Sleep for Injury Free Sports Performance: A Short Review

Gagan Kumar Banodhe[1], H.B. Sharma[2*]

[1]AIIMS, Gorakhpur, U.P., [2]Heritage IMS, U.P.

*Email: dr.barun.hanjabam@gmail.com

Mobile: +91 94178 06332

Abstract:

A good quality and adequate sleep is absolutely essential for optimal adaptation to training, physiological & psychological wellbeing, overall good health and best sports performance. It is also essential for memory consolidation, motor skills and leaning. Sleep deprivation on the other hand, has various adverse health effects, and predisposes the players for sports injuries, illness due to weak immunity, chronic fatigue, maladaptation and hence performance deterioration. The coaches and the supports staff including sports medicine doctors, should clearly understand the important role which sleep plays, and hence should ensure the players get adequate & optimal recovery and sleep; and also make sure to minimize the adverse effect of jet lag.

Keywords: Sleep, Sports Performance, Injury, Memory, Motor Skills, Jet Lag.

Introduction:

Physical activity has a direct correlation with health and fitness. It has been observed that regular physical activity improves cardiovascular fitness, motor skills, memory and sleep. Elite athletes sleep usually less than non-athlete and sleep deprivation studies have already established that insufficient sleep prolong reaction time, decreases sports performance, increases injury risk, delay recovery and deteriorate memory (1). Sleep plays an important role in memory consolidation, motor skills development and learning, which are essential for optimal training adaptation and sports specific techniques & skills. A good sleep is absolutely essential for injury prevention, avoiding chronic fatigue and maladaptations, and hence for best sports performance. A thorough search for articles on online databases like pubmed and google scholar was done with appropriate key words, and the review was written accordingly.

Sleep and Sports Performance:

The duration of sleep is associated with sports performance, self-rated health and quality of life. A study done on Taiwanese adults shown that sleep duration and quality were significantly correlated with fitness performance (2). To establish the relationship between the sleep duration and sports performance, an assessment was done on elite super rugby team in

2017 and the authors found out that there was a progressive increase in sleep duration before the game, which was most probably to maximize alertness during training session and game (3). A sleep deprivation study found out that the distance covered by sleep deprived male subjects were reduced as compared to normal slept male individuals (4). Even a single night of sleep deprivation after heavy exercise decreases 3 km time trial performance by 4% in cyclist, when assessed on next day (5). Similarly a study done on eight young adult men found out that there was a significant decrease in weightlifting performance after three consecutive nights of only three hours sleep (6). A sleep extension protocol (banking sleep) can enhance sports performance, as shown in male basketball players in which a daily sleep extension of 2 hours was done for 5-7 weeks and found out that sprint test time significantly improved (7, 8).

Sleep and Injury Prevention & Recovery:

Sufficient sleep decreases the chance of injury and also enhances recovery. A comparative study was done between individuals with different sleep duration to see the effect of sleep on injury and it was found out that the individuals with sleep duration of <8 hours were more prone for injury as compared to individual with >8 hours (9). The risk of injury increases further when decrease in sleep duration is combined with increase in training load, as commonly seen in athletes travelling with teams and residing in training camps (10). The mechanism of action of increased risk due to decrease in sleep is not clear yet, but it may be due to increased fatigue and less time for recovery from the previous strenuous exercise session (10). Loss of sleep also decreases immunity, as shown in a study in which the subjects were given rhinovirus in nasal drops and observed that the individuals who slept <7 hours developed infection three time more than the individuals who slept >8 hours (11, 12).

Sleep and Jet Lag:

Travel across the time zones causes jet lag, which may cause sleep impairment, and fatigue, as seen in athletes travelling across the globe to attend sports events. It may make athletes susceptible for injuries and can also lead to poor sports performance (10). Sleep disturbances are not only seen in long flight but also been observed in short duration flight (upto 6.5h) (13). Sleep hygiene guidelines should be followed to deal with the adverse effect of jet lag. There should be a gradual progressive sleep plan and bright light treatment in the morning to adjust circadian rhythms before travelling to east (14). The proper use of sleep hygiene and sleep extension protocols, like avoiding use of mobile phone during bed time, not taking tea or coffee and smoking cigarette before going to sleep, while travelling with the teams

and even in preparatory phase during extensive training schedules may help in improving sports performances, fast recovery and preventing injuries (15).

