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Do your exercise and you'll sleep well: interweaving sleep quality and physical activity engagement

Haz ejercicio y dormirás bien: cómo combinar la calidad del sueño y la actividad física

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Abstract

Sleep quality is a crucial factor in overall well-being, and physical activity is widely recognized for its potential benefits in promoting better sleep. This study explored the relationship between physical activity engagement and sleep quality, focusing on vigor, dedication, and absorption among 366 college students enrolled in Physical Activity Towards Health and Fitness (PATH-Fit) courses. The study examined how different dimensions of engagement contribute to sleep outcomes. Findings suggest that physical activity engagement has a statistically significant yet modest influence on sleep quality. Among its dimensions, absorption emerged as a key predictor, indicating that students who are deeply immersed in physical activity tend to experience better sleep. In contrast, vigor and dedication did not show a significant relationship, suggesting that merely being energetic or highly committed to physical activity does not necessarily lead to improved sleep. This highlights the importance of psychological involvement and enjoyment in exercise rather than just intensity or consistency. However, the findings should be interpreted with caution due to the low predictive power of the model, indicating that physical activity engagement alone may not be a strong determinant of sleep quality. Other factors such as stress, sleep hygiene, and exercise timing may play a more dominant role. These results underscore the need for further research to examine additional variables that may influence sleep quality. Encouraging engaging and enjoyable physical activities in PATH-Fit courses may serve as a potential strategy for improving sleep health among college students.

Keywords: sleep quality, physical activity engagement, physical education, college students.

Resumen

La calidad del sueño es un factor crucial para el bienestar general, y la actividad física es ampliamente reconocida por sus posibles beneficios para promover un mejor descanso. Este estudio exploró la relación entre la participación en la actividad física y la calidad del sueño, centrándose en el vigor, la dedicación y la absorción en 366 estudiantes universitarios matriculados en cursos de Actividad Física para la Salud y el Bienestar (PATH-Fit). El estudio examinó cómo las diferentes dimensiones de la participación contribuyen a los resultados del sueño. Los hallazgos sugieren que la participación en la actividad física tiene una influencia estadísticamente significativa, aunque modesta, en la calidad del sueño. Entre sus dimensiones, la absorción surgió como un predictor clave, lo que indica que los estudiantes que están profundamente inmersos en la actividad física tienden a dormir mejor. Por el contrario, el vigor y la dedicación no mostraron una relación significativa, lo que sugiere que el mero hecho de ser enérgico o estar muy comprometido con la actividad física no necesariamente conduce a un mejor sueño. Esto resalta la importancia de la participación psicológica y el disfrute del ejercicio, más que solo la intensidad o la constancia. Sin embargo, los hallazgos deben interpretarse con cautela debido al bajo poder predictivo del modelo, lo que indica que la participación en la actividad física por sí sola podría no ser un determinante sólido de la calidad del sueño. Otros factores, como el estrés, la higiene del sueño y el horario de ejercicio, podrían desempeñar un papel más importante. Estos resultados subrayan la necesidad de realizar más investigaciones para examinar otras variables que puedan influir en la calidad del

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sueño. Fomentar actividades físicas atractivas y placenteras en los cursos PATH-Fit podría ser una posible estrategia para mejorar la salud del sueño entre los estudiantes universitarios.

Palabras clave: calidad del sueño, participación en la actividad física, educación física, estudiantes universitarios.

Introduction

Sleep quality is a multifaceted concept that includes different characteristics of sleep, such as its length, uninterruptedness, intensity, and the ability to rejuvenate the body (Nelson et al., 2022). High-quality sleep is defined by a sufficient duration of sleep, few disturbances, and a sense of rejuvenation upon awakening (Wang et al., 2023). Sleep quality is influenced by several factors, including environmental conditions (Johnson et al., 2018), lifestyle choices (Dzierzewski et al., 2021) and psychological states (Bayoumy et al., 2023). Moreover, inadequate sleep quality may present itself as insomnia, characterized by trouble initiating sleep, frequent nocturnal awakenings, or early morning awakening with an inability to resume sleep (Bollu & Kaur, 2019). Furthermore, various scholars have stated that sleep disruptions can result in notable health complications, including compromised immune system, susceptibility to cardiovascular ailments, obesity, and diminished cognitive abilities (Madan Jha, 2023; Worley, 2018). Hence, it is imperative to uphold proper sleep hygiene, which refers to the habits and routines that facilitate regular and uninterrupted sleep, in order to support optimal health and well-being.

