Int. J. Sport Psychol., 2025; 56: 201-217
doi: 10.7352/IJSP.2025.56.201

The mediating role of dispositional optimism in the relationship between athletes' quality of sleep and mental energy relationship: A cross-sectional study

***Bin-Bin Fang*[1], *Frank J. H. Lu*[2]*, *Garry Kuan*[3], *Jiarun Wu*[3], *Diane L. Gill*[4], & *Mu-Cai Su*[1,5]**

[1] *Quanzhou Normal University, China*
[2]* *Chinese Culture University, Taiwan*
[3] *Universiti Sains Malaysia, Malaysia*
[4] *University of North Carolina at Greensboro, U.S.A*
[5] *Fujian Normal University, China*

Although extant literature indicates that sufficient sleep links to many positive consequences, its association with athletes' mental energy has never been examined. This study aimed to examine the triangular relationships among athletes' quality of sleep, mental energy, and optimism; and explore the mediating role of optimism. We administered the Pittsburgh Sleep Quality Index, the Life Orientation Test-Revised, and the Athletic Mental Energy Scale to 316 elite and sub-elite student-athletes engaged in diverse sports. Bivariate correlation analyses found that athletes' quality of sleep, mental energy, and optimism all correlated with each other. Further, multiple hierarchical regressions found that optimism partially mediated the relationship between quality of sleep and mental energy. The preliminary findings advance our understanding of the influence of the quality of sleep on athletes' mental energy, and the role of optimism. We suggest offering sleep management programs for athletes not only to promote health but also enhance performance and mental energy.

Key Words: Positive psychology, Psychology of sport excellence, Psychological well-being, Youth athletes.

Introduction

Sleep is essential for life and vital in promoting physical health, psychosocial well-being, cognition, and daily functioning, and in reducing all causes of mortality (Cappuccio et al., 2010). For adolescents, sound and quality sleep

Correspondence to: Frank J. H. Lu, Professor, Chinese Culture University, Taiwan. #55, Hua-Kang Road, Yang-Ming-Shan, Taipei 11114, Taiwan. (E-mail: frankjlu@gmail.com or ljh25@ulive.pccu.edu.tw).

benefits cognition, psychosocial health, cardiovascular health, and reduces adiposity (Matricciani et al., 2019). While sleeping, bodies undergo crucial processes that maintain life's functioning. These processes include repairing damaged tissues, replenishing energy stores, and strengthening the immune system. Another important function of sleep is consolidating and organizing newly acquired information, experiences, and skills, enhancing learning, attention, concentration, problem-solving, reasoning, decision-making, and creativity. Sleep also plays a role in reducing negative emotions such as anxiety, anger, worry, confusion, and depression to promote overall emotional well-being and resilience. Additionally, it maintains cardiovascular health by reducing risk factors such as obesity, diabetes, and hypertension. Furthermore, sleep improves work efficiency and cognitive abilities such as concentration, problem-solving, memory recall, and reaction time (Shneerson, 2009). Insufficient or poor sleep has been found to lead to degraded cognitive function (Killgore, 2010), impaired metabolic function (Knutson et al., 2007), lower immune function (Spiegel et al., 2002), increased the risk of cardiovascular disease (Tobaldini et al., 2017), and increased anxiety and depression (Kang et al., 2021; Rahmani et al., 2020).

Sleep is essential for athletes' daily training, cognitive function, injury recovery, and performance. A systematic review examining the effects of sleep on athletic performance with 40 studies from 1980 to 2018 indicated that sufficient sleep enhances athletes' reaction time, accuracy, strength, endurance, and cognitive function. In contrast, insufficient or poor sleep decreases athletes' reaction time, accuracy, vigor, sub-maximal strength, endurance, and competition performance (Vitale et al., 2019). Poor sleep in athletes has been found to be associated with sport injury in adolescents (Milewski et al., 2014), soccer players (Silva et al., 2019), and college student-athletes (Burke et al., 2020).

In addition to athletic performance, poor sleep has been related to negative psychological responses, such as tiredness, low motivation, reduced interest in training/competition, and loss of confidence/concentration during training and competition. For example, a study with 190 National Collegiate Athletic Association Division-I student-athletes on sleep quality, depression, anxiety, and mental health found that shorter sleep duration, poor sleep quality, and insomnia are associated with psychological stress, depression, anxiety, and mental health (Grandner et al., 2021). Similarly, Doherty et al. (2021) assessed sleep, training recovery, and nutritional practices of 338 elite and sub-elite athletes from Ireland and the United Kingdom. They found that poor sleep was reported by both the elite and sub-elite athlete groups, and was associated with high levels of fatigue, stress, and pain. Further, in a large-scale investigation of athletic burnout, Granz et al. (2019) found poor sleep is one of the key factors that lead to athletic burnout.

For athletes, the negative consequences of poor sleep, such as fatigue and lowered motivation (e.g., Doherty et al., 2021; Grandner et al., 2021), are similar to low mental energy. Mental energy is important for human functioning/performance because it enables individuals to continue long hours of thinking, concentrating, and blocking distractions to complete a given task (Lykken, 2005). According to the North American Branch of the International Life Science Institute (ILSI), mental energy is defined as "*...the intensity of subjective feeling about one's capacity to accomplish tasks of daily life-these feelings fluctuate from moment to moment* (O'Connor & Burrowes, 2006, p. 2)" and comprised five major components including motivation, cognition, quality of life, mood, and sleepiness (O'Connor & Burrowes, 2006, p. 2).

