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Exploring the Interplay between Caffeine Intake, Sleep Quality, and Gastrointestinal Health in Male Combat Sports Athletes: Implications for Performance Optimization and Well-Being

Musab Çağın[1], Gönül Tekkurşun Demir[2], Kezban Gülşen Eşkil[3], Hüsnü Kocaman[4], Remzi Eşkil[5], İmdat Yarım[6]

1Gazi University, Sport Science Faculty; Ankara/Turkey; Email ID: musabcagin@gazi.edu.tr
2Gazi University, Sport Science Faculty; Ankara/Turkey; Email ID: gonultekkursun@hotmail.com
3Gazi University, Sport Science Faculty; Ankara/Turkey; Email ID: kezban-gulsen@hotmail.com
4Gazi University, Sport Science Faculty; Ankara/Turkey; Email ID: husnu.kocaman@gazi.edu.tr
5Gazi University, Sport Science Faculty; Ankara/Turkey; Email ID: remzieskil@gmail.com
6Gazi University, Sport Science Faculty; Ankara/Turkey; Email ID: imdat@gazi.edu.tr

***Corresponding Aouthr:**
Email ID: musabcagin@gazi.edu.tr

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ABSTRACT

Caffeine is widely acknowledged for its positive impact on athletic performance and is frequently consumed by athletes but has also been reported to affect the gastrointestinal system and sleep quality depending on its consumption frequency. In this study, we investigate how the frequency of caffeine intake influences gastrointestinal symptoms and sleep quality in male athletes. A total of 196 active male combat sports athletes with an average age of 21.36±2.457 years and a sporting experience of 9.30±3.786 years were assessed for their caffeine intake frequency using a structured self-report questionnaire. Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), while gastrointestinal health symptoms were measured using the Gastrointestinal Symptom Rating Scale. The collected data were analyzed using the SPSS (Statistical Package for the Social Sciences) 26.0 software, and Pearson Correlation Analysis and descriptive statistics were used to assess the relationships. The analysis revealed that there was no significant relationship between frequency of caffeine consumption and gastrointestinal symptoms and sleep quality in male athletes ($p>0.05$). Additionally, when specific sleep quality subscales were examined, no significant relationship was found with the frequency of caffeine use ($p>0.05$). In addition to this, no significant relationship was found between the frequency of caffeine intake and the sub-dimensions of gastrointestinal symptoms ($p>0.05$). As a result of the research, it was determined that caffeine, an ergogenic aid that is not classified as doping, does not have any negative effects on sleep and stomach health. In this context, it is thought that caffeine supplementation does not negatively affect health and can be a good alternative ergogenic aid to increase the performance of male athletes.

Keywords: *caffeine; gastrointestinal symptoms; sleep quality; male athletes*

1. INTRODUCTION

The International Olympic Committee (IOC) officially recognizes caffeine as one of the five nutritional supplements based on compelling evidence for its ability to enhance athletic performance [1]. Research studies indicate that caffeine can improve performance in athletes by 2% to 4% [2]. Consequently, athletes commonly use caffeine in their routines to enhance their performance and overall work efficiency [3], with reports showing that approximately 76% of performance athletes regularly consume caffeine.

Caffeine's primary mechanism for maximizing workout performance is its impact on the central nervous system. Specifically, caffeine elevates the levels of norepinephrine and dopamine, leading to increased alertness and improved concentration. Additionally, caffeine can reduce the perception of effort and pain experienced during exercise [3]. Beyond its physical performance enhancements, caffeine may also offer acute cognitive benefits, particularly for individuals struggling with insomnia and has been investigated among military personnel, where caffeine was found to affect not only physical

performance but also cognitive aspects such as wakefulness, memory and mood both during nighttime operations and

following sleep deprivation. Similar findings have been reported in athletes as well. Cook et al. (2011) reported that caffeine doses of 1 and 5 mg/kg mitigated skill performance decline resulting from sleep restriction in elite rugby players [4], while it demonstrated that caffeine can enhance sport-specific skill performance in individuals without sleep deprivation [5].

Despite the various performance-enhancing mechanisms attributed to caffeine, it is important to acknowledge that caffeine can adversely affect both the ability to initiate and maintain high-quality sleep. This impact can be long-lasting, as demonstrated by Drake et al., who found that consuming 400 mg of caffeine six hours before bedtime disrupted sleep quality, reduced sleep duration, and prolonged the time it takes to fall asleep, which is particularly relevant in sports where competitions frequently occur in the evening [6]. The pre-competition consumption of caffeine may lead to a transfer effect, compromising sleep quality, duration, and subsequent recovery. A study associated the consumption of caffeine by a rugby team before an evening match with increased sleep onset latency and decreased both sleep duration and efficiency [7].