Various life phases and individual variances might have an impact on the quality of sleep (Ness & Saksvik-Lehouillier, 2018). According to studies, adolescents and individuals in their early adulthood frequently encounter disrupted sleep schedules (Bruce et al., 2017; Gariepy et al., 2020). These are usually scholastic demands, social engagements, and the inclination towards delayed sleep phase syndrome (Bacaro et al., 2023; Hosokawa et al., 2022). Conversely, elderly individuals may experience disrupted sleep patterns as a result of physiological alterations, medical ailments, or the adverse effects of medicines (Suzuki et al., 2017; Tatineny et al., 2020). Moreover, psychological issues such as stress, anxiety, and depression can profoundly influence the quality of sleep

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(Dülger & Ayaz-Alkaya, 2025). Individuals experiencing elevated levels of stress may encounter challenges in initiating or maintaining sleep due to racing thoughts or physiological arousal (Weiner et al., 2021). Both the quality of sleep and general health can be significantly improved by identifying the underlying causes of poor sleep (Okano et al., 2019). Most importantly, taking appropriate action to treat them through lifestyle modifications, stress reduction methods, or medicinal therapies (Leonidis et al., 2021).

The association between the quality of sleep and the level of physical activity is reciprocal and mutually beneficial (Chennaoui et al., 2015). Engaging in regular physical activity has been proven to enhance the quality of sleep by facilitating a deeper and more rejuvenating sleep experience (McGranahan & O'Connor, 2024). It enhances the secretion of endorphins, which can alleviate tension and anxiety, both of which are major obstacles to obtaining restful sleep (Alnawwar et al., 2023). Alnawwar et al. also added that, the variations in body temperature caused by physical exercise can assist in regulating the sleep-wake cycle, facilitating the process of falling asleep at night. Conversely, inadequate sleep can have a detrimental impact on participation in physical activities (Charest & Grandner, 2020). This can be due to decreased energy levels, motivation, and overall physical performance. According to Ye et al. (2022), individuals who suffer from inadequate sleep may experience exhaustion and less motivation to participate in physical activities. This can lead to a harmful cycle in which lack of exercise further worsens sleep quality. Therefore, adhering to a consistent regimen of physical activity can serve as a helpful approach to improving both the quality of sleep and general health.

Importance of sleep quality to physical activity for college students

Sleep is essential for engaging in physical exercise as it directly affects an individual's energy levels, recuperation processes, and overall performance. Recent studies emphasizes that sufficient as well as better sleep promotes athletic performance (Cunha et al., 2023; Watson, 2017). This can be in the form of enhancing motor abilities, reaction times, and cognitive functioning. A recent study by Hamlin et al. (2021) revealed that athletes who adhered to normal sleep patterns had enhanced endurance, strength, and coordination during training compared to their counterparts. Furthermore, Chennaoui et

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al. (2015) stated that sufficient sleep promotes muscle healing and restoration. This is due to the secretion of growth hormone reaches its highest levels during the deep phases of sleep. Hormonal activity has a vital role in promoting muscle growth, repairing tissues, and enhancing overall physical fitness (Velloso, 2008). These are crucial for athletes and anyone who engage in regular physical exercise.

On the other hand, inadequate sleep or low-quality sleep can greatly impede the participation and performance in physical activities. Patel et al. (2024) found that sleep deprivation results in heightened perception of effort, less desire, and an elevated likelihood of injury. This is due to compromised cognitive and motor abilities. Hirotsu et al. (2015) added that long-term lack of sleep has been linked to increased levels of cortisol. It is a hormone that causes stress and can hinder muscle recovery and contribute to fatigue. This negative feedback loop worsens the difficulties of maintaining regular physical activity. Due to these factors, individuals may experience increased muscle discomfort, longer recovery times, and decreased exercise capacity. According to Cunha et al. (2023), implementing interventions like sleep hygiene education (Vitale et al., 2019), cognitive-behavioral therapy for insomnia or CBT-I (Bensen-Boakes et al., 2022) and optimizing sleep settings (Imbergamo et al., 2021), can greatly improve physical activity levels and overall athletic performance.

Furthermore, the importance of sleep in regulating metabolic and hormonal processes is crucial for maximizing involvement in physical exercise. According to Zuo et al. (2012), sleep has an impact on glucose metabolism and insulin sensitivity, which are essential for maintaining energy levels during physical activity. Meaning, sufficient sleep guarantees effective glycogen storage and usage, delivering a consistent energy source essential for endurance exercises (Murray & Rosenbloom, 2018). Moreover, sleep has an impact on hormones that regulate hunger, such as leptin and ghrelin (van Egmond et al., 2023). These hormones can affect the management of body weight and general energy balance. Effective management of these hormones is crucial for athletes and active individuals to maintain an optimal body composition. This is essential for achieving peak performance and preventing injuries.

The relationship between sleep and the immune system highlights the significance of sleep for individuals involved in consistent physical exercise. Sufficient sleep enhances

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the immune system's ability to defend against diseases and infections (Garbarino et al., 2021). Hence, decreasing the chances of getting sick and experiencing disruptions in training routines and performance objectives. According to Charest and Grandner (2022), athletes who regularly obtained adequate sleep had a reduced risk of upper respiratory tract infections compared to those with inconsistent sleep habits. This protective effect enables continuous training and facilitates faster recovery from physical exertion, hence promoting continued participation in physical activity. By giving priority to sleep, athletes and active individuals can improve their immune function (Costa et al., 2022), minimize time off due to sickness (Cunha et al., 2023) and sustain a regular training routine (Baron et al., 2013), ultimately resulting in enhanced performance and long-term health advantages.

