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**Leisure-time sedentary behavior and loneliness among 148,045 adolescents aged 12–15 years from 52 low- and middle-income countries**

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**Abstract**

*Background:* Loneliness is widespread in adolescents and is associated with a myriad of adverse physical and mental health outcomes. Exploring variables associated with loneliness is important for the development of targeted interventions. The aim of the current study was to explore associations between leisure-time sedentary behavior and loneliness in adolescents from 56 low- and middle-income countries.

*Methods:* Data from the Global School-based Student Health Survey were analyzed. Self-report data on past 12-month loneliness and leisure-time sedentary behaviour were collected. Multivariable logistic regression and meta-analysis were conducted to assess the associations.

*Results:* Among 163,727 adolescents (age 13.7±SD 0.95 years; 48.3% female), the prevalence of loneliness increased with increasing time spent in leisure-time sedentary behavior: from 8.7% (1-2 hours/day) to 17.5% (>8 hours/day). After adjustment for potential confounders, compared to those who engage in less than 1 hour of leisure-time sedentary behavior per day, the OR (95%CI) of loneliness for 1-2 hours/day, 3-4 hours/day, 5-8 hours/day and >8 hours/day were 1.01 (0.92-1.11), 1.31 (1.18-1.45), 1.43 (1.25-1.65), and 1.72 (1.47-2.01), respectively.

*Limitations:* The study is cross-sectional, therefore the directionality of the relationships cannot be deduced.

*Conclusions:*Our data suggest that leisure-time sedentary behavior is associated with increased odds for feeling lonely in adolescence. Future longitudinal data are required to confirm/refute the findings to inform public prevention campaigns.

**Keywords:** loneliness; sitting; sedentary; physical activity; mental health; adolescents

**Introduction**

Loneliness is defined as the discrepancy between a person’s desired and actual social relationships (Perlman and Peplau, 1981). It has been associated with a myriad of adverse physical and mental health outcomes in adulthood including premature mortality (Holt-Lunstad et al., 2015). Contrary to common stereotypes, loneliness is not restricted to middle-aged or older people, but can occur at any life stage, even in early adolescence (Luhmann and Hawkley, 2016). Indeed, the prevalence of loneliness in adolescents aged 13 to 15 years has been reported to range from 5.2 to 14.7% (Stickley et al., 2016). Although evidence regarding the adverse health outcomes of loneliness in adolescence is limited compared to older adults (Choi and Matz-Costa, 2017; Neergheen et al., 2019), there is growing evidence that loneliness is already in this life stage associated with a variety of negative mental and physical health outcomes. In the Social and Health Assessment (SAHA) survey which included 2205 Czech, 1995 Russian, and 2050 U.S. male and female adolescents aged 13 to 15 years old, adolescents who were lonely had higher odds for reporting headaches, anxiety and depressive symptoms across all subgroups (Stickley et al., 2016). Loneliness was also associated with other somatic symptoms in at least half of the adolescents (Stickley et al., 2016).

The underlying mechanisms for the higher risk for mental and physical health problems in adolescents who feel lonely remain entirely unclear (Cacioppo and Patrick, 2008). In adults, several psychobiological processes including neuroendocrine dysregulation (Cacioppo et al., 2015a) and exaggerated blood pressure and inflammatory reactivity to acute stress (Brown et al., 2018) have been suggested. It is also possible that poorer health behaviors might be central to the association between loneliness and mental and physical health problems in adolescents (Stickley et al., 2016). For example, a recent study showed that adolescent loneliness is linked to different forms of substance use (Stickley et al., 2014), while previous research has demonstrated an association between adolescent alcohol and drug use and somatic symptoms and mental health problems (Addiction and Abuse, 2011).

