ORIGINAL ARTICLE

CONTENTS

Is happiness the strongest predictor of sleep quality? A study on physical activity, stress, and health in Uzbekistan

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ABSTRACT

Aim: To identify key predictors of sleep quality among adults in Uzbekistan, with a focus on health-related factors such as physical activity, psychological well-being (happiness, stress, loneliness), and self-rated health status. The research addresses a critical and growing public health issue in transitional societies, where sleep disturbances remain underexplored despite their widespread impact on overall health and well-being

Materials and Methods: A cross-sectional survey was conducted online in June 2024 among 450 adults aged 18 and older from various regions of Uzbekistan. Sleep quality was assessed using a 5-point Likert scale. Independent variables included physical activity, happiness, stress, loneliness, and health status. Ordinal logistic regression was applied, controlling for socio-demographic characteristics

Results: Happiness ($OR = 1.812$, $p < 0.001$) and physical activity ($OR = 1.293$, $p = 0.045$) were significantly associated with better sleep quality, while stress ($OR = 0.833$, $p = 0.026$) and poor health ($OR = 0.526$, $p < 0.001$) predicted lower sleep quality. Subgroup analysis confirmed that age and gender modulate these associations, with happiness remaining the strongest and most consistent predictor.

Conclusions: These findings highlight the pivotal roles of emotional well-being, lifestyle, and health in shaping sleep quality. Public health strategies should incorporate mental wellness, physical activity, and stress management to improve population-level sleep outcomes in Uzbekistan and similar socio-cultural contexts.

KEYWORDS: sleep, exercise, health status, public health, cross sectional study, Uzbekistan

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INTRODUCTION

In today's fast-paced world, sleep deprivation has emerged as a significant public health concern, adversely affecting global well-being. According to ResMed's 2024 Global Sleep Survey (N=36,000), nearly 40% of individuals' experience fewer than three nights of quality sleep per week, leading to excessive daytime sleepiness in 50% of respondents and morning negativity in 40% [1]. These alarming statistics underscore the urgent need to prioritize sleep as a fundamental pillar of health, alongside diet and exercise. Addressing sleep quality is essential for improving overall well-being and mitigating the adverse consequences of the global sleep crisis.

Sleep quality is a crucial determinant of physical and emotional well-being, influenced by biological, psychological, environmental, and cultural factors. Kline [2] defines sleep quality as "one's satisfaction with the sleep experience, integrating aspects of sleep initiation, sleep maintenance, sleep quantity, and refreshment upon awakening". High-quality sleep is essential for cognitive functioning, emotional regulation, and overall health [3]. Conversely, poor sleep quality is associated with impaired cognitive performance, mood disturbances, and an increased risk of chronic illnesses [4]. Understanding the determinants of sleep quality is essential for developing effective public health policies and promoting sleep health advocacy.

While global sleep disturbances have been widely studied, there is limited research on how cultural and socio-economic factors influence sleep quality in transitioning societies such as Uzbekistan. Given the rapid urbanization and changing lifestyles in the region, it is critical to assess the interplay of physical activity, psychological factors (happiness, stress, and loneliness), and health status in shaping self-reported sleep quality. This study aims to bridge this gap by examining these

relationships within Uzbekistan's unique socio-cultural framework. The findings will contribute to the growing body of literature on sleep health determinants, offering insights for public health interventions and policy recommendations tailored to transitional economies and collectivist societies.

Importantly, sleep health is increasingly recognized as a critical component of public health and is directly aligned with Sustainable Development Goal 3 (SDG 3): Good Health and Well-being, which advocates for comprehensive strategies to ensure healthy lives and promote well-being for all at all ages. In this context, improving sleep quality through targeted interventions- particularly those addressing mental well-being and lifestyle behaviors - becomes essential for advancing health equity and resilience in rapidly transforming social environments such as Uzbekistan.

Sleep is a fundamental biological necessity, yet its patterns and quality are significantly influenced by cultural norms, social behaviors, and environmental factors. While biological mechanisms regulate circadian rhythms, cultural traditions dictate when, where, and how individuals sleep, leading to notable variations across societies [5]. In collectivist cultures such as Uzbekistan, strong family and community ties influence sleep arrangements and quality, whereas individualistic societies prioritize personal autonomy in sleep schedules [6]

Uzbekistan presents a unique intersection of traditional and modern sleep behaviors. The collectivist nature of Uzbek society, characterized by extended family structures and community-based living, may act as a protective factor against sleep-related loneliness, mirroring findings in other collectivist cultures (6). Co-sleeping practices, extended family support, and shared social obligations may enhance perceived sleep quality despite external stressors. However, rapid urbanization, increased exposure to digital screens, economic stressors, and shifting work patterns may introduce sleep disturbances similar to those observed in high-income nations [7].