College students must prioritize maintaining optimal sleep quality to properly participate in diverse physical education subjects. According to Mehta (2022), the quality of sleep has a direct impact on the energy levels, reaction speeds, and capacity to acquire new motor skills of students. These factors are crucial for engaging in a wide range of physical activities, including team sports and fitness programs. Memon et al. (2021), revealed that college students who consistently obtained high-quality sleep were more inclined to engage in physical education classes. Furthermore, students exhibited superior performance and enjoyment during these sessions. Conversely, students who have difficulty sleeping often encounter heightened exhaustion, less drive, and impaired physical abilities (Craven et al., 2022). These results to decreased engagement levels and a less favorable encounter in physical activities. Prioritizing sleep hygiene practices can help college students to optimize their participation and achievement in physical education programs. These practices may enhance students' overall physical well-being and academic achievements (Ruiz-Pérez et al., 2018).

Research gap, objectives of the study and hypotheses testing

Fascinatingly, there have been numerous studies conducted worldwide that have thoroughly investigated the association between sleep quality and physical activity engagement. However, in the higher education settings, there is still a notable lack of research being conducted in the Philippines. The current literature primarily consists of

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investigations undertaken in Western and other international contexts, overlooking the distinctive elements that could influence this association among Filipino college students. Moreover, most of these studies focus primarily on athletes or student-athletes, leaving out the general student population engaging in physical education classes. The absence of localized studies create a significant gap in comprehending the relationship between sleep quality and physical activity engagement among students. In this regard, this study filled the gap by examining the direct influence of sleep quality on the level of physical activity among college students in a selected HEI the Philippines. The findings of this study could provide valuable information for developing specific interventions and policies to improve the health and engagement of students in physical education.

H_1: There is a significant relationship between physical activity engagement and sleep quality

H_{1a}: vigor does not predict sleep quality

H_{1b}: dedication does not predict sleep quality

H_{1c}: absorption does not predict sleep quality

Methods

Participants

The respondents for the study are purposively selected first- and second-year undergraduate students from a public higher education institution in the Philippines. Furthermore, these students are currently enrolled in various Physical Activity Towards Health and Fitness (PATH-Fit) courses during the second semester of the academic year 2023-2024. The respondents were selected in the present study since PATH-Fit courses are usually only offered to first- and second-year students. In order to obtain the most reliable data from the respondents, the following are the criteria: (a) students who identify themselves as heterosexual men/women and/or LGBTQIAP+ and (b) enrolled to PATH-Fit courses during the stipulated semester and academic year from the selected public higher education institution.

Additionally, *Raosoft Sample Size Calculator* has been utilized to determine the sample size from the target population of the study. The approximate number of enrollees is 5000, and the target sample size is 357 with 95% confidence level and 5% margin of error. The demographic data in Table 1 show that heterosexual women (47.5%) and

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heterosexual men (37.7%) made up the majority of participants, with LGBTQIAP+ individuals (13.1%) and a small percentage (1.6%) choosing not to disclose their identity. In terms of year-level, second-year students (61.5%) outnumbered first-year students (38.5%) in the sample.

Table 1. Distribution of the respondents based on sex/gender identity and year-level

Demographic	Item	*n*(%)
Sex/gender identity	Heterosexual men	138(37.7)
	Heterosexual women	174(47.5)
	LGBTQIAP+	48(13.1)
	Prefer not to disclose	6(1.6)
Year Level	First-year	141(38.5)
	Second-year	225(61.5)
	Total	**366(100.0)**

Instruments

In this present study, online survey was performed. Online survey offers the advantage of efficient data collection to gather responses quickly, reach a broader audience, and minimize costs versus the traditional pen and pencil method. The data collection was conducted between the month of March to May 2024. The online survey was disseminated through the Learning Management Systems of PATH-Fit instructors. From the 422 original responses received during the data collection phase, 366 retained as valid after performing data cleansing procedures. As have mentioned, the total number of respondents is 357 (95% CL and 5% MOE) which far exceeded the target sample size. This corresponds to 84.60% response rate and 102.52% distribution rate. This ensures a higher likelihood of reaching the required sample size, accounting for non-responses, incomplete answers and potential data exclusions.

This online survey form consisted of three parts. The first part obtained the demographic data of the respondents according to sex/gender identity and year-level. Meanwhile, the second part consisted of the 28-item Sleep Quality Scale by Yi et al. (2006). It measured the overall sleep quality of the respondents based on six domains

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(daytime symptoms, restoration after sleep, problems initiating, maintaining sleep, difficulty waking and sleep satisfaction). Responses are recorded using 4-point Likert scale from 1 (rarely / none or 1-3 times a month) to 4 (almost always / 6-7 times a week). Based from the original study of Yi et al. (2006), the overall reliability of the instrument is excellent (α = .92). Lastly, the third part is the 15-item Sports Engagement Scale by (Guillén & Martínez-Alvarado, 2014). It measures three distinct dimensions of engagement (vigor, dedication and absorption). Responses are then encoded using 7-point Likert scale ranging from 1 (hardly ever) to 7 (almost always). The original study of Guillén and Martínez-Alvarado (2014) unravelled that the reliability of each dimensions are mostly good (α = .74 to .75). Meanwhile, the overall scale's reliability is excellent (α = .90). In this particular study, some words were changed from "sports" to "physical activity" to tailor fit the instrument in the current context of the study.

