THE EFFECT OF SWIMMING ON SLEEP QUALITY IN UNIVERSITY COMBAT SPORT ATHLETES FOLLOWING INTENSE TRAINING

Cătălin PĂUNESCU[1*], Teodor PĂUNESCU[2], Dănuț PASCU[3]
[1] *University of Medicine and Pharmacy "Carol Davila", Bucharest, Romania*
[2] *National Physical Education and Sport University, Bucharest, Romania*
[3] *University of Craiova, Faculty of Physical Education and Sport, Romania*
**Corresponding author: e-mail: catalinpaunescu@umfcd.ro*

https://doi.org/10.52846/46.2025.1.15

Abstract: *Background:* Adequate sleep is fundamental for recovery and performance in combat sport athletes, yet high-intensity training often disrupts sleep architecture. Active recovery strategies such as swimming may counteract these effects, though evidence is limited. *Methods*: Twenty-four medical students (19–24 years), members of the university combat sport team, were randomly assigned to an intervention group (n = 12) or a control group (n = 12). Following training at 85% of maximal heart rate (HRmax), the intervention group completed 20 minutes of low-intensity swimming, while the control group followed passive recovery routines. Sleep was assessed objectively using Garmin Fenix 5 smartwatches. Parameters included total sleep time (TST), sleep efficiency (SE), deep sleep, REM sleep, and resting heart rate (RHR). Data were analysed using paired and independent t-tests, with significance set at $p < .05$.
Results: Baseline comparisons showed no significant group differences. After the intervention, the swimming group demonstrated significant improvements: TST increased by 11% versus an 18% decline in controls; SE rose by 1% compared with a 5% reduction; deep sleep and REM sleep increased by 8% and 16%, while controls declined by 46% and 40%, respectively. RHR decreased by 4% in swimmers but increased by 5% in controls.
Conclusion: Post-exercise swimming significantly improved sleep duration, efficiency, and restorative stages in combat sport athletes compared with passive recovery. These findings suggest swimming facilitates both physiological and cognitive-emotional recovery, supporting its integration into recovery protocols for athletes following intense training.
Keywords: swimming, sleep quality, combat sports, recovery, Garmin Fenix 5, athletes

Introduction

Sleep is a fundamental biological process that plays a critical role in recovery, adaptation, and overall health. For athletes, especially those engaged in high-intensity and combat-based sports, sleep is not only essential for physiological restoration but also for cognitive and emotional regulation (Fullagar et al., 2015). Poor sleep quality has been linked to impaired recovery, decreased performance, and increased susceptibility to injury and illness (Watson et al., 2017). Therefore, optimising sleep through evidence-based interventions is a priority for sports science and athletic training. Combat sports, such as judo, wrestling, and mixed martial arts, place unique demands on athletes. Training sessions typically combine intense anaerobic bursts, high levels of neuromuscular stress, and significant psychological load due to weight management, tactical preparation, and competition anxiety (Chaabene et al., 2015). These stressors frequently contribute to disturbed sleep patterns and delayed recovery in combat athletes. As a result, coaches and researchers are increasingly interested in recovery modalities that could mitigate these effects and promote restorative sleep. Active recovery strategies, including low-intensity exercise, have gained attention as complementary approaches to enhance recovery. Swimming, in particular, is a form of exercise with low mechanical load, which allows athletes to maintain cardiovascular activity while reducing musculoskeletal strain (Bessa et al., 2016). Beyond its physiological benefits, swimming has also been associated with psychological relaxation, stress reduction, and improvements in mood states, all of which can contribute to better sleep outcomes (Driver & Taylor, 2000). Kredlow et al. (2015) highlighted that regular exercise improves sleep efficiency and reduces sleep latency, while Fullagar et al. (2015) emphasised the importance of recovery modalities in enhancing both physical and psychological restoration in elite athletes. Our study extends this evidence by addressing the specific role of swimming as a targeted recovery intervention in combat sport athletes. The relationship between exercise and sleep has been investigated in various populations. Several studies indicate that moderate-intensity exercise may improve total sleep time, sleep efficiency, and the proportion of restorative sleep stages (Kredlow et al., 2015). Deep sleep, in particular, is vital for physical restoration, muscle repair, and hormonal regulation (Dattilo et al., 2011), while aquatic-based exercise has been shown to enhance parasympathetic activity and relaxation (Chen et al., 2020). However, while general exercise–sleep interactions are well documented, there is limited research focusing specifically on the effect of swimming as a recovery modality for combat sport athletes. Furthermore, the use of wearable technology, such as smartwatches, has introduced new opportunities for the objective measurement of sleep in applied sport settings (de Zambotti et al., 2019). Devices like the Garmin Fenix 5 provide detailed insights into sleep duration, efficiency, and sleep stage distribution, offering reliable data without disrupting natural sleep environments. Given the critical importance of sleep in recovery and performance, and the potential of swimming to act as both a physiological and psychological recovery strategy, this study aimed to investigate the effect of post-exercise swimming on sleep quality in university combat sport athletes following intense training. In this context, the preparation of medical students who are members of the university's representative combat team is a demanding process, designed to maximise individual performance for institutional representation at the highest levels while fulfilling planned objectives (Mircică et al., 2024). By employing a controlled experimental design with intervention and control groups and utilising wearable sleep monitoring technology, the study provides novel insights into practical recovery strategies for combat sports at the collegiate level.