Additionally, sleep patterns in Uzbekistan may differ from those in Western nations due to cultural expectations. For instance, individuals in East Asian countries often experience shorter sleep durations due to academic and work pressures, while Mediterranean and Latin American societies incorporate biphasic sleep (siestas) into daily life [8;9]. These cultural influences suggest that sleep quality in Uzbekistan is shaped by both traditional and modern lifestyle factors, affecting how physical activity, happiness, stress, loneliness, and health status contribute to overall sleep health.

Among health-related variables, physical activity has been widely recognized as a significant predictor of sleep quality. Defined as any bodily movement produced by skeletal muscles that results in energy expenditure, physical activity encompasses occupational, domestic, and recreational activities [10]. As a modifiable behavior, physical activity serves as an effective, non-pharmacological intervention for enhancing sleep quality [11].

Furthermore, structured physical activity programs contribute to improved overall health

[12] and help prevent conditions such as obesity, which is associated with obstructive sleep apnea [13]. Additionally, regular exercise is linked to reductions in symptoms of depression and anxiety - two psychological factors that frequently disrupt sleep - thereby fostering improved mood and better sleep outcomes [14;15]

Psychological and psychophysiological factors, such as happiness, loneliness and stress, play a crucial role in shaping sleep quality. Happiness has been found to regulate neurobiological pathways, including dopamine and serotonin, which are critical for emotional stability and sleep-wake cycles [16].

Lajunen [17] identified a strong correlation between happiness and sleep pattern across 52 countries, linking these variables to broader societal factors such as governance quality, education, and obesity prevalence. Similarly, Otsuka et al. [18] demonstrated that sleep disturbances significantly lower perceived happiness, highlighting the bidirectional nature of this relationship.

In contrast, stress negatively affects sleep by triggering physiological responses that disrupt sleep initiation and maintenance (19). Daily stressors - such as work pressures, financial concerns, and social stress—can lead to hyperarousal of the central nervous system, prolonging sleep latency and reducing slow-wave sleep. This phenomenon has been observed across various occupational groups, irrespective of gender or job position [20].

Moreover, loneliness and sleep quality are closely interrelated. Defined as perceived social isolation, loneliness is increasingly recognized as a key determinant of sleep disturbances. A systematic review identified a significant correlation between loneliness and self-reported sleep disturbances, though sleep duration remained unaffected [21].

Loneliness has been linked to poor subjective sleep quality, extended sleep latency, increased nocturnal awakenings, and reduced daytime functioning [22] It also indirectly impacts sleep quality by heightening pre-sleep arousal and contributing to morning tiredness [23]. However, in collectivist societies like Uzbekistan, strong social support networks may buffer against the negative effects of loneliness on sleep, making its influence less pronounced than in individualistic cultures [24].

Health status is another significant predictor of sleep quality. Individuals with better overall health experience higher-quality sleep, whereas those with chronic health conditions, such as cardiovascular diseases and metabolic disorders, often report poor sleep [25]. Additionally, mental health conditions such as anxiety and depression are strongly linked to sleep disturbances. Poor mental health disrupts sleep initiation and maintenance, and sleep disturbances, in turn, exacerbate mental health conditions, creating a bidirectional relationship [26].

As for socio-demographic factors, including age, gender, marital status, and employment, further influence sleep quality [27;28]. For instance, younger adults and females often report poorer sleep quality due to life stage-specific stressors, hormonal differences, and obesity [29].

Additionally, employment status and socio-economic position play crucial roles, as low-income individuals are more likely to experience sleep disturbances due to financial stress or unstable living conditions [30]. Environmental factors, such as urban noise and light pollution, further interact with these variables, worsening sleep quality [31].

AIM

To identify key predictors of sleep quality among adults in Uzbekistan, with a focus on health-related factors such as physical activity, psychological well-being (happiness, stress, loneliness), and self-rated health status. The research addresses a critical and growing public health issue in transitional societies, where sleep disturbances remain underexplored despite their widespread impact on overall health and well-being

RESEARCH QUESTIONS (RQ):

RQ1: What is the contribution of physical activity, psychological factors (happiness, stress, loneliness), and health status to self-reported sleep quality?

