Sleep Health xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

No evidence for an epidemiological transition in sleep patterns among children: a 12-country study

Taru Manyanga, MSc [a], Joel D. Barnes, MSc [a], Mark S. Tremblay, PhD [a], Peter T. Katzmarzyk, PhD [b], Stephanie T. Broyles, PhD [b], Tiago V. Barreira, PhD [b,c], Mikael Fogelholm, ScD [d], Gang Hu, MD, PhD [b], Carol Maher, PhD [e], Jose Maia, PhD [f], Timothy Olds, PhD [e], Olga L. Sarmiento, MD, PhD [g], Martyn Standage, PhD [h], Catrine Tudor-Locke, PhD [b,i], Jean-Philippe Chaput, PhD [a,*], for the ISCOLE Research Group

[a] Children's Hospital of Eastern Ontario Research Institute, Ottawa, Canada
[b] Pennington Biomedical Research Center,, Baton Rouge, LA, USA
[c] University of Syracuse, Syracuse, NY, USA
[d] University of Helsinki, Helsinki, Finland
[e] University of South Australia, Adelaide, Australia
[f] CIFI2D, University of Porto, Porto, Portugal
[g] Universidad de los Andes, Bogota, Colombia
[h] University of Bath, Bath, United Kingdom
[i] University of Massachusetts Amherst, Amherst, MA, USA

ARTICLE INFO

Article history:
Received 2 June 2017
Received in revised form 20 October 2017
Accepted 26 October 2017
Available online xxxx

Keywords:
Sleep
Socioeconomic status
Income
Education
Human development index
Gini index

ABSTRACT

Objective: To examine the relationships between socioeconomic status (SES; household income and parental education) and objectively measured sleep patterns (sleep duration, sleep efficiency, and bedtime) among children from around the world and explore how the relationships differ across country levels of human development.
Design: Multinational, cross-sectional study from sites in Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the United Kingdom, and the United States.
Setting: The International Study of Childhood Obesity, Lifestyle and the Environment.
Participants: A total of 6040 children aged 9-11 years.
Measurements: Sleep duration, sleep efficiency, and bedtime were monitored over 7 consecutive days using waist-worn accelerometers. Multilevel models were used to examine the relationships between sleep patterns and SES.
Results: In country-specific analyses, there were no significant linear trends for sleep duration and sleep efficiency based on income and education levels. There were significant linear trends in 4 countries for bedtime (Australia, United States, United Kingdom, and India), generally showing that children in the lowest income group had later bedtimes. Later bedtimes were associated with lowest level of parental education in only 2 countries (United Kingdom and India). Patterns of associations between sleep characteristics and SES were not different between boys and girls.
Conclusions: Sleep patterns of children (especially sleep duration and efficiency) appear unrelated to SES in each of the 12 countries, with no differences across country levels of human development. The lack of evidence for an epidemiological transition in sleep patterns suggests that efforts to improve sleep hygiene of children should not be limited to any specific SES level.

Introduction

Sleep is an essential pillar of health. Inadequate sleep patterns characterized by short sleep duration, poor sleep quality, and late bedtimes have become pervasive in contemporary societies, especially in children.[1–3] Studies have consistently reported adverse health

* Corresponding author at: Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, 401 Smyth Road, Ottawa, Ontario, Canada, K1H 8L1. Tel.: +1 613 737 7600x3683; fax: +1 613 738 4800.
E-mail address: jpchaput@cheo.on.ca (J.-P. Chaput).

https://doi.org/10.1016/j.sleh.2017.10.010
2352-7218/

consequences associated with these sleep patterns.[4–6] In particular, previous studies have shown that the socioeconomically disadvantaged are more likely to experience sleep patterns that are associated with adverse health outcomes.[7] However, studies in this field have largely been conducted in high-income countries, and it is unknown whether the same observations would apply in low/middle-income countries or if indeed there is some gradient.

The theory of epidemiological transition, which characterizes changes across levels of a country's development in patterns of morbidity and mortality, was originally proposed by Omran.[8] We recently showed, using the same dataset, that adiposity in children increased linearly across levels of socioeconomic status (SES) in countries at lower levels of human development but decreased linearly with SES in countries at higher levels of human development.[9] Human development was measured with the Human Development Index (HDI), a composite statistic of life expectancy, education, and per capita income indicators used to rank countries into 4 tiers of human development. The "nutrition transition" (shifts from undernutrition to overnutrition and from traditional diets to energy-dense diets) and "physical activity transition" (shifts away from high levels of occupation- and transportation-based physical activity to more sedentary lifestyles) have also been reported previously.[10,11]

To our knowledge, no studies to date have examined whether a similar epidemiological transition exists with regard to sleep patterns among children. Understanding how sleep patterns may be linked to SES across countries at different levels of human development is important to inform public health policies and tailor interventions aimed at improving sleep and health outcomes that are setting specific. However, if an epidemiological transition in sleep patterns is not occurring, this would mean that efforts to improve sleep of children would need to focus on other determinants of inadequate sleep patterns across all segments of the population (high income or low income, educated or not).