One health behavior which has rarely been studied in relation to loneliness is sedentary behavior (i.e., any behavior during waking hours with energy expenditure less than or equal to 1.5 metabolic equivalents while in a sitting or reclining posture (Cart, 2012)). There is now evidence that adolescent sedentary behavior is, independent from physical activity levels, associated with physical and mental disease risk (de Oliveira and Guedes, 2016; Farren et al., 2018; Raudsepp et al., 2019; Wu et al., 2017). Thus, if loneliness is associated with increasing time spent sedentary, this information may provide clues on the mechanisms that link loneliness with adverse health outcomes. The current evidence in adolescents comes from a few studies in Western countries and concluded that there is insufficient evidence for an association between time spent in specific sedentary behaviors and loneliness (Hoare et al., 2016). One study including 261 7th and 10th graders from suburban California public schools found no significant associations between loneliness and total daily average time spent talking on the phone, watching TV and using the Internet (Gross, 2004), while another Australian study including 336 young people aged between 15 and 21 years from a secondary school and a university population  reported no significant associations with time spent online (categorized by time spent communicating, entertainment purposes, or information-related activities) (Donchi and Moore, 2004). However, data on overall time spent sedentary during leisure-time is missing. Such information is important as it might provide a better picture about the association between being sedentary and loneliness compared with exploring associations with specific behaviors such as internet use. These specific behaviors might be insufficiently representative for a sedentary lifestyle. Also, evidence from low and middle-income countries (LMICs) is currently lacking. Exploring associations between loneliness and sedentary behavior with a focus on LMICs is important given different sociocultural attitudes towards sedentary behavior (e.g., being able to use motorized transport may be viewed as a sign of wealth), different access to devices (e.g., television, computers) and different environmental factors (e.g., safety, climate) in LMICs compared with high-income countries (Arat and Wong, 2017).

Given the current gaps in the literature, the aim of the current study was to assess the association between loneliness and sedentary behavior in adolescents using data from 56 LMICs from six World Health Organization (WHO) regions [African Region (AFR), Region of the Americas (AMR), Eastern Mediterranean Region (EMR), EUR (European Region), South-East Asia Region (SEAR), Western Pacific Region (WPR)].

**Methods**

*The survey*

Publicly available data from the Global school-based Student Health Survey (GSHS) were analyzed. Details on this survey can be found at http://www.who.int/chp/gshs and http://www.cdc.gov/gshs. Briefly, the GSHS was jointly developed by the WHO and the US Centers for Disease Control and Prevention (CDC), and other UN allies. The core aim of this survey was to assess and quantify risk and protective factors of major non-communicable diseases. The survey draws content from the CDC Youth Risk Behavior Survey (YRBS) for which test-retest reliability has been established (Brener et al., 1995). The survey used a standardized two-stage probability sampling design for the selection process within each participating country. For the first stage, schools were selected with probability proportional to size sampling. The second stage involved the random selection of classrooms which included students aged 13-15 years within each selected school. All students in the selected classrooms were eligible to participate in the survey regardless of age. Data collection was performed during one regular class period. The questionnaire was translated into the local language in each country and consisted of multiple choice response options; students recorded their response on computer scannable sheets. All GSHS surveys were approved, in each country, by both a national government administration (most often the Ministry of Health or Education) and an institutional review board or ethics committee. Student privacy was protected through anonymous and voluntary participation, and informed consent was obtained as appropriate from the students, parents and/or school officials. Data were weighted for non-response and probability selection.

 From all publicly available data, we selected all nationally representative datasets that included the variables used in the current analysis. If there were more than two datasets from the same country, we chose the most recent dataset. A total of 56 countries were included in the current study. The characteristics of each country or survey are provided in **Table 1**. For the included countries, the survey was conducted between 2003 and 2016, and consisted of 10 low-income (N=20,388), 30 lower middle-income (N=81,878), 16 upper middle-income (N=61,461) countries based on the World Bank classification at the time of the survey.