Research Hypothesis: It was hypothesised that swimming sessions performed after high-intensity training would significantly improve objective sleep parameters—such as total sleep time, sleep efficiency, and deep sleep duration—compared to standard passive recovery routines.

Materials and method

Participants

Twenty-four medical students (n = 24), members of the representative combat sport teams (karate, taekwondo, and judo) at the "Carol Davila" University of Medicine and Pharmacy, Bucharest, voluntarily participated in this study. Participants were aged between 19 and 24 years (M = 21.54, SD = ±1.69) and reported no injuries or sleep disorders at the time of enrolment. Randomisation was conducted using a computer-generated sequence obtained from Random.org, with 1:1 allocation stratified by sport discipline. Athletes were allocated to either the intervention group (n = 12), which engaged in swimming as a recovery modality, or the control group (n = 12), which followed standard passive recovery routines. Written informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki and approved by the institutional ethics committee.

Study Design and Procedure

A randomised controlled design was employed over a three-week period. Following high-intensity training sessions at 85% of maximal heart rate (HRmax), the intervention group undertook a swimming-based recovery protocol. Specifically, participants commenced the swimming session 15 minutes after training, lasting 20 minutes, at an intensity of 55–60% of maximal heart rate (HRmax), alternating between front crawl and backstroke in a randomised order, using the university swimming pool. In contrast, the control group, also 15 minutes post-training for 20 minutes, followed standard post-exercise routines consisting of passive rest. Both groups completed sport-specific training sessions under identical supervision throughout the study.

Measures

The parameters monitored during exercise and recovery, as well as objective sleep quality, were individually assessed using Garmin Fenix 5 smartwatches, which have been validated for sleep monitoring under natural conditions (de Zambotti et al., 2019) and for physical activity tracking (Düking et al., 2020; Evenson & Spade, 2020). Devices were worn nightly by each participant, beginning one week prior to the intervention to establish baseline values. Over the following two weeks, participants continued to wear the devices during high-intensity training sessions, performed three times per week with four-day recovery intervals, as well as during the post-exercise recovery period and sleep. Key sleep parameters recorded and analysed included:

- Total Sleep Time (TST, hours)
- Sleep Efficiency (%)
- Deep Sleep Duration (minutes)
- REM Sleep Duration (minutes)
- Light (minutes)
- Awake (minutes)
- Resting Heart Rate during sleep (beats per minute)

Participants were instructed to consistently wear the device during sleep to maintain stable routines throughout the study. All participants completed the recovery session at 21:35, following a similar post-exercise routine regarding meals and bedtime for both groups, in order to minimise variability related to sleep habits, meal timing, caffeine intake, and stress levels.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 25 and Microsoft Excel. Descriptive statistics (means ± SD) were calculated for all variables. Paired-sample t-tests were used to compare pre- and post-intervention values within groups, while independent-sample t-tests were employed to assess post-training differences between groups. Statistical significance was set at $p < 0.05$. Effect sizes (Cohen's d) were computed to quantify the magnitude of observed differences.

Results

Baseline analyses indicated no significant differences between the swimming and control groups across any sleep parameters ($p > 0.05$), confirming successful randomisation. Post-intervention analyses, however, revealed significant improvements in the swimming group across multiple objective sleep measures, while the control group exhibited minimal or no change (table 1). These findings suggest that swimming as a recovery modality elicited meaningful enhancements in sleep quality following high-intensity exercise, in contrast to passive recovery.

