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Towards a More Active Lifestyle: Effects of Caffeine Consumption on Sleep Quality and Physical Activity Levels Among Young Adults

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ABSTRACT

Physical activity (PA) levels, caffeine consumption (CC), and sleep quality (SQ) in young adults are among the key lifestyle factors influencing the physiological balance and overall health profile of the human body. This cross-sectional study investigated the relationships among CC, SQ, and PA levels in 563 university students (female = 287; male = 276; mean age = 20.60 ± 1.99 years). CC was assessed using a standardized Caffeine Consumption Frequency Form, SQ was measured with the Basic Scale on Insomnia Complaints and Sleep Quality (BaSIQS), and PA was evaluated via the Physical Activity Scale-2 (PAS-2). Data analyses included Mann–Whitney U, Kruskal–Wallis, Spearman correlation, and multiple linear regression tests, with significance set at $p < 0.05$. Results indicated a borderline significant association between CC and overall SQ ($p = 0.050$) and a significant relationship with sleep-onset difficulties (SOD) ($p = 0.011$). Regression analyses suggested that higher CC was associated with a tendency toward increased SQ and SOD scores, indicating potential adverse effects of caffeine on sleep. No significant associations were observed between CC and awakening disturbances (AD) or overall PA levels; however, participants in the "very high" CC group exhibited the highest PA levels. In conclusion, the findings of this study indicate that the interactions between CC, SQ, and PA among young adults are important factors in promoting an active and healthy lifestyle. These findings underscore the importance of limiting caffeine intake—particularly in the evening—and maintaining regular physical activity to support both sleep health and overall quality of life in young adults.

Keywords: Caffeine consumption, Sleep quality, Physical activity, Young adults.

Introduction

Sleep is an indispensable physiological requirement for neurocognitive restoration, immune modulation, and metabolic balance (Grandner, 2022). “Sleep quality” (SQ) is not a unidimensional construct but rather a multifaceted phenomenon encompassing both subjective satisfaction and objective indicators such as duration, efficiency, and continuity (Killgore et al., 2022). Factors including subjective SQ, sleep latency, total duration, habitual efficiency, fragmentation, and the use of sleep medication contribute to the deterioration of SQ (Simón et al., 2022). Poor SQ scores are associated with an increased risk of type 2 diabetes, cardiovascular disease, obesity, depression, and mortality or morbidity due to traffic and occupational accidents (Grandner, 2022). Despite the recommendation of ≥7 hours of nightly sleep for adults, approximately one-third of adults in the United States sleep less than this threshold (WHO, 2024). University students constitute one of the most vulnerable populations to poor SQ due to irregular circadian rhythms, high academic stress, and the consumption of alcohol and caffeine (Claydon et al., 2023). According to the Spring 2021 report of the American College Health Association, 76.4% of students reported experiencing moderate to high stress levels within the past 30 days, while 24% indicated that sleep difficulties negatively affected their academic performance (Kuhn et al., 2025). The literature consistently emphasizes that longer and more consistent sleep duration and quality are associated with higher academic achievement (Seun-Fadipe & Mosaku, 2017).

Coffee and coffee-based beverages are the most widely consumed liquids globally after water, with their prevalence largely attributed to caffeine’s neurostimulant properties (Kobylińska et al., 2025). Recent data indicate that individuals aged 19–30 consume significantly more coffee than other age groups, while energy drink consumption is also particularly high among young adults (Lone et al., 2023; Aonso-Diego et al., 2024). Caffeine acts as a competitive antagonist of adenosine A_1/A_2A receptors, thereby increasing alertness, dopaminergic tone, and neuromuscular excitability within the central nervous system (Nehlig & Debry, 1994; Roehrs & Roth, 2008). Through this mechanism, a moderate dose of 3–6 $mg \cdot kg^{-1}$ caffeine reaches its plasma peak within 30–60 minutes, shortening cognitive reaction time and enhancing motor performance (Ataka et al., 2008; Shen et al., 2019). Recent meta-analyses have reported that caffeine extends time to exhaustion in endurance running with a moderate effect size ($g \approx 0.39$) (Wang et al., 2022) and significantly improves high-intensity movements such as single or repeated jumps (Siquier-Coll et al., 2023). Given these ergogenic benefits, caffeine has become one of the most commonly used performance-enhancing substances among both recreational and elite athletes. In line with this widespread use, the World Anti-Doping Agency’s decision in 2004 to remove caffeine from its list of prohibited substances further facilitated its accessibility and acceptance in sports settings (Aguilar-Navarro et al., 2019). However, the same pharmacological profile also creates a dose- and timing-sensitive “double-edged sword.” When consumed in the evening or at doses ≥6 $mg \cdot kg^{-1}$, caffeine prolongs sleep latency, shortens deep sleep duration, and increases nocturnal awakenings (Schlichtiger et al., 2025). The reduction in deep sleep may impair tissue repair, immune modulation, and metabolic balance, thereby increasing the long-term risk of obesity and cardiometabolic disorders (Patel et al., 2025; Grandner, 2022; Atkinson & Davenne, 2007). Conversely, regular moderate-intensity exercise can reorganize sleep architecture and buffer the adverse effects of caffeine. Accelerometer-based observations have shown that under free-living conditions, caffeine consumption may increase daily activity duration while maintaining sleep efficiency (Sakal et al., 2024). Hence, caffeine establishes a delicate balance between “a more active day” and “a shorter night.”

