Effect of Sleep Deprivation on Perceived Exertion in Endurance Athletes: A Critically Appraised Topic

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Abstract

Context: Many studies have been conducted in order to determine the effects of sleep deprivations on athletes due its effects on performance. These studies focus on objective performance measures but have less commonly used a subjective measure of performance in the athletic population is used, called "perceived exertion." Therefore, the purpose of this Critically Appraised Topic was formulated in order to find out the hypothetical question of "In endurance athletes, what is the effect of normal sleep compared to that of sleep deprivation when looking at perceived exertion?"

Methods: Keywords and Boolean modifiers were used in sources such as PubMed, CINAHL, SportsDiscus, MEDLINE, and Cochrane Library in order to find a wide arrange of articles. Originally thirty results were brought to our attention but through the use of inclusion/exclusion criteria (human participants, endurance athletes, perceived exertion, within the last ten years). This number was reduced to three, Souissi W et al.[1], Roberts SSH et al.[2], Roberts, Spencer S H et al[3]. All three articles were further evaluated through the use of the Physiotherapy Evidence Database (PEDro) Scale, Souissi W et al[4] 8/10, Roberts SSH et al[5] 7/10, Roberts Spenser S H et al[7] 6/10 .

Results: All three studies analyzed found a significant difference between the performance of endurance athletes and perceived exertion between participants who received a full night of normal sleep as compared to those who had sleep deprivation in some way. Roberts SSH et al[5] found that those who get more and/or longer sleep and rest (3+ days) will have better performance than even those who get normal nights of sleep. Souissi W et al[4] found that a good night of sleep is important for the body to recover and respond to any physiological effects, along with better performance demands. Roberts, Spencer S H et al[7] goes on to explain that performance times for those with proper sleep were slower than the group with sleep deprivation by nearly four minutes.

Conclusions: Evidence suggests that a good night of sleep will result in improved performance through perceived exertion and productivity. Each article found a significant difference between the outcomes recorded between the groups who got natural sleep and those with sleep deprivation and their subsequent performances. Grade A evidence shows a high degree of statistical support between sleep and perceived exertion.

Introduction – Clinical Scenario

Sleep is a biological process that enables the body to rest and recover. It is a time period where the body is in a reduced mental and physical state where external stimulus responsiveness is reduced. Sleep allows for different parts of the brain to regenerate and for neurons to function properly. When a person is sleep deprived or suffers from a lack of sleep their behavior and performance can be altered to that of their normal state.[1] The optimal amount of sleep a person should be getting each night is 7 to 9 hours.[2] Studies show that individuals who get less than 7 hours a night of sleep have a higher risk of adverse health issues than individuals who sleep 7 hours or more.[2]

In athletics sleep is vital to overall health and performance. When the body is not able to recover fully or maintain a healthy sleep schedule changes can occur to behavior, health, performance, and mood. Research indicates there is a connection to decreased performance and sleep loss but the factors to cause decreased performance are not pinpointed.[3] Not much research has been conducted on how sleep deprivation affects endurance athletes specifically. Therefore, the purpose of this paper is to examine the extent to which sleep deprivation affects athletic performance, focusing on endurance athletes and perceived exertion.

Methods – Summary of Search Strategy

The literature search identified 13 studies. Of the 13, 9 were removed because of title or abstract and 1 removed based on relevance. Three randomized controlled trials met the inclusion and exclusion criteria. All studies compared sleep deprivation to normal sleep and measured perceived exertion as a key outcome. The databases searched were PubMed, CINAHL, SportDiscus, MEDLINE, and Cochrane Library.