Sleep and Memory:

There were two famous concepts given in early 1920s to describe the cause of memory loss and the role of sleep in its prevention. According to "decay" theory the memories decay over time. And as per "interference" theory, the newly formed memories interfere with the old memories retroactively and new memories replace old memories. To clarify these concepts an experiment was done on two subjects for two months, in which the subjects were asked to recall nonsense syllables after various hours of wake and sleep period (one, two, four and eight hours) and it was find out that the successful recall of nonsense syllables were significantly more in the experimental protocol in which subjects slept as compared to same period of wakefulness (16). Boyce et al., 2016 did experiments in rats to prove that hippocampal theta wave generated during REM sleep is involved in memory consolidation. They decreased the hippocampal theta wave rhythm experimentally and concluded that the task performance on fear conditioning and context memory recall test were impaired, though there was no memory deficit in a cued memory recall test (17). To strengthen the fact that sleep helps in strengthening of the memories Ellenbogen et al., did a study on 48 human subjects in 2006. In this study they divided the participants into four groups, sleep, wake, sleep with interference and wake with interference. All the subjects were asked to learn 20 word pairs associate and 12 hours later they were tested for recall. The authors concluded in the results that the percent of recall was comparable in both groups in without interference experimental protocol but percent of recall was better in slept subjects as compared to wake subjects in with interference protocol. So they concluded that sleep strengthens the memory by preventing it from various interferences (18).

The sleep is divided into various stages and according to dual-process hypothesis, NREM (non-rapid eye movement) and REM (rapid eye movement) sleep are involved in consolidation of different types of memories. Slow wave sleep and NREM sleep are associated with consolidation of episodic memory and semantic memories respectively. It is also shown that the number and density of sleep spindles increased in stage-2 NREM sleep after a motor learning task (19). The sleep spindles, ponto-geniculo-occipital waves, hippocampal rhythms, and slow waves were proposed as the physiological mechanism behind memory consolidation on the basis of various functional neuroimaging techniques of the brain (20).

There are various neuromodulators involved in memory consolidation like adrenaline, acetylcholine and dopamine, and sleep has an important effect on them (6–8). To describe the

role of acetylcholine in memory consolidation, Hasselmo et al in 1999 proposed a model in which they said that due to high level of acetylcholine, flow of information from neocortex to hippocampus occurred and allowed the encoding of information. But this prevented the flow of information from hippocampus to neocortex and prevented memory consolidation. However, when we sleep, the level of acetylcholine reduced and it allowed the flow of information from hippocampus to neocortex and finally lead to memory consolidation (21). To support this hypothesis the experiments were done in which scopolamine and mecamylamine were given and result shows that the cholinergic receptor blockers significantly improve the consolidation of declarative memory due to low level of acetylcholine activity in central nervous system (22). It has also been seen in the experiments that after giving cholinesterase inhibitor physostigmine, the memory consolidation of declarative memory was completely blocked due to high central nervous cholinergic activation (23). Hence, sleep plays an important role in memory consolidation, and learning and memory do play an essential role in sports training.

Sleep and Motor Skills:

Sleep has a major determining role in relation to motor skills. There was report of improvement in motor skill after a night of sleep, when a finger tapping task was done from non-dominant hand to determine the role of sleep in motor skill (24). In another study, to evaluate the association of sleep spindle activity with performance, a finger tapping task was done from left hand in a right-handed person so as to evaluate the right cortex, after a period of wakefulness and sleep. After topographical sleep spindle analysis the authors concluded that the sleep spindle activity was significantly more after the motor task in sleep group than waking group (25). Similarly Rasch et al., did a study to see the neurotransmitters involved in improvement in motor skill after a sleep period. He gave fluvoxamine and reboxetine to suppress REM sleep. They found out that the fast spindle activity increased in stage 2 NREM sleep and also there were no impairment in motor skill (26). To assess the effect of variation of sleep duration on sports performance a comparison was done in between day time sleep of 60 minutes against whole night sleep and found out that there were no REM sleep present in day time naps, but skill still improved significantly in daytime naps group participants as compared to whole night sleep group (27). It has also been proven that skill task performances and motor skills like playing piano or typing on keyboard etc. improves after a session of sleep at day and night both (25, 28).

Conclusion:

The evidences based on various studies suggest that a proper, adequate and good quality sleep can improve sports performance, motor skills and memory. Conversely, sleep deprivation has deteriorating effects on performance and may increase the risk of sports injuries. Coaches and the supports staff including sports medicine doctors, should understand the importance of sleep, and hence should ensure sufficient recovery and sleep among athletes; as well as should make sure to minimize the adverse effects associated with jet-lag, specially while travelling with team, so as to get the maximum psychological and physiological benefits and wellbeing, leading to injury-free best performance.

References:

