



CLINICAL REVIEW

Sleep and exercise: A reciprocal issue?

Mounir Chennaoui^{a, b, **}, Pierrick J. Arnal^{a, b, c}, Fabien Sauvet^{a, b}, Damien Léger^{b, d, *}^a Institut de recherche biomédicale des armées (IRBA), Brétigny-sur-Orge, France^b Université Paris Descartes, Equipe d'accueil Vigilance Fatigue SOMmeil (VIFASOM) EA 7330, France^c Laboratoire de Physiologie de l'Exercice, Université de Lyon, Saint Etienne, France^d Université Paris Descartes, Sorbonne Paris Cité, APHP, Hôtel Dieu, Centre du Sommeil et de la Vigilance, Paris, France

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SUMMARY

Sleep and exercise influence each other through complex, bilateral interactions that involve multiple physiological and psychological pathways. Physical activity is usually considered as beneficial in aiding sleep although this link may be subject to multiple moderating factors such as sex, age, fitness level, sleep quality and the characteristics of the exercise (intensity, duration, time of day, environment). It is therefore vital to improve knowledge in fundamental physiology in order to understand the benefits of exercise on the quantity and quality of sleep in healthy subjects and patients.

Conversely, sleep disturbances could also impair a person's cognitive performance or their capacity for exercise and increase the risk of exercise-induced injuries either during extreme and/or prolonged exercise or during team sports.

This review aims to describe the reciprocal fundamental physiological effects linking sleep and exercise in order to improve the pertinent use of exercise in sleep medicine and prevent sleep disorders in sportsmen.

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Introduction

Over the last decade exercise has been extensively recommended as a major factor for improved health in the general population, in the elderly and in many groups with chronic diseases such as obesity, type 2 diabetes, cardiovascular diseases, depression and even cancer [1,2]. Increasing exercise has been found beneficial for reducing weight, preventing pain, improving mood and enhancing the quality of sleep in patients with insomnia [1,3–5].

Getting sufficient sleep has also been recommended as insufficient sleep has been identified as an associated risk factor for major public health concerns: obesity, type 2 diabetes, cardiovascular diseases, depression and accidents [6–8]. Sleeping 7–8 h has systematically been found to be associated with lower risks of morbidity and mortality.

However it is still difficult to understand exactly how exercise impacts on sleep and vice versa. In particular, very frequent associations have been found between sleep loss and exercise-induced injuries [9,10] suggesting physiopathological interactions between sleep and injuries. Conversely, good sleeping habits and moderate physical activity could be mutually beneficial [11–13] and trigger a virtuous circle that improves fitness, particularly in sleep disorders patients.

The aim of this review is therefore: 1) to understand how exercise affects sleep physiology, via its impact on temperature, cardiac and autonomic function and the endocrine and immune systems; 2) to clarify how the duration of sleep affects exercise (exploring the impact of sleep loss, sleep restriction and sleep extension); 3) to observe the reciprocal influence between sleep disorders (insomnia and sleep apnea) and exercise.

Effects of exercise on sleep physiology (Fig. 1)

Definitions

Physical activity, sport, exercise and physical fitness are terms that lead to confusion. The term physical activity describes any form of movement that results in energy expenditure and includes all the activities in day-to-day living, whether professional,

* Corresponding author. Centre du sommeil et de la vigilance, Hôtel Dieu, APHP, 1 Place du parvis Notre-Dame, 75181, Paris Cedex 4, France. Tél.: +33 01 42 34 82 43; fax: +33 01 42 34 82 27.

** Corresponding author. Institut de Recherche Biomédicale des Armées (IRBA), Brétigny-sur-Orge cedex, BP73, 91223, France. Tel.: +33 (0) 1 42 34 89 70; fax: +33 (0) 1 78 65 14 58.

E-mail addresses: mounir.chennaoui@irba.fr (M. Chennaoui), damien.leger@htd.aphp.fr (D. Léger).