Statistical analysis

Descriptive statistics such as frequency and percentage were used to describe the distribution of the respondents in relation to sex/gender identity and year-level. Furthermore, mean, standard deviation, variance and normality estimates were performed to assess the normality of the data and central tendencies of the variables studied. Lastly, a multiple regression analysis was performed to examine the relationship between physical activity engagement and sleep quality.

The descriptive statistics provide insights into the distribution and central tendencies of the study variables. SLEEPQUAL had a mean score of 2.68 (SD = 0.39) with low variance (0.155), indicating relatively consistent responses among participants. The slightly negative skewness (-0.204) and kurtosis (-0.377) suggest that sleep quality scores were fairly symmetric with no extreme deviations. For the dimensions of physical activity engagement, VR had a mean = 4.25 (SD = 1.16), showing moderate engagement in vigorous activity. The near-zero skewness (0.053) and slightly negative kurtosis (-0.346) indicate a normal distribution. DD had the highest mean = 4.71 (SD = 1.35), reflecting strong commitment to physical activity, with slight negative skewness (-0.330) suggesting a tendency for participants to report higher dedication levels. AB had a mean = 4.48 (SD = 1.16), indicating that participants were moderately to highly immersed in

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physical activity, with a slight leftward skew (-0.365) and near-zero kurtosis (-0.011), suggesting a relatively even distribution.

Table 2. Variance in the distribution of responses and normality estimates of the constructs

Constructs	Mean ± SD	Variance	Skewness	Kurtosis
SLEEPQUAL	2.68 ± .39	.155	-.204	-.377
VR	4.25 ± 1.16	1.357	.053	-.346
DD	4.71 ± 1.35	1.817	-.330	-.347
AB	4.48 ± 1.16	1.354	-.365	-.011

Ethical Statement

This study was conducted in accordance with ethical research standards. It was exempted from review by the Local Research Ethics Committee of the College of Sports, Exercise, and Recreation, as it posed minimal risk to participants. Informed consent was obtained, and confidentiality and anonymity were strictly maintained throughout the study in accordance with the Republic Act No. 10173, also known as the Data Privacy Act of 2012 of the Philippines.

Results

As can be seen in Table 3, the overall model testing the effect of physical activity engagement on sleep quality was statistically significant [$F(3, 362) = 3.702$, $p = .012$], but with a low explanatory power ($R^2 = .030$) or 3.0%. This indicates that while engagement in physical activity may have some influence on sleep, it accounts for only a small portion of the variance. Other factors, such as sleep hygiene, stress levels, and exercise timing, are likely stronger determinants of sleep quality. Thus, H_1 has been rejected. Given the low R^2 value, the results should be interpreted with caution, as the practical significance of the findings is limited. The small explained variance suggests that PAE alone is not a sufficient predictor of SLEEPQUAL. In this regard, future studies should consider additional variables that may provide a more comprehensive understanding of the relationship. Additionally, unmeasured confounding factors (e.g., diet, screen exposure before bedtime, and individual differences in sleep patterns) could

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have influenced the results. Thus, while the model achieved statistical significance, the findings should not be overgeneralized, and further research is needed to explore more nuanced interactions between physical activity engagement and sleep quality. On the other hand, H_1 has been rejected.

Moreover, the negative coefficient suggests a weak inverse relationship between VR and SLEEPQUAL, though it was not statistically significant (β = -.054, t = -1.673, p = .079). This implies that higher vigor in physical activity may not necessarily enhance sleep and could potentially disrupt it, especially if performed at high intensity or close to bedtime. A few factors may explain this, such as increased heart rate, heightened physiological arousal, and delayed melatonin production, which can interfere with sleep onset. In this, H_{1a} has been accepted.

Additionally, the relationship between DD and SLEEPQUAL showed no significant relationship (β = -.022, t = -.757, p = .449). This suggests that being highly committed to physical activity does not directly influence sleep quality. Dedication reflects persistence and commitment, but it does not account for exercise recovery, relaxation, or mental detachment from physical exertion, which are crucial for better sleep outcomes. Highly dedicated individuals may also engage in prolonged or intense exercise without prioritizing proper cooldown or sleep-friendly habits, potentially negating any benefits to sleep. Moreover, psychological engagement in training or performance goals may lead to pre-sleep cognitive arousal, further disrupting sleep quality. Hence, H_{1b} has been accepted.

