Game, Nap, and Match: The Impact of Nap Conditions on Tennis Performance

Grant Proposal

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Game, Nap, and Match: The Impact of Nap Conditions on Tennis Performance Abstract

Sleep plays a vital role in physical and mental recovery, especially for athletes who need to be in peak condition. Numerous studies have observed how a full night's sleep affects athletic performance. For instance, a 2011 study by Mah et al. on sleep extensions found that UCLA basketball players showed improved performance overall compared to preliminary testing. The players demonstrated faster timed sprints following sleep extension 16.2 ± 0.61 sec at baseline vs. 15.5 ± 0.54 sec at the end of sleep extension, higher shooting accuracy with free throw percentage increasing by 9% and 3-point field goal percentage increasing by 9.2%. However, there remains a gap in evaluating the effects of naps on athletic performance, as very few studies have explored this. This study observed the effects of various nap conditions on sleep quality and athletic performance among tennis players. Surveys conducted before and after naps in different room temperatures, sound levels, and phone usage conditions, along with tennis performance testing, suggested improvements when players napped under optimal conditions compared to baseline testing. Players served better, with an average improvement of 13%, and performed better in agility tests, with an average improvement of 4.83%. Additionally, players' reaction times improved by approximately 3%. This data provides evidence of a positive correlation between pre-match naps and enhanced tennis performance. Understanding how naps impact performance could help in creating advice for athletes to perform at their best consistently while also prolonging their health.

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Sleep is an important activity every human goes through daily, and it is known to affect human mental and motor function. It is commonly recommended that the average adult should get between 7 to 9 hours of sleep each night, averaging out to about 33% of their day being spent sleeping (National Institute of Neurological Disorders and Stroke, n.d.). The sleep cycle consists of four main stages: three stages of non-rapid eye movement (NREM) sleep and one stage of rapid eye movement (REM) sleep. NREM sleep includes light and deep sleep, where the body repairs and regenerates tissues. REM sleep is when dreaming occurs, which is essential for cognitive functions such as memory and learning (Harvard Health Publish, 2024). Sleep plays a vital role in the human body, as it is the time in which the human body regulates itself (recovery) and the human mind recharges itself (National Heart, Lung, and Blood Institute, n.d.). The quality of sleep, in terms of duration and cycles of sleep, affects the ability to perform and the quality of execution of various life. In competitive sports, sleep is vital for peak athletic performance, body recovery, and overall health. Research has consistently shown that sleep quality directly influences cognitive function, reaction time, and endurance, all critical factors in high-performance sports (Sleep Foundation, 2023). These aspects are especially important for tennis players, given the sport's unique demands on agility, focus, and endurance. Similarly, the high prevalence of naps among rugby players, particularly before away matches, reflects their recognition of the restorative benefits of sleep to counteract stressors like travel and unfamiliar environments (see figure 1 in the appendix). This finding is supported by a study involving 26 professional Rugby Union players from New Zealand, Australia, South Africa, and Argentina, which examined the relationship between pre-game naps and self-rated performance. Teece et al. (2023) observed that athletes were more likely to nap

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before away matches, and those who napped reported better match performance than those who did not, particularly in challenging away settings. Napping before games helps mitigate the physical and mental strain associated with disrupted routines, travel fatigue, and environmental changes by improving alertness, enhancing mood, and boosting recovery. These findings highlight the strategic use of naps not only as a recovery tool but also as a proactive method to optimize mental clarity, reaction time, and physical readiness for high stakes matches (Teece et al, 2023). In addition, studies indicate that athletes who experience high-quality sleep perform better in areas such as accuracy, speed, and mental resilience. In contrast, sleep-deprived athletes face increased risks of errors, injuries, and prolonged recovery times (Reilly & Edwards, 2007). Furthermore, a bar chart comparing the self-rated match performances of athletes who napped or did not nap before matches (see figure 2 in appendix), based on the same previous Rugby study, observed that players who napped reported a significantly higher percentage of "Good" performance ratings, particularly for away matches, where the restorative effects of napping counteracted travel fatigue and unfamiliar environments. The results of Teece et al. (2023)'s rugby study suggest that incorporating pre-game naps may be a valuable strategy to enhance perceived performance, especially under more stressful conditions (Teece et al., 2023).

It is important to explore the specific physiological and physical factors influencing sleep quality to maximize performance among tennis players. Existing research in sports science has primarily focused on general training and recovery strategies without examining how individual physiological indicators—such as heart rate variability (HRV), rapid eye movement (REM) levels, and body composition—affect sleep quality and, consequently, performance in tennis (Fullagar et al., 2014). For instance, athletes with

lower heart rate variability often report poorer sleep quality and longer recovery periods, potentially hindering their performance in high-stress situations like competitive matches (Nédélec et al., 2012).