***Loneliness*** *(dependent variable)*

Loneliness was assessed with the question “During the past 12 months, how often have you felt lonely?” with answer options ‘never’, ‘rarely’, ‘sometimes’, ‘most of the time’, and ‘always’. This variable was dichotomized as never, rarely, sometimes (coded=0) and most of the time, always (coded=1) as in a previous GSHS publication.(Glozah et al., 2018)

***Leisure-time sedentary behavior*** *(independent variable)*

Leisure-time sedentary behavior was assessed with the question “How much time do you spend during a typical or usual day sitting and watching television, playing computer games, talking with friends, or doing other sitting activities?” with six answer options: <1, 1-2, 3-4, 5-6, 7-8, and >8 hours/day. This excluded time at school and when doing homework. This variable was used as a five-category variable (5-6 and 7-8 hours/day were merged as the proportion of those who replied 7-8 hours/day was small) or a dichotomized variable (≥3 hours/day or not) (Guthold et al., 2010). This question was based on the National Health And Nutrition Examination Survey (NHANES) questionnaire from 1999-2000, and modified for use in children.

***Control variables***

Covariates included sex, age, food insecurity, anxiety-induced insomnia, number of friends, and physical activity. As in previous studies using the same dataset (Balogun et al., 2014; Carvalho et al., 2018), food insecurity was used as a proxy for socioeconomic status as there were no variables on socioeconomic status in the GSHS. Also, anxiety-induced insomnia was considered a proxy of psychiatric disorders as there were no variables on psychiatric disorders in the dataset (Carvalho et al., 2018). Food insecurity was assessed by the question “During the past 30 days, how often did you go hungry because there was not enough food in your home?” Answer options were categorized as ‘never’, ‘rarely/sometimes’, and ‘most of the time/always’. Anxiety-induced insomnia was defined as replying ‘most of the time’ or ‘always’ to the question “During the past 12 months, how often have you been so worried about something that you could not sleep at night?” (Carvalho et al., 2018). The number of friends was assessed by the question “How many close friends do you have?”. Answer options were categorized as 0, 1-2, and ≥3. To assess levels of physical activity, questions that represented the PACE+ Adolescent Physical Activity Measure (Prochaska et al., 2001) were asked. This measure has been tested for validity and reliability (Prochaska et al., 2001). The question asked about the number of days with physical activity of at least 60 minutes during the past 7 days.

***Statistical analysis***

Statistical analyses were performed with Stata 14.1 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged 12-15 years as the exact age outside of this age range was not available. Age-sex adjusted prevalence of loneliness and leisure-time sedentary behavior by country were calculated using the proportions derived from the overall sample as the standard population. We used multivariable logistic regression analysis to estimate the association between leisure-time sedentary behavior (independent variable) and loneliness (dependent variable) using the overall, sex-wise, and country-wise samples. The exposure variable was the five-category leisure-time sedentary behavior variable when the overall and sex-wise samples were used. However, for country-wise analyses, we used the dichotomized leisure-time sedentary behavior variable to obtain stable estimates, as the sample size in each country was small. In order to assess between-country heterogeneity in the association between leisure-time sedentary behavior and loneliness, we calculated the Higgin’s *I*2 which represents the degree of heterogeneity that is not explained by sampling error with a value of <40% often considered as negligible and 40-60% as moderate heterogeneity (Higgins and Thompson, 2002). A pooled estimate was obtained by combining the estimates for each country into a fixed effect meta-analysis (overall and by country-income level). Heterogeneity between groups was tested by Cochran’s Q tests.

 All regression analyses were adjusted for age, sex, food insecurity, anxiety-induced insomnia, number of friends, physical activity, and country with the exception of the sex-wise and country-wise analyses which were not adjusted for sex and country, respectively. Adjustment for country was done by using fixed effects models as in a previous GSHS study (McKinnon et al., 2016). All variables were included in the regression analysis as categorical variables with the exception of age and physical activity (continuous variable). Under 2.6% of the data were missing for the variables included in the study. Complete case analysis was done. Sampling weights and the clustered sampling design of the surveys were taken into account to obtain nationally representative estimates. Results from the logistic regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at p<0.05.