Lastly, the findings revealed a positive and significant relationship between AB and SLEEPQUAL (β = .091, t = 3.157, p = .002), indicating that individuals who are deeply immersed in their physical activity tend to experience better sleep quality. Absorption fosters psychological flow and mental relaxation, which may help in reducing stress and enhancing pre-sleep cognitive calmness, promoting better sleep. This may be because engaging fully in an activity reduces anxiety and intrusive thoughts, which are common barriers to sleep. Additionally, a sense of accomplishment and enjoyment from being absorbed in physical activity may contribute to lower evening stress levels, allowing for smoother sleep transitions. Therefore, H_{1c} has been rejected.

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In summary, the findings suggest that while physical activity engagement as a whole has limited predictive power on sleep quality, the psychological experience of deep absorption in activity is a key factor. Future research should explore other contributing factors, such as exercise type, duration, and individual sleep habits, to better understand how physical activity engagement influences sleep.

Table 3. Multiple regression analysis and hypotheses testing

Hypothesis	Paths	*β*	R^2	*F*	*t*-value	*p*-value	Decision
H_1	PAE → SLEEPQUAL	-	.030	3.702	-	<.012	Accepted
H_{1a}	VR → SLEEPQUAL	-.054	-	-	-1.673	.079	Accepted
H_{1b}	DD → SLEEPQUAL	-.022	-	-	-.757	.449	Accepted
H_{1c}	AB → SLEEPQUAL	.091	-	-	3.157	.002	Rejected

Note: Significance is at p <.001.
Legend: PAE- Physical activity engagement, VR- Vigor, DD- Dedication, AB- Absorption.

Discussion

The present study examined the predictive relationship between engagement in physical activity and sleep quality, considering three dimensions of engagement. The regression model was found to be statistically significant, suggesting that engagement in physical activity plays a role in determining sleep quality. However, while absorption significantly predicted sleep quality, vigor and dedication were not individually significant predictors. These findings suggest that while isolated aspects of engagement may not always directly influence sleep, the holistic construct of physical activity engagement has an overall impact on sleep quality. Nevertheless, the relatively low R^2 value (3%) indicates that the proportion of variance in sleep quality explained by engagement in physical activity is modest, suggesting that other unmeasured factors may play a larger role in determining sleep outcomes.

Furthermore, the results indicate that absorption in physical activity is a significant positive predictor of sleep quality. Absorption, which refers to deep psychological immersion in an activity (Koehn et al., 2017), is linked to flow states

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(Csikszentmihalyi, 2014), where individuals experience a high level of focus, enjoyment, and intrinsic motivation (Waterman, 2024). This aligns with prior studies demonstrating that deep engagement in exercise is associated with lower stress levels and improved emotional regulation contributing to better sleep quality (Alnawwar et al., 2023; Korkutata et al., 2025; Wang et al., 2025). Moreover, it can be construed that absorption in physical activity may lead to cognitive fatigue, which promotes faster sleep onset and increased sleep depth. Neurobiological evidence suggests that regularly engaging in mentally immersive physical activities enhances serotonin and dopamine production (Marques et al., 2021; Ren & Xiao, 2023), both of which play a key role in melatonin synthesis and sleep regulation (Lee et al., 2021; Thambyrajah et al., 2023).

Contrary to expectations, vigor and dedication were not significant independent predictors of sleep quality. Vigor was negatively associated with sleep quality but did not reach statistical significance. This suggests that while vigorous exercise can induce physical fatigue and thermoregulatory effects beneficial for sleep (Chennaoui et al., 2015; Driver & Taylor, 2000), its timing and intensity may determine whether it enhances or disrupts sleep (Altunalan et al., 2024; Burgess et al., 2020). Research has shown that late-night high-intensity exercise can delay sleep onset and reduce slow-wave sleep (SWS) due to heightened physiological arousal (Alkhaldi et al., 2023; Frimpong et al., 2021; Suppiah & Chia, 2015). The lack of a significant association in the present study suggests that vigorous engagement in physical activity alone is not sufficient to predict sleep quality, potentially due to variations in exercise timing, individual fitness levels, or recovery practices.

Meanwhile, dedication was also not a significant predictor of sleep quality. While previous studies have suggested that individuals who are more committed to exercise report greater psychological resilience and reduced stress (Liu et al., 2024; Neumann et al., 2022), this does not necessarily translate into better sleep. One possible explanation is that dedication does not directly influence sleep quality unless it is accompanied by effective recovery strategies (Doherty et al., 2021; Scott et al., 2021) and psychological detachment from exercise-related stressors (Balk et al., 2019; Tucker et al., 2008). Highly dedicated individuals may experience cognitive and emotional engagement beyond

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exercise sessions, potentially leading to rumination and delayed sleep onset (Sim et al., 2023; You et al., 2023).

Conclusion

This study provides novel insights into the relationship between engagement in physical activity and sleep quality, specifically examining the dimensions of vigor, dedication, and absorption. While the overall regression model was statistically significant, only absorption emerged as a significant predictor of sleep quality. This findings suggests that deep psychological immersion in physical activity is positively associated with better sleep outcomes. In contrast, vigor and dedication did not independently predict sleep quality, indicating that exercise intensity and commitment alone may not be sufficient determinants of sleep health.