Extending ILSI's work, Lu et al. (2018) defined mental energy in sports as "*…an athlete's perceived existing state of energy, which is characterized by its intensity in motivation, confidence, concentration, and mood.*" Lu et al. (2018) used six studies to develop a sport-specific mental energy measure termed "The Athletic Mental Energy Scale (AMES), which is comprised of six factors- motivation, confidence, and concentration, which are all cognitive components); and vigour, tirelessness, and calm, which are all affective components. Empirical studies support that athletes' mental energy predicts competition performance (Chuang et al., 2022; Lu et al., 2018; Shieh et al., 2023), is associated with flow experience (Öner, 2022), sport courage (Islam, 2023), and moderates athletes' life stress burnout relationship (Chiu et al., 2021). Thus, one purpose of this study was to examine the relationship between athletes' quality of sleep and mental energy.

The study of the sleep-optimism relationship can be traced to an early study by Abramson et al. (1989) who found that hopeless individuals tend to have sleep disturbance. In psychosomatic medicine, researchers have examined whether sleep is associated with optimism. For example, Lemola et al. (2011) observed 291 children (age = 8±0.3 years) for seven consecutive nights using an actigraph electronic device. They found children with shorter sleep latency and optimal sleep time (i.e., high quality of sleep) scored higher in optimism than children with poor sleep. From the reverse perspective, researchers examined whether optimism predicts sleep. For example, Conway et al. (2011) found that optimistic participants reported less sleep disorder. Further, to determine the causal relationship between sleep and optimism, Lau et al. (Lau et al., 2015; 2017) conducted two studies. In the first study, Lau et al. (2015) assessed quality of sleep, optimism, and depression in 987 Hong Kong residents. Then, after 19 months, they assessed these variables again. The cross-lagged analyses showed bidirectional causality between optimism and sleep - optimism influences sleep, and sleep also influences optimism. Further, they found the sleep-optimism relationship is mediated by depressive mood.

In the second study, Lau et al. (2017) assessed 1,684 university students' optimism, sleep, depression, anxiety, and stress at three time points, spanning 19 months. Again, there was a bidirectional relationship between sleep and optimism; the influence of sleep on optimism was mediated by depression, while the influence of optimism on sleep was mediated by stress and anxiety. Thus, the second purpose of this study was to examine the relationship between athletes' sleep and optimism.

The third purpose of this study was to examine the relationship between athletes' optimism and mental energy. Though not directly using the term "mental energy," many researchers found that optimistic individuals tend to report higher vigor, confidence, motivation, concentration, and low anxiety (Kelberer et al., 2018; Li & Wu, 2011; Thompson & Gaudreau, 2008; Salminen et al., 2014; Zenger et al., 2010). For example, Salminen et al. (2014) investigated the moderating role of optimism in the relationship between job resources and work engagement with 747 Finnish managers. They found that optimism predicts work engagement (i.e., vigor, dedication, and absorption) and moderates the negative impact of low job resources on work engagement. Similarly, Thompson and Gaudreau (2008) assessed optimism and academic motivation in 299 undergraduate students two weeks prior to midterm exams, and collected academic motivation and coping two weeks after midterm exams. They found optimism correlated with self-determined motivation in Time #1 and Time #2, and self-determined motivation mediated the relationship between dispositional optimism and task-oriented coping. Further, Li and Wu (2011) recruited 970 college students to examine the relationships among optimism, creative self-efficacy, and innovative behavior and the mediating role of creative self-efficacy via structural equations. They found that optimism correlated with creative self-efficacy and innovative behavior, and creative self-efficacy partially mediated the relationship between optimism and innovative behavior.

In considering that optimism may influence cognitive processes when facing ambiguous events, Kelberer et al. (2018) assessed hope and optimism in 104 undergraduates who completed an eye-tracking task to measure attention to emotional scenes. They found that optimism and hope were associated with less sustained attention to dysphoric information, and optimism was associated with increased attention to positive information. Moreover, optimism is believed to have buffering effects when encountering stress. Similarly, Zenger et al. (2010) examined the predictive value of optimism on anxiety, depression, and health-related quality of life in cancer patients during their stay in the hospital (T1), two weeks later (T2), and three months later. They found that optimism at T1 was negatively associated with anxiety and depression but positively correlated with quality of life.

Built on the aforementioned literature, it is hypothesized that athletes' quality of sleep correlates with optimism and mental energy. In addition, athletes' optimism is hypothesized to correlate with mental energy. Further, because optimism is related to quality of sleep, and sleep influences many positive outcomes such as vigor, motivation, confidence, concentration, and lower anxiety, we hypothesized that optimism plays a mediating role in the quality of sleep-mental energy relationship. We adopted Baron and Kenny (1986) suggestions to examine whether the mediator (i.e., optimism in this study) explain how external physical events (i.e., quality of sleep in this study) take on internal psychological significance (i.e., mental energy). In sum, the purposes of this study were: (a) to examine the triangular relationships of athletes' quality of sleep, dispositional optimism, and mental energy and (b)