**Results**

A total of 163,727 adolescents aged 12-15 years [mean (SD) age 13.7 (0.95) years; 48.3% female] constituted the final sample. Overall, the prevalence of loneliness was 10.0%, while the prevalence of <1, 1-2, 3-4, 5-8, and >8 hours of leisure-time sedentary behavior were 41.1%, 33.5%, 14.9%, 7.1%, and 3.4%, respectively. The age-sex adjusted prevalence of loneliness and leisure-time sedentary behavior varied widely between countries, with the ranges being 2.3% (Laos) to 28.5% (Afghanistan) for loneliness and 7.6% (Pakistan) to 53.7% (Antigua & Barbuda) for leisure-time sedentary behavior (Table 1). The prevalence of loneliness was lower in low-income countries (8.8%) as opposed to lower middle-income (10.1%) and upper middle-income countries (10.3%) (Chi-squared test; P=0.016), while the prevalence of ≥3 hours/day of leisure-time sedentary behavior increased linearly with increasing country-income level: 19.9% (low-income countries), 23.2% (lower middle-income countries), and 41.6% (upper middle-income countries) (Chi-squared test; P<0.001). An upward trend in the prevalence of loneliness was observed with increasing hours per day spent in leisure-time sedentary behavior especially beyond ≥1-2 hours/day (**Figure 1**). For example, in the overall sample, the prevalence of loneliness increased from 8.7% (1-2 hours/day of leisure-time sedentary behavior) to 17.5% (>8 hours/day). This was also confirmed in the adjusted models where in the overall sample, compared to those who engage in less than 1 hour of leisure-time sedentary behavior per day, the OR (95%CI) for 1-2 hours/day, 3-4 hours/day, 5-8 hours/day and >8 hours/day were 1.01 (0.92-1.11), 1.31 (1.18-1.45), 1.43 (1.25-1.65), and 1.72 (1.47-2.01), respectively (**Table 2**). The estimates for males and females were similar although 3-4 hours/day of leisure-time sedentary behavior was significantly associated with loneliness only among females. The country-wise association between leisure-time sedentary behavior of ≥3 hours/day and loneliness is shown in **Figure 2**. The pooled estimate based on a meta-analysis for all 56 countries was 1.31 (95%CI=1.26-1.37) with a negligible level of between-country heterogeneity (*I2*=30.5%). The association was more pronounced in countries of lower income levels: low-income countries (OR=1.43; 95%CI=1.24-1.65), lower middle-income countries (OR=1.36; 95%CI=1.28-1.44), and upper middle-income countries (OR=1.22; 95%CI=1.13-1.31). This between-group difference was statistically significant (P=0.043).

**Discussion**

To the best of our knowledge, this is the first multinational study to investigate the relationship between leisure-time sedentary behavior and perceived loneliness in adolescence. We found consistent evidence that adolescents who engaged in sedentary behavior, excluding time at school and when doing homework, for 3 or more hours a day, were more likely to feel lonely across the vast majority of countries included in our study, with this association being most pronounced in low-income countries. We also found some evidence suggesting a dose-dependent association between sedentary behavior and loneliness. The prevalence of loneliness increased from 8.9% (<1 hour/day of leisure-time sedentary behavior) to 17.5% (>8 hours/day). This was also confirmed in the analysis adjusting for potential confounders including physical activity where compared to those who were sedentary for <1 hour/day, individuals who were sedentary for >8 hours/day (excluding time at school and when doing homework) were 1.72 times more likely to feel lonely.