The impact of caffeine intake on athletic performance can vary based on several factors, including the time of day [3,8], the athlete's training status [9] and the athlete's age [10,11]. Orally ingested caffeine is metabolized in the gastrointestinal system. Upon consumption, caffeine is absorbed by the small intestine within 15-45 minutes, depending on its form, and is subsequently distributed to all tissues [12].

Notably, the relationship between caffeine consumption and the optimal dosage for athletes has been found to be inconsistent across different studies. Nevertheless, previous research has generally suggested that a caffeine intake of approximately 3-9 mg/kg provides effective ergogenic support, while doses exceeding 9 mg/kg may lead to adverse side effects, and also emphasized that the ideal caffeine dosage may vary depending on factors such as the frequency of consumption, the type of exercise, the mode of muscle contraction, and the form of caffeine ingested [13]. Given these considerations, we designed this present study to investigate the influence of caffeine intake frequency on gastrointestinal symptoms and sleep quality in male athletes.

2. MATERİALS AND METHODS

2.1. Research Design

Here in, a relational survey design was used among quantitative models. A correlational survey design is a research design that aims to determine the presence and/or degree of co-variance between two or more variables [14]. In the sampling selection, the criterion sampling method, which is one of the purposeful sampling methods, was used. Purposive sampling is a method appropriate to be conducted on individuals with specific, limiting and hard-to-reach individual characteristics [15].

2.2. Participants of the Research

The study's sample group was determined using a power analysis method, which considered a 95% confidence level (1-α), a test power of 95% (1-β), and a Pearson correlation analysis with p=0.3, which indicated that a minimum sample size of 138 participants was necessary (Figure 1). As a result, the study included 196 male combat sports athletes currently enrolled in Ankara/Turkey. These participants had an average age of 21.36±2.45 years, a sports background of 9.30±3.78 years, an average height of 174.6±9.91 cm, and a body weight of 69.20±16.40 kg. Participation in the study was entirely voluntary, and all participants provided their informed consent by signing a voluntary consent form. Before starting the research, participants were thoroughly briefed about the testing procedures and the study's protocol. The study adhered to the principles of the Declaration of Helsinki and was granted ethical approval by the Ethics Committee of Gazi University (Code: E-77082166-604.01.02-461219).

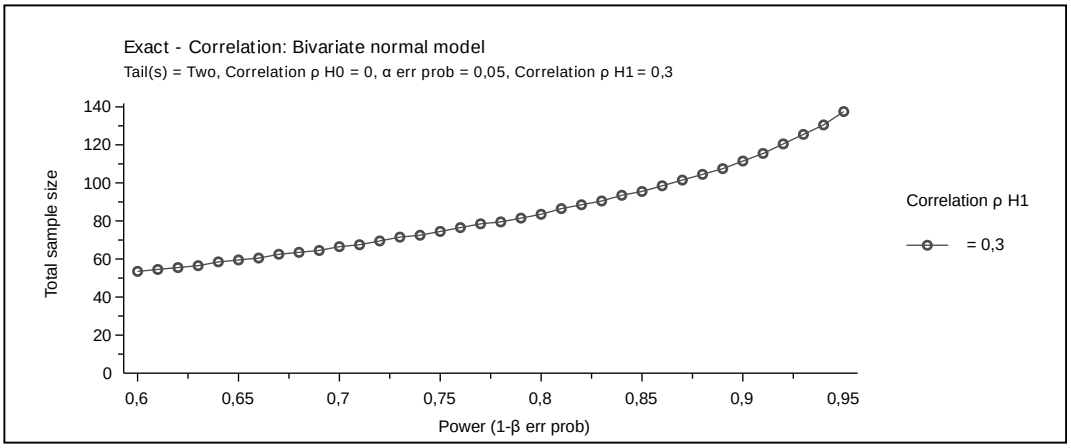

Figure 1. Power analysis result.

2.3. Data Collection

The athletes' caffeine intake frequency was assessed using a structured self-report form administered by the researchers. Sleep quality data were collected using the Pittsburgh Sleep Quality Index (PSQI), while data related to gastrointestinal health were obtained using the Gastrointestinal Symptom Rating Scale. These questionnaires were distributed to the participants via Google Form.

