



How Much Time to Spend in Physical Activity, Sleep and be Sedentary in 24 h to Achieve Good Health?

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Abstract

One should have adequate amount of good quality sleep on a regular and consistent basis on weekdays and weekends along with adequate amount of physical activity and good nutrition for good health. We discuss current evidence in relation to sleep and physical activity and share how the general public can plan their 24 h incorporating adequate amount of good quality sleep and physical activity to achieve good health. We recommend 150 min of moderate to vigorous physical activity, 7–9 h of sleep and less than 8 h of sedentary time for adults.

Keywords Sleep · Sedentary · Exercise · Time spend

Physical activity, sleep, and sedentary time are part of our 24 h activity profile, and increasing time spent on one activity will take away the time from the other activity with its consequences. All of us need to understand how increasing the time in one of these activities at the expense of the other two will affect health.

Millions of years ago, our ancestors lived in jungles and had to move around during the day to collect food or run to hunt animals. They were exposed to sunlight while moving outside looking for food or hunting. At the night, they would look for a safe place to protect themselves from predators and sleep. They were exposed to moonlight as the only source of light at night. This exposure to light and darkness, regular movement, and timely eating leads to the development of robust rhythms in our body referred to as circadian rhythms. They will not sit sedentary for long hours as they were not growing their food and must collect food during the daytime before night falls and will sleep during the night at a safe place.

In the last 100 years with the advent of artificial light, our society has become a 24 h society where many people are working at night and sleeping during the day, food is available round the clock and most of the work involves sitting for extended periods affecting the daily amount of physical activity, sleep, and sedentary time.

1 Sleep is Important for Good Health

We spend 1/3rd of our lives sleeping, and sleep is present in all mammals. Sleep must serve an important function for the evolutionary process to retain sleep until the present day over millions of years. There are two types of sleep—non-rapid eye movement (NREM) and rapid eye movement (REM). Adults spend 75–80% of sleep time in NREM sleep and 20–25% of sleep time in REM sleep.

Research has shown that sleep helps to clear toxic metabolites from the brain by increasing the activity of the glymphatic system [1], improves immune system function [2], leads to better response to vaccination [3], improves performance [4], keeps cardiovascular system in good shape [5], plays role in memory consolidation [6] and adequate REM sleep decreases all-cause mortality [7].

Recently American Academy of Sleep Medicine has published a position statement stating that sleep is a biological necessity, and insufficient sleep and untreated sleep disorders are detrimental to health, well-being, and public safety [8].

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Adults need to sleep for 7–9 h every night [9]. But there are interindividual variations in the amount of sleep required by each person. Sleeping less than 5 or 6 h has been shown to increase sleep propensity during the daytime [10], increases odds for hypertension [11], increased the prevalence of type 2 diabetes and impaired glucose tolerance [12], increased the risk of all-cause mortality, especially from cardiovascular causes [13], obesity [14], increases road traffic accidents [15], short sleep duration (< 6 h) might be an early marker of Alzheimer disease [16], elevated levels of evening Cortisol, sympathetic activity, decreased thyrotropin levels and decreased glucose tolerance levels [17], leads to lower job satisfaction, decreased charisma of others, decreased helping behavior among colleagues and increased hostility [18], one becomes irritable, impulsive, have more negative emotions, prone to errors and accidents [19], and poor sperm health [20, 21].

Resident physicians obtaining less than 4 h of spontaneous overnight sleep on 92% of extended-duration work shifts had serious neurobehavioral performance impairment [22]. Cognitive performance in sleep-restricted (5.6 h per night sleep) individuals was worse within 2 min of awakening, remained worse across the dissipation of sleep inertia, was worse during the biological night, and worsened as days of insufficient sleep increased. This has implications for all individuals needing to perform tasks quickly after awakening like Physicians [23].

2 Sleep Duration is Decreasing, and Sedentary Time is Increasing

More people are becoming short sleepers (sleep < 6 h), and they are trading their sleep time with sedentary leisure time [24]. The finding that short sleepers are replacing sleep time with sedentary leisure time is worrisome. A recent study has shown that replacing sleep with sedentary time is associated with poor cardiometabolic health [25]. The study also reported that replacing sleep, sedentary time, or light physical activity with moderate-vigorous physical activity is associated with more favorable cardiometabolic health [25].