 Although the mechanisms linking sedentary behavior and loneliness are unknown, several hypotheses may be proposed. First, social media use might be one of the explanatory factors. It has been associated with increased sitting time while using a computer, and total sitting time during leisure (Alley et al., 2017) and is an important driver of sedentary behavior in adolescents (Sandercock et al., 2016). More time spent on social media has been associated as well with higher levels of interest loss, concentration problems, fatigue, and loneliness (Aalbers et al., 2018). Indeed, social media is an increasingly popular activity among young people, which can increase feelings of social rejection due to inherent design aspects of these platforms (Firth et al., 2019) . As this study did not include any measures of social media usage, further longitudinal and int{Firth, 2019 #12789}ervention studies (for example limiting time spent on internet and social media) are needed to determine how this may mediate the association between sedentary behaviour and loneliness. Besides social media use, the presence of somatic conditions might be a mediator in the relationship between sedentary behavior during leisure time and loneliness. More time spent sedentary is associated with a higher risk for functional somatic symptoms in adolescents (Janssens et al., 2014), while having a chronic condition in adolescents is strongly linked with feelings of loneliness (Maes et al., 2017).

An interesting finding in the current study was that the association between sedentary behavior during leisure time and loneliness was more pronounced in low-income countries. The underlying mechanisms remain unclear. However, in accordance with previous studies, poorer socioeconomic status is associated with loneliness (Qualter et al., 2018) and with being more sedentary (Mielke et al., 2017).

Although the current study is cross-sectional, some suggestions for future interventions can be made. For example, campaigns designed to raise awareness about the growing problem of loneliness for old age people should also be applied in adolescents and should include messages on the link between loneliness and unhealthy lifestyle behaviors such as being sedentary. These campaigns could raise awareness about the problem of loneliness during adolescence, but they represent only a first step. Effective public health interventions are also needed. In the adult literature, four primary types of intervention programs have been tested to address loneliness: (a) those that increase opportunities for social contact (e.g., facilitating social recreation), (b) those that enhance social support (e.g., through buddy programs, e.g. going for a walk with a buddy), (c) those that focus on social skills (e.g., enhancing non-verbal communication skills), and (d) those that address maladaptive social cognition (e.g., cognitive behavioral therapy) (Cacioppo et al., 2015b). Among these four types, interventions designed to address maladaptive social cognition via cognitive behavioral therapy was associated with the largest effect size (mean effect size = −0.6, i.e. moderate effect) (Cacioppo et al., 2015b). Our current findings indicate that incorporating cognitive behavioral change techniques focusing on the associated sedentary lifestyle might be of added value. For example, previous research demonstrated that motivational interviewing techniques (Mutschler et al., 2018) are an effective intervention for reducing sedentary time and it can be easily integrated within a cognitive behavioral therapy framework (Naar and Safren, 2017). Vice versa, lifestyle interventions that focus on reducing sedentary behavior should be aware of loneliness as a potential barrier.

Our findings and practical implications should however be interpreted in the light of several potential limitations. First of all, the study is cross-sectional, therefore the directionality or causality of the relationships cannot be deduced. For example, the association could be secondary to other factors that are related to social behavior and physical inactivity, such as poor self-rated health, a debilitating chronic illness, and mobility limitations. Longitudinal and intervention studies are required to better disentangle the relationships observed. However, regardless of causality, the mere co-existence of sedentary behavior and loneliness in adolescence is likely to be deleterious to health as they are both independently associated with adverse physical and mental health outcomes (Hoare et al., 2016; Oliveira et al., 2011; Stickley et al., 2016; Stickley et al., 2014). Second, self-reported time spent sedentary excluded time at school and when doing homework and therefore is an underestimate of the real time spent sedentary during the entire day. Future research should utilize objective measures of sedentary behavior. Accelerometers-inclinometers are available that allow for valid and reliable assessment of sedentary behavior. However, the association between sedentary behavior and loneliness may be dependent on the reason for a specific sedentary behavior, something which cannot be captured with an objective assessment tool. For example, while social media use can increase feelings of loneliness if used for social skill compensation, its’ use for making new friends reduces peer-related loneliness over time (Teppers et al., 2014).  Therefore, increasing time spent using social media platforms may be associated with more loneliness while at the same time can be used to stay in touch with friends, make plans, get to know people better, and present oneself to others (Shapiro and Margolin, 2014), all of which might have protective benefits. Similarly, it has been suggested that access to internet mayoffer increased access to health information, includingmental health support (Horgan and Sweeney, 2010).Therefore, in order to better understand the relationship between time spent sedentary during leisure and loneliness, a combination of both objective and subjective assessment of sedentary behavior is warranted. Next, although we adjusted for anxiety-related insomnia as a proxy for mental disorders, it would have been more ideal to adjust for specific mental disorders such as depression and anxiety. In addition, the loneliness variable was based on a single-item question but it has been previously reported that single-item questions produce similar findings to multiple-item scales (Stack, 1998), and that these are generally robust especially when using extreme categories to define loneliness (Victor et al., 2012) as in our study. Finally, varying degrees of bias may have been introduced by interviewing only schoolchildren, especially in countries where schooling attendance rates are low. Nonetheless, the majority of 12–15 years old adolescents from most of the countries in our study do attend school (UNICEF, 2015).