RQ2: Among these predictors, which factor explains the greatest variance in sleep quality?

Hypotheses (H). This study examines the relationship between sleep quality and multiple predictors, including physical activity, psychological factors (happiness, stress, loneliness), and health status. Prior research has established links between these variables, but their relative contribution in transitioning societies such as Uzbekistan remains underexplored. Based on previous findings, the following hypotheses were formulated:

H1: Physical activity positively predicts better sleep quality,

H2: Happiness is positively associated with better sleep quality,

H3: Higher stress negatively predicts sleep quality,

H4: Better self-reported health positively predicts sleep quality,

H5: Higher levels of loneliness negatively predict sleep quality

Among these predictors, physical activity is expected to be one of the strongest determinants of sleep quality (Kline, 2014)

MATERIALS AND METHODS

PARTICIPANTS

This study collected data through an anonymous online survey in June 2023, using convenience sampling via Telegram and WhatsApp. Participants were required to be Uzbek citizens, at least 18 years old, free of evident health or mental impairments, and willing to provide informed consent voluntarily. The final sample included 450 adults after excluding incomplete surveys. The sample had a mean age of 27.79 years (SD = 9.81), with 40.7% identifying as female. Regarding education, participants reported a mean education level of 3.38 (SD = 1.25), corresponding to professional or higher education. Additionally, 40.4% of respondents were married, 77.8% resided in urban areas, and 75.3% were employed.

All participants were informed about the study's purpose and assured of confidentiality. In line with the Declaration of Helsinki, the study ensured voluntary participation, informed consent, and the protection of participants' rights and data privacy.

VARIABLES AND MODEL

The primary outcome variable in this study is sleep quality, assessed using a 5-point Likert scale ranging from 1 ("Very Poor") to 5 ("Excellent"). The mean sleep quality score among participants was 2.35 (SD = 0.99).

To examine the predictors of sleep quality, the following key independent variables were included:

Sleep Duration: Measured on a 3-point scale (1 = "Never/Rarely," 2 = "Sometimes," 3 = "Almost Every Day"), capturing the frequency of sleeping at least seven hours per night.

Physical Activity: Assessed on a 3-point scale (1 = "Never/Rarely," 2 = "Sometimes," 3 = "Almost Every Day"), representing the frequency of engagement in regular bodily movement.

Happiness: Evaluated using a 3-point self-reported scale (1 = "Not Very Happy," 2 = "Fairly Happy," 3 = "Very

Table 1. Descriptive Statistics

Variable	Descriptive	Mean/Percentage	St. Dev.
Age	Age expressed in years.	27.79	9.811
Gender	Percentage of respondents who are female.	40.7%	N/A
Marital status	Percentage of respondents who are married.	40.4%	N/A
Education	Respondent's highest education level achieved: 1. Middle school; 2. Graduated from high school; 3. Professional education (community college); 4. Bachelor's degree (currently enrolled); 5. Bachelor's degree graduated; 6. Post-graduate degree.	3.382	1.252
Children	Percentage of respondents who have children.	38.9%	N/A
Residence	Percentage of respondents living in urban areas.	77.8%	N/A
Employment	Percentage of respondents who are employed.	75.3%	N/A
Labor sector	Percentage of respondents in each labor sector: 1. Public sector; 2. Private sector; 3. Other.	N/A	N/A
Income	Total monthly income level: 1. Less than 2mill. UZS*; 2. 2-4mill. UZS; 3. 4-6mill. UZS; 4. 6 mill. UAS and above.	1.722	1.506
SMU	Time spent on social media daily: 1. Less than 1 hour; 2. 1-2 hours; 3. 2-3 hours; 4. 3-5 hours; 5. More than 5 hours.	2.542	1.218
Sleep duration	Frequency of sleeping at least 7 hours: 1. Never/rarely; 2. Sometimes; 3. Almost every day.	1.376	0.673
Sleep quality	Self-reported sleep quality: 1. Very poor; 2. Poor; 3. Fair; 4. Good; 5. Excellent.	2.347	0.985
Physical activity	Frequency of physical activity: 1. Never/rarely; 2. Sometimes; 3. Almost every day.	1.336	0.691
Happiness	Self-reported happiness: 1. Not very happy; 2. Fairly happy; 3. Very happy.	1.100	0.623
Stress	Self-reported stress: 1. Not stressful or irrelevant; 2. A little stressful; 3. Moderately stressful; 4. Quite stressful; 5. Very stressful.	2.753	1.208
Health	Percentage of respondents with good self-reported health (fair or good).	44.7%	N/A
Sedentary behavior	Sitting time daily: 1. Less than 1 hour; 2. 1-2 hours; 3. 3-4 hours; 4. 4-6 hours; 5. 6-7 hours; 6. More than 7 hours.	2.698	1.947
Loneliness	Self-reported loneliness: 1. Not lonely; 2. Lonely but don't suffer; 3. Suffer a little from loneliness; 4. Suffer greatly from loneliness.	2.502	0.782
BMI	Body Mass Index (BMI) was calculated using an online calculator based on self-reported weight (in kilograms) and height (in centimeters) provided by respondents. BMI categorizes individuals as follows: 1. Underweight: BMI < 18.5 2. Normal weight: BMI 18.5–24.9 3. Overweight: BMI 25–29.9 4. Obesity: BMI ≥ 30	1.413	0.753