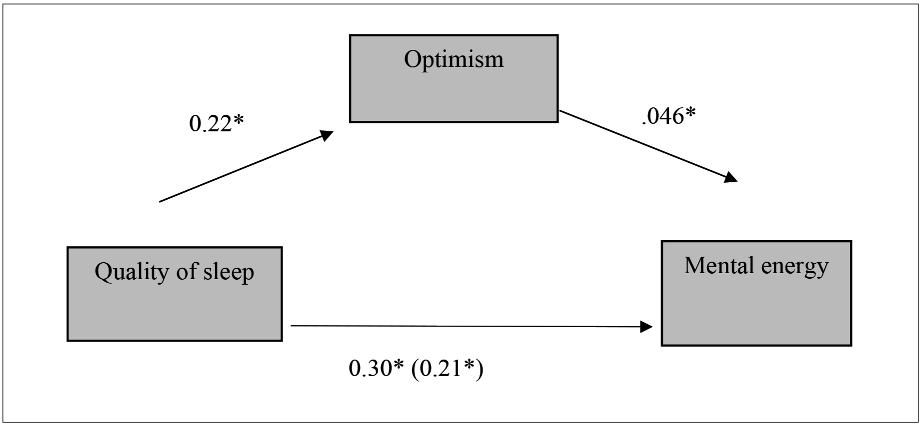

Figure 1. - Mediating effect of optimism on the quality of sleep-mental energy relationship.

Note: Path diagrams indicate that partial mediating effects. The numbers outside the parenthesis denote the path coefficients between variables, whereas the number in the parenthesis indicates the path coefficient between quality of sleep and mental energy after excluding mediator (optimism).

to examine the mediating role of dispositional optimism in the quality of sleep-mental energy relationship.

Methods

Participants

Pilot Study.

To ensure the applicability of the research design, this study implemented a pilot study suggested by Connelly (2008), involving 55 collegiate basketball players. The pilot study aimed to examine measurement feasibility, item comprehensibility, and provide parameter estimates for subsequent power analysis. Internal consistency was evaluated using Cronbach's alpha coefficients. We found that the Athletic Mental Energy Scale (AMES) exhibited high reliability ($\alpha = 0.88$), meeting psychometric standards ($\alpha > 0.80$); the Life Orientation Test-Revised (LOT-R) and Pittsburgh Sleep Quality Index (PSQI) showed marginal reliability (α = 0.60 and 0.67, respectively), which remains acceptable for small sample despite falling below the ideal threshold ($\alpha \geq 0.70$). Participants reported questionnaire clarity with no semantic ambiguities. We found mental energy negatively correlated with sleep quality ($r = -0.28$, $p = 0.036$), while positively associating with optimism ($r = 0.447$, $p = 0.001$). No significant relationship emerged between optimism and sleep quality ($p > 0.05$). These preliminary findings support basic theoretical relationships, though small sample size ($n = 55$) may inflate Type II error risks and underestimate effect magnitudes. So we decided to use a larger sample for more in-depth analysis and rigorously test mediation pathways.

Formal Study.

Following our pilot study, 316 college student-athletes (Females = 165, Males = 151) with a mean age of 19.78 years (SD = ±1.75) were recruited for this study. Participants had an average of 7.72 years (SD = ±3.02) of participation in their sports, training days per week (M = 5.33, SD = ±2.30), and training hours per day (M = 3.43, SD = ±1.53). They had been participating in 21 varied sports, including individual sports of archery, gymnastics, judo, kendo, and team sports of rugby, hockey, basketball, and baseball. Inclusion criteria were engaging in competitive sports in college regularly and at least once in competition after they entered college. Exclusion criteria were: (a) recreational sport participants without regular and formal training; (b) new varsity members with no competition experiences; and (c) varsity athletes, but injured without competition more than six months.

Measures

Demographic questionnaire

The demographic questionnaire collected participants' age, gender, sport, and details of athletic experience.

The Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) was designed to assess overall sleep quality within the past month. The 18 items are derived into seven components: (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) sleep efficiency, (5) sleep disturbance, (6) use of sleep medication, and (7) daytime dysfunction. The PSQI was rated on a four-point Likert scale that ranged from 0 to 3. Traditionally, the PSQI is reverse-scored - that is, the higher the score, the poorer the sleep quality. For our study, we used a reverse scoring system. For example, if participants rated subjective sleep quality as very good, they were scored 3, fairly good =2, fairly bad=1, and very bad=0. The sum of the scores produces a global PSQI score (range 0 to 21), with higher scores representing better sleep quality. We used the total score of the PSQI for the main analysis, and its Cronbach's α was .73.

Life Orientation Test-Revised

The Life Orientation Test-Revised (LOT-R; Scheier et al., 1994) was used to measure dispositional optimism. The LOT-R consists of 10 items, measuring two dimensions of optimism and pessimism. Three items evaluate optimism, three items evaluate pessimism, and four items are not scored. The LOT-R was rated on a five-point Likert scale that ranged from 1 to 5. The high score of the original LOT-R represents low optimism. To avoid confuse readers, we used a reverse scoring system for both dimensions - for optimism, 1 = strongly disagree to 5 = strongly agree; for pessimism, 1 = strongly agree to 5 = strongly disagree, with higher scores indicating greater optimism (pessimism), and lower scores representing lower optimism (pessimism). We only used the optimistic dimension to conduct mediation analysis, and Cronbach's α was .64.

Athletic Mental Energy Scale

The Athletic Mental Energy Scale (AMES; Lu et al., 2018) was used to assess the athlete's perception of their mental energy state. The 18-item AMES comprises six subscales: confidence, vigor, tirelessness, concentration, calmness, and motivation. A sample question for vigor is, " I feel spiritual to do everything in sports." For confidence, a sample question is, "I feel I can win all competitions in the future." For motivation, a sample question is, "I am full of passion to attend my sports." For calmness, a sample question is, "When facing to my opponents I am calm." For concentration, a sample question is, "There's nothing distracting me in competition." For tirelessness, a sample question is, "No matter how long the training lasts, I don't feel tired." Participants indicated their responses on a six-point Likert scale that ranging from 1 (not at all) to 6 (completely so), with higher scores representing high mental energy. The Cronbach's α of the subscales of AMES ranged from .77 to .94, and the total score of AMES was .94. We used the six factors of AMES and the total AMES score for the primary analysis.

