Physiology & Behavior 120 (2013) 46–53

Contents lists available at ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Increased self-reported and objectively assessed physical activity predict sleep quality among adolescents

Christin Lang [a,*], Serge Brand [a,b], Anne Karina Feldmeth [a], Edith Holsboer-Trachsler [b], Uwe Pühse [a], Markus Gerber [a]

[a] Institute of Exercise and Health Sciences, University of Basel, Basel, Switzerland
[b] Psychiatric Hospital of the University of Basel, Center for Affective, Stress and Sleep Disorders, Basel, Switzerland

HIGHLIGHTS

- Increased subjective and objective PA predict better subjective and objective sleep.
- Self-reported PA levels are a better predictor for self-reported sleep.
- Objective PA levels have a higher influence on objective sleep.
- Vigorous PA levels tend to be a better predictor for good sleep than moderate PA.
- Males reported fewer sleep complaints than females.

ARTICLE INFO

Article history:
Received 10 January 2013
Received in revised form 5 June 2013
Accepted 2 July 2013

Keywords:
Adolescent
Sleep deprivation
Insomnia
Sleep-EEG
Exercise
Actigraphy

ABSTRACT

Both scientists and the general public assume that physical activity (PA) is an effective, non-pharmacological approach to improvement in sleep quality. However, objective and reliable data on this relationship are scarce, particularly for adolescents. Therefore, the aims of the present study were to test the relationship by assessing both PA and sleep subjectively and objectively. A total of 56 adolescent vocational school students (Mean age = 17.98, SD = 1.36; 28 males, 28 females) participated in the study. Sleep and PA were subjectively assessed via questionnaires. Accelerometers objectively assessed PA, while sleep-EEG devices objectively assessed sleep. The data supported our prediction that adolescents with high PA levels would have longer TST, fewer wakening at night (WASO), fewer symptoms of insomnia, and higher sleep quality. However, gender influenced this pattern of results in that significant findings were only found between high self-reported PA levels and shorter perceived sleep onset latency (SOL). Though self-reported PA levels were a better predictor of good sleep than objectively assessed PA levels, gender was associated with sleep complaints; females reported more sleep complaints. Results indicate that among a non-clinical sample of adolescents increased PA is favorably associated with restoring sleep. Therefore, PA seems beneficial not only for physical and mental health, but also for sleep restoration.

1. Introduction

Adolescence is defined as a vulnerable period characterized by several changes in physiological, psychiatric, socio-cultural and psychological factors that affect health and behavior, including sleep quality and quantity [1–4]. For vocational students, additional responsibilities arise in the transition to a vocational school and balancing academic and job requirements [5]. Neurobiological sleep-regulatory mechanisms also play a role; there are underlying changes in both circadian and homeostatic components of sleep which influence the sleep–wake cycle, as well as sleep timing, duration, and architecture [2,6,7]. The most striking change in sleep architecture is the decrease in slow wave sleep (SWS) [8–10].

Whereas poor sleep is associated with maladaptive functioning and a number of psychiatric and physical diseases [1], there is a dearth of knowledge on the sleep quality of adolescents attending vocational education and training. Pharmacological and psychotherapeutic treatments of insomnia have proved successful but entail negative side effects or require professional intervention [11,12]. In contrast, physical activity (PA) is an alternative favored by many sleep experts [13–15]. There are two main hypotheses about the mechanism through which PA positively influences sleep. First, PA produces physiological changes favorable to sleep regulation. For

* Corresponding author at: University of Basel, Switzerland, Institute for Exercise and Health Sciences, Birsstrasse 320, CH-4052 Basel, Switzerland. Tel.: +41 61 377 87 85; fax: +41 61 377 87 89.
E-mail address: christin.lang@unibas.ch (C. Lang).

0031-9384/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.physbeh.2013.07.001

example, Dworak et al. [16] were able to show that among young adolescents (12.6 years old) high-intensity exercise resulted in a significant rise in the proportion of SWS, less sleep in stage 2, greater sleep efficiency (SE %), and shorter sleep onset latency (SOL). Kalak et al. [17] assessed the sleep of 19 year olds via sleep-EEGs after three consecutive weeks of morning running, compared to a control condition. Objective sleep improved (SWS increased; SOL decreased) in the running group compared to the control group. The second hypothesis is that the sleep-promoting effects of PA are mediated via psychological functioning [18–20], by decreased symptoms of depression [21,22], anxiety [23,24], and stress [25,26]. Thus, in previous studies of adolescents, we have found that self-reported exercise was positively related to adolescents' sleep and psychological functioning: Adolescent exercisers reported better sleep patterns, while males with low exercise levels were at increased risk for poor sleep and psychological functioning [12]. In a second study [22], objectively assessed but not self-reported sleep was significantly related to exercise level, higher positive coping and curiosity scores, and lower depressive symptom scores.