* UZS refers to the Uzbekistani sum, the national currency of Uzbekistan.
At the time of data collection, the exchange rate was approximately 1 USD = 12,000 UZS
Source: compiled by the authors of this study

Happy"), reflecting participants' subjective well-being as a determinant of emotional regulation.

Stress: Measured on a 5-point scale (1 = "Not Stressful or Irrelevant," 5 = "Very Stressful"), indicating perceived stress intensity.

Health Status: Self-reported health categorized as "good" (fair or good) or "poor", reflecting participants' perception of their overall physical and mental well-being.

Loneliness: Assessed using a 4-point scale to capture both the presence and severity of loneliness (1 = "Not lonely," 2 = "Lonely but don't suffer," 3 = "Suffer a little from loneliness," 4 = "Suffer greatly from loneliness").

Body Mass Index (BMI): Calculated from self-reported weight (kg) and height (cm), with BMI values categorized as underweight (<18.5), normal weight (18.524.9), overweight (25–29.9), and obese (≥30).

Additionally, socio-demographic variables-including age, gender, marital status, number of children, education level, employment status, income, and place of residence-were included as control variables. Behavioral variables such as social media use and sedentary behavior were also incorporated to account for potential confounding effects on sleep quality.

Table 2. Ordinal Logistic Regression Model: Predictors of Sleep Quality (N = 450)

Variable	Coefficient	Odds Ratio	Std. Error	z-value	p-value	95% Confidence Interval
Physical activity	0.2572	1.293	0.1284	2.00	0.045	[0.0056, 0.5088]
Happiness	0.5943	1.812	0.1553	3.83	0.000	[0.2899, 0.8987]
Stress	-0.1822	0.833	0.0817	-2.23	0.026	[-0.3424, -0.0220]
Health	-0.6430	0.526	0.1775	-3.62	0.000	[-0.9910, -0.2951]

Source: compiled by the authors of this study

STATISTICAL ANALYSIS

The study employed ordinal logistic regression to identify predictors of sleep quality. Odds ratios were calculated to provide an intuitive interpretation of the relationship between predictors and the likelihood of improved sleep quality.

Subgroup analyses were conducted to explore variations in predictors of sleep quality based on:

1. Gender (male and female)
2. Age groups (18–29, 30–49, and 50+ years)
3. Physical activity levels (non-exercising, moderately active, and highly active)

Descriptive statistics (means, standard deviations, and proportions) were reported for all variables. Group differences were evaluated using p-values to identify statistically significant associations (Table 1).

ETHICS

This work complies with the principles of the Declaration of Helsinki.

AI STATEMENT

The author states that no AI tools were used in writing this article.

RESULTS

MAIN RESULTS

KEY PREDICTORS OF SLEEP QUALITY: FULL REGRESSION MODEL

To identify the most significant predictors of sleep quality, Ordinal logistic regression model was estimated, initially including all independent variables. Following the analysis, only those variables that reached statistical significance were retained and reported in Table 2-specifically, physical activity, happiness, stress, and health status. Non-significant variables were excluded from the final presentation of results.

