) and energy gel 0.0 mg (0.0−0.0). Males were found to consume more coffee drink and energy drink compared to females whereas females consumed more tea drink and cocoa drink.

Table 1. Socio-demographic characteristic of the participants

Socio-demographic variables (n=236)	n (%)	Median (IQR)
Age (years)		23 (22–24)
Body weight (kg)		63.5 (56–75.8)
Height (m)		170 (164–178)
BMI (kg/m^2)		22.2 (20.2–25.3)
Gender		
Male	135 (57.2)	
Female	101 (42.8)	
Classification of sports		
Contact sport	109 (46.2)	
Non-contact sport	127 (53.8)	
Mode of play		
Individual	71 (30.1)	
Team	130 (55.1)	
Mix mode	35 (14.8)	
Location of university area		
Klang valley	126 (53.4)	
Non-Klang valley	110 (46.6)	

BMI: Body Mass Index; IQR: Interquartile Range; n: number of respondents

The consumption of caffeinated beverage by athletes revealed that coffee drink was the highest category of beverages consumed by athletes. This indicated that coffee drinks were the most popular caffeine-containing drinks consumed by athletes. Caffeine is consumed daily by about 80% of the world's population through coffee beverages, including athletes and those who use it as part of their lifestyle (Samoggia & Rezzaghi 2021). Since the participants in the present study were university athletes, caffeinated beverage from coffee sources were the most common beverages that were conveniently accessible to them. Coffee is regarded as the most suitable and accessible substitute for caffeine-containing beverages worldwide due to its similar caffeine content (Mohammed *et al.* 2022).

Additionally, in Malaysia, coffee is a popular traditional drink that is typically served especially during social occasions such as family, friends or community gatherings, cultural celebrations and academic events. Thus, this makes coffee was the first choice for caffeine lovers including students and athletes, due to cultural preferences and its availability. Our study is consistent with (Jahrami *et al.* 2020) that reported students' athletes who regularly consume caffeine tend to rely on coffee and tea as their traditional main source of beverage. Their study found that university students and young adults in Arab countries were most likely to consume caffeinated beverages, especially coffee and tea, due to the most commonly available drink products. In addition, coffee and tea were essential beverages for the hospitability in their country, which was influenced by their social norms.

Despite this, current findings emphasize the importance of educating athletes to broaden their awareness and understanding regarding commercial coffee drinks and caffeine-containing beverages besides the benefits as well as the health impact.

Table 2. The favourable types of caffeinated beverages among athletes

Category of caffeinated beverages	Overall (n=236) Median (IQR)	Male (n=135) Median (IQR)	Female (n=101) Median (IQR)
Energy drink	43.0 (0.0–165.8)	52.0 (0.0−189.0)	43.0 (0.0−162.5)
Energy gel	0.0 (0.0–0.0)	0.0 (0.0−0.0)	0.0 (0.0−00)
Soft drink	0.0 (0.0–62.0)	0.0 (0.0−76.0)	0.0 (0.0−51.0)
Coffee drink	243.0 (0.0–919.5)	324.0 (0.0−1020.0)	172.0 (0.0−686.5)
Tea drink	152.5 (0.0–436)	117.0 (0.0−409.0)	210.0 (0.0−471.0)
Cocoa drink	3.5 (0.0–24)	3.0 (0.0−24.0)	4.0 (0.0−23.5)

IQR: Interquartile range; Amount of caffeine consumed (mg); IQR: Interquartile Range; n: number of respondents

Caffeine ingestion level based on daily safe dose recommendation

The vast majority of athletes participating in sporting events consumed (69.1%) high levels of caffeine exceeding the recommended daily allowance with (39.8%) males showing higher levels of unsafe consumption compared to (29.2%) females (Table 3).

It was observed that most athletes had consumed more caffeine than the daily allowance for caffeine intake according to daily safe dose recommendation. This is in line with the findings of a previous study conducted among Tokyo 2020 Olympic athletes in which half of the representative athletes had consumed excessive intake of caffeine and they were unconscious. They expected more caffeinated beverage as ergogenic aids could enhance the benefits of performance. This finding corroborates the results by (Myoenzono *et al.* 2023) in which athletes posited that caffeine supplements providing complete coverage lead to greater sports' benefits.