1. Venter R. Role of sleep in performance and recovery of athletes: A review article. South African Journal for Research in Sport, Physical Education and Recreation. 2012;34(1):167-84.
2. Hsu CC, Gu M, Lee TS, Lu CJ. The Effects of Daily Sleep Condition on Performances of Physical Fitness among Taiwanese Adults: A Cross-Sectional Study. Int J Environ Res Public Health. 2020;17(6).
3. Dunican IC, Higgin CC, Murray K, Jones MJ, Dawson B, Caldwell JA, et al. Sleep Patterns and Alertness in an Elite Super Rugby Team During a Game Week. J Hum Kinet. 2019;67:111-21.
4. Oliver SJ, Costa RJ, Laing SJ, Bilzon JL, Walsh NP. One night of sleep deprivation decreases treadmill endurance performance. Eur J Appl Physiol. 2009;107(2):155-61.
5. Chase JD, Roberson PA, Saunders MJ, Hargens TA, Womack CJ, Luden ND. One night of sleep restriction following heavy exercise impairs 3-km cycling time-trial performance in the morning. Appl Physiol Nutr Metab. 2017;42(9):909-15.
6. Reilly T, Piercy M. The effect of partial sleep deprivation on weight-lifting performance. Ergonomics. 1994;37(1):107-15.
7. Mah CD, Mah KE, Kezirian EJ, Dement WC. The effects of sleep extension on the athletic performance of collegiate basketball players. Sleep. 2011;34(7):943-50.
8. Arnal PJ, Lapole T, Erblang M, Guillard M, Bourrilhon C, Leger D, et al. Sleep Extension before Sleep Loss: Effects on Performance and Neuromuscular Function. Med Sci Sports Exerc. 2016;48(8):1595-603.

9. Milewski MD, Skaggs DL, Bishop GA, Pace JL, Ibrahim DA, Wren TA, et al. Chronic lack of sleep is associated with increased sports injuries in adolescent athletes. J Pediatr Orthop. 2014;34(2):129-33.
10. von Rosen P, Frohm A, Kottorp A, Friden C, Heijne A. Multiple factors explain injury risk in adolescent elite athletes: Applying a biopsychosocial perspective. Scand J Med Sci Sports. 2017;27(12):2059-69.
11. Cohen S, Doyle WJ, Alper CM, Janicki-Deverts D, Turner RB. Sleep habits and susceptibility to the common cold. Arch Intern Med. 2009;169(1):62-7.
12. Prather AA, Janicki-Deverts D, Hall MH, Cohen S. Behaviorally Assessed Sleep and Susceptibility to the Common Cold. Sleep. 2015;38(9):1353-9.
13. Thornton HR, Miller J, Taylor L, Sargent C, Lastella M, Fowler PM. Impact of short- compared to long-haul international travel on the sleep and wellbeing of national wheelchair basketball athletes. J Sports Sci. 2018;36(13):1476-84.
14. Eastman CI, Gazda CJ, Burgess HJ, Crowley SJ, Fogg LF. Advancing circadian rhythms before eastward flight: a strategy to prevent or reduce jet lag. Sleep. 2005;28(1):33-44.
15. Vitale KC, Owens R, Hopkins SR, Malhotra A. Sleep Hygiene for Optimizing Recovery in Athletes: Review and Recommendations. Int J Sports Med. 2019;40(8):535-43.
16. Jenkins J, Dallenbach K. Obliviscence During Sleep and Waking. The American Journal of Psichology. 1924;35:605-12.
17. Boyce R, Glasgow SD, Williams S, Adamantidis A. Causal evidence for the role of REM sleep theta rhythm in contextual memory consolidation. Science. 2016;352(6287):812-6.
18. Ellenbogen JM, Hulbert JC, Stickgold R, Dinges DF, Thompson-Schill SL. Interfering with theories of sleep and memory: sleep, declarative memory, and associative interference. Curr Biol. 2006;16(13):1290-4.
19. Morin A, Doyon J, Dostie V, Barakat M, Hadj Tahar A, Korman M, et al. Motor sequence learning increases sleep spindles and fast frequencies in post-training sleep. Sleep. 2008;31(8):1149-56.
20. Dang-Vu TT, Schabus M, Desseilles M, Sterpenich V, Bonjean M, Maquet P. Functional neuroimaging insights into the physiology of human sleep. Sleep. 2010;33(12):1589-603.
21. Hasselmo ME. Neuromodulation: acetylcholine and memory consolidation. Trends Cogn Sci. 1999;3(9):351-9.

22. Rasch B, Born J, Gais S. Combined Blockade of Cholinergic Receptors Shifts the Brain from Stimulus Encoding to Memory Consolidation. Journal of Cognitive Neuroscience. 2006;18(5):793-802.
23. Gais S, Born J. Low acetylcholine during slow-wave sleep is critical for declarative memory consolidation. Proc Natl Acad Sci U S A. 2004;101(7):2140-4.
24. Whitehead RH, Hughes LE. Proceedings: Attempts to culture human tumours in vitro. Br J Cancer. 1975;32(2):244.
25. Nishida M, Walker MP. Daytime naps, motor memory consolidation and regionally specific sleep spindles. PLoS One. 2007;2(4):e341.
26. Rasch B, Born J. About sleep's role in memory. Physiol Rev. 2013;93(2):681-766.
27. Sugawara SK, Koike T, Kawamichi H, Makita K, Hamano YH, Takahashi HK, et al. Qualitative differences in offline improvement of procedural memory by daytime napping and overnight sleep: An fMRI study. Neurosci Res. 2018;132:37-45.
28. Fischer S, Hallschmid M, Elsner AL, Born J. Sleep forms memory for finger skills. Proc Natl Acad Sci U S A. 2002;99(18):11987-91.