Among the predictors analyzed, happiness emerged as the strongest positive influence on sleep quality. The regression results showed that higher levels of happiness significantly increased the likelihood of reporting better sleep (coefficient = 0.5943, $p < .001$), with an odds ratio of 1.812—indicating an 81.2% greater chance of improved sleep quality. Physical activity also had a positive association (coefficient = 0.2572, p = .045), with each unit increase linked to a 29.3% increase in the odds of better sleep (odds ratio = 1.293). In contrast, stress showed a significant negative relationship (coefficient = -0.1822, p = .026), reducing the odds of good sleep by 16.7% (odds ratio = 0.833). Health status had the largest negative effect (coefficient = -0.6430, $p < .001$), with poor health decreasing the likelihood of quality sleep by 47.4% (odds ratio = 0.526). Together, these findings highlight the central role of emotional well-being, lifestyle, and health in shaping sleep quality (Table 2).

Ordinal Logistic Regression Model: Predictors of Sleep Quality (N = 450)

A visual representation of these findings is provided in Fig. 1, illustrating the relative impact of key predictors on sleep quality. This figure enhances interpretability by demonstrating the magnitude and direction of each predictor's effect.

EXPLORATORY ANALYSIS: GENDER DIFFERENCES

Since gender differences were not a primary hypothesis, a post hoc exploratory analysis was conducted to examine potential variations between male (N = 267) and female (N = 183) participants. The results, summarized in Table 3, indicate notable differences in predictor significance based on gender. For females, happiness (coefficient = 1.1095, p < 0.001) and health (coefficient = -1.0034, p < 0.001) significantly influenced sleep quality, whereas physical activity (p = .155) and stress (p = .289) were not significant predictors. For males, happiness was a marginal predictor (p = .077), while stress (p = .057) and health (p=.087) were negative determinants.

ADDITIONAL ANALYSIS: SLEEP QUALITY ACROSS AGE GROUPS

To further explore age-related trends, ordinal logistic regression analysis was performed across different age groups (18–29, 30–49, and 50+ years). The results are presented in Table 4.

Table 3. Gender-specific predictors of sleep quality

Variable	FEMALE (N=183)					MALE (N=267)				
	Coefficient	Std. Error	z-value	p-value	95% CI	Coefficient	Std. Error	z-value	p-value	95% CI
Physical activity	0.2579	0.1812	1.42	.155	[-0.0972, 0.6129]	0.2629	0.1905	1.38	.168	[-0.1105,0.6362]
Happiness	1.1095	0.2680	4.14	.000	[0.5842, 1.6347]	0.3409	0.1929	1.77	.077	[-0.0371, 0.7189]
Stress	-0.1513	0.1426	-1.06	.289	[-0.4307, 0.1282]	-0.1915	0.1004	-1.91	.057	[-0.3883, 0.0054]
Health	-1.0034	0.2804	-3.58	.000	[-1.5530, -0.4538]	-0.4088	0.2390	-1.71	.087	[-0.8773, 0.0597]

Source: compiled by the authors of this study

Table 4. Ordered logistic regression for sleep quality by age group

Age Group	Variable	Coefficient	Std. Error	z-value	p-value	95% Confidence Interval
18–29 (N=289)	Physical activity	0.2383	0.1790	1.33	.183	[-0.1124, 0.5891]
	Happiness	0.5762	0.1951	2.95	.003	[0.1939, 0.9586]
	Stress	-0.1498	0.1060	-1.41	.158	[-0.3575, 0.0580]
	Health	-0.7499	0.2306	-3.25	.001	[-1.2020, -0.2979]
30–49 (N=145)	Physical activity	0.3689	0.1988	1.86	.064	[-0.0208, 0.7585]
	Happiness	0.5479	0.2601	2.11	.035	[0.0381, 1.0577]
	Stress	-0.2619	0.1349	-1.94	.052	[-0.5263, 0.0026]
	Health	-0.3928	0.3018	-1.30	.193	[-0.9842, 0.1986]
50+ (N=16)	Physical activity	-43.0755	7773.733	-0.01	.996	[-15279.31, 15193.16]
	Happiness	76.5068	11296.22	0.01	.995	[-22063.68, 22216.70]
	Stress	2.4107	1.3842	1.74	.082	[-0.3022, 5.1236]
	Health	19.2010	4095.124	0.00	.996	[-8007.10, 8045.50]

Source: compiled by the authors of this study

Findings indicate that happiness remained a consistent predictor across all age groups, while stress and health status effects varied. Among older adults (50+ years), the results were statistically unstable due to a smaller sample size (N=16).

SLEEP QUALITY BY PHYSICAL ACTIVITY LEVELS

An additional analysis explored how physical activity levels affected sleep quality by categorizing participants into non-exercising, moderately active, and highly active groups. The results, displayed in Table 5, indicate that moderately active individuals exhibited the highest sleep quality, while those engaging in high-intensity physical activity did not show additional benefits.