Table 1 Characteristics of Included Studies

	Souissi W et al.[4]	Roberts SSH et al.[5]	Roberts, Spencer S H et al.[7]
Title	Partial sleep deprivation affects endurance performance and psychophysiological responses during 12-minute self-paced running exercise.	Extended Sleep Maintains Endurance Performance Better than Normal or Restricted Sleep.	Effects of total sleep deprivation on endurance cycling performance and heart rate indices used for monitoring athlete readiness
Study Design	Randomized cross over	Randomized control trial	Randomized cross over
Participants	Twenty male runners (age: 20.8 ± 1.1 years, weight: 70.6 ± 4.9 kg, and height: 175.1 ± 3.9 cm, body mass index (BMI): 23.3 ± 1.6 kg.m−2)	Nine males (mean ± SD; age, 30 ± 6 yr, VO2max: 63 ± 6 mL·kg^{-1}·min^{-1}) were recruited from cycling (n = 7) and triathlon (n = 2) clubs.	Thirteen males (mean ± SD, Age = 33 ±6 years;_VO2max=64±7-mL·kg−1·min−1) were recruited from cycling (n = 8) and triathlon(n = 5) clubs. Participants were considered trained according to adapted criteria for classifying cyclists (≥1 year of competitive racing,≥3 × training sessions per week,_VO2max≥55 mL
Inclusion and Exclusion Criteria	Competed in national competitions and exercised 3 hours/day, 4 days/week for 5 years at least	Athletes were considered "trained" according to adapted criteria for classifying cyclists (≥1 yr competitive racing, ≥3 training sessions per week, $V^{\cdot}O_{2max}$ ≥ 55 mL·kg^{-1}·min^{-1})	Inclusion and Exclusion Criteria Not Mentioned
Interventions Investigated	1. CONT: normal night sleep 2. PSD: partial sleep deprivation	1. SR: sleep reduced by 30% 2. NS: normal sleep 3. SE: sleep increased by 30%	1. NS: normal sleep 2. SD: sleep deprivation
Outcomes Measures	Recorded before exercise: Core temperature, motivation During exercise: Speed, covered distance, heart rate (HR), rating of perceived exertion (RPE), and respiratory parameters (i.e., minute ventilation (VE), oxygen uptake (VO2), and carbon dioxide production (VCO2)) 2 min After exercise: Blood lactate concentration [La] was assessed 2 min after exercise. Before and after exercise: Simple reaction time (SRT), mood, barrage test (BT)	Measurements were recorded(Mood disturbance, Psychomotor vigilance, Endurance time trial) after each night of SR, NS, and SE for four days(D1-D4). RPE (perceived exertion) was recorded during each endurance time trial.	Finishing time (RPE) perceived exertion Mood Psychomotor vigilance Heart rate (HR)
Main Findings	Higher RPE (p=0.01, d=0.90) and lower physical performance (i.e., p=0.001, d=0.59 for running speed and p=0.01, d=0.7 and Δ(%)=-6% for covered distance), following PSD, were obtained compared to CONT. Similarly, PSD attenuated core temperature (p=0.01, d=0.84), HR (p=0.006), VE (p=0.001), VO2 (p=0.001), BT (p<0.0005), SRT (p=0.0009) and mood (p<0.0005).	On nights D1, D2, and D3, total sleep time was longer (P < 0.001) in the SE condition (8.6 ± 1.0, 8.3 ± 0.6, and 8.2 ± 0.6 h, respectively) and shorter (P < 0.001) in the SR condition (4.7 ± 0.8, 4.8 ± 0.8, and 4.9 ± 0.4 h) compared with NS (7.1 ± 0.8, 6.5 ± 1.0, and 6.9 ± 0.7 h). Compared with NS, TT performance was slower (P < 0.02) on D3 of SR (58.8 ± 2.5 vs 60.4 ± 3.7 min) and faster (P < 0.02) on D4 of SE.	Time on D2 of SD was 10% slower than D2 of NS (64 ± 7 vs59 ± 4 min, P < 0.01), and 11% slower than D1 of SD (58 ± 5 min, P < 0.01). Subjective to objective (RPE:mean HR) intensity ratio was higher on D2 of SD compared with D2 of NS and D1 of SD (P < 0.01). Mood Disturbance and PVT mean response time increased on D2 of SD compared with D2 of NS and D1 of SD. Anaerobic threshold and change in TT time were correlated (R =−0.73, P < 0.01).
Level of Evidence	4	4	4
Conclusion	The decrease in running performance and the increase of physical discomfort or perceived exertion(RPE) after PSD could be the reason for lower cardio-respiratory responses to the 12-minute self-paced exercise. Physical performance and physiological responses after PSD both contribute to a decrease in overall performance.	Sleep extension for three nights led to better endurance performance compared with normal and restricted sleep. Sleep restriction impaired performance. Cumulative sleep time affects performance by altering the perceived exertion of a given exercise intensity. Endurance athletes should sleep more than 8 h per night to optimize performance.	Sleep is important for optimizing endurance performance, as total sleep deprivation impaired prolonged (~60 minutes) self-paced endurance performance by 10%. Subjective to objective intensity ratios (e.gRPE:HR) may be sensitive to the effects of sleep on the fatigue status, or readiness, of endurance athletes. Results highlight the importance of psychometric indices in athlete monitoring protocols.
Abbreviations:			

Image Source: Fitbit[9]