Table 1. Sleep Parameters at Baseline and Post-Intervention (Mean ± SD)

Parameter	Group	Baseline	Post-Intervention	Δ (%)	p-value (within roup)	95%CI	Cohen's d
Total Sleep Time (hrs)	Swimming	6.47 ±0.05	7.16 ±0.07	+11%	0.00*	1.711 1.868	20.738
	Control	6.52 ±0.15	5.37 ±0.10	-18%	0.00*		
Sleep Efficiency (%)	Swimming	96.9 ±0.24	97.5 ±0.24	+1%	0.01*	4.331 4.869	15.732
	Control	97.1±0.23	92.5 ±0.38	-5%	0.00*		
Deep Sleep Duration (min)	Swimming	78 ±3.16	85 ±3.41	+8%	0.01*	14.946 28.520	9.246
	Control	80 ±2.29	55 ±3.07	-46%	0.00*		
REM Sleep Duration (min)	Swimming	86 ±2.66	95 ±2.37	+16%	0.00*	23.006 26.993	13.388
	Control	88 ±2.29	63 ±2.41	-40%	0.00*		
Resting HR (bpm)	Swimming	58.6 ±0.35	56.2 ±0.16	-4%	0.00*	-7.108 -6.491	-31.924
	Control	58.5 ±0.34	65.3 ±0.37	+5%	0.00*		

**Note: p < .05 = statistically significant.*
Δ (%) = percentage change relative to the initial value
Abbreviations: 95% Confidence Interval (CI)= [Lower, Upper] for mean difference at post-intervention
Cohen's d = effect size for swimming vs. control at post-intervention

Table 1 summarizes the sleep parameters at baseline and post-intervention for both groups. Post-intervention analysis indicated significant improvements in the swimming group compared to the control group across all sleep parameters. Total Sleep Time increased by +11% in the swimming group versus −18% in the control group, while Sleep Efficiency rose slightly (+1%) compared to a decline in controls (−5%). Deep Sleep Duration and REM Sleep Duration improved by +8% and +16%, respectively, whereas controls showed marked reductions (−46% and −40%). Resting Heart Rate decreased by −4% after swimming recovery but increased by +5% in controls. The 95% confidence intervals for all mean differences did not cross zero, confirming the statistical robustness of these effects. Large Cohen's d values further highlight the substantial impact of swimming as a recovery strategy on sleep quality in combat sport athletes.

These findings indicate that post-exercise swimming significantly enhanced sleep quality and recovery markers in university-level combat sport athletes when compared with standard passive recovery. The most pronounced improvements were observed in deep sleep duration and overall sleep efficiency, both of which are critical for physiological restoration, including tissue repair, hormonal regulation, and neuromuscular recovery.

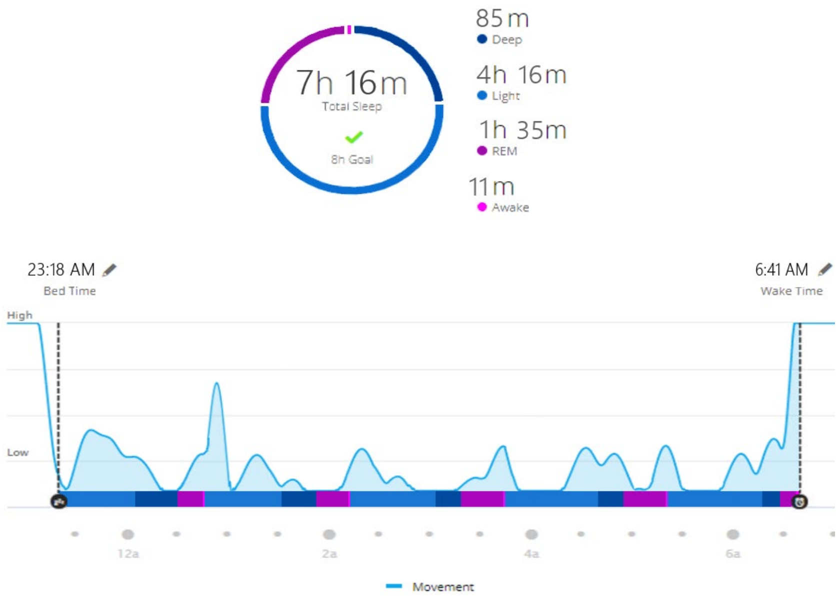

Figure 1. Mean Nocturnal Movement Pattern During Sleep in the Swimming Group

Body movement during sleep, following active recovery through swimming, is relatively low, with five cycles that can be associated with an equal number of brief and low-intensity awakenings (Figure 1). There is a greater proportion of deep sleep, which generally reduces muscular tension and stress, accompanied by short awakenings. Overall, sleep is more restorative and consolidated.