Sleep-deprived people accumulate sleep debt, and they try to pay sleep debt by extending their sleep time on weekends [26, 27] or by taking naps. A recent study has shown that napping and catching up sleep on weekends paid sleep debt only in 1 in four subjects who restricted their sleep to < 6 h [27]. 75% of subjects with sleep debt did not do anything to pay their sleep debt [27]. We are worried about these data as these people may not be even aware that their poor health is due to sleep deprivation and they need to take some actions to correct their sleep patterns.

The above data also highlight that by devoting time for naps or extending sleep time over the weekends and exchanging sleep time with sedentary time, one is taking time away from physical activity which is again detrimental to health. This also means that devoting a regularly recommended duration of sleep on weekdays and weekends will ensure that you have enough time to devote to another important determinant of health which is physical activity.

3 Physical Activity and Health

Optimal exercise and sleep, apart from diet, are both essential for good health. Unfortunately, the inadequacy of both in the current society is leading to increasing various adverse health conditions, chronic illness, morbidity, and all-cause mortality [28, 29]. Increasing awareness of minimum physical activity and optimal sleep for health is thus becoming very important.

4 Recommended Physical Activity

With the association of physical inactivity and sedentarism with various adverse health issues and NCDs (non-communicable diseases) [30], one should engage in the age-specific minimum recommended regular physical activity for improving and maintaining overall health and fitness [31]. If one is not able to meet the minimum physical activity recommendation, at least doing some physical activity will still give health benefits, as doing some physical activity is always better than nothing. Physical activity should be started by doing some small amount first and then slowly progress with increasing frequency, intensity, and duration over adequate time. One should also limit the sedentary time like screen time or duration of seated time, etc., and adults may replace the same with the activity of any intensity for health benefits [31].

The minimum recommendation of physical activity for children (5–17 years) consists of ≥ 1 h/day of moderate-to-vigorous mostly aerobic physical activity on ≥ 3 days/week. Exercise for strengthening muscle and bone should also be incorporated. For adults (18–64 years), ≥ 150 –300 min/week of moderate-intensity; or ≥ 75 –150 min/week of vigorous-intensity aerobic physical activity; or an equivalent combination of moderate & vigorous-intensity throughout the week should be done. For additional health benefits, the above aerobic physical activity may be increased to ≥ 300 min/week of moderate-intensity; or ≥ 150 min/week of vigorous-intensity; or an equivalent combination of moderate & vigorous-intensity throughout the week. Muscle building exercise focusing involving all major muscle groups of the body should also be

done at $\geq$ moderate intensity for ≥ 2 days/week for additional health benefits. In addition to the minimum physical activity recommendation for adults, older adults (≥ 65 years) should also do multicomponent physical activity to prevent falls and increase functional capacity, with emphasis on strength and functional balance training at $\geq$ moderate intensity for ≥ 3 days/week. They should try to be as much physically active as per their functional ability and fitness level.

Pregnant and postpartum ladies, in the absence of any contraindication, should also engage in ≥ 150 min/week moderate-intensity aerobic physical activity, with additions of muscle strengthening exercise and mild stretching. Those who did regular vigorous physical activity before pregnancy or were physically active can continue doing so during pregnancy or postpartum period. They may also do pelvic floor muscle training daily to reduce the risk of urinary incontinence. However, adequate precautions and safety considerations should be taken during the physical activity, which may include avoiding activity during excessive heat and humidity; maintaining adequate hydration before, during and after the activity; avoiding risky activities like activities with physical contact, or risk of falling or limit oxygenation (like high altitude activity, etc.); and avoiding supine physical activity after 1st trimester. Consultation and supervision of a specialized and qualified healthcare provider is a must for athletic competition or exercise above recommended guidelines for pregnant ladies, or gradual starting of physical activity after cesarean delivery. They should also know all the danger signs as informed by the healthcare provider and should know when to stop or limit activity and consult a qualified specialist immediately in case of the presence of those signs [31].

5 Exercise and Sleep: The Interrelationship

Exercise and sleep, the two pillars of good health, have a bidirectional and reciprocal relationship between them, with optimal exercise associated with good sleep and sleep affecting exercise and sports performance [32, 33].

5.1 Effect of Exercise on Sleep

Physical activity and exercise help in promoting a healthy sleep pattern and maintaining a stable circadian rhythm. Low physical activity exacerbates the detrimental health effect of poor sleep, whereas meeting the recommended minimum physical activity guideline, and doing regular exercise eliminates the deleterious effect of poor sleep to some extent [29]. This is especially important in the present urban society where poor sleep is very common.