Although the World Health Organization recommends that adults aged 18–64 years engage in at least 150 minutes of moderate or 75 minutes of vigorous aerobic activity per week, 31% of adults fail to meet this threshold, and this rate is projected to rise to 35% by 2030 (WHO, 2024). Physical inactivity remains a leading modifiable risk factor for cardiometabolic diseases (Hallal et al., 2012), while insufficient sleep produces comparably detrimental outcomes on cognitive function and hormonal homeostasis (Grandner, 2022). Regular moderate exercise improves SQ by reducing sleep latency and increasing deep sleep duration and is thus considered protective against insomnia (Wang & Boros, 2021); however, these benefits may be less pronounced among sedentary young adults. Due to its low cost and social acceptability, caffeine can reduce perceived exertion and extend voluntary exercise duration, potentially serving as a behavioral catalyst that promotes engagement in PA (Schrader et al., 2013). Yet, improper dosing or timing can impair SQ and hinder recovery (Lorist & Snel, 2008). Therefore, achieving a balance between “a more active day” and “a more restorative night” requires a finely tuned adjustment sensitive to the dose, source, and timing of caffeine consumption, a relationship that remains insufficiently quantified, particularly among sedentary or lightly active young adults (Schrader et al., 2013).

This cross-sectional study aims to investigate the independent and potentially non-linear effects of daily total CC on SQ and PA level (MET-min/week) among young adult university students. The study quantitatively examines how daily CC and PA habits influence SQ. In doing so, it systematically delineates the interactions between CC, PA, and SQ. The findings are expected to provide a foundation for the development of dose- and timing-sensitive personalized caffeine strategies that support the balance between “a more active day” and “a more restorative night” in sedentary young adults. A multivariate approach will minimize single-factor bias, focusing on sedentary populations to ensure cultural and behavioral specificity, while combining objective and subjective (sleep experience) measures to yield a holistic health profile. With its campus-level applicability, the study holds potential for behavioral interventions that may reduce chronic disease risk and enhance academic performance in line with the World Health Organization’s 2030 projection of a global physical inactivity rate approaching 35% (Claydon et al., 2023; Grandner, 2022; Wang & Boros, 2021; WHO, 2024). Accordingly, the core hypotheses tested in this study are as follows: H_1: Daily caffeine consumption negatively affects sleep quality among young adults. H_2: Daily caffeine consumption is associated with physical activity levels among young adults.H_3: There are significant gender differences in caffeine consumption, physical activity levels, and sleep quality.

METHOD

Research Design

This study adopted a quantitative, cross-sectional survey design to examine the effects of CC on SQ and PA levels among young adults. Data were collected through standardized self-report questionnaires, which are widely acknowledged for their reliability and practicality in behavioral and health-related research. The cross-sectional nature of the design allowed for the assessment of associations among variables without manipulating experimental conditions, thereby offering a descriptive yet comprehensive framework for understanding how CC may influence SQ and PA levels within a sample of young adult university students.