Understanding these intricate connections is not only essential for optimizing the performance of tennis players but also offers valuable insights into other sports and general health practices. This research can contribute to developing tailored training and recovery protocols that prioritize sleep and its impact on physiological functions. Additionally, the findings could inform guidelines for enhancing overall well-being, emphasizing the significance of sleep quality in everyday life beyond athletic performance. Furthermore, investigating these factors in tennis—a sport demanding elevated levels of agility, precision, and sustained mental focus—can provide a unique perspective on the interplay between sleep, physical health, and performance. As tennis players often face intense schedules and high-stress conditions, understanding how physiological indicators like HRV and REM sleep levels relate to their sleep quality and performance can help in creating more effective recovery strategies. Such insights may lead to improvements not only in individual athletic success but also promote long-term health and career longevity.

Problem Statement

Tennis players' reliance on quick reflexes, mental acuity, and sustained endurance creates distinct recovery needs that could be better understood and optimized with targeted research. Physiological indicators like heart rate and sleep stages, alongside physical factors such as muscular endurance and flexibility, might have specific impacts on sleep quality and athletic performance. Yet, these potential connections have only been somewhat explored. Understanding these interactions could allow for a more personalized approach to training and recovery, tailored to the unique demands of

tennis athletes (Leeder et al., 2012). Therefore, this study sought to investigate the impact of various physical, physiological, and environmental factors on sleep quality and their subsequent effects on tennis performance. This research aims to provide actionable insights into optimizing nap environments to enhance outcomes for tennis players, recognizing the critical role of sleep in athletic recovery and performance.

Section II: Specific Aims

The primary aim of this proposal is to investigate the effects of physiological and environmental factors on sleep quality and their subsequent impact on the athletic performance of tennis players. The ultimate goal is to develop personalized recovery plans that leverage sleep optimization data to enhance player performance. This study proposes that certain physiological factors, such as heart rate variability (HRV) and REM sleep levels, and physical factors, such as endurance and flexibility, significantly influence both sleep quality and tennis performance. By understanding the relationship between these factors, we can create data-driven, sport-specific protocols for training and recovery that improve overall performance and player well-being.

This research will explore the relationship between sleep quality and tennis performance by examining how various physiological, environmental, and performance factors interact. Specifically, we aim to determine how sleep quality—affected by factors such as HRV, screen exposure, and noise levels—correlates with cognitive and motor performance on the court. The long-term goal is to develop a tailored, data-informed approach that optimizes sleep quality, enhancing athletic performance in tennis. The central hypothesis is that improved sleep quality, indicated by favorable physiological and environmental factors, will correlate with enhanced cognitive and motor skills essential for tennis, including reaction time, agility, and serve accuracy. This hypothesis is based on the understanding that tennis requires a unique combination of mental focus, agility, and physical stamina, all of which are closely tied to sleep quality.

Specific Aim 1: To determine the impact of physiological sleep indicators (such as HRV and REM levels) on tennis players' cognitive and motor performance. The impact can be determined by measuring HRV and sleep states during a nap preceding tennis performance testing and then correlating these physiological metrics with their subsequent performance results.

Specific Aim 2: To investigate how environmental factors (including phone use, light exposure, noise levels, and room temperature) affect sleep quality in tennis players. The objective is to document these factors and assess their impact on self-reported sleep sought quality, followed by measuring athletic performance in reaction time, agility, and serve accuracy.

Specific Aim 3: To analyze the relationship between the factors affecting sleep quality and enhanced athletic performance. The goal is to correlate sleep quality metrics with changes in performance, identifying trends that reveal optimal and suboptimal sleep conditions for maximizing tennis performance.

The expected outcome of this study is to identify specific sleep-related factors that significantly influence tennis performance. These findings will provide valuable insights into how sleep can be optimized for athletes, informing personalized training and recovery strategies designed to improve athletic outcomes.

Section III: Project Goals and Methodology

Relevance/Significance:

Sleep is a vital aspect of athletic performance. Yet, many athletes, particularly those in high-intensity sports like tennis, often neglect the impact of sleep quality on their physical and cognitive abilities. This study is significant as it seeks to establish a direct link between sleep quality and tennis performance by investigating how both physiological and environmental factors influence sleep quality and, in turn,

athletic performance. Sleep has been shown to affect cognitive functions such as decision-making, reaction time, and focus, all of which are critical in tennis. Additionally, physical recovery, agility, and motor skills, which are integral to performance in tennis, are also influenced by sleep. By examining how factors like heart rate variability (HRV), REM sleep, phone use, room temperature, and noise exposure affect sleep quality, this study will provide valuable insights into optimizing recovery protocols for athletes. Understanding the relationship between sleep and performance could lead to tailored recovery strategies that enhance athletic outcomes and reduce the risk of injuries (Fullagar et al., 2014; Reilly & Edwards, 2007).