For optimal sleep, one should regularly engage in physical activity which meets at least the recommended minimum

threshold [28, 29, 32–34]. Although there are reports of acute exercise in the form of cycling providing more sleep benefits than running [35], engaging in any form of exercise irrespective of type is more important than being sedentary for better sleep benefits. Mind–body exercise also may have a significant positive effect on sleep quality [35]. 60 min of vigorous exercise did not improve subjective sleep quality but decreased REM sleep latency and increased delta power in slow wave sleep [36].

The improvement of sleep quality and architecture by exercise is irrespective of the timing of the day one exercises. This is especially true for exercise done earlier in the day with nocturnal sleep quality [28]. Exercise performed up to 3–4 h before sleep irrespective of chronotypes [37, 38], or even 1.5–2 h before sleep has been reported to improve sleep quality [28, 37, 38]. This also includes high-intensity exercise ending 2 h before sleep which does not affect sleep negatively irrespective of a person's chronotypes, but in fact may shorten sleep-onset latency (SOL) and increase total sleep time (TST) with REM sleep reduction [38]. Hence, the minimum duration before bedtime up to which exercise may be done to improve sleep is about ≥ 1.5 –2 h.

There is a widespread apprehension that evening exercise harms subsequent sleep. However, this may not be true as such, especially for mild and moderate exercise ending 2 h or 1 h; and for athletes and physically fit individuals, even 0.5 h or possibly less; before bedtime [37, 39]. High-intensity acute and regular exercise completing 0.5/1–4 h before sleep has been reported not to disturb the subsequent nocturnal sleep and hence no significant change in SOL, TST among healthy young and middle-aged adults [38]. Vigorous exercise ending 0.5–1 h before bedtime may increase sleep-onset latency (SOL), decrease total sleep time (TST) and sleep efficiency (SE) [37–39]. The minimum duration before bedtime up to which exercise may not affect sleep negatively is about ≥ 0.5 h & ≥ 1 h for mild-moderate and vigorous exercise, respectively.

Also, evening exercise may affect negatively only the morning-type and not the evening-type individuals [37]. Morning exercise may not necessarily affect sleep quality negatively in both the chronotypes [38]. Hence, exercise and training in line with one's chronotype may thus be preferred. High-intensity cycling done in the evening high-intensity cycling as compared to running may be associated with more positive or at least no change in subsequent sleep [35, 38]. However, running as compared to cycling has also been reported to associate with less wake-after sleep onset (WASO), but with a trend of higher SOL [39].

As far as the duration of exercise is concerned, positive changes in sleep are associated more with longer (> 30 –60 min) than shorter (25–30 min) exercise. Early evening high-intensity exercise of duration of 30–60 min shortens sleep onset and increases sleep duration with

reduction of REM sleep stage [38]. However, in the late evening, much longer (> 60 min), intense or vigorous exercise ending very close to bedtime may affect sleep negatively [38].

The effect of exercise on sleep may also depend on the previous sleep status, with the effect more among those with baseline impaired sleep or poor sleepers [37]. More slow-wave sleep benefits after acute exercise have also been reported for those with high baseline physical activity and fitness levels [35]. A negative association of sleep disorders with fitness level is thus possible to some extent [28]. Regular physical and mind–body exercise like yoga and tai-chi may be one of the effective non-pharmacological therapies for sleep disorders like insomnia, thereby improving subjective sleep quality, insomnia severity, and daytime sleepiness, etc., especially with moderate aerobic exercise; and for sleep-disordered breathing like obstructive sleep apnea, etc. [32–34, 40]. For the sleep-disordered patients, adequate preparticipation health screening and physical including cardiovascular check-up and examination should be done before initiating any progressive physical activity and exercise program, which should start at low intensity with the close watch for possible exercise-associated illness especially acute cardiovascular events, and injuries [33].

5.2 Effect of Sleep on Exercise and Performance

Optimal quality and quantity of sleep is essential not only for good health, lowering morbidity and mortality, but also for exercise and sports performance [32, 33]. For players, adequate quality and quantity of sleep are required for adequate recovery, optimal adaptation without having overtraining, injury-illness minimization and performance maximization; poor sleep contributes to the detrimental effect on exercise and sports performance, possible physical inactivity, and low fitness [33, 41, 42].