Procedure

Before data collection, we gained approval from a local institute ethical committee named Antai- Tian-Sheng Memorial Hospital Institutional Review Board (TSMHIRB-23-

090-B). Then, we contacted the target teams' coaches through emails and phone calls and briefly informed them of the purpose of the research, confidentiality, and anonymity for participation. We used a convenience sampling strategy, focusing on collegiate athletic teams that are actively participating in sports. To mitigate potential selection bias, our sample included athletes of varying skill levels, sport type (e.g., basketball, swimming, baseball, and golf), and a wide range of athletic training experience from 1 year to more than 10 years. After agreement, we made an appointment to visit target teams and collect data. The survey package included a demographic questionnaire, AMES, LOT-R, and PSQI. To prevent social desirability effects, we informed participants that this was a study to explore college students' life experiences; there were no right or wrong answers, and all responses would be confidential. If they agreed, they signed the consent forms and completed the survey package. We collect our data from September 10 to October 10, 2024.

Stattistical Analysis

Descriptive statistical analysis was used to examine means, standard deviations, skewness, kurtosis, outliers, and missing data. The reliability of the scales was evaluated by calculating Cronbach's alpha coefficients. Pearson product-moment correlation analysis was used to examine the correlations of all variables. Furthermore, multiple hierarchical regressions were conducted following Baron and Kenny's (1986) suggestion to examine the mediating effect of optimism on the relationship between sleep quality and athletes' mental energy. In the present study, the independent variable was sleep quality, the mediator was optimism, and the dependent variable was athletes' mental energy. We examined the following conditions based on Baron and Kenny's (1986) suggestions: (a) quality of sleep should be able to account for variance in optimism; (b) optimism should be able to account for variance in mental energy; and (c) quality of sleep should be able to account for variance in mental energy. If all three conditions were met, the subsequent mediating of optimism on the relationship between quality of sleep and mental energy was further analyzed. To examine the main effects, quality of sleep was entered into the regression in the first step. Optimism was entered in the second step, and quality of sleep and optimism were entered in the third step. The final test of mediation was to examine whether optimism would still predict mental energy when the quality of sleep was controlled. Furthermore, we used the Sobel test to examine the mediating effect. We used SPSS 18.0 statistical software for all analyses, and the significance was set at $p < 0.05$.

Results

The first inspection of the completed questionnaire packages confirmed no missing or error data. Therefore, data from the entire sample of 316 participants (males = 151; females = 165; with $M_{age} = 19.78$, SD ± 1.75) were analyzed. The participants' demographic characteristics are listed in Table 1.

Preliminary analysis revealed that skewness (−.1.4 ~ .70) and kurtosis (−.48~ .60) for all variables were normally distributed, which indicated all acceptable ranges (Sharma & Ojha, 2020). All subscales exhibited appropriate internal reliability ($\alpha = 0.51\text{-}0.94$). Descriptive statistics showed more

TABLE I
Frequency distribution of participants' demographics

Characteristics	(n = 316) Frequency (%)
Sex	
Male	151 (47.78%)
Female	165 (52.22%)
Age	
16-19 years	172 (54.43%)
20-23 years	131 (41.46%)
24 & above	13 (4.11%)
Years of participation in sports	
1-5 years	78 (24.68%)
6-10 years	193 (61.08%)
11-15 years	41 (12.97%)
16 & above	4 (1.27%)

female participants than males (52.22% vs. 47.78%). Most participants' ages were 16-23 years, with mostly 6-10 years of sports experience (see Table 1). Further, participants had slightly high quality of sleep (M = 15.15; SD = ± 2.86), optimism (M = 10.40; SD = ± 1.94) and mental energy (M = 69.00; SD = ± 14.13) as Table 2 indicates. The correlation matrix and descriptive statistics for all variables are presented in Table 2. Total PSQI correlated with all factors of PSQI (quality, latency, duration, efficiency, medication, disturbance, and dysfunction) ranging from r = .68~ .34 (p < .01). Also, PSQI positively correlated with the six factors and the total score of AMES (r = .15~ .35, p < .01). Further, PSQI also positively correlated with optimism (r =.22, p < .01). Furthermore, pessimism was negatively correlated with the total score of AMES and six factors of the AMES (r = -0.18~-0.12, p < .05). Further, a simple regression analysis showed that PSQI positively predicted optimism (β =0.22, p < .01) and AMES (β =0.30, p < .01). Optimism positively predicted AMES (β =0.46, p < .01), as Table 3 indicates. Therefore, subsequent mediation analysis is appropriate.