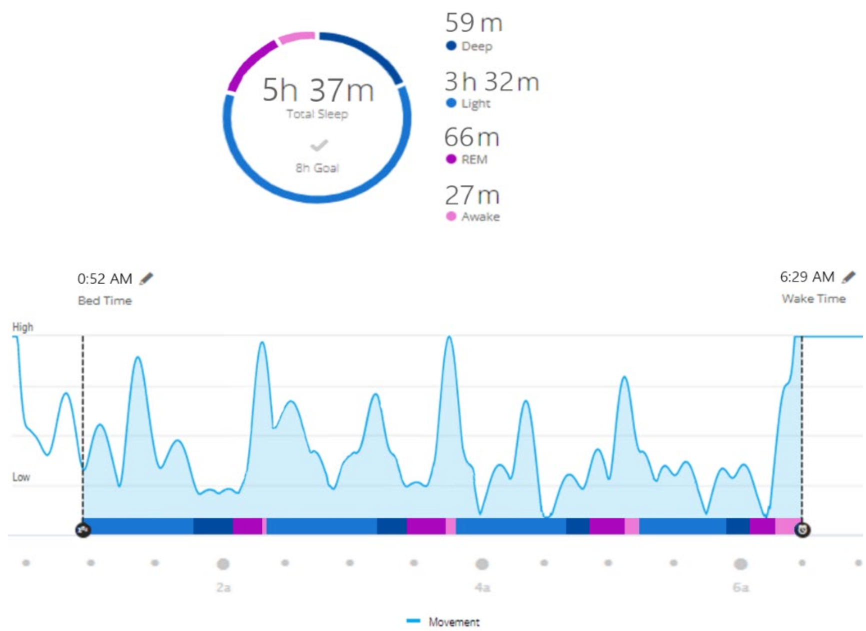

Figure 2. Mean Nocturnal Movement Pattern During Sleep in the Control Group

For the control group, which did not benefit from recovery through swimming, body movement during sleep across the four cycles is relatively active and is associated exclusively with awakening phases (Figure 2). The control group experienced restless sleep, characterised in the initial hours by fragmented sleep with shorter periods of deep sleep. The reduced amount of deep sleep provides insufficient muscular recovery, while the markedly diminished REM sleep directly impairs cognitive and emotional restoration. These patterns may be a consequence of intense training, lack of regular recovery practices, or elevated stress.

Discussion

The present study investigated the effects of post-exercise swimming on objective sleep quality in university combat sport athletes. The findings indicate that athletes who engaged in 20 minutes of low-intensity swimming following intense training sessions experienced significant improvements in total sleep time, sleep efficiency, deep sleep duration, and REM sleep duration compared to those who underwent standard passive recovery.

The present study demonstrates that swimming performed as an active recovery modality following high-intensity combat sport training has a significant positive effect on sleep quality in university athletes. Participants in the swimming group exhibited improvements in total sleep time, sleep efficiency, deep sleep, and REM sleep, together with a reduction in resting heart rate during sleep, while the control group showed pronounced deterioration across all parameters. These findings are consistent with previous evidence indicating that active recovery strategies such as swimming and low-intensity aerobic exercise facilitate autonomic balance, reduce sympathetic activation, and accelerate parasympathetic reactivation, thereby promoting better sleep architecture (Dupuy et al., 2018; Fullagar et al., 2015).

The observed decrease in nocturnal heart rate in the intervention group highlights the role of swimming in enhancing cardiovascular recovery, corroborating earlier studies that have identified resting HR as a sensitive marker of training load and recovery status in athletes (Stanley et al., 2013). Moreover, the preservation and even improvement of deep and REM sleep suggest that swimming attenuates the sleep disturbances typically induced by strenuous exercise, such as delayed sleep onset, fragmented sleep, or reduced restorative stages (Shapiro et al., 1981). Within deep sleep, essential processes occur such as muscular regeneration, growth hormone secretion, and tissue repair, while REM sleep supports neurocognitive recovery, memory consolidation, and emotional regulation (Chandrasekaran et al., 2020). Thus, sufficient amounts of both deep and REM sleep are fundamental for restorative sleep.