Sleep amount of 7–9 h/night is recommended for younger adults (18–25 years) and adults (26–64 years) [28], which may even be more for athletes [43]. The recommended sleep amount for older adults (≥ 65 years), school-aged children (6–13 years), and teenagers (14–17 years) is 7–8 h/night, 9–11 h/night, and 8–10 h/night, respectively [28]. For players, sleep extension of about ≥ 2 h to make ≥ 9 h/night, napping, and sleep banking may help to recover and perform well [43]. This is especially important for elite athletes as they are more at risk of getting less quantity and quality sleep than non-athletes [43]. Adult athletes on average reported to sleep around 7.2 h/night with 86.3% SE, with SE being even lower (80.3%) among young athletes due to high WASO [44]. The heavy training period was reported to associate with lower sleep duration and SE than pre-season (36 min

& 0.8% lower) and in-season training periods (42 min & 3% lower) [44]. If need be, napping of about 20–90 min in the afternoon (1–4 pm) may be considered by athletes, with at least 30 min for sleep inertia reduction before training/competition for better performance, without compromising nocturnal sleep quality [45].

6 New Perspectives: Sleep, Physical Activity, and Sedentary Behavior Part of 24 h Activity Profile

It is important to conceptualize sleep as part of 24 h activity profile as studies are showing that at the population level sleep time is being replaced with inactive leisure time [24]. A recent study has shown that replacing sleep with sedentary time is associated with poor cardiometabolic health [25]. The study also reported that replacing sleep, sedentary time, or light physical activity with moderate-vigorous physical activity is associated with more favorable cardiometabolic health [25].

Our approach to the relationship between sleep, physical activity, and health needs to change. Rather than focusing on individual sleep parameters and their relationship to health, we need to study multi-dimensional aspects of sleep health and activity-sleep patterns and their relationship to health.

A recent study has reported activity-sleep patterns based on the duration of moderate to vigorous physical activity (MVPA), frequency of resistance training, sitting time, sleep duration, sleep quality, and variability in bed and wake times [46]. This study identified the following activity-sleep patterns—very active good sleepers, inactive good sleepers, inactive poor sleepers, and moderately active good sleepers, representing 38.2%, 22.2%, 21.2%, and 18.4% of the sample, respectively.

The above suggestion is supported by a study that showed that the addition of sleeping sufficiently to a combination of good physical activity, diet, moderate alcohol consumption, and smoking cessation further decreased the risk of fatal cardiovascular disease by 16% [47].

A recent systematic review reported that health would improve if time was reallocated into MVPA and that health would worsen if time was taken out of MVPA, irrespective of what other movement behavior MVPA was reallocated out of or into. Health would also improve if time were taken out of sedentary behavior and reallocated into sleep or LPA [48].

The Canadian Society of Exercise Physiology recently published 24 h movement guidelines on integrating physical activity, sedentary behavior, and sleep [49]. They gave the following recommendations for adults aged 18–64 yr:

1. **Physical activity-** Adults should perform different types and intensities of physical activity including-
 - a. 150 min per week of MVPA
 - b. Muscle-strengthening activities using major muscle groups twice a week
 - c. Several hours of light physical activity including standing
2. **Sleep-** Adults should try to sleep for 7–9 h of good quality sleep maintaining consistent bed and wake times
3. **Sedentary behavior-** Adults should reduce sedentary time to less than 8 h with the following recommendations-
 - a. Reduce recreational screen to less than 3 h
 - b. Move-in between sedentary work routines as often as possible

Following recommendations were given for adults aged > 65 years [49]-

1. **Physical activity-** Adults should perform different types and intensities of physical activity including-
 - a. 150 min per week of MVPA
 - b. Muscle-strengthening activities using major muscle groups twice a week
 - c. Physical activities challenging balance
 - d. Several hours of light physical activity including standing
2. **Sleep-** Adults should try to sleep for 7–8 h of good quality sleep maintaining consistent bed and wake times
3. **Sedentary behavior-** Adults should reduce sedentary time to less than 8 h with the following recommendations-
 - a. Reduce recreational screen to less than 3 h
 - b. Move-in between sedentary work routines as often as possible

We would commend the Canadian Society of Exercise Physiology vision in recognizing this important concept of physical activity, sleep, and sedentary behavior as part of 24 h activity profile and laying down clear guidelines for each of these domains during the 24 h period.

This is an excellent beginning, and we hope that in the future more data will allow us to have more detailed

definitions of regularity and consistency of sleep times, and sleep quality in these definitions. Until then, the clinical community should start to include advice on sleep also along with advice on physical activity and good nutrition to their patients.

Declarations

Conflict of Interest Tripat Deep Singh is part time employee of REM42. Hanjabam Barun Sharma has no conflict of interest.

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