Mediating effects of optimism on the relationship between PSQI and AMES

As Table 4 shows, when optimism was controlled in the first step of the regression analyses, PSQI significantly predicted AMES (R^2 = 0.09, F (1, 315) = 31.56). However, when the mediator of optimism was introduced in the second step, the prediction of PSQI on AMES was significantly less after controlling optimism (β from 0.30 to 0.21), but PSQI still significantly

TABLE II
Correlation matrix and descriptive statistics of the study variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Sl quality	-																
(2) Sl latency	.48**	-															
(3) Sl duration	.20**	.18**	-														
(4) Sl efficiency	.14*	.19**	.39**	-													
(5) SL disturbance	.27**	.30**	.10	.15**	-												
(6) Use medicines	.19**	.20**	.06	.13*	.13*	-											
(7) DT dysfunction	.40**	.28**	.18**	.09	.21**	.20**	-										
(8) PSQI	.66**	.68**	.60**	.59**	.48**	.34**	.58**	-									
(9) Confidence	.19**	.28**	-.01	.14*	.10	.08	.16**	.24**	-								
(10) Vigor	.39**	.30**	.06	.05	.20**	.14*	.31**	.35**	.57**	-							
(11) Tireless	.25**	.26**	.02	-.02	.08	.09	.26**	.23**	.55**	.51**	-						
(12) Concentra-tion	.22**	.30**	-.02	.05	.13*	.07	.21**	.24**	.63**	.52**	.48**	-					
(13) Calm	.14*	.15**	-.03	.06	.10	-.02	.19**	.15**	.63**	.42**	.47**	.59**	-				
(14) Motivation	.17**	.22**	.06	.10	.18**	.10	.17**	.24**	.63**	.51**	.49**	.56**	.53**	-			
(15) Mental energy	.28**	.32**	.02	.08	.17**	.09	.27**	.30**	.85**	.73**	.74**	.81**	.79**	.79**	-		
(16) optimistic	.21**	.24**	-.04	.09	.13*	.06	.19**	.22**	.43**	.35**	.34**	.39**	.32**	.34**	.46**	-	
(17) pessimism	-.01	-.14*	-.01	-.05	-.08	-.06	-.10	-.11	-.15**	-.17**	-.13*	-.16**	-.12*	-.13*	-.18**	-.16**	-
Mean	1.85	1.88	2.06	2.42	1.92	2.96	2.05	15.15	11.58	11.75	9.35	11.53	11.39	13.40	69.00	10.40	9.00
SD	0.66	0.88	0.88	0.91	0.52	0.27	0.73	2.86	2.86	2.71	3.19	3.49	3.39	3.12	14.73	1.94	2.02
α	NA	.76	NA	NA	.70	NA	.51	.73	.77	.94	.85	.92	.87	.82	.94	.64	.57

Notes: $^{**}p < 0.01$, $^{*}p < 0.05$, Sl = sleep, DT = daytime

TABLE III
Simple regression of PSQI and optimism on AMES.

Variables	Optimism		AMES	
	β	ΔR^2	β	ΔR^2
Regression 1[a]				
PSQI	0.22**	0.04		
Regression 2[b]				
PSQI			0.30**	0.09
Optimism			0.46**	0.21

Note:
[a] Dependent variable is Optimism.
[b] Dependent variable is AMES.
**$p < 0.01$

TABLE IV
Summary of the hierarchical regression in predicting AMES.

	Predictor	R^2	β
Step 1		.09	
	Sleep quality		.30**
Step 2		.25	
	Sleep quality		.21**
	optimism		.41**
Sobel's *Z*			3.71**

Note. ** $p < 0.01$

predicted AMES ($R^2 = 0.25$, $F(1, 315) = 53.19$), thus indicating a partial mediating effect. The Sobel test found that the mediating effect was significant (Sobel's Z = 3.71, $p < .01$).

Discussion

To fill the gap in the current literature, the purposes of this study were to examine the triangular relationships of quality of sleep, optimism, and athletes' mental energy; and examine the mediating role of optimism in the quality of sleep-mental energy relationship. As predicted, athletes' quality of sleep, mental energy, and optimism all correlated, and optimism mediated the relationship between quality of sleep and mental energy. The initial findings have several implications.

Theoretical contributions/implications

First, our results support past research that quality of sleep is associated with positive physical and mental outcomes for athletes (e.g., Vitale et al., 2019). However, our study extends such effects to mental energy. The significant relationship between quality of sleep and mental energy suggests that sports professionals offer sleep management programs for athletes, not only for athletes' physical health/performance but also mental energy. Specifically, recent studies found mental energy predicts competition performance (Chuang et al., 2022; Hsih et al., 2023), is associated with flow experience (Öner, 2022), sport courage (Islam, 2023), and moderates athletes' life stress and burnout (Chiu et al., 2021). To promote athletes' sport participation and well-being, offering sleep management programs are imperative.

The association between quality of sleep and optimism echoes extant literature that appropriate sleep is beneficial to the development of dispositional optimism (Abramson et al.,1989). Healthy sleep not only enhances physical health but also regulates mood and emotions (Matricciani et al., 2019). After a well-rested sleep, athletes are more likely to have a better mood and be willing to engage in intensive training and competition with a constructive and optimistic mindset. In contrast, lack of sleep can lead to irritability, anxiety (Park, 2022), and even depression, making it difficult to maintain an optimistic perspective (Shneerson, 2009). We suggest that athletes maintain a healthy sleep habit. After enough restful sleep, they are more likely to feel optimistic and motivated to face challenges and difficulties in sports.

One of the unique findings of this study was the relationship between quality of sleep and athletes' mental energy. Quality sleep are crucial for maintaining energy levels in the body and mind (Shneerson, 2009). In contrast, chronic sleep deprivation or poor sleep quality can lead to feelings of anxiety (Park, 2022), fatigue, and low vitality (Killgore, 2010). Several theoretical mechanisms may explain why quality of sleep is so important to mental energy. First, a good sleep restores adenosine triphosphate (ATP)- the body's primary energy molecule. By sufficient ATP supplies, athletes are able to engage in sports training and competition with high vigor (Adam & Oswald, 1977). Further, research found after a good sleep the mitochondria function will become more efficiently. Mitochondria are often called the "powerhouses of the cell" because it generates the majority of the cell's energy in the form of ATP through cellular respiration. Mitochondria not only influences energy generation but also regulates cell metabolism, programs cell's birth and death, maintains body temperature, produces reactive oxygen species, and circulates DNA (Han et al., 2024). Furthermore, during sleep it constitutes the recuperative process of the central nervous system. In the daytime, the wakefulness will lead to energy depletion in the cortical areas locally responsible for activity. A sufficient sleep will restore brain physiology to normal levels, which in turn, results in restored alertness, memory capacity, and mood (Åkerstedt et al. 2009).