Ethical Approval and Participant Rights

The study was approved by the Ethics Committee of Uşak University (Decision No: 2025-197, Date: 17.06.2025). All participants were informed about the purpose and scope of the research, and written consent was obtained on a voluntary basis. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Sample

The study included 563 university students (females: n = 287; males: n = 276), with a mean age of 20.60 ± 1.99 years. Participants were selected using a simple random sampling method. Inclusion criteria were: (a) no history of chronic disease, (b) no regular medication use, and (c) no shift work in the last three months. Exclusion criteria included incomplete data, more than 10% missing responses, and erroneous or extreme values. The sample size was determined using G*Power 3.1 software to ensure adequate power for correlational and multiple regression analyses. The interpretation of correlation coefficients was guided by the criteria proposed by Schober et al. (2018): 0.00–0.09: no relationship; 0.10–0.39: poor relationship; 0.40–0.69: moderate relationship; 0.70–0.89: significant relationship; >0.90: extremely high relationship. Based on a 95% confidence level ($\alpha = 0.05$), 95% test power ($1 - \beta = 0.95$), and an expected small-to-moderate effect size ($r = 0.20$), the minimum required sample size was calculated as approximately 262. However, 563 participants were included to increase variance and reliability.

Demographic Data

Of the 563 university students, 51.0% were female (n = 287) and 49.0% were male (n = 276). Female participants had a mean age of 20.51 ± 1.90 years (Median = 20.0; IQR = 2), while male participants had a mean age of 20.70 ± 2.07 years (Median = 20.0; IQR = 3). Regarding age distribution, 75.3% were between 18–21 years, 21.1% between 22–25 years, and 3.6% between 26–30 years. In terms of CC, 23.4% were low consumers (0–100 mg/day), 25.0% mild (101–200 mg/day), 16.7% moderate (201–300 mg/day), 7.1% high (301–400 mg/day), and 27.7% very high consumers (≥401 mg/day). PA levels indicated that 1.2% were low (0–600 MET-min/week), 43.0% moderate (601–2999 MET-min/week), and 55.8% highly active (≥3000 MET-min/week). All comparisons were evaluated using the Mann–Whitney U test, and statistical significance was set at $p < 0.05$.

Data Collection Instruments

Demographic Information Form

Participants' age and gender, along with relevant lifestyle characteristics, were systematically recorded.

Caffeine Consumption (CC) Frequency Form

To determine CC, participants completed a form adapted from Tamer Otman (2017), which was previously used to assess caffeine intake in Türkiye. This form evaluates the frequency and amount of caffeine-containing foods and beverages consumed. Caffeine content was calculated using international food composition databases, including those of the U.S. Department of Agriculture (USDA), and product label information. CC was quantified based on the consumption frequency and type of caffeinated products. In this study, daily caffeine intake was categorized as follows: Low (0–100 mg), Mild (101–200 mg), Moderate (201–300 mg), High (301–400 mg), and Very High (≥401 mg) (Wierzejska & Gielecińska, 2024).

Basic Scale on Insomnia Complaints and Sleep Quality (BaSIQS)

Originally developed by Allen Gomes et al. (2015) and validated with a Cronbach's alpha of 0.776 (n = 2995), the scale was adapted into Turkish by Mıhçıoğlu et al. (2021). It includes seven items assessing sleep latency, frequency of sleep-onset difficulties (SOD), number of nighttime awakenings, early awakenings, perception of SQ, and overall restfulness. Responses are provided on a five-point Likert scale. The Turkish version demonstrated internal consistency (Cronbach's $\alpha = 0.752$). The BaSIQS is a reliable and valid screening instrument for the Turkish population. It provides subscale scores for SOD and Awakening Disturbances (AD), which together yield the total Insomnia Complaints and Sleep Quality (SQ) score.

Physical Activity Scale-2 (PAS-2)
The PAS-2, validated in Turkish by Gür (2021), demonstrated strong linguistic, content, and construct validity, with item content validity values between 0.8–1.0 and an overall value of 0.92. Correlation with the International Physical Activity Questionnaire–Short Form (IPAQ-SF) indicated a moderate relationship ($r = 0.576$), while test–retest reliability showed a high correlation ($r = 0.814$). PAS-2 was found to be a reliable and valid tool for assessing PA in healthy young adults. Weekly energy expenditure was calculated in MET-min/week using standard IPAQ coefficients for walking (3.3 METs), moderate-intensity activity (4.0 METs), and vigorous activity (8.0 METs). Participants were categorized by PA level as follows: low (<600 MET-min/week), moderate (600–2999 MET-min/week), and high (≥3000 MET-min/week).