A fragmented and shortened sleep pattern may indicate inadequate recovery, characterised by reduced physical restoration due to diminished deep sleep and poor cognitive and emotional recovery due to decreased REM sleep. Furthermore, a predominance of light sleep is associated with superficial and less restorative sleep, with potential negative consequences on physical and cognitive performance the following day (Shepherd et al., 2024). By contrast, achieving a total sleep duration between 7 and 8 hours provides additional quantitative recovery benefits, with an increase in deep sleep reflecting improved somatic recovery—including protein synthesis, hormonal regulation, and muscular repair—while an increase in REM sleep supports better cognitive-emotional recovery, such as emotional processing and procedural memory consolidation (Kawasaki et al., 2023).

Swimming itself may contribute to these favourable outcomes by eliciting parasympathetic relaxation, enhancing thermoregulation, and reducing muscle tension, all of which promote rapid entry into deep and REM sleep. In contrast, high-intensity training is often associated with elevated adrenaline and cortisol levels, which can delay sleep onset and fragment sleep quality (Fullagar et al., 2023). Additionally, it is important to note that even during sleep, brief episodes of wakefulness occur, particularly during transitions between cycles or in the later part of the night when deep sleep diminishes and REM increases. These short arousals, often not remembered, represent a normal physiological phenomenon and do not necessarily impair the restorative value of sleep (Dattilo et al., 2011).

These adaptations are of particular importance in combat sport athletes, where adequate sleep is critical for optimising both physical and cognitive performance, as well as reducing injury risk. Overall, the present results reinforce the value of integrating swimming into recovery protocols for combat sport athletes. Future studies with larger cohorts and longitudinal designs are warranted to further validate these effects and to investigate the underlying physiological mechanisms, such as hormonal modulation and neuromuscular recovery.

Practical Implications

Short sessions of low-intensity swimming after high-intensity training provide a simple and effective recovery strategy for combat sport athletes in non-sport-focused universities. This approach requires minimal equipment, reduces mechanical load compared to land-based recovery, and promotes adherence through its relaxing nature. Coaches and sport scientists may integrate swimming into recovery protocols, particularly during pre-competitive and competitive periods, to optimise performance and well-being.

Conclusion

Combat sport athletes who engaged in post-exercise swimming demonstrated a significant increase in total sleep duration, exceeding seven hours, which aligns closely with recommendations for high-performance athletes. In contrast, the control group experienced a reduction below 5.5 hours, underscoring the need for active recovery strategies to counteract the detrimental effects of intense training on sleep. Although both groups began with high sleep efficiency (>96%), only the swimming group maintained and slightly improved this parameter, while the control group showed a 5% decline, indicative of increased nocturnal fragmentation and awakenings. Swimming-based recovery was also associated with enhanced deep sleep, linked to muscular repair, growth hormone secretion, and tissue regeneration, as well as increased REM sleep, crucial for memory consolidation, emotional regulation, and stress adaptation. Conversely, the control group exhibited pronounced reductions in both deep and REM sleep, with potential negative implications for cognitive performance, psychological balance, and physiological recovery.

Moreover, resting heart rate decreased significantly in the swimming group, reflecting heightened parasympathetic activity and more restorative sleep, while it increased in the control group, suggesting persistent sympathetic activation and incomplete recovery.

Overall, the findings demonstrate that swimming as an active recovery modality exerts a significant and beneficial effect on sleep quality in combat sport athletes following high-intensity exertion. The intervention not only prevented training-induced sleep deterioration but also improved key parameters—total sleep time, deep sleep, REM sleep, and sleep efficiency—while reducing nocturnal heart rate. In contrast, passive recovery was associated with marked declines in sleep quality and sustained autonomic imbalance. These results support the inclusion of post-exercise swimming as a practical and effective recovery strategy that promotes both physiological restoration and athlete well-being.

References

Bessa, A. L., Oliveira, V. N., Agostini, G. G., Oliveira, R. J., Oliveira, A. C., White, G. E., Wells, G. D., & Teixeira, D. N. (2016). Exercise intensity and recovery: Biomarkers of oxidative stress and immune function. *International Journal of Sports Medicine, 37*(6), 436–444. https://doi.org/10.1055/s-0035-1564255

Chaabene, H., Mkaouer, B., Franchini, E., Souissi, N., Selmi, M. A., & Chamari, K. (2015). Physiological responses and performance analysis difference between official and simulated karate combat. *Asian Journal of Sports Medicine, 6*(3), e24042. https://doi.org/10.5812/asjsm.24042