Despite these findings, the relatively low R^2 value underscores that engagement in physical activity explains only a small portion of the variance in sleep quality. Thus, highlighting the influence of other factors such as chronotype, stress levels, sleep hygiene, and lifestyle behaviors. Given the limited empirical research on the psychological dimensions of physical activity engagement and sleep quality, this study contributes to an emerging area of research and emphasizes the need for future studies to further investigate these relationships through longitudinal or experimental designs. Additionally, developing standardized measures of engagement in physical activity may enhance the accuracy of future analyses.

In practical terms, these findings suggest that promoting immersive and mindful exercise experiences, rather than focusing solely on intensity or commitment, may be more beneficial for improving sleep quality. Encouraging activities that foster absorption, such as yoga, dance, or flow-based sports, may help individuals optimize both their physical activity engagement and sleep health. Ultimately, a holistic approach to exercise—balancing intensity, engagement, and recovery—may be key to maximizing its benefits for well-being and restorative sleep.

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A novel contribution to the literature and precautionary considerations

To date, no known studies have specifically examined the three dimensions of engagement in physical activity in relation to sleep quality in the Philippines. Furthermore, existing literature primarily focuses on general physical activity levels, exercise intensity, or duration rather than the psychological dimensions of engagement. While research has explored the relationship between work engagement and sleep quality, as well as the role of exercise in promoting general well-being, there is a lack of studies investigating how different facets of engagement in physical activity contribute to sleep outcomes. The present study, therefore, provides a novel contribution by being one of the first to explore how the psychological experience of physical activity engagement—beyond mere participation—may shape sleep quality in college students based from the Philippines.

However, it is important to interpret these results with caution. The findings suggest that while engagement in physical activity contributes to sleep quality, it accounts for only a small proportion of the variance. This implies that additional factors such as stress levels, chronotype, sleep hygiene, and other lifestyle behaviors may have a stronger influence on sleep quality than engagement alone. Therefore, future research should aim to explore these additional influences and incorporate more comprehensive models to better understand the multifaceted nature of sleep determinants.

Given the limited empirical evidence on this topic, these findings open new directions for future research. Specifically, further studies should examine the independent and combined effects of vigor, dedication, and absorption on sleep quality. Additionally, this can also be possible by developing standardized tools for measuring engagement in physical activity across different populations. Lastly, investigating moderating factors such as exercise timing, intensity, and individual differences in fitness levels is highly recommended. Additionally, exploring the long-term effects of engagement in physical activity on sleep quality through longitudinal or experimental designs would help establish causal relationships.

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References

Alnawwar, M. A., Alraddadi, M. I., Algethmi, R. A., Salem, G. A., Salem, M. A., & Alharbi, A. A. (2023). The effect of physical activity on sleep quality and sleep disorder: A systematic review. *Cureus*. https://doi.org/10.7759/cureus.43595

Bacaro, V., Andreose, A., Grimaldi, M., Natale, V., Tonetti, L., & Crocetti, E. (2023). The association between sleep patterns, educational identity, and school performance in adolescents. *Brain Sciences*, *13*(2), 178–178. https://doi.org/10.3390/brainsci13020178

Baron, K. G., Reid, K. J., & Zee, P. C. (2013). Exercise to improve sleep in insomnia: Exploration of the bidirectional effects. *Journal of Clinical Sleep Medicine*, *09*(08), 819–824. https://doi.org/10.5664/jcsm.2930

Bayoumy, H. M. M., Sedek, H., Omar, H., & Ayman, S. (2023). Investigating the relationship of sleep quality and psychological factors among health professions students. *International Journal of Africa Nursing Sciences*, *19*, 100581–100581. https://doi.org/10.1016/j.ijans.2023.100581

Bensen-Boakes, D.-B., Osman, A., Lack, L., Catcheside, P., Antic, N., Smith, S. S., Chai-Coetzer, C. L., O'Grady, A., Dunn, N., Robinson, J., McEvoy, D., & Sweetman, A. (2022). The effect of Cognitive Behavioural Therapy for Insomnia (CBT-I) on subjective–objective sleep discrepancy in individuals with co-morbid insomnia and sleep apnoea: A randomised controlled trial. *Applied Sciences*, *12*(4), 1787–1787. https://doi.org/10.3390/app12041787

Bollu, P. C., & Kaur, H. (2019). Sleep medicine: Insomnia and sleep. *Missouri Medicine*, *116*(1), 68–75.