Statistical Analysis
Data analysis was performed using SPSS version 26.0. The distribution of continuous variables was assessed using the Kolmogorov–Smirnov test, and non-normal distributions were addressed with nonparametric tests. Mann–Whitney U tests were used for two-group comparisons, while Kruskal–Wallis tests were applied for variables with three or more categories. When the Kruskal–Wallis test yielded significant results, post-hoc pairwise comparisons were conducted with the Mann–Whitney U test and Bonferroni correction to reduce Type I error risk. Multiple linear regression analysis was performed to explore predictive relationships, while Spearman's rank correlation was used to assess the strength and direction of associations among variables. Correlation coefficients (r) and significance levels were reported. Analyses systematically evaluated relationships among CC, SQ, SOD, AD, and PA. Continuous variables were presented as median (IQR) or mean ± standard deviation ($\bar{X} \pm SD$), while categorical variables were expressed as frequencies and percentages (%). Statistical significance was accepted at $p < 0.05$ and $p < 0.001$.

Findings

Table 1. Gender Differences in CC (mg/day), PA (MET-min/week), and SQ.

	N	Median (IQR)	MR	U	p
CC	287	247,84 (359,54)	304,58	33125,0	0,001*
	276	171,34 (315,97)	258,52		
SQ	287	12 (6)	290,22	34270,50	0,041*
	276	12 (6)	262,57		
SOD	287	7 (5)	296,66	32995,50	0,004*
	276	6 (5)	257,92		
AD	287	5 (3)	282,84	38249,50	0,670
	276	4 (3)	277,09		
PA	287	2965,14 (1285,28)	253,05	31298,0	0,000*
	276	3482,78 (1506,32)	312,10		

U: Mann–Whitney U test; IQR: Interquartile Range; MR: Mean Rank. *p < 0.05.

Table 1 examines gender differences in CC, PA, and SQ variables using the Mann–Whitney U test. According to the results, male participants had significantly higher SQ and SOD scores compared to females (SQ: $p = 0.041$; SOD: $p = 0.004$). No significant gender difference was observed for AD ($p = 0.670$). In terms of PA levels, males exhibited significantly higher values than females ($p < 0.001$).

Table 2. Differences in Overall SQ and PA (MET-min/week) by CC (mg/day) Levels

Variable	CC Levels	N	Mean Rank	X^2	sd	p
SQ	Very Low	132	256,26	9,488	4	0,050
	Low	141	264,94			
	Moderate	94	296,77			
	High	40	299,06			
	Very High	156	305,93			
SOD	Very Low	132	248,88	13.071	4	0,011*
	Low	141	265,62			
	Moderate	94	310,94			
	High	40	295,81			
	Very High	156	303,85			
AD	Very Low	132	277,51	3,21	4	0,523
	Low	141	273,36			
	Moderate	94	267,75			
	High	40	294,85			
	Very High	156	298,90			
PA	Very Low	132	271,55	7,825	4	0,098
	Low	141	291,07			
	Moderate	94	246,67			
	High	40	290,51			
	Very High	156	301,74			

Kruskal–Wallis test; *p < 0.05 indicates significance.

According to the Kruskal–Wallis test results presented in Table 2, a borderline significant difference was observed between CC and overall SQ ($X^2 = 9.488$; df = 4; p = 0.050). A significant association was found between CC and SOD ($X^2 = 13.071$; df = 4; p = 0.011), whereas no significant difference was detected for AD ($X^2 = 3.21$; df = 4; p = 0.523). Post-hoc pairwise comparisons using the Mann–Whitney U test with Bonferroni correction revealed significant differences in SQ and SOD scores between the "Low" and "Moderate" CC groups (p < 0.005). Regression analysis indicated that CC did not exhibit a statistically significant linear relationship with SQ (B = 0.001, β = 0.069, p = 0.101), SOD (B = 0.000, β = 0.057, p = 0.175), or AD (B = 0.000, β = 0.057, p = 0.180) (p > 0.05). However, the positive directional coefficients across all variables suggest that increased caffeine consumption may be associated with trends toward higher SQ, SOD, and AD scores. Regarding PA levels across CC groups, no significant differences were observed ($X^2 = 7.825$; df = 4; p = 0.098). Nevertheless, the highest mean rank was found in the "Very High" caffeine group (301.74), suggesting a potential tendency for higher CC to correspond with increased PA levels, despite the lack of statistical significance. Regression analysis yielded similar results, showing no statistically significant association between CC and PA (B = 0.039; β = 0.081; p = 0.056), although the positive coefficient indicates a directional trend where higher CC may be linked to higher PA levels.