MEAN SLEEP QUALITY BY GENDER, AGE GROUP, AND PHYSICAL ACTIVITY

The mean sleep quality scores and standard deviations for different demographic groups are presented in Table 6.

The mean sleep quality scores for males (2.356, SD = 0.987) and females (2.333, SD = 0.985) were similar, with no statistically significant difference observed (p = 0.8125).

Age Group: Sleep quality scores varied slightly among the three age groups, with younger adults (18–29 years) reporting the highest mean sleep quality (2.377, SD = 0.986), followed by middle-aged adults (30–49 years) (2.317, SD = 0.991) and older adults (50+ years) (2.063, SD = 0.929). However, these differences were not statistically significant (p = .4205).

*Physical Activity Level***:** Significant differences were observed in sleep quality based on physical activity levels (p = .0003). Non-exercising individuals reported the lowest mean sleep quality (1.860, SD = 1.156), while moderately active (2.432, SD = 0.998) and highly active participants (2.404, SD = 0.885) reported notably higher sleep quality.

Fig. 2 demonstrates a clear trend where moderate levels of physical activity correspond to the highest sleep quality scores, whereas non-exercising individuals report the poorest sleep. However, the lack of further improvement in highly active individuals suggests a potential threshold effect, where excessive exercise may not provide additional benefits for sleep.

Table 5. Ordered logistic regression for sleep quality by physical activity levels

Physical Activity Level	Variable	Coefficient	Std. Error	z-value	p-value	95% Confidence Interval
Non-Exercising (N = 57)	Happiness	0.924	0.440	2.10	.036	[0.061, 1.786]
	Stress	-0.004	0.238	-0.02	.985	[-0.470, 0.461]
	Health	-0.377	0.516	-0.73	.465	[-1.387, 0.634]
Moderately Active (N = 185)	Happiness	0.635	0.253	2.51	.012	[0.138, 1.131]
	Stress	-0.250	0.129	-1.94	.052	[-0.502, 0.003]
	Health	-0.644	0.320	-2.01	.044	[-1.271, -0.017]
Highly Active (N = 208)	Happiness	0.435	0.226	1.92	.054	[-0.008, 0.878]
	Stress	-0.160	0.120	-1.33	.185	[-0.396, 0.076]
	Health	-0.626	0.253	-2.48	.013	[-1.121, -0.131]

Source: compiled by the authors of this study

Table 6. Mean sleep quality by gender, age group, and physical activity level

Category	Group	Mean	Std. Dev.	Observations (N)	p-value
Gender	Male	2.356	0.987	267	.8125
	Female	2.333	0.985	183	
Age Group	18–29 Years	2.377	0.986	289	.4205
	30–49 Years	2.317	0.991	145	
	50+ Years	2.063	0.929	16	
Physical Activity	Non-Exercising	1.860	1.156	57	.0003
	Moderately Active	2.432	0.998	185	
	Highly Active	2.404	0.885	208	

Source: compiled by the authors of this study

DISCUSSION

This study examined the key predictors of sleep quality among adults in Uzbekistan, focusing on the impact of physical activity, psychological factors (happiness, stress, loneliness), and health status. The findings largely confirmed our hypotheses, providing strong empirical support for the role of happiness, stress, and health in shaping sleep quality, while the impact of physical activity exhibited nuanced patterns. These results have significant public health implications, highlighting the need for tailored interventions aimed at improving sleep quality through psychosocial and behavioral modifications.

The hypothesis that physical activity positively predicts better sleep quality (H1) was supported, with higher engagement in physical activity associated with improved sleep outcomes. This finding aligns with previous studies demonstrating that regular physical activity enhances sleep patterns [32]. However, subgroup analysis revealed a non-linear relationship: moderately active individuals experienced the greatest sleep benefits, while highly active individuals did not show a proportional improvement. This aligns with prior research suggesting that excessive physical exertion may lead to physiological stress, delaying sleep onset and reducing overall sleep efficiency [11]. These results emphasize the importance of promoting moderate-intensity physical activity - such as walking, yoga, and recreational sports - as an effective sleep-enhancing strategy in public health interventions [33].

Among all predictors, happiness emerged as the strongest determinant of sleep quality (H2), with individuals reporting higher happiness levels exhibiting significantly greater sleep quality (OR = 1.812, $p < 0.001$). These findings suggest that positive affect, emotional well-being, and life satisfaction play a crucial role in sleep regulation.