The objective of this study was to investigate the relationships between SES (household income and parental education) and objectively measured sleep patterns (sleep duration, sleep efficiency, and bedtime) among a large cross-sectional sample of children from all inhabited continents of the world and explore how the relationships differ across levels of human development as assessed using the HDI.

Participants and methods

Study design and setting

The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) is a cross-sectional, multinational study designed to examine the relationships between lifestyle behaviors and obesity in 12 study sites located in Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the United Kingdom and the United States. These countries represent a wide range of economic development (low to high income), HDI (0.509 in Kenya to 0.929 in Australia), and inequality (Gini index of 26.9 in Finland to 63.1 in South Africa).[12–14] Detailed descriptions of the design and methods for ISCOLE have been reported elsewhere.[12] By design, the within-site samples were not intended to be nationally representative. The primary sampling frame was schools, which were typically stratified by an indicator of SES to maximize variability within sites. A standardized protocol was used to collect data across all sites, and all study personnel underwent rigorous training and certification to ensure high-quality data. The Institutional Review Board at the Pennington Biomedical Research Center in Baton Rouge, LA, USA (coordinating center), approved the ISCOLE protocol, and the Ethical Review Boards at each participating institution also approved the local protocol. Written informed consent was obtained from parents or legal guardians, and child assent was also obtained. Data were collected during the school year at each study site and occurred between September 2011 and December 2013.

Participants

ISCOLE targeted grade levels likely to ensure minimal variability around a mean age of 10 years. All children within the targeted grade level in a sampled school were eligible to participate; hence, the sample included 9- to 11-year-old children. Based on a priori sample size and power calculations,[12] each site aimed to recruit a sex-balanced sample of at least 500 children. Of the 7372 children who participated in ISCOLE, a total of 6040 remained in the present analytic data set after excluding participants without valid sleep data ($n = 1054$), reported level of parental education ($n = 247$), and body mass index (BMI) z-scores ($n = 31$). Except for significantly higher BMI z-scores, the descriptive characteristics of participants who were excluded for missing data did not significantly differ from those who were included in the present analysis.

Measurements

Sleep patterns

Nocturnal sleep duration, sleep efficiency, and bedtime were all objectively assessed using 24-hour, waist-worn accelerometry. Waist-worn accelerometry has been chosen instead of wrist-worn accelerometry in ISCOLE because it has been reported to provide better physical activity and sedentary time data.[12] An Actigraph GT3X+ accelerometer (ActiGraph LLC, Pensacola, FL) was worn at the waist on an elasticized belt at the right midaxillary line. Participants were encouraged to wear the accelerometer 24 hours per day (removing only for water-based activities) for at least 7 days, including 2 weekend days. The minimal amount of daytime data that was considered acceptable for inclusion was at least 4 days with at least 10 hours of wake wear time per day, including at least 1 weekend day. Data were collected at a sampling rate of 80 Hz, downloaded in 1-second epochs with the low-frequency extension filter using the ActiLife software version 5.6 or higher, and reintegrated to 60-second epochs for analysis. Nocturnal sleep duration was estimated using a fully automated algorithm for 24-hour waist-worn accelerometers that was developed and validated for ISCOLE.[15,16] This algorithm produces more precise estimates of sleep duration than previous algorithms and captures total sleep time from sleep onset to sleep offset, including all epochs and wakefulness after onset.[15,16] The weekly sleep duration averages were calculated using only days where valid sleep was accumulated (ie, total sleep period time ≥ 160 min/night and >90% estimated wear time) and only for participants with at least 3 nights of valid sleep, including 1 weekend night (Friday or Saturday). The same device was used to determine sleep efficiency (total sleep episode time divided by sleep period time) and bedtime (first 5 consecutive minutes defined as sleep).[15,16]

Socioeconomic status

Two different measures of SES were used in the current study: annual household income and highest level of parental education. Participants' parents/legal guardians self-reported household income using a monetary scale in the currency of each country. Each country-specific income scale (8-10 categories) was collapsed into 4 levels to facilitate multicountry analyses.[9] Although not corresponding exactly to quartiles, the 4 levels were created to ensure the most balanced distribution possible within each country. For education, both parents/legal guardians self-reported their highest education levels, which were then combined into a single measure indicating the highest level of parental education. Three categories were used to facilitate analysis across sites: "did not complete high school," "completed high school or some college," or "bachelor's or

Please cite this article as: Manyanga T, et al, No evidence for an epidemiological transition in sleep patterns among children: a 12-country study, Sleep Health (2017), https://doi.org/10.1016/j.sleh.2017.10.010