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Original Article

Sleep deficiency on school days in Icelandic youth, as assessed by wrist accelerometry

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ABSTRACT

Aims: The purpose of this study was to objectively measure, with wrist-worn actigraphy, free-living sleeping patterns in Icelandic adolescents, and to compare sleep duration, sleep quality and clock times between school days (SchD) and non-school days (NSchD) and the association between sleep and body mass index (BMI).

Methods: A cross-sectional study on 15.9-year-old (±0.3) adolescents from six schools in Reykjavík, Iceland, took place in the spring of 2015. Free-living sleep was measured on 301 subjects (122 boys and 179 girls) over seven days using wrist-worn actigraphy accelerometers. Total rest time (TRT), total sleep time (TST), sleep quality markers, and clock times for sleep were quantified and compared between SchD and NSchD and between the sexes, using paired and group *t*-tests as appropriate. Linear regression was used to assess the association between sleep parameters and BMI.

Results: On SchD, TST was 6.2 ± 0.7 h, with sleep efficiency (SLE) of 87.9 ± 4.4% for the group. On NSchD, TST increased to 7.3 ± 1.1 h ($p < 0.001$), although SLE decreased to 87.4 ± 4.7% ($p < 0.05$). On SchD and NSchD, 67% and 93% had bed times after midnight, respectively, and on SchD 10.7% met sleep recommendations (8 h/night). There was no association between BMI and average sleep parameters.

Conclusion: The majority of Icelandic adolescents did not get the recommended number of hours of sleep, especially on SchD. While TST increased on NSchD, many participants still did not achieve the recommendations. These findings provide information on the sleep patterns of adolescents and may serve as reference for development of policies and interventions to promote better sleep practices.

1. Introduction

Sleep plays an important role in adolescents' health and well-being. Adequate sleep is an essential element for proper function of body and mind, which influences quality of life. The National Sleep Foundation recommends that teenagers, aged 14–17 years old, should sleep at least 8–10 h a night [1]. Inadequate sleep duration in adolescents is associated with higher body mass index (BMI) [2,3], greater body fat [4], increased insulin resistance [5], and reduced academic performance [6].

A previous study using questionnaires and sleep diaries found that Icelandic youth had shorter sleep duration than their European peers [7]. Although subjective, self-report methods were commonly used in the past to assess adolescent sleep patterns [8], they tend to overestimate actual sleep length, suggesting that adolescents may sleep even less than previously reported [9]. Wrist actigraphy is an objective method of studying free-living sleep patterns via a watch-like accelerometer and well-validated sleep detection algorithms [10–14]. Although an actigraphy based sensor using the chosen algorithm has been validated against polysomnography (PSG), this specific device is newer to the market and has only been used in conjunction with PSG in other populations. However, it is designed and marketed specifically to researchers and not for the commercial market. It is believed that no study, to date, has objectively measured free-

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living sleeping patterns during school and non-school days in Icelandic children or adolescents.

Whilst sleep duration, or the minutes of sleep per night, is the most widely reported and studied sleep measure, emerging research has also shown that sleep timing is another important component of sleep that may influence overall metabolic health [5]. The biological circadian clock is an important regulator of sleep and other individual behaviors. However, in modern society, the sleep–wake cycle is heavily influenced by factors like school, work, or other social schedules [15,16]. The term "social jetlag" has been coined to describe the misalignment between social schedules and the circadian clock [16,17]. Consequently, along with investigating sleep duration, it is also important to study the influence of other sleep dimensions, such as sleep quality, and the consistency in bed time (BT) and wake-up time [3] on health outcomes such as BMI.

1.1. Aims of the study

The primary purpose of this study was to objectively investigate, with wrist actigraphy, free-living sleeping patterns in Icelandic adolescents. Secondary aims included: (a) assessing differences in sleep duration, sleep quality and clock times between the sexes; (b) examining differences in sleep patterns between school days (SchD) and non-school days (NSchD); and (c) investigating the association between sleep and BMI.