On a biological level, happiness is associated with higher levels of serotonin and dopamine, which regulate mood and contribute to sleep-wake balance [17]. Serotonin, a precursor to melatonin, is crucial for initiating and maintaining restful sleep, while dopamine helps modulate arousal and relaxation cycles. Additionally, happiness reduces stress-induced cortisol secretion, which can disrupt sleep quality by increasing nighttime arousal.

Overall, strong social ties and interpersonal relationships in collectivist cultures may provide emotional stability, reduce loneliness, and buffer against the adverse effects of stress, thereby enhancing sleep quality. This is further supported by national well-being indicators, as countries ranking high in the World Happiness Report-such as Finland and Denmark—consistently report superior sleep quality [34]. Uzbekistan's 47th place in

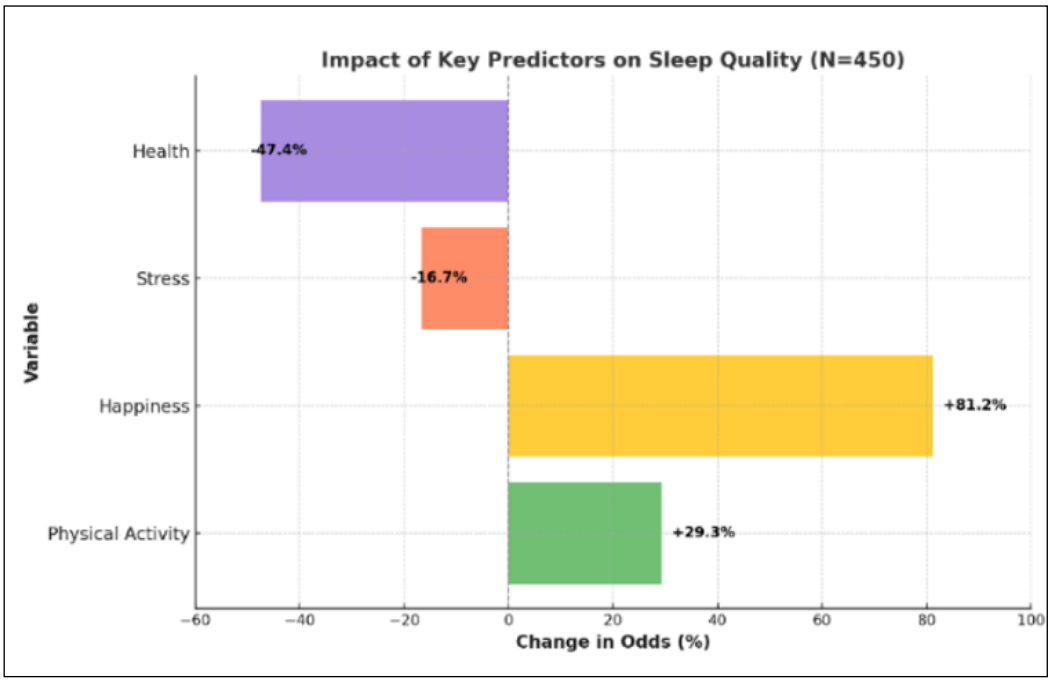

Fig. 1. Impact of key predictors on sleep quality
Authors' own work

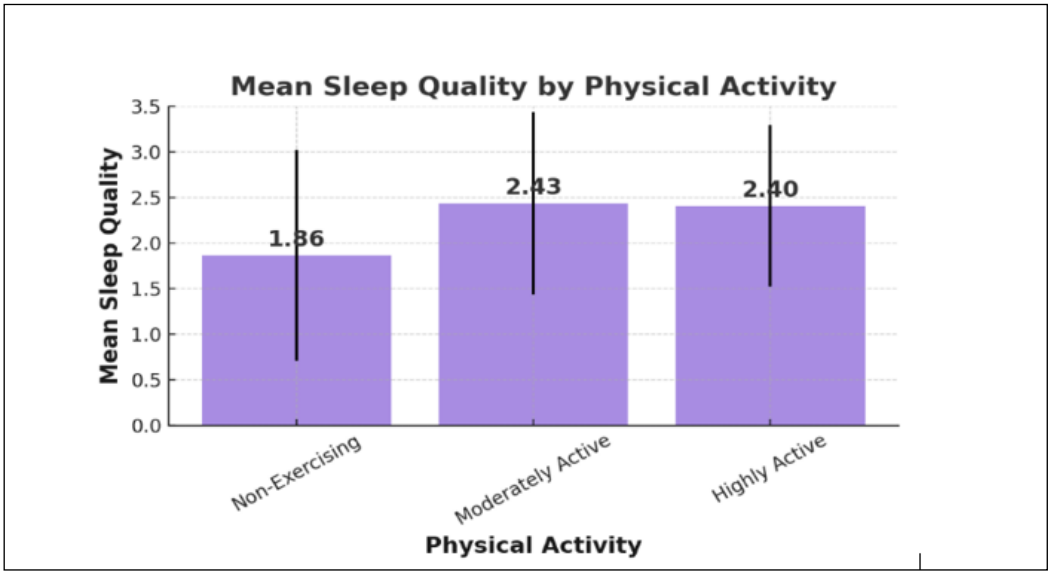

Fig. 2. Mean sleep quality by physical activity
Authors' own work

the 2024 ranking, leading the Central Asian region, suggests that socio-cultural factors may mitigate the negative effects of stress and loneliness on sleep.

The hypothesis that higher stress negatively predicts sleep quality (H3) was also confirmed. Stress has long been established as a key disruptor of sleep, leading to difficulties in sleep initiation, fragmented sleep cycles, and insomnia [35].

Daily stressors—such as work pressures, financial concerns, and social stress—trigger hyperarousal of the central nervous system, prolonging sleep latency and reducing slow-wave (deep) sleep. Previous studies indicate that stress-related sleep disturbances may also exacerbate mental health conditions, creating a vicious cycle of poor sleep and heightened stress [36]. Given these findings, public health strategies should prioritize stress management interventions, such as cognitive behavioral therapy (CBT), relaxation techniques, and mindfulness-based approaches, to improve both sleep quality and psychological resilience.

Consistent with our hypothesis (H4), poorer self-reported health was strongly associated with lower sleep quality. This finding reinforces the bidirectional relationship between physical health and sleep, where chronic conditions contribute to sleep disturbances, and insufficient sleep exacerbates health problems.

Contrary to expectations, higher levels of loneliness did not significantly predict sleep quality (H5). This finding contrasts with previous studies which have consistently shown that loneliness is a strong predictor of sleep disturbances due to pre-sleep cognitive rumination, increased nighttime awakenings, and heightened physiological