The other unique contribution of the present study was we adopted a sport-specific measure -AMES to conduct our study. We found PSQI correlated with all sub-factors of AMES, including confidence, vigor, motivation, calmness, concentration, and tirelessness. The results extend current knowledge of sleep literature and outline the vital role of sleep for athletes (Hsieh et al., 2022; Chuang et al., 2023). Athletes need quality sleep - not only to help them to recover from intensive training but also for mental energy (Copenhaver & Diamond, 2017).

The significant correlation between optimism and mental energy merits discussion. A positive outlook on life (i.e., optimism) can boost confidence and motivation toward challenges. An optimistic attitude can promote motivation and enthusiasm to tackle difficulties and adversities in sports (Grove & Heard, 1997). In addition, when athletes believe they can achieve their goals, they are more likely to stay motivated and have the energy to pursue goals (Solberg Nes et al., 2009). Furthermore, an optimistic attitude can enhance emotional energy by fostering a sense of happiness, contentment, and overall well-being (Segerstrom et al., 1998). We found optimism correlated with all mental energy cognitive components (i.e., motivation, confidence, and concentration) and emotional components (i.e., vigor, tirelessness, and calm), adding our knowledge in this line of research.

The mediating role of optimism in the quality of sleep and mental energy is theoretically meaningful. According to Baron and Kenny (1986), mediation plays an explanatory role between stimulus and response. According to our results, athletes might have sufficient sleep quality, but whether they perceive high mental energy partially depends on optimism. In other words, the quality of sleep influences mental energy because of optimism. As Lau et al. (2015; 2017) indicated, the quality of sleep can contribute to the development of optimism, and optimism is the consequence of sleep. Further, several studies (e.g., Kelberer et al., 2018; Li & Wu, 2011) contend that optimistic individuals tend to exhibit higher vigor, confidence, motivation, and concentration, which suggests that optimism is the antecedent of mental energy. Thus, optimism plays a central role in the quality of sleep-mental energy relationships. Athletes must establish healthy sleep habits, which can be beneficial to the development of optimism and mental energy.

Limitations And Future Suggestions

Several limitations need to be discussed. First, because we adopted a cross-sectional approach, the results do not imply causal relationships. We suggest that future studies adopt a longitudinal design to investigate athletes' sleep quality, optimism, and mental energy over time to examine causal effects. Second, we sampled college student-athletes as participants. Whether the results can be generalized to other athletes, such as youth athletes, recreational athletes, or professional athletes, needs to be further examined. Third, Cronbach's α for the LOT-R optimism was in the marginal range in terms of reliability. Gronier (2022, pp.1-13) suggested that cultural factors might potentially influence psychometric properties of psychological measures. We advise readers to interpret results cautiously. Further, we measured participants' mental energy with a sport-specific measure, AMES. Whether other measures such as attention ability (e.g., Mohajeri et al., 2014; Snitz et al.,2009), reaction time (Mohajeri et al., 2014), or memory (e.g., Kennedy et al., 2004; 2007) have the same results need to be further examined. Moreover, we only examined optimism as a mediator for the quality of sleep and mental energy. Whether similar factors, such as trait hope, resilience, and mental toughness, have similar effects needs to be further examined.

Conclusion

We examined the triangular relationships among athletes' quality of sleep, optimism, and mental energy. We found athletes' quality of sleep closely relates to optimism and mental energy, and optimism mediates the quality of sleep-mental energy relationship. The results advance our understanding of quality of sleep, optimism, and mental energy, and provide insightful information for sports professionals and researchers. We hope future studies adopt a longitudinal approach to investigate the cause-and-effect relationships among athletes' quality of sleep, optimism, and mental energy. Also, we suggest sports professionals provide sleep management programs for athletes- not only for their health/performance but also for mental energy.

REFERENCES

Abramson, L. Y., Metalsky, G. I., & Alloy, L. B. (1989). Hopelessness depression: A theory-based subtype of depression. *Psychological review*, *96*(2), 358. https://psycnet.apa.org/doi/10.1037/0033-295X.96.2.358

Adam, K., & Oswald, I. (1977). Sleep is for tissue restoration. *Journal of the Royal College of Physicians of London*, *11*(4), 376.

Åkerstedt, T., Nilsson, P. M., & Kecklund, G. (2009). Sleep and recovery. In *Current perspectives on job-stress recovery* (pp. 205-247). Emerald Group Publishing Limited.Alvaro, P. K., Roberts, R. M., & Harris, J. K. (2013). A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep*, *36*(7), 1059-1068. https://doi.org/10.5665/sleep.2810

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology*, *51*(6), 1173. https://psycnet.apa.org/doi/10.1037/0022-3514.51.6.1173

Burke, T. M., Lisman, P. J., Maguire, K., Skeiky, L., Choynowski, J. J., Capaldi, V. F., ... & Dobrosielski, D. A. (2020). Examination of sleep and injury among college football athletes. *The Journal of Strength & Conditioning Research*, *34*(3), 609-616. https://doi.org/10.1016/j.cpr.2020.101895

Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry research*, *28*(2), 193-213. https://doi.org/10.1016/0165-1781(89)90047-4

Connelly, L. M. (2008). Pilot studies. *Medsurg nursing*, 17(6), 411-2.