Innovation:

This research is innovative in its approach to studying sleep quality by incorporating both physiological and environmental factors, which are often studied separately. While previous studies have focused on the general impact of sleep on athletic performance, few have specifically examined how various environmental factors—such as room temperature, noise, and phone exposure—affect sleep quality and subsequently impact cognitive and motor skills in a specific sport like tennis. Additionally, by measuring physiological sleep indicators such as HRV and REM levels, this study will provide deeper insights into the physiological mechanisms that underlie sleep quality and performance. These novel data can inform better, individualized sleep and recovery strategies for tennis players and athletes in similar sports, offering more personalized solutions for optimizing performance and recovery (Nédélec et al., 2015).

Methodology

Specific Aim #1:

The objective is to measure HRV and REM sleep levels during a nap before tennis performance testing, then correlate these physiological metrics with performance results. Our approach will involve the use of wearable devices to monitor HRV and REM levels during naps. The electroencephalogram (EEG) is focused on brain activity in the motor cortex and frontal cortex during naps to examine how sleep stages, particularly REM and slow-wave sleep (SWS), support recovery and athletic performance (Cheron et al., 2016). REM sleep, linked to motor memory consolidation and procedural learning, enhances skills like reaction time and serve accuracy (Rasch et al., 2009). SWS, associated with physical recovery and muscle repair, is vital for agility and endurance. The EEG will identify sleep stages and allow researchers to correlate them with physiological (HRV) and tennis performance metrics. The EEG is a non-invasive, reliable method for capturing neural activity and has been shown to effectively measure sleep-related recovery processes (Silber et al., 2007). Understanding these mechanisms will provide actionable insights into how naps influence cognitive and physical performance.

HRV and REM sleep data will be recorded during each nap, and these physiological metrics will be compared with tennis performance metrics such as reaction time, agility, and accuracy. Reaction time

will be measured using a click reaction time test, agility will be measured using an agility T-test drill, and tennis serve accuracy will be evaluated on first and second serves on both the deuce and ad sides with 25 serves for each type and side.

Our rationale for this approach stems from existing research demonstrating that higher HRV and better REM sleep are associated with improved recovery and better athletic performance (Nédélec et al., 2015). HRV has been widely recognized as a key marker of recovery and autonomic nervous system regulation, which can directly influence motor performance and cognitive functioning (Leeder et al., 2012). Similarly, REM sleep is essential for cognitive functions such as memory consolidation and focus, which are crucial for high-performance sports like tennis. By correlating HRV and REM sleep with tennis performance, this study aims to reveal how specific physiological markers contribute to improved athletic outcomes.

Specific Aim #2:

The objective is to document these factors and assess their impact on self-reported sleep quality, followed by measuring athletic performance in reaction time, agility, and serve accuracy. The approach will involve controlled manipulation of environmental factors such as temperature (64.4°F, 71.6°F, and 78.8°F), noise exposure (silence, white noise), and phone use (using phones vs. no phone use before naps). Participants will complete self-reported sleep quality surveys, and their performance metrics will be measured the following day.

Justification and Feasibility:

Environmental factors like noise, temperature, and light exposure have been shown to influence sleep quality in athletes. A study by Fullagar et al. (2014) demonstrated that temperature regulation during sleep plays a key role in sleep efficiency and recovery. Additionally, exposure to blue light from screens, such as phones, has been linked to disrupted sleep patterns (Harvard Health Publishing, 2024), further supporting the relevance of investigating phone use as an environmental factor. This controlled manipulation of environmental factors is feasible and practical, as it allows for the direct observation of how each factor influences sleep and performance without confounding variables.

Specific Aim #3:

The goal is to correlate sleep quality metrics with changes in performance, identifying trends that reveal optimal and suboptimal sleep conditions for maximizing tennis performance. After identifying key factors that affect sleep quality in Specific Aims 1 and 2, we will correlate these factors with performance metrics such as reaction time, agility, and serve accuracy. The expected outcome is to

identify specific sleep conditions that improve tennis performance, providing recommendations for players and coaches.

Justification and Feasibility

By analyzing the relationship between sleep quality and athletic performance, this study will build on existing research demonstrating the connection between recovery and performance. Previous studies have shown that athletes who experience better sleep quality have improved reaction times, decision-making skills, and endurance (Reilly & Edwards, 2007). Correlating these sleep metrics with tennis-specific performance measures will provide evidence for how sleep optimization can lead to more effective recovery and better on-court performance. This approach is relevant and feasible as it builds on established methodologies for measuring both sleep quality and performance metrics.