arousal [23]. A possible explanation is that Uzbekistan's collectivist culture may mitigate the adverse effects of loneliness, as individuals are more likely to receive social and emotional support from extended family and community networks. Future research should explore whether social cohesion mediates the relationship between loneliness and sleep disturbances.

LIMITATIONS AND FUTURE DIRECTIONS

While this study provides valuable insights into the determinants of sleep quality in Uzbekistan, several limitations should be noted. First, the use of self-reported measures introduces potential bias, as participants may overestimate or underestimate their sleep quality and psychological states. Future studies should incorporate objective sleep assessments, such as polysomnography or actigraphy, to enhance measurement accuracy.

Second, the cross-sectional design limits causal inference. While significant associations were found, longitudinal studies are necessary to determine whether changes in physical activity, happiness, stress, or health status directly lead to changes in sleep quality over time.

Third, this study primarily relied on a convenience sample, recruited via online platforms, which may not fully represent the broader Uzbek population. Future research should aim for more diverse and representative sampling, including participants from various socioeconomic backgrounds, rural areas, and different occupational groups.

Lastly, the study did not assess the role of dietary habits, overall screen exposure, and chronotype—factors that have been shown to influence sleep quality in other populations. Integrating these variables in future studies would provide a more comprehensive understanding of sleep determinants in Uzbekistan.

CONCLUSIONS

This study highlights the complex interplay between happiness, physical activity, stress, and health in shaping sleep quality. Happiness emerged as the strongest predictor, likely due to its role in dopamine and serotonin regulation, emotional resilience, and stress buffering. Moderate physical activity contributed to better sleep outcomes, while excessive exercise showed diminishing returns due to physiological overactivation. Stress remained a key disruptor of sleep, reinforcing the need for stress management interventions.

Future research should employ longitudinal designs to establish causality and develop intervention-based approaches tailored to different demographic groups. Public health policies should prioritize holistic strategies incorporating psychosocial, behavioral, and physiological components to enhance sleep outcomes in Uzbekistan and similar socio-cultural contexts. These findings underscore the importance of integrating mental well-being programs, physical activity guidelines, and stress reduction strategies into national health initiatives to improve population-level sleep quality and overall health as well.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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