Cappuccio, F. P., D'Elia, L., Strazzullo, P., & Miller, M. A. (2010). Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep*, *33*(5), 585-592. https://doi.org/10.1093/sleep/33.5.585

Chiou, S. S., Hsu, Y. W., Chiu, Y. H., Chou, C. C., Gill, D. L., Lu, F. J. H., (2020). Seeking Positive Strengths in Buffering Athletes' Life Stress-Burnout Relationship: The Moderating Roles of Athletic Mental Energy. *Frontiers in Psychology, 10*, 3007. https://doi.org/10.3389/fpsyg.2019.03007.

Chuang W, Lu, F.J.H., Gill DL, & Fang B. (2022). Pre-competition mental energy and performance relationships among physically disabled table tennis players. PeerJ 10:e13294 https://doi.org/10.7717/peerj.13294

Doherty, R., Madigan, S. M., Nevill, A., Warrington, G., & Ellis, J. G. (2021). The sleep and recovery practices of athletes. *Nutrients*, *13*(4), 1330. https://doi.org/10.3390/nu13041330

Gronier, G. (2022). Psychometric analyses in the transcultural adaptation of psychological scales. In S. Misciagna (Ed.), *Psychometrics -new insights* (pp. 1–13). IntechOpen

Grandner, M. A., Hall, C., Jaszewski, A., Alfonso-Miller, P., Gehrels, J. A., Killgore, W. D., & Athey, A. (2021). Mental health in student athletes: associations with sleep duration, sleep quality, insomnia, fatigue, and sleep apnea symptoms. *Athletic training & sports health care*, *13*(4), e159-e167. https://doi.org/10.3928/19425864-20200521-01

Granz, H. L., Schnell, A., Mayer, J., & Thiel, A. (2019). Risk profiles for athlete burnout in adolescent elite athletes: A classification analysis. *Psychology of Sport and Exercise*, *41*, 130-141. https://doi.org/10.1016/j.psychsport.2018.11.005

Grove, J. R., & Heard, N. P. (1997). Optimism and sport confidence as correlates of slump-related coping among athletes. *The Sport Psychologist*, *11*(4), 400-410. https://doi.org/10.1123/tsp.11.4.400

Han, S., Kim, D. K., Jun, S. E., & Kim, N. (2024). Association of sleep quality and mitochondrial DNA copy number in healthy middle-aged adults. *Sleep Medicine*, *113*, 19-24. https://doi.org/10.1016/j.sleep.2023.11.011

İslam, A. (2023). Three variables in the training of female soccer players: The relationship between psychological skills, mental energy and courage. *E-International Journal of Educational Research*, *14*(1), 73-390.

Kelberer, L. J., Kraines, M. A., & Wells, T. T. (2018). Optimism, hope, and attention for emotional stimuli. *Personality and Individual Differences*, *124*, 84-90. https://doi.org/10.1016/j.paid.2017.12.003

Kennedy, D.O., Jackson, P.A., Haskell, C.F., and Scholey, A.B., (2007). Modulation of cognitive performance following single doses of 120 mg *Ginkgo biloba* extract administered to healthy young volunteers. *Hum Psychopharmacology, 22, (8),* 559-566. https://doi.org/10.1002/hup.885.

Killgore, W. D. (2010). Effects of sleep deprivation on cognition. *Progress in brain research*, *185*, 105-129. https://doi.org/10.1016/B978-0-444-53702-7.00007-5

Knutson, K. L., Spiegel, K., Penev, P., & Van Cauter, E. (2007). The metabolic consequences of sleep deprivation. *Sleep medicine reviews*, *11*(3), 163-178. https://doi.org/10.1016/j.smrv.2007.01.002

Lau, E. Y. Y., Hui, C. H., Cheung, S. F., & Lam, J. (2015). Bidirectional relationship between sleep and optimism with depressive mood as a mediator: a longitudinal study of Chinese working adults. *Journal of Psychosomatic Research*, *79*(5), 428-434. https://doi.org/10.1016/j.jpsychores.2015.09.010

Lau, E. Y. Y., Hui, C. H., Lam, J., & Cheung, S. F. (2017). Sleep and optimism: A longitudinal study of bidirectional causal relationship and its mediating and moderating variables in a Chinese student sample. *Chronobiology international*, *34*(3), 360-372. https://doi.org/10.1080/07420528.2016.1276071

Lemola, S., Räikkönen, K., Scheier, M. F., Matthews, K. A., Pesonen, A. K., Heinonen, K., ... & Kajantie, E. (2011). Sleep quantity, quality and optimism in children. *Journal of sleep research*, *20*(1pt1), 12-20. https://doi.org/10.1111/j.1365-2869.2010.00856.x

Li, C. H., & Wu, J. J. (2011). The structural relationships between optimism and innovative behavior: Understanding potential antecedents and mediating effects. *Creativity Research Journal*, *23*(2), 119-128. https://doi.org/10.1080/10400419.2011.571184

Lu, F. J. H., Gill, D. L., Yang, C. M. C, Lee, P. F., Chiu, Y. H., Hsu, Y. W., & Kuan, G. (2018). Measuring athletic mental energy (AME): instrument development and validation. *Frontier in Psychology, 9*, 1-15. https://doi.org/10.3389/fpsyg.2018.02363.