Preliminary Data

Baseline data for serving accuracy, agility, and reaction time was initially collected. On a subsequent day, the researcher napped under optimal conditions—defined as a room temperature of 68 to 72 degrees Fahrenheit, minimal noise, and no phone usage prior. Post-nap, the data showed an 18% increase in net first serves made and an 8% improvement in net second serves made (refer to Figure 3 in the appendix). Additionally, agility times improved by 4.83% (see Table 1 in the appendix), and reaction time improved by 3% (see Table 2 in the appendix). With the potential additional usage of HRV and EEG, we can identify specific sleep stages and physiological markers to analyze sleep quality and correlate them with performance outcomes. In doing so, we can see physiological improvement and agility, reaction time, and serve accuracy improvement, providing scientific and practical evidence and advice for napping for athletes and coaches.

Section IV: Resources and Equipment

This project will use several pieces of technological equipment, including an electroencephalogram (EEG) and a heart rate monitor. Tennis balls will be provided by the research team, but each participant must have access to a tennis racket. Additionally, the project requires access to a tennis court; the research team plans to use a public or indoor tennis court. Finally, the project will call for some sort of place in which the researchers can control (or use as along they fit the range) the temperature of a room when the participant is to nap.

Section V: Ethical Considerations

In this study, ethical considerations are prioritized to ensure the well-being and rights of participants. Informed consent will be obtained, clearly explaining the purpose of the research, procedures, potential risks, and the voluntary nature of participation. Participants' confidentiality will be maintained through anonymization of data and secure storage. Safety measures will be in place to minimize any discomfort from physiological measurements, with monitoring for any adverse events. Participants can withdraw at any time without penalty. Ethical approval will be sought from an internal review board, and steps will be taken to avoid bias and ensure fairness in participant treatment. Finally, all equipment will be used safely and ensured to be reliable, and data security will be carefully maintained throughout the research process.

Section VI: Timeline

6/14 – 11/26: Brainstorming and researching

11/27-12/8: Preliminary data gathering, analysis, and preparation for December Fair.

12/14-1/26: Gathering participants/testing and gathering final data, finish grant proposal, and STEM Thesis Abstract/Intro

1/27-2/19: Analyze final data, finish STEM Thesis, and prepare for February Fair.

Section VII: Appendix

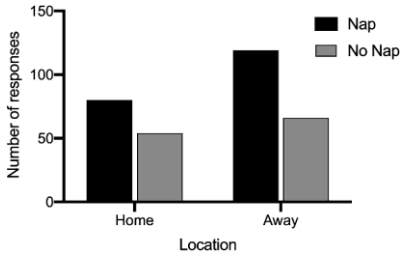

Figure 1. Prevalence of rugby players who napped or did not nap at home and away match locations. (Teece et al., 2023).

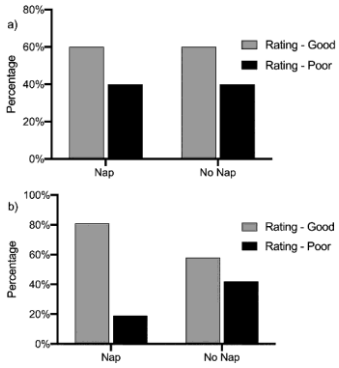

Figure 2. Comparison of self-rated match performance of rugby players who napped or did not nap before matches before (a) home matches and (b) away matches as reported by athletes. (Teece et al., 2023)

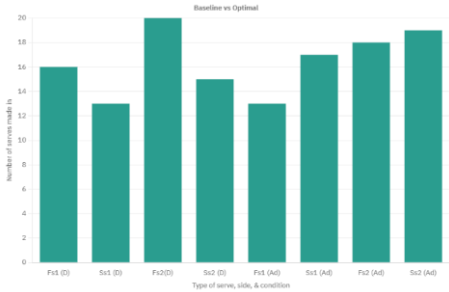

Figure 3. A bar chart comparing the number of serves made before and after taking a nap in optimal conditions. Fs1 and Ss1 represent first and second serves during baseline testing, while Fs2 and Ss2 represent serves after napping on the deuce (D) and ad (Ad) sides.

AGILITY T-TEST (BASELINE)	AGILITY T-TEST (OPTIMAL)
12.96 Seconds	12.36 Seconds
12.73 Seconds	12.10 Seconds

Table 1. A table comparing the trial times of the agility T-test during baseline measurement and after taking a nap in optimal conditions.

Baseline	Post-optimal Nap
0.323	0.312
0.329	0.315

Table 2. The results of the reaction time test during the baseline and post-optimal conditioned nap.

Section VIII: References

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