Table 3. Spearman Correlation Analysis Among CC (mg/day), SQ, and PA (MET-min/week) (N = 563)

	PA	CC	SQ	SOD	AD
PA	1				
CC	.060 (.157)	1			
SQ	-.011 (.796)	.117** (.006)	1		
SOD	-.044 (.293)	.132** (.002)	.880** (.000)	1	
AD	.023 (.579)	.045 (.288)	.593** (.000)	.186** (.000)	1

r(p); r: Spearman correlation coefficient; **p < 0,01; **p* < 0,05.

The Spearman correlation results presented in Table 3 illustrate the relationships among PA, CC, and sleep parameters (N = 563). No significant association was found between PA levels and any of the sleep parameters (r = -0.011 to 0.023; p > 0.05), and the correlation between CC and PA was weak and non-significant ($r = 0.060$; $p = 0.157$). In contrast, CC demonstrated positive and statistically significant correlations with overall SQ ($r = 0.117$; $p < 0.01$) and SOD ($r = 0.132$; $p < 0.01$). This finding indicates that as CC increases, both SOD and overall SQ tend to rise, suggesting a potential deterioration in SQ associated with higher caffeine consumption. No significant association was observed between AD and CC ($r = 0.045$; $p > 0.05$). Strong and significant positive correlations were identified among the sleep parameters themselves—between SQ and SOD ($r = 0.880$; $p < 0.01$), between SQ and AD ($r = 0.593$; $p < 0.01$), and a weaker yet significant relationship between SOD and AD ($r = 0.186$; $p < 0.01$).

Discussion

This study examined the effects of CC on SQ and PA levels among young adult university students, providing valuable insights into lifestyle behaviors in young adults. The findings revealed that higher levels of CC were associated with poorer SQ and lower PA engagement. Moreover, CC significantly differed by gender, with males consuming more caffeine than females. Analysis of sleep parameters indicated that males also exhibited greater difficulties in sleep onset and more frequent insomnia complaints. These results align with the findings of Choi (2020), who similarly reported higher coffee consumption among male students compared with their female counterparts.

Caffeine, commonly ingested via coffee, tea, energy drinks, chocolate, and certain medications, is rapidly absorbed, reaching peak plasma levels within 30–60 minutes (Snel & Lorist, 2011). Its effects on both cognitive and physical performance have been extensively investigated (O’Callaghan et al., 2018). Controlled studies indicate that low-to-moderate caffeine consumption can improve attention, focus, and alertness in the short term (Glade et al., 2010; Kennedy et al., 2008; O’Callaghan et al., 2018), primarily by antagonizing adenosine receptors, which increases central nervous system arousal and reduces perceived fatigue (Nehlig & Debry, 1994). Conversely, high or irregular CC may negatively affect SQ (Clark & Landolt, 2017; Sin et al., 2009). In the present study, Kruskal–Wallis analyses revealed a borderline significant relationship between CC and SQ ($X^2 = 9.488$; $df = 4$; $p = 0.050$), and a significant relationship with SOD ($X^2 = 13.071$; $df = 4$; $p = 0.011$). Regression analyses suggested that increased CC is associated with a positive trend in SQ and SOD, implying a potential adverse impact of caffeine on these sleep parameters. Previous studies have similarly shown that low CC may prolong sleep duration (Sakal et al., 2024), whereas high consumption delays sleep onset and reduces total sleep time (Watson et al., 2016; Roehrs & Roth, 2008; Sin et al., 2009). These findings highlight the importance of limiting CC, particularly in the evening, to maintain healthy sleep habits. Studies on university students have emphasized controlling caffeinated beverage consumption to improve SQ (Lee et al., 2014).