However, many adolescents reduce their PA levels during this period of life [27–29]. Vocational students in particular report lower levels of exercise than peers attending regular high schools [30,31]. However, the relationship between PA and the functional importance of sleep among vocational students has received little attention thus far. This is surprising, given that 74% of all secondary school diplomas in Switzerland are granted to students with vocational education and training (VET) [32]. In Switzerland, VET serves as the primary gateway to numerous occupations. Most students start at the age of 16 or 17. Swiss VET combines apprenticeships in a company and vocational training in a school; students work three to four days a week in a company and attend a vocational school on one to two days a week. While apprentices receive a limited salary for their work in the company, they often have equal workloads in terms of working hours as well as responsibilities similar to adult employees. Overall, compared to academic high school students, vocational students face a dual burden of academic and work requirements: Depending on vocation, students have to manage this challenging condition for three to four years. With respect to the relationship between sleep and work, in one study the number of working hours was negatively correlated with hours of sleep, and decreased sleep quality was correlated with increased strain, depression and anxiety [33]. Additionally, employees who report poor sleep or symptoms of insomnia tend to consume more medical resources [34] and at work they exhibit lower self-esteem [35], lower work efficiency and higher absenteeism rates [36,37]. Collectively, these findings suggest that adolescents attending vocational schools are at greater risk for developing sleep disturbances or sleep-related psychological dysfunction.

Despite the evidence from two studies [16,17] that PA has beneficial effects on sleep, findings from cross-sectional studies among adolescents remain inconclusive [15,20,38–41]. Whereas epidemiological data from self-reports have consistently revealed a positive relationship between PA and sleep [42–44], findings are difficult to interpret and compare given the vast array of different measurement methods in this field of research. To the best of our knowledge, no previous study has assessed PA and sleep via both subjective and objective methods in the adolescent population. Therefore, the present study aims to establish findings for the adolescent population, and overcome methodological limitations, by assessing PA and sleep both subjectively and objectively.

Five hypotheses were tested (see Fig. 1). (1) PA levels as assessed subjectively by questionnaire and objectively by accelerometer will correlate positively [45,46]. (2) Sleep quality as assessed by questionnaires and by sleep-EEG device will positively intercorrelate [47]. Subjective sleep quality will be positively associated with both (3a) subjective PA level [12,22], and (3b) objective PA level [48]. We further expected that more favorable objectively assessed sleep will be related to higher (4a) subjective, and (4b) objective PA levels [49,50]. (5) Following cognitive models of insomnia [51], our final hypothesis was that subjective PA levels would better predict sleep quality than objective PA levels.

2. Materials and method

2.1. Participants and procedure

A sample of 1581 young people (age: 16–25 years, mean = 17.98, SD = 1.36, 43% females) attending two vocational schools in central and German speaking Switzerland completed a series of questionnaires related to PA, psychological functioning and sleep (see below for details). They were all participants in the EPHECT-study (www.ephect.unibas.ch), a research project focusing on the interplay between stress, coping, sleep and health among Swiss vocational students. Baseline data were collected in August 2010. All participants completed the questionnaires during class hours (range 20–40 min). Participants received detailed information about the purpose of the study and about the voluntary nature of their participation. They were assured confidentiality and provided informed written consent prior to completing the questionnaires. Parents' informed consent was required for those under 18 years old. The study was approved by the local ethical committee and was performed according to the ethical standards in the Declaration of Helsinki.

Next, from this larger sample 56 adolescents (M_{age} = 17.98, SD = 1.36; 28 males, M_{age} = 18.14, SD = 1.17; females, M_{age} = 18.21, SD = 0.89) were selected for further objective PA and sleep assessments. The following inclusion criteria were applied: 1) Willing and able to participate in further assessments of PA and sleep, consisting of wearing an accelerometer for three consecutive days and nights, and sleeping for one night with a sleep-EEG. 2) Reporting low or high scores (based on median splits) on both a 30-item short version of the Adolescents Stress Questionnaire (ASQ) [52] (median = 69.0, possible range: 0–150) [53] and the 4-item version of the Insomnia Severity Index (ISI) [54] (median = 8.0; possible range: 0–20). 28 participants were randomly selected from each group, stratified for gender (50% female). Objective measurements were carried out shortly after the adolescents had completed the survey questionnaires.

Three participants (two males, one female) were excluded from the analyses because accelerometer recordings were missing. There were 18 further exclusions (16 males, 2 females) due to missing EEG-recordings. Thus, complete subjective and objective data for PA and sleep were available from 37 participants (13 males, 24 females). Independent samples *t*-tests revealed no differences between participants with complete vs. incomplete data for sleep and PA parameters. Therefore, all analyses are based on the 37 participants with complete data.

2.2. Measurements

2.2.1. Assessment of subjective PA

To assess self-reported PA, participants indicated how many days they had engaged in vigorous PA over the previous week. The response categories ranged from 0 to 7 days. In addition, participants were asked to indicate the average duration (per day) for the days they engaged in these activities. PA frequency multiplied by duration yielded hours of weekly exercise and sport. Moderate PA was assessed in a similar way. Both items were taken from the International Physical Activity Questionnaire (IPAQ) [55]. Following the IPAQ (see www.ipaq.ki.se/scoring.pdf), guidelines for data processing and analysis PA time exceeding '3 h' was set to '3 h'. Therefore, 21 h of moderate and vigorous PA per week was the maximum value. The guideline further suggests commuting total moderate and vigorous PA min/week into MET-min/week (metabolic equivalent of task). Moderate PA minutes were multiplied by 4.0 METs and vigorous PA minutes by 8.0 METs. Moderate to vigorous PA (MVPA) was then calculated by summing across moderate PA METs and vigorous PA METs. Ottevaere et al. [46] showed that the IPAQ predicts cardio-respiratory fitness among adolescents equally as well as actigraph accelerometers.