Bruce, E. S., Lunt, L., & McDonagh, J. E. (2017). Sleep in adolescents and young adults. *Clinical Medicine*, *17*(5), 424–428. https://doi.org/10.7861/clinmedicine.17-5-424

Charest, J., & Grandner, M. A. (2020). Sleep and athletic performance. *Sleep Medicine Clinics*, *15*(1), 41–57. https://doi.org/10.1016/j.jsmc.2019.11.005

Chennaoui, M., Arnal, P. J., Sauvet, F., & Léger, D. (2015). Sleep and exercise: A reciprocal issue? *Sleep Medicine Reviews*, *20*, 59–72. https://doi.org/10.1016/j.smrv.2014.06.008

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Costa, J., Figueiredo, P., Y. Nakamura, F., & Brito, J. (2022). The importance of sleep in athletes. In *Exercise Physiology*. IntechOpen. https://doi.org/10.5772/intechopen.102535

Craven, J., McCartney, D., Desbrow, B., Sabapathy, S., Bellinger, P., Roberts, L., & Irwin, C. (2022). Effects of acute sleep loss on physical performance: A systematic and meta-analytical review. *Sports Medicine*, *52*(11), 2669–2690. https://doi.org/10.1007/s40279-022-01706-y

Cunha, L. A., Costa, J. A., Marques, E. A., Brito, J., Lastella, M., & Figueiredo, P. (2023). The impact of sleep interventions on athletic performance: A systematic review. *Sports Medicine - Open*, *9*(1), 58–58. https://doi.org/10.1186/s40798-023-00599-z

Dülger, H., & Ayaz-Alkaya, S. (2025). Prevalence of stress, anxiety, depression, and sleep quality among young adults in Turkiye: A cross-sectional study. *Journal of Evaluation in Clinical Practice*, *31*(1), e70002. https://doi.org/10.1111/jep.70002

Dzierzewski, J. M., Sabet, S. M., Ghose, S. M., Perez, E., Soto, P., Ravyts, S. G., & Dautovich, N. D. (2021). Lifestyle factors and sleep health across the lifespan. *International Journal of Environmental Research and Public Health*, *18*(12), 6626–6626. https://doi.org/10.3390/ijerph18126626

Garbarino, S., Lanteri, P., Bragazzi, N. L., Magnavita, N., & Scoditti, E. (2021). Role of sleep deprivation in immune-related disease risk and outcomes. *Communications Biology*, *4*(1), 1304–1304. https://doi.org/10.1038/s42003-021-02825-4

Gariepy, G., Danna, S., Gobiņa, I., Rasmussen, M., Gaspar De Matos, M., Tynjälä, J., Janssen, I., Kalman, M., Villeruša, A., Husarova, D., Brooks, F., Elgar, F. J., Klavina-Makrecka, S., Šmigelskas, K., Gaspar, T., & Schnohr, C. (2020). How are adolescents sleeping? Adolescent sleep patterns and sociodemographic differences in 24 European and North American countries. *Journal of Adolescent Health*, *66*(6), S81–S88. https://doi.org/10.1016/j.jadohealth.2020.03.013

Guillén, F., & Martínez-Alvarado, J. R. (2014). Escala de compromiso deportivo: Una adaptación de la Escala de Compromiso en el Trabajo de Utrecht (UWES) para ambientes deportivos. *Universitas Psychologica*, *13*(3). https://doi.org/10.11144/Javeriana.UPSY13-3.sesa

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Hamlin, M. J., Deuchrass, R. W., Olsen, P. D., Choukri, M. A., Marshall, H. C., Lizamore, C. A., Leong, C., & Elliot, C. A. (2021). The effect of sleep quality and quantity on athlete's health and perceived training quality. *Frontiers in Sports and Active Living*, *3*. https://doi.org/10.3389/fspor.2021.705650

Hirotsu, C., Tufik, S., & Andersen, M. L. (2015). Interactions between sleep, stress, and metabolism: From physiological to pathological conditions. *Sleep Science*, *8*(3), 143–152. https://doi.org/10.1016/j.slsci.2015.09.002

Hosokawa, R., Tomozawa, R., Fujimoto, M., Anzai, S., Sato, M., Tazoe, H., & Katsura, T. (2022). Association between sleep habits and behavioral problems in early adolescence: A descriptive study. *BMC Psychology*, *10*(1), 254–254. https://doi.org/10.1186/s40359-022-00958-7

Imbergamo, C. M., Patankar, A. G., & Milewski, M. D. (2021). Sleep optimization in the young athlete. *Journal of the Pediatric Orthopaedic Society of North America*, *3*(3), 306–306. https://doi.org/10.55275/JPOSNA-2021-306

Johnson, D. A., Billings, M. E., & Hale, L. (2018). Environmental determinants of insufficient sleep and sleep disorders: Implications for population health. *Current Epidemiology Reports*, *5*(2), 61–69. https://doi.org/10.1007/s40471-018-0139-y

Leonidis, A., Korozi, M., Sykianaki, E., Tsolakou, E., Kouroumalis, V., Ioannidi, D., Stavridakis, A., Antona, M., & Stephanidis, C. (2021). Improving stress management and sleep hygiene in intelligent homes. *Sensors*, *21*(7), 2398. https://doi.org/10.3390/s21072398

Madan Jha, V. (2023). The prevalence of sleep loss and sleep disorders in young and old adults. *Aging Brain*, *3*, 100057–100057. https://doi.org/10.1016/j.nbas.2022.100057