Another possible reason for this finding is the insufficient knowledge among athletes regarding the sources of caffeine-containing drinks product and the adverse health effects of consuming more than the recommended doses due to motivated and influenced from the surrounding for better performance. This event was supported by a study conducted among Egypt athletes as athletes demonstrated poor knowledge about the sources, ingredients and health impacts of caffeinated beverages, specifically the caffeine content (Mohamed & Abdelaziz 2022). These athletes, without knowing the consequences of over-intake, believed that caffeine definitely could enhance performance by improving physical endurance, reducing fatigue, as well as increasing mental alertness and concentration (Mohamed & Abdelaziz 2022).

The preferences category of caffeine-containing beverages ingested among athletes based on timing ingestion in sports event

The Spearman's rho correlation results demonstrated a significant correlation ($p<0.05$) between all types of caffeinated beverages with the ingestion time in sports event (Table 4). Thus, current results reveal that the consumption of caffeine from all sources of caffeinated drinks showed athletes highly dependent with caffeine in their day of tournament due to physical performance enhancement. Consuming regularly multiple caffeine-containing beverages in a single day could exceeding the recommended doses and might pose several health's issues due to the additive effects of caffeine.

In liquid form, caffeine often high concentrated due to it is highly soluble in water that makes liquid formulations efficient for delivering a concentrated dose. This allows manufacturers to create products like energy drinks, energy gels, and other liquid supplements that deliver caffeine quickly and effectively (Reddy *et al.* 2024). The FDA recommends a maximum intake of 400 mg of caffeine per day approximately 4–5 cups of coffee for most adults (Roberts 2021). Often exceeding this can increase health risks and lead to symptoms like restlessness, rapid heartbeat, nausea, vomiting, tremors, and in severe cases seizures (Celi *et al.* 2022). Thus, might impair the athletes' performance.

Daily training and often competition schedules would diminish the energy and lead to the ingestion on variety of caffeinated drinks in order to overcome the tiredness. Besides the caffeine contains in caffeinated beverages, athletes could relate with the unintended of high sugar level and calorie intake. Numerous of caffeinated beverages such as energy drinks, sodas or flavoured coffees are loaded with sugar and calories as well as other components of

Table 3. Caffeine consumption level based on daily safe dose recommendation

Daily safe dose allowance	Caffeine intake (mg/day)	Male n (%)	Female n (%)	Total n (%)
		n=236		
Safe	Low	18 (7.6)	15 (6.4)	33 (14)
	Moderate	23 (9.7)	17 (7.2)	40 (16.9)
Not safe	High	94 (39.8)	69 (29.2)	163 (69.1)

Daily safe dose allowance by Food and Drug Administration (FDA) (Low: <200 mg; Moderate: 201−400 mg; High: >401 mg); n: number of respondents

Table 4. The preferences category of caffeine-containing beverages ingested among athletes based on timing ingestion in sports event

Types of caffeinated beverage	Time ingestion of caffeinated drink								
	Pre-event			During event			Post-event		
	n	r	*p*	n	r	*p*	n	r	*p*
Energy drink	236	0.280***	0.001	236	0.447**	0.001	236	0.291***	0.001
Energy gel	236	0.139*	0.033	236	0.498**	0.001	236	0.170**	0.009
Soft drink	236	0.328***	0.001	236	0.228**	0.001	236	0.304***	0.001
Coffee drink	236	0.534***	0.001	236	0.132*	0.042	236	0.240***	0.001
Tea drink	236	0.148*	0.023	236	0.05	0.441	236	0.190**	0.003
Cocoa drink	236	0.158*	0.015	236	0.07	0.283	236	0.137*	0.035

Spearman's rho Correlation test; *: Significant at the 0.05 level (2-tailed); **: Significant at the 0.01 level (2-tailed); ***: Significant at the 0.001 level (2-tailed); n: number of respondents

ingredients. By frequent consumption of these beverages could increase the risk of weight gain, type 2 diabetes and also dental issues among active individuals and athletes (Hashem *et al.* 2018). Hence, if this condition continuously happens, the athletes might prone to multiple adverse effect later.

The dose level of caffeine ingestion among athletes based on sports event

Most of the dose level caffeine intake were at exceed level which above 401 mg per day as presented in Table 5. The association between ingestion time of caffeinated beverages with dose of caffeine intake was significant for pre-event ingestion (p=0.000), during event ingestion (p=0.000) and post-event ingestion (p=0.000) (Table 5). Based on results, the caffeine intake of athletes at all intake timing (pre, during and after) event of tournament definitely over the daily allowance (>400 mg) as stated by FDA. This condition brings concern toward athletes' health either in acute or chronic effect, though the beneficial of caffeine within the range dose allowance (low to moderate) were well studied to enhance physical and sports performance. Usually, mild stimulation of caffeine is obtained with a dosage of 50 mg–200 mg, while fatal caffeine intoxication is rare, nevertheless acute ingestion more than daily allowance frequently