Abbreviations

AHI	apnea-hypopnea index
BDNF	brain-derived neurotrophic factor
BMI	body mass index
CPAP	continuous positive air pressure
GH	growth hormone
HR	heart rate
HRV	heart rate variability
ICSD-2	international classification of sleep disorders-2nd edition
MAE	moderate-intensity aerobic exercise
NO	nitric oxide
NREM	non-rapid eye movement

OSA	obstructive sleep apnea syndrome
PSG	polysomnography
PSQI	Pittsburgh sleep quality index
REM	rapid eye movement
RLS	restless leg syndrome
SD	sleep deprivation
SMD	standardized mean difference
SNS	sympathetic nervous system
SOL	sleep onset latency
SWS	slow wave sleep
TST	total sleep time
VO ₂ max	maximal oxygen consumption
WASO	wake after sleep onset

domestic or leisure-time activities [14]. Contrary to sport, physical activity is not performed competitively. Exercise is a component of physical activity; it is planned, structured and defined by its frequency, intensity and duration. Physical fitness is the ability to perform physical activity. A recent recommendation from the American College of Sports Medicine and the American Heart Association regarding physical activity and public health in adults advises that, in order to promote and maintain health, moderate-intensity aerobic physical activity for a minimum of 30 min on five days each week, or vigorous-intensity aerobic physical activity for a minimum of 20 min on three days each week should be carried out [15]. Schematically, moderate-intensity activities are those in which the heart rate (HR) and breathing are raised but where it is still possible to speak comfortably; whereas vigorous-intensity activities are those in which the heart rate is higher, breathing is heavier and conversation is harder.

Effects of exercise on sleep architecture

The effects of exercise on sleep are modulated by factors such as individual characteristics and exercise protocol. Individual characteristics include sex, age, fitness level, type of sleeper and body mass index (BMI), whereas exercise protocol includes acute or regular, aerobic or anaerobic, and different characteristics such as intensity, duration, environment (indoor or outdoor, hot or cold environment) and the time of day. These variables have contradictory effects on sleep. Various studies of this topic have concentrated on good and relatively young sleepers (<35 y) [16–19]; the scientific literature on the elderly and poor-sleepers using objective measurements (polysomnography) is poor [17,20]. It is important to keep in mind a possible ceiling and floor effect of exercise on sleep in good sleepers (i.e., little room for improvement in sleep); subjects with sleep disorders would have the greatest potential for improvement. Interestingly, several studies have since focused on these groups [2,11,21,22].

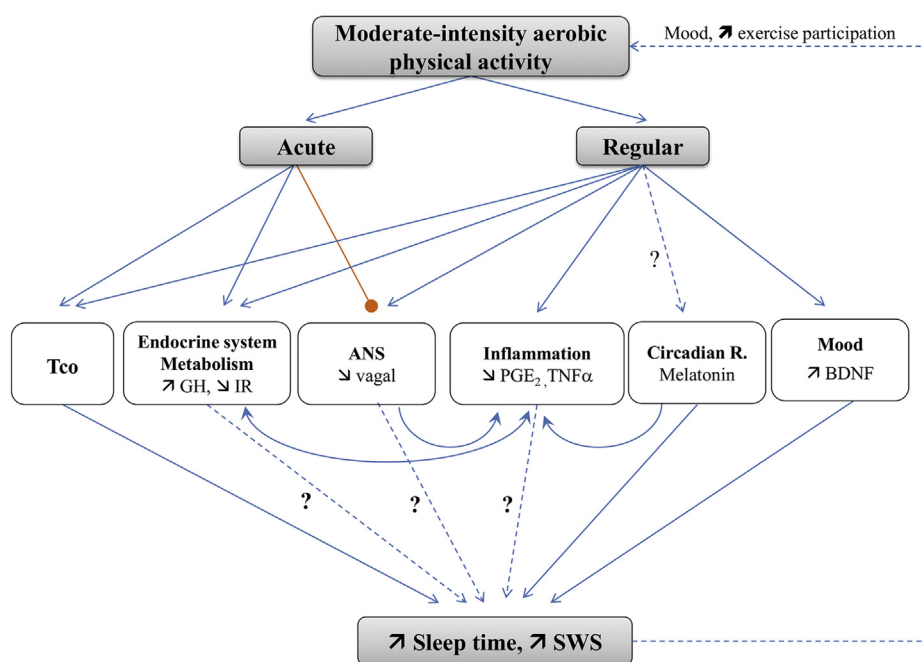


Fig. 1. Possible effects of acute or regular moderate intensity aerobic physical activity on sleep. ANS = autonomic nervous system, BDNF = brain-derived neurotrophic factor, Circadian R. = circadian rhythm, GH = growth hormone, IR = insulin resistance, PGE₂ = prostaglandin E₂, SWS = slow wave sleep, Tco = body core temperature, TNF-α = tumor necrosis factor alpha, —> link, - - -> probable link, —●— inhibits (red). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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