McGranahan, M. J., & O'Connor, P. J. (2024). Influence of regular physical activity on sleep. In J. M. Cisler, K. M. Crombie, & T. G. Adams (Eds.), *Exercise and Mental Health* (Vol. 67, pp. 309–328). Springer International Publishing. https://doi.org/10.1007/7854_2024_503

Mehta, K. J. (2022). Effect of sleep and mood on academic performance—At interface of physiology, psychology, and education. *Humanities and Social Sciences Communications*, *9*(1), 16–16. https://doi.org/10.1057/s41599-021-01031-1

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Memon, A. R., Gupta, C. C., Crowther, M. E., Ferguson, S. A., Tuckwell, G. A., & Vincent, G. E. (2021). Sleep and physical activity in university students: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *58*, 101482–101482. https://doi.org/10.1016/j.smrv.2021.101482

Murray, B., & Rosenbloom, C. (2018). Fundamentals of glycogen metabolism for coaches and athletes. *Nutrition Reviews*, *76*(4), 243–259. https://doi.org/10.1093/nutrit/nuy001

Nelson, K. L., Davis, J. E., & Corbett, C. F. (2022). Sleep quality: An evolutionary concept analysis. *Nursing Forum*, *57*(1), 144–151. https://doi.org/10.1111/nuf.12659

Ness, T. E. B., & Saksvik-Lehouillier, I. (2018). The relationships between life satisfaction and sleep quality, sleep duration and variability of sleep in university students. *Journal of European Psychology Students*, *9*(1), 28–39. https://doi.org/10.5334/jeps.434

Okano, K., Kaczmarzyk, J. R., Dave, N., Gabrieli, J. D. E., & Grossman, J. C. (2019). Sleep quality, duration, and consistency are associated with better academic performance in college students. *Npj Science of Learning*, *4*(1), 16. https://doi.org/10.1038/s41539-019-0055-z

Patel, H., Vanguri, P., Kumar, D., & Levin, D. (2024). The impact of inadequate sleep on overtraining syndrome in male and female college athletes 18–22 years old: A literature review. *Cureus*. https://doi.org/10.7759/cureus.56186

Suzuki, K., Miyamoto, M., & Hirata, K. (2017). Sleep disorders in the elderly: Diagnosis and management. *Journal of General and Family Medicine*, *18*(2), 61–71. https://doi.org/10.1002/jgf2.27

Tatineny, P., Shafi, F., Gohar, A., & Bhat, A. (2020). Sleep in the elderly. *Missouri Medicine*, *117*(5), 490–495.

van Egmond, L. T., Meth, E. M. S., Engström, J., Ilemosoglou, M., Keller, J. A., Vogel, H., & Benedict, C. (2023). Effects of acute sleep loss on leptin, ghrelin, and adiponectin in adults with healthy weight and obesity: A laboratory study. *Obesity*, *31*(3), 635–641. https://doi.org/10.1002/oby.23616

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Velloso, C. P. (2008). Regulation of muscle mass by growth hormone and IGF-I. *British Journal of Pharmacology*, *154*(3), 557–568. https://doi.org/10.1038/bjp.2008.153

Vitale, K. C., Owens, R., Hopkins, S. R., & Malhotra, A. (2019). Sleep hygiene for optimizing recovery in athletes: Review and recommendations. *International Journal of Sports Medicine*, *40*(08), 535–543. https://doi.org/10.1055/a-0905-3103

Wang, Y., Dai, X., Zhu, J., Xu, Z., Lou, J., & Chen, K. (2023). What complex factors influence sleep quality in college students? PLS-SEM vs. fsQCA. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1185896

Watson, A. M. (2017). Sleep and athletic performance. *Current Sports Medicine Reports*, *16*(6), 413–418. https://doi.org/10.1249/JSR.0000000000000418

Weiner, L., Martz, E., Kilic-Huck, Ü., Siegel, N., Bertschy, G., Geoffroy, P. A., Weibel, S., & Bourgin, P. (2021). Investigating racing thoughts in insomnia: A neglected piece of the mood-sleep puzzle? *Comprehensive Psychiatry*, *111*, 152271. https://doi.org/10.1016/j.comppsych.2021.152271

Worley, S. L. (2018). The extraordinary importance of sleep: The detrimental effects of inadequate sleep on health and public safety drive an explosion of sleep research. *P&T: A Peer-Reviewed Journal for Formulary Management*, *43*(12), 758–763.

Ye, J., Jia, X., Zhang, J., & Guo, K. (2022). Effect of physical exercise on sleep quality of college students: Chain intermediary effect of mindfulness and ruminative thinking. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.987537

Yi, H., Shin, K., & Shin, C. (2006). Development of the sleep quality scale. *Journal of Sleep Research*, *15*(3), 309–316. https://doi.org/10.1111/j.1365-2869.2006.00544.x

Zuo, H., Shi, Z., Yuan, B., Dai, Y., Hu, G., Wu, G., & Hussain, A. (2012). Interaction between physical activity and sleep duration in relation to insulin resistance among non-diabetic Chinese adults. *BMC Public Health*, *12*(1), 247–247. https://doi.org/10.1186/1471-2458-12-247