Chandrasekaran, B., Fernandes, S., & Davis, F. (2020). Science of sleep and sports performance–a scoping review. *Science & Sports*, *35*(1), 3-11. https://doi.org/10.1016/j.scispo.2019.03.006

Chen, L. J., Fox, K. R., Ku, P. W., Chang, Y. W., & Chu, D. C. (2020). Effects of water-based exercise on sleep in older adults with mild sleep disturbance: A randomized controlled trial. *Journal of Aging and Physical Activity, 28*(2), 230–238. https://doi.org/10.1123/japa.2018-0352

Dattilo, M., Antunes, H. K. M., Medeiros, A., Mônico-Neto, M., Souza, H. S., Lee, K. S., Tufik, S., & de Mello, M. T. (2011). Sleep and muscle recovery: Endocrinological and molecular basis for a new and promising hypothesis. *Medical Hypotheses, 77*(2), 220–222. https://doi.org/10.1016/j.mehy.2011.04.017

de Zambotti, M., Cellini, N., Goldstone, A., Colrain, I. M., & Baker, F. C. (2019). Wearable sleep technology in clinical and research settings. *Medicine & Science in Sports & Exercise, 51*(7), 1538–1557. https://doi.org/10.1249/MSS.0000000000001947

Driver, H. S., & Taylor, S. R. (2000). Exercise and sleep. *Sleep Medicine Reviews, 4*(4), 387–402. https://doi.org/10.1053/smrv.2000.0110

Düking, P., Giessing, L., Frenkel, M. O., Koehler, K., Holmberg, H. C., & Sperlich, B. (2020). Wrist-worn wearables for monitoring heart rate and energy expenditure while sitting or performing light-to-vigorous physical activity: validation study. JMIR mHealth and uHealth, 8(5), e16716. DOI: 10.2196/16716

Dupuy, O., Douzi, W., Theurot, D., Bosquet, L., & Dugué, B. (2018). An evidence-based approach for choosing post-exercise recovery techniques to reduce markers of muscle damage, soreness, fatigue, and inflammation: A systematic review with meta-analysis. *Frontiers in Physiology, 9*, 403. https://doi.org/10.3389/fphys.2018.00403

Evenson, K. R., & Spade, C. L. (2020). Review of validity and reliability of Garmin activity trackers. Journal for the measurement of physical behaviour, 3(2), 170-185. DOI: 10.1123/jmpb.2019-0035

Fullagar, H. H., Vincent, G. E., McCullough, M., Halson, S., & Fowler, P. (2023). Sleep and sport performance. *Journal of Clinical Neurophysiology*, *40*(5), 408-416. https://doi.org/10.1097/WNP.0000000000000638

Fullagar, H. H., Skorski, S., Duffield, R., Hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: The effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Medicine, 45*(2), 161–186. https://doi.org/10.1007/s40279-014-0260-0

Kawasaki, Y., Kitamura, E., & Kasai, T. (2023). Impact of body composition on sleep and its relationship with sleep disorders: current insights. *Nature and science of sleep*, 375-388. https://doi.org/10.2147/NSS.S340946

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., & Otto, M. W. (2015). The effects of physical activity on sleep: A meta-analytic review. *Journal of Behavioral Medicine, 38*(3), 427–449. https://doi.org/10.1007/s10865-015-9617-6

Mircică, M. L., Păunescu, C., & Păunescu, T. (2024). The effect of practicing taekwondo on some psychomotor characteristics of medical students. *Revista Românească pentru Educaţie Multidimensională, 16*(4), 651-668. https://doi.org/10.18662/rrem/16.4/934

Shapiro, C. M., Bortz, R., Mitchell, D., Bartel, P., & Jooste, P. (1981). Slow-wave sleep: A recovery period after exercise. *Science, 214*(4526), 1253–1254. DOI: 10.1126/science.7302594

Shepherd, M. H., Neilson, B., Siengsukon, C., & Young, J. L. (2024). Restless sleep is associated with increased anxiety in physical therapy students: a cross sectional survey study. *BMC Medical Education*, *24*(1), 1170. https://doi.org/10.1186/s12909-024-06140-4

Stanley, J., Peake, J. M., & Buchheit, M. (2013). Cardiac parasympathetic reactivation following exercise: Implications for training prescription. *Sports Medicine, 43*(12), 1259–1277. https://doi.org/10.1007/s40279-013-0083-4

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S. F., & Tasali, E. (2017). Recommended amount of sleep for a healthy adult: A joint consensus statement. *Sleep, 40*(6), zsx050. https://doi.org/10.1093/sleep/zsx050