Lykken, T. D. (2005). Mental energy. *Intelligence 33*, 331-335. https://doi.org/ 10.1016/j.intell.2005.03.005

Matricciani, L., Paquet, C., Galland, B., Short, M., & Olds, T. (2019). Children's sleep and health: a meta-review. *Sleep medicine reviews*, *46*, 136-150. https://doi.org/10.1016/j.smrv.2019.04.011

Milewski, M. D., Skaggs, D. L., Bishop, G. A., Pace, J. L., Ibrahim, D. A., Wren, T. A., & Barzdukas, A. (2014). Chronic lack of sleep is associated with increased sports injuries in adolescent athletes. *Journal of Pediatric Orthopaedics*, *34*(2), 129-133. https://doi.org/10.1097/BPO.0000000000000151

Mohajeri, M. Wittwer, H. Vargas, J.K. et al. (2014). Chronic treatment with a tryptophan-rich protein hydrolysate improves emotional processing, mental energy levels and reaction time in middle-aged women. *British Journal of Nutrition (2015), 113*, 350-365. https://doi.org/10.1017/S0007114514003754

O'Connor, P.J., & Burrowes, J. (2006). Mental energy: Defining the science. *Nutrition Reviews, 64 (3),* s1-s11.

O'Connor, P.J., & Burrowes, J. (2006). Mental energy: Defining the science. *Nutrition Reviews, 64 (3),* s1-s11.

Öner, Ç. (2022). The determinative role of athletic mental energy and mindfulness in the flow experience of football players. *International Journal of Education Technology & Scientific Researches*, *7*(20).

Park, S. H. (2022). Effects of sleep quality on internal-external anxiety in elite shooters before competitions. *International Journal of Sport Psychology*, *53*(5), 497-505. doi: 10.7352/IJSP.2022.53.497

Rahmani, M., Rahmani, F., & Rezaei, N. (2020). The brain-derived neurotrophic factor: missing link between sleep deprivation, insomnia, and depression. *Neurochemical research*, *45*(2), 221-231.

Salminen, S., Mäkikangas, A., & Feldt, T. (2014). Job resources and work engagement: Optimism as moderator among Finnish managers. *Journal of European Psychology Students*, *5*(1). https://doi.org/10.5334/jeps.bu

Scheier, M. F., Carver, C. S., & Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): a reevaluation of the Life Orientation Test. *Journal of personality and social psychology*, *67*(6), 1063. https://psycnet.apa.org/doi/10.1037/0022-3514.67.6.1063

Segerstrom, S. C., Taylor, S. E., Kemeny, M. E., & Fahey, J. L. (1998). Optimism is associated with mood, coping, and immune change in response to stress. *Journal of personality and social psychology*, *74*(6), 1646. https://psycnet.apa.org/doi/10.1037/0022-3514.74.6.1646

Shieh, S. F., Lu, F. J., Gill, D. L., Yu, C. H., Tseng, S. P., & Savardelavar, M. (2023). Influence of mental energy on volleyball competition performance: a field test. *PeerJ*, *11*, e15109.

Shneerson, J. M. (2009). *Sleep medicine: a guide to sleep and its disorders*. John Wiley & Sons. Suinn R. (1986). *Seven steps to peak performance*. Toronto: Hans Huber.

Silva, A., Narciso, F. V., Soalheiro, I., Viegas, F., Freitas, L. S., Lima, A., ... & de Mello, M. T. (2019). Poor sleep quality's association with soccer injuries: preliminary data. *International journal of sports physiology and performance*, *15*(5), 671-676. https://doi.org/10.1123/ijspp.2019-0185

Sing, C. Y., & Wong, W. S. (2011). The effect of optimism on depression: The mediating and moderating role of insomnia. *Journal of health psychology*, *16*(8), 1251-1258. https://doi.org/10.1177/1359105311407366

Snitz, B.E., O'Meara, E.S., Carlson, M.C., et al. (2009). *Ginkgo biloba* for preventing cognitive decline in older adults: a randomized trial. *JAMA*, *302 (63),* 2663–2670. https://doi.org/10.1001/jama.2009.1913.

Solberg Nes, L., Evans, D. R., & Segerstrom, S. C. (2009). Optimism and college retention: mediation by motivation, performance, and adjustment 1. *Journal of Applied Social Psychology*, *39*(8), 1887-1912. https://doi.org/10.1111/j.1559-1816.2009.00508.x

Spiegel, K., Sheridan, J. F., & Van Cauter, E. (2002). Effect of sleep deprivation on response to immunizaton. *Jama*, *288*(12), 1471-1472. https://doi:10.1001/jama.288.12.1469

Thompson, A., & Gaudreau, P. (2008). From optimism and pessimism to coping: The mediating role of academic motivation. *International Journal of Stress Management*, *15*(3), 269. https://psycnet.apa.org/doi/10.1037/a0012941

Tobaldini, E., Costantino, G., Solbiati, M., Cogliati, C., Kara, T., Nobili, L., & Montano, N. (2017). Sleep, sleep deprivation, autonomic nervous system and cardiovascular diseases. *Neuroscience & Biobehavioral Reviews*, *74*, 321-329. https://doi.org/10.1016/j.neubiorev.2016.07.004

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

Zenger, M., Brix, C., Borowski, J., Stolzenburg, J. U., & Hinz, A. (2010). The impact of optimism on anxiety, depression and quality of life in urogenital cancer patients. *Psycho-Oncology*, *19*(8), 879-886. https://doi.org/10.1002/pon.1635

Manuscript submitted November 2024 . Accepted for publication April 2025 .