Table 5. The dose level of caffeine consumption among athletes based on sports event

Time ingestion of CB during a sport event	Dose caffeine intake (mg/day)	n	Median	Mean rank	Kruskal-Wallis H	df	*p*
Pre event	Low	33	26.00	52.29			
	Moderate	40	83.00	77.74	64.857	2	0.001*
	High	163	320.00	141.91			
During event	Low	33	0.00	91.83			
	Moderate	40	0.00	93.30	19.403	2	0.001*
	High	163	0.00	130.08			
Post event	Low	33	0.00	67.68			
	Moderate	40	0.00	87.48	40.389	2	0.001*
	High	163	106.00	136.40			

Timing intake based on total score (Low: <200 mg; Moderate: 201−400 mg; High: >401 mg) n: number of respondents; *: p<0.05 using Kruskal-Wallis Test; CB: Caffeinated Beverage

could be unsafe and will impact athletes' health (Andrade *et al.* 2018).

According to Rodda *et al.* (2020) often excessive doses of caffeine may contribute to the development of diverse physiological changes, mainly related to the nervous system, cardiovascular system and hepatic systems. The consumption of caffeine (above 450 mg/day) have reported to cause a state of dysfunctional excitation in the nervous system that leading to sleeping disturbances thus could negatively affect endurance performance among athletes (Onaolapo & Onaolapo 2020). Moreover, high doses of caffeine ingestion (>500 mg/day) can cause high levels of tension, nervousness, irritability, nausea, palpitations and restlessness among healthy populations such as active individuals and athletes (Viana 2019). Hence, possibly leading to a decline in accuracy towards physical and action performance (Bougrine *et al.* 2024).

The effects of caffeine regarding cardiovascular disorders show that the consumption of low to moderate amount of caffeine per day is associated with a reduced risk of cardiovascular disease (Weng *et al.* 2021), nonetheless an acute caffeine intake (>500 mg/day) can stimulates a modest increase in blood pressure triggering supraventricular tachycardia perhaps due to the increased of intracellular calcium concentrations, norepinephrine releasing and sensitization of dopamine receptors (Chrysant 2017). In addition, arrhythmia, atrial fibrillation and coronary disease also have been detected in healthy and hypertensive individuals or with historic of cardiovascular problems (Bodar *et al.* 2019).

As a case study reported by Andrade *et al.* (2018) from the pre-workout caffeine supplement on healthy active 32-year-old woman who went to the local emergency department 30 minutes after ingesting more than 2,000 mg of caffeine. She presented an episode of presyncope followed by agitation. Her ECG showed polymorphic broad complex QRS tachycardia and arterial blood gas revealed metabolic acidaemia with severe hypokalemia. Another case study from Ciszowski *et al.* (2014), 44-year-old man with no medical history was admitted to hospital about 21 hours after ingestion 1,600 mg of caffeine. Typical symptoms of caffeine toxicity (i.e. nausea, vomiting, anxiety and palpitations) occurred shortly after ingestion. Approximately 45 hours post ingestion, the patient developed atrial fibrillation with fast ventricular rhythm. Then, a worst-case scenario from Poussel *et al.* (2013), reported a fatal of cardiac arrhythmia following voluntary caffeine overdose in an amateur body-builder athlete after having intentionally ingested a huge amount of 10 g caffeine due to for the enhancement of physical performance.

Although caffeine is a recreational drug that is permitted for daily consumption, careful attention must be given to the allowable dosage range to prevent potential health issues specially among athletes and active individuals.

CONCLUSION

The majority of university athletes consume caffeine during sporting events. Coffee drinks are the primary source of caffeine intake, followed by tea drinks, energy drinks, cocoa drinks, soft drinks and energy gels. Male athletes consume more caffeine than their female counterparts. Daily caffeine consumption among university athletes frequently exceeds the recommended safe dose. Thus, it is crucial to monitor, track and regulate caffeine intake by establishing clear guidelines, incorporating caffeine-related facts, implementing warning labels and raising awareness. This approach aims to prevent potential adverse health effects while allowing athletes to leverage the performance-enhancing benefits of caffeine safely. Additionally, further research should investigate caffeine intake patterns based on specific activities during sports event, as well as athletes' preferences for brands and types of caffeinated beverages to assess their influence on performance, recovery, and overall health. Moreover, exploring the role of individual differences, such as metabolism and tolerance levels, could provide deeper insights into safe and effective caffeine use among athletes.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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