The PSQI is a quantitative measure of sleep quality, distinguishing between "good sleep" and "poor sleep." In 1996, reliability and validity studies for the Turkish version of the scale were conducted by Agargun et al. Each question on the PSQI is rated on a scale from 0 to 3, and the sum of scores from the 7 components yields the PSQI score [16]. The total score ranges from 0 to 21, with a PSQI total score exceeding 5 indicating poor sleep quality, while a lower score signifies good sleep quality.

To assess symptoms commonly associated with gastrointestinal disorders, we used the Gastrointestinal Symptom Rating Scale developed by Revicki et al. in 1997 and validated by Turan et al. in 2017 [17-18]. This scale comprises 15 items, employing a 7-point Likert-type scale that ranges from "no symptoms" to "very severe symptoms." Through factor analysis, the 15 items of the Gastrointestinal Symptom Rating Scale are categorized into five subscales, namely, abdominal pain, reflux, diarrhea, indigestion and constipation. The starting date of this research recruitment is 16/08/2023 and the ending date is 27/10/2023.

2.4. Statistical Analysis

The data were transferred to the SPSS (Statistical Package for the Social Sciences) 26.0 software, following which Pearson Correlation Analysis and descriptive statistical analysis were conducted. Statistical significance was set at $p<0.05$.

3. RESULTS

When statistical data were analyzed, a significant correlation was observed between gastrointestinal symptoms and sleep quality total score ($p<0.05$), while no significant correlation was found between caffeine intake frequency and neither gastrointestinal symptoms nor sleep quality ($p>0.05$) (Table 1).

Table 1. The correlation between frequency of caffeine intake and gastrointestinal symptoms and sleep quality.

Variables		Frequency of Caffeine Intake	Gastrointestinal Symptoms
Gastrointestinal Symptoms	r	-.049	-
	p	.499	
Total Sleep Score	r	.028	.442
	p	.700	**.000***

However, no significant correlation was found when assessing the relationship between the frequency of caffeine intake and the individual subscales of sleep quality ($p>0.05$) (Table 2).

Table 2. The correlation between frequency of caffeine intake and sleep quality subscales.

Variables		Subjective Sleep Quality	Sleep Latency	Sleep Duration	Habitual Sleep Activity	Sleep Disorder	Sleep Medication Use	Daytime Dysfunction
Frequency of Caffeine Intake	r	.057	-.075	.102	.048	-.101	.024	.071
	p	.425	.297	.154	.501	.157	.737	.326

On the other hand, no significant correlation was detected between the frequency of caffeine intake and specific subscales of gastrointestinal symptoms ($p>0.05$) (Table 3).

Table 3. The correlation between frequency of caffeine intake and gastrointestinal symptoms subscales.

Variables		Abdominal Pain	Reflux	Diarrhea	Indigestion	Constipation
Frequency of Caffeine Intake	r	.009	.008	-.030	-.081	-.078
	p	.895	.913	.673	.260	.276

4. DİSCUSSİON

The study comprised 196 male combat sports athletes and did not reveal a significant correlation between the frequency of caffeine intake and gastrointestinal symptoms. Nonetheless, it can be indirectly inferred that the frequency of caffeine intake may influence gastrointestinal symptoms because a significant correlation was observed between sleep quality, the frequency of caffeine intake, and gastrointestinal symptoms ($p<0.05$). With an increase in the frequency of caffeine intake, there was a corresponding decrease in sleep quality. Given that diminished sleep quality has a statistically significant impact on gastrointestinal symptoms, it could be concluded that the frequency of caffeine intake might indirectly contribute to the occurrence of gastrointestinal symptoms.

Examining the existing literature reveals a consistent and statistically significant relationship between sleep quality and gastrointestinal symptoms, with improved sleep quality associated with reduced gastrointestinal symptoms. This correlation is supported by various studies, such as the one conducted by Ozan and Ataseven in 2017, which emphasized the strong impact of sleep disorders on gastrointestinal diseases and the reciprocal influence of gastrointestinal disorders on sleep-wake patterns and sleep quality [19]. High sleep quality is often characterized by waking up feeling refreshed and energized, marking the importance of both qualitative (restfulness and depth of sleep) and quantitative (sleep latency, duration, and nighttime awakenings) dimensions of sleep [20]. Reduced sleep quality is known to be a potential precursor to various health issues, amplifying the significance of preserving sleep quality [21]. Therefore, maintaining a healthy gastrointestinal system is important to promoting quality and efficient sleep, as it can positively impact sleep efficiency.