2. Methods

2.1. Participation

A total of 411 tenth-grade students (15–16 years old) – 47% boys and 53% girls – from six schools in Reykjavík, Iceland, received an invitation letter to participate in this study. The data collection took place in the spring of 2015 (April–June). A total of 315 pupils participated in the study (Fig. 1). Non-participation ($n = 104$) was mainly due to absence from school during measurement days and lack of interest in the study. Study participation is shown in Fig. 1.

Written informed consent was obtained from all participants and their guardians. Strict procedures were followed to ensure confidentiality. The study was approved by the National Bioethics Committee and the Icelandic Data Protection Authority (Study number: VSN b200605002&03).

2.2. Sleep parameters

Free-living sleep was measured with wrist-worn raw signal accelerometers: ActiGraph GT3X+ (ActiSleep by Actigraph Inc., Pensacola, Florida, USA). The small (3.8 cm × 3.7 cm × 1.8 cm) and light (27 g) Actigraphy watches were placed on the non-dominant wrist of each subject, at school, and each was asked to continuously wear the monitor for seven days. Raw triaxial data were sampled at 80 samples/second (Hz). Sleep parameters were derived from the Actilife software from Actigraph (Pensacola, FL, USA) (version 6.13.0.) using a sleep detection algorithm specifically validated for adolescents [13]. Wrist actigraphy has high sensitivity and moderate specificity, and overall high accuracy when compared to PSG [12], which is the gold standard in sleep research. Wrist actigraphy has been recommended for characterization of sleep parameters in population-based studies of young adults [10].

Rest and sleep durations, timing, and other sleep quality parameters (such as sleep efficiency (SLE), and wakening after sleep onset (WASO), as shown in Table 1) were first determined by auto-detection of the Actilife sleep analysis. Self-reported sleep logs of BT and rise time were then used to confirm the rest intervals determined by the software detection, and two expert scorers adjusted them, when necessary (inter-scorer variability was evaluated, data not shown). Total rest time (TRT) was compared to the recommended 8 h of sleep for adolescents in this age range [1], and the proportion of participants going to bed after midnight was also calculated. Measurements of daily sleep data for at least three valid SchD and one valid NSchD with wear time >14 h were considered valid. Naptime was not included in the analyses, due to low incidents of naps detected in the data (22 total naps taken by 18 different subjects).

2.3. Anthropometric measures

Standing height was measured with a stadiometer (Seca model 217, Seca Ltd. Birmingham, UK) to the nearest 0.1 cm. Body weight was measured on a balance scale (Seca model 813, Seca Ttd., Birmingham, UK) to the nearest 0.1 kg, with participants wearing light clothes. BMI was calculated by dividing weight by height squared (kg/m^2). All measurements were performed at individual schools.

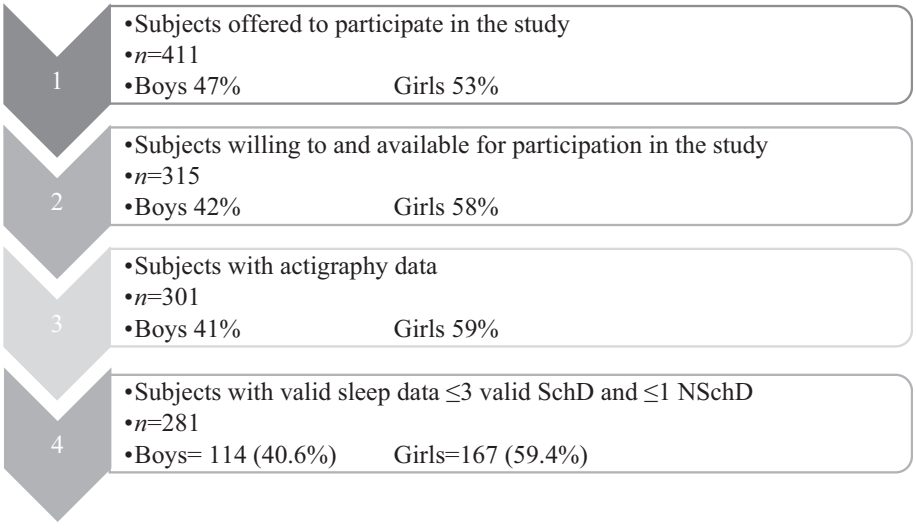

Fig. 1. Participation in the study. SchD, school days; NSchD, non-school days.