Based on the correlation analysis, no significant relationship was observed between PA and SQ ($r = -.011$, $p = 0.796$), SOD ($r = -.044$, $p = .293$), or insomnia symptoms (AD) ($r = .023$, $p = .579$). Similarly, regression analyses indicated that PA level did not have a statistically significant effect on SQ ($B = 4.897$; $p = 0.743$), sleep onset difficulties ($B = -7.658$; $p = 0.515$), or insomnia symptoms ($B = 9.338$; $p = 0.200$) ($p > 0.05$). Nevertheless, directional assessments suggested a positive tendency for PA to improve SQ and reduce insomnia symptoms, and a negative tendency for SOD. Although not statistically significant, these trends imply that more active individuals may generally report better SQ and experience fewer difficulties initiating sleep. This finding aligns with previous studies highlighting PA as a beneficial lifestyle component for sleep regulation. For instance, Kovacevic et al. (2018) described PA as an effective non-pharmacological intervention to enhance SQ, and Tseng et al. (2020) reported that moderate-intensity exercise programs significantly improve sleep outcomes.

Collectively, these observations imply that maintaining regular PA may contribute to better sleep health, even when short-term statistical associations are weak.

The present findings indicate that the relationship between sleep and PA is multidimensional and may be indirectly influenced by lifestyle behaviors such as CC. Caffeine has physiological stimulant effects that can enhance physical performance and promote participation in PA (Goldstein et al., 2010). It increases muscle contractility, delays fatigue, and supports endurance, potentially enhancing engagement in PA (Nehlig & Debry, 1994; Glade, 2010; Schrader et al., 2013). Although no statistically significant differences in PA were observed across CC levels in this study ($X^2 = 7.825$; $p = 0.098$), the highest Mean Rank observed in the "very high" CC group suggests a potential trend toward increased PA with higher caffeine consumption. Similarly, Sakal et al. (2024) reported that older adults consuming >3 mg/kg caffeine demonstrated 16.5% more daytime activity and an average of 42.8 minutes longer active periods compared to non-consumers. In contrast, Tunnicliffe et al. (2008) found that elite Canadian athletes primarily obtained caffeine through coffee, but consumption levels (193–895 mg/day) were insufficient to meaningfully enhance performance. These findings suggest that while high CC may potentially enhance PA, individual health status and dosage play critical roles in determining its effectiveness. Literature indicates that, considering caffeine's ergogenic effects, moderate doses (3–6 mg/kg) approximately 60 minutes before exercise can improve performance (Southward et al., 2018; Grgic et al., 2020).

Result

This study examined the relationships between CC, SQ, and PA among young adult university students. Higher CC levels were associated with greater sleep onset difficulties and lower overall SQ, with males consuming more caffeine and reporting more sleep problems than females. Moreover, CC appeared to have a directional effect on PA, as higher caffeine intake was linked to a tendency toward increased physical activity levels. Although the association between PA and SQ was not statistically significant, more active participants tended to experience better sleep and fewer insomnia complaints. These findings underscore the importance of limiting caffeine intake—particularly in the evening—and maintaining regular physical activity to support both sleep health and overall quality of life in young adults.

Limitations and Recommendation

This study has several limitations that should be acknowledged. The sample was composed exclusively of university students, which may limit the generalizability of the findings to the broader young adult population. Additionally, the cross-sectional design precludes the ability to infer causal relationships among the variables. Data on CC, SQ, and PA were collected through self-report questionnaires, which may be subject to recall bias and measurement error. Other relevant lifestyle factors, such as stress levels, dietary habits, screen time, and academic workload, were not assessed, potentially further constraining the interpretability of the results.

Future research should consider employing longitudinal or experimental designs with larger and more diverse samples to better elucidate causal relationships. Furthermore, detailed assessments of caffeine sources, timing, and dosage are recommended to provide a more comprehensive understanding of the interactions between CC, PA, and SQ. In university students, promoting balanced CC—particularly limiting intake in the evening—and supporting regular PA may enhance SQ, improve lifestyle behaviors, and support overall health in young adults.

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Data Availability Declaration

Data Availability Upon Formal Request: While the primary datasets utilized in this study are not publicly accessible due to certain constraints, they are available to researchers upon a formal request. The authors have emphasized maintaining the integrity of the data and its analytical rigor. To access the datasets or seek further clarifications, kindly reach out to the corresponding author. Our aim is to foster collaborative academic efforts while upholding the highest standards of research integrity.

Author Contributions

Single Author Study:

The sole author of this research, Bekir TOKAY, was responsible for the conceptualization, methodology formulation, data collection, analysis, and interpretation. Furthermore, Bekir TOKAY took charge of drafting the initial manuscript, revising it critically for vital intellectual content, and finalizing it for publication. The author has read and approved the final manuscript and takes full accountability for the accuracy and integrity of the work presented.

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