The findings of the study showed that there was no significant correlation between the frequency of caffeine intake and sleep quality in male athletes ($p>0.05$), however, several studies were found in the literature showing that caffeinated beverages may have a negative effect on sleep quality [22]. Some studies have also reported that excessive caffeine consumption can disrupt the sleep cycle [23] and lead to morning fatigue [24]. Furthermore, a study involving 300 university students found that the consumption of caffeine-containing foods and beverages was associated with 49% of insomnia symptoms [25]. Also it has been reported that caffeine-containing beverages can affect the process of falling asleep, disrupt sleep [26] and have a negative impact on sleep quality [20,27]. Frequent caffeine intake can lead to adverse consequences, such as disturbing regular sleep patterns, compromising sleep efficiency, or necessitating the use of sleep aids to counter these negative effects. Nevertheless, some studies have found that the consumption of tea and coffee does not significantly affect the mean total score of PSQI [21], and this discrepancy may be attributed to individuals developing a tolerance to caffeine due to prolonged exposure, enabling the body to adapt to factors affecting sleep metabolism. However, the prevailing belief is that caffeine has a negative impact on various aspects of sleep quality.

Data analysis showed that a variety of gastrointestinal symptoms, including abdominal pain, reflux, diarrhea, indigestion and constipation, were reported among 196 male combat sports athletes who consumed caffeine. However, there was no statistically significant relationship between any of the gastrointestinal symptoms subscales and the frequency of caffeine intake ($p>0.05$). Our literature review found that, contrary to our research findings, high caffeine consumption can stimulate gastric acid secretion [28]. Therefore, it has been reported that excessive caffeine consumption can have long-term effects on the stomach and potentially lead to problems such as reflux. However, it is clear that more research is needed to provide clearer ideas on this subject.

In conclusion, our results suggest that frequency of caffeine consumption does not have a detrimental effect on sleep quality and gastrointestinal symptoms. In line with these results, it can be said that caffeine, an ergogenic aid used by athletes to increase their performance, can also be a reliable supplement for health. Considering both the danger of being classified as doping and the possible side effects of other ergogenic aids used to increase performance, based on these research findings, it can be said that caffeine is a reliable ergogenic aid. Of course, when evaluating research findings, athletes' regular use of caffeine and their body's caffeine resistance should not be ignored. Because, like other ergogenic aids, the body may show different reactions during the first use of caffeine. In this context, it is thought that future studies on athletes who have not used caffeine supplements before and who have high caffeine resistance may be very important in shedding light on this issue. In addition, it should not be ignored that the athlete's training period, hormonal balance, nutrition pattern, sleep quality and cognitive state may also affect the effectiveness of caffeine and sports performance [29-31]. Another result of our research, which is that sleep quality decreases as gastrointestinal symptoms increase, is a very important detail for athletes and coaches. Considering that sleep quality, which is considered the most important phase of the recovery process, is directly

related to sports performance, it is recommended that athletes should be very careful about nutritional and ergogenic supplements that may increase the frequency of gastrointestinal symptoms.

5. CONCLUSİONS

In conclusion, our results suggest that frequency of caffeine consumption does not have a detrimental effect on sleep quality and gastrointestinal symptoms. In line with these results, it can be said that caffeine, an ergogenic aid used by athletes to increase their performance, can also be a reliable supplement for health. Considering both the danger of being classified as doping and the possible side effects of other ergogenic aids used to increase performance, based on these research findings, it can be said that caffeine is a reliable ergogenic aid. Of course, when evaluating research findings, athletes' regular use of caffeine and their body's caffeine resistance should not be ignored. Because, like other ergogenic aids, the body may show different reactions during the first use of caffeine. In this context, it is thought that future studies on athletes who have not used caffeine supplements before and who have high caffeine resistance may be very important in shedding light on this issue. In addition, it should not be ignored that the athlete's training period, hormonal balance, nutrition pattern, sleep quality and cognitive state may also affect the effectiveness of caffeine and sports performance [29-31]. Another result of our research, which is that sleep quality decreases as gastrointestinal symptoms increase, is a very important detail for athletes and coaches. Considering that sleep quality, which is considered the most important phase of the recovery process, is directly related to sports performance, it is recommended that athletes should be very careful about nutritional and ergogenic supplements that may increase the frequency of gastrointestinal symptoms.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Consent for Publication

Not applicable.

Data Availability: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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