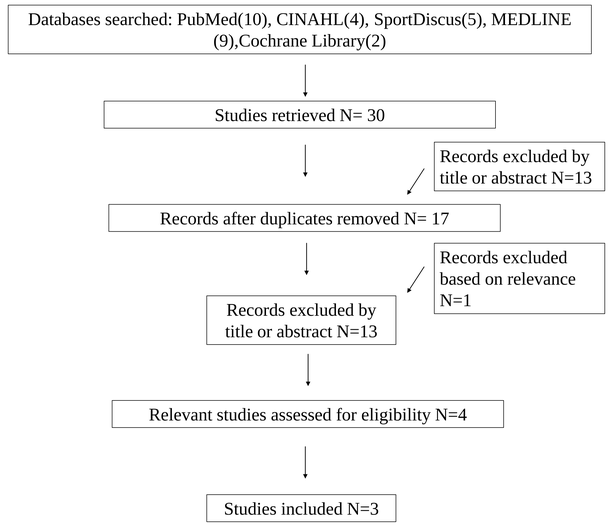

Table 2: Results of PEDro Scale for Each Article

	Souissi W et al[4]	Roberts SSH et al[5]	Roberts, Spencer S H et al[7]
1.Eligibility criteria specified (yes/no)	**Yes**	**Yes**	**Yes**
2. Subjects randomly allocated to groups (yes/no)	**Yes**	**No**	**No**
3. Allocation was concealed (yes/no)	**Yes**	**Yes**	**Yes**
4. Groups similar at baseline (yes/no)	**Yes**	**Yes**	**Yes**
5. Subjects were blinded to group (yes/no)	**No**	**No**	**No**
6. Therapists who administered therapy were blinded (yes/no)	**No**	**No**	**No**
7. Assessors were blinded (yes/no)	**Yes**	**Yes**	**No**
8. Minimum 85% follow-up (yes/no)	**Yes**	**Yes**	**Yes**
9. Intent to treat analysis for at least 1 key variable (yes/no)	**Yes**	**Yes**	**Yes**
10. Results of statistical analysis between groups reported (yes/no)	**Yes**	**Yes**	**Yes**
11. Point measurements and variability reported (yes/no)	**Yes**	**Yes**	**Yes**
Overall Score (out of 10)	**8/10**	**7/10**	**6/10**

Note: Item 1 was not included in overall score
Abbreviations: PEDro: Physiotherapy Evidence Database score

Results, Discussions, and Conclusions

The studies included in this CAT were identified to examine the relationship between sleep deprivation and endurance performance. Sleep is vital for the body's systems to recover, function, and optimally perform. A loss of or decrease in sleep an athlete gets can affect their performance. Research has not looked at how or why performance is affected, especially related to sleep deprivation. Therefore, perceived exertion is being attributed to why performance is decreased compared to psychological effects.

All three studies were conducted on endurance athletes of different events and sports. The participants in the study by Roberts SSH et al.[5] and Roberts, Spencer S H et al.[7] involved cycling and triathlon athletes. The participants in the study by Souissi W et al.[4] were runners who competed nationally and exercised 3 hours/day, 4 days/week, for 5 years.[4]

The methods of the research studies all consisted of comparing a night of normal or extended sleep versus a night sleep deprived or no sleep. The study by Souissi W et al.[4] had a group of normal sleep (8 hours) and a group of partial sleep deprivation (4 hours). The study by Roberts SSH et al[5] examined the differences between a normal night's sleep (NS), sleep reduction (SR) by 30% and sleep extension (SE) by 30%.[5] The study by Roberts, Spencer S H et al.[7] examined a normal night sleep (NS) and a night sleep deprivation (SD) effect on performance outcomes.[7]

The three research studies all suggest that partial sleep deprivation or sleep that is not normal to oneself can affect performance especially in terms of perceived exertion. Perceived exertion can be defined as how hard the body thinks it is working. The study by Souissi W et al.[4] saw RPE or perceived exertion was increased in the partial sleep deprivation group compared to the normal sleep group during a self-paced run.[4] This measure implies that the discomfort level and amount of effort were more difficult/increased after a night of sleep loss. The study by Roberts SSH et al.[5] analyzed an endurance time trial while the study by Roberts, Spencer S H et al.[7] analyzed a self-paced endurance time trial. In both studies the endurance time trial was affected negatively. RPE was not significantly affected between or within the groups, but psychomotor vigilance improved for the sleep extension group in the study by Roberts SSH et al.[5] Perceived exertion was however increased in correlation to finishing time/power output on D3 of sleep restriction compared to normal sleep.[5] On D4 of sleep extension the perceived exertion scores in relation to power output were the lowest. This suggests that an athlete's ability to identify their maximal exertion is impaired after sleep restriction compared to sleep extension over the span of four nights.[5] The ratio between RPE to mean HR showed an increase on D2 of SD compared with D2 of NS in the study by Roberts, Spencer S H et al.[7] The decrease in performance could be explained by the increase in perceived exertion a night of sleep deprivation brings on. The body is not able to properly recover physically or mentally when the adequate amount of sleep is not present.

Other studies show that sleep extension and an athlete's pain tolerance are correlated.[6] Pain tolerance is the amount of discomfort the body can withstand and when sleep is extended this threshold increases. This could explain why at higher outputs of force during the endurance time trial the perceived exertion seemed to be higher as well. Previous research has suggested that sleep deprivation is associated with mental fatigue rather than central fatigue.[8] Central fatigue is the inhibition of muscle activation alone while mental fatigue attributes perceived exertion for the delay of muscle activation.

Implications for Clinical Practice and Future Research

More in depth research is needed to differentiate between the psychological and physiological affects of sleep deprivations on performance. The correlation between perceived exertion and decrease performance must also be examined more in depth to pinpoint the actual cause of sleep deprivations affect on performance. Future research must examine the affect of sleep deprivation on different types of athletes and sports. The affect of sleep deprivation on fast twitch/plyometric exercises or power movements in unknown. Future research must examine the adequate amount of sleep that is needed to preform optimally and at what threshold for sleep loss will performance be affects negatively.

References and Acknowledgments

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