 In conclusion, the current study provides multi-national evidence from LMICs of a relationship between leisure time sedentary behavior and loneliness in adolescents and this was irrespective of physical activity levels. The consistency of these relationships observed, at least beyond 3 hours/day of sedentary behavior, across the included countries adds further weight to the growing evidence for a connection between sedentary behavior and loneliness in adolescents. Following future longitudinal studies, these findings could offer important new targets and strategies for interventions to tackle the loneliness-sedentary behavior relationship at its very early stages.

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| **Table 1** Survey characteristics and age-sex adjusted prevalence of loneliness and leisure-time sedentary behavior |
| Country income | Country | Year | Na | Response rate (%) | Loneliness (%) | Sedentary behavior (%)b |
| Low | Afghanistan | 2014 | 1,493 | 79 | 28.5 | 22.8 |
|  | Benin | 2016 | 717 | 78 | 10.5 | 25.3 |
|  | Cambodia | 2013 | 1,812 | 85 | 3.3 | 9.9 |
|  | Kenya | 2003 | 2,971 | 84 | 17.8 | 37.6 |
|  | Mozambique | 2015 | 668 | 80 | 8.0 | 40.6 |
|  | Myanmar | 2007 | 2,227 | 95 | 3.9 | 10.0 |
|  | Nepal | 2015 | 4,616 | 69 | 5.6 | 9.9 |
|  | Tanzania | 2014 | 2,615 | 87 | 6.7 | 20.4 |
|  | Uganda | 2003 | 1,904 | 69 | 9.3 | 27.1 |
|  | Zambia | 2004 | 1,365 | 70 | 23.6 | 32.6 |
| Lower middle | Bangladesh | 2014 | 2,753 | 91 | 10.3 | 14.1 |
|  | Belize | 2011 | 1,600 | 88 | 12.4 | 36.1 |
|  | Bolivia | 2012 | 2,804 | 88 | 9.9 | 24.2 |
|  | East Timor | 2015 | 1,631 | 79 | 10.8 | 15.2 |
|  | Egypt | 2006 | 4,981 | 87 | 8.0 | 25.5 |
|  | El Salvador | 2013 | 1,615 | 88 | 7.9 | 33.6 |
|  | Ghana | 2012 | 1,110 | 82 | 12.7 | 18.3 |
|  | Guatemala | 2015 | 3,611 | 82 | 9.2 | 22.5 |
|  | Guyana | 2010 | 1,973 | 76 | 16.6 | 35.9 |
|  | Honduras | 2012 | 1,486 | 79 | 10.1 | 30.4 |
|  | India | 2007 | 7,330 | 83 | 8.2 | 22.3 |
|  | Indonesia | 2015 | 8,806 | 94 | 6.3 | 25.7 |
|  | Jordan | 2007 | 1,648 | 100 | 15.0 | 38.1 |
|  | Kiribati | 2011 | 1,340 | 85 | 4.9 | 14.9 |
|  | Laos | 2015 | 1,644 | 70 | 2.3 | 17.4 |
|  | Macedonia | 2007 | 1,550 | 93 | 5.8 | 50.3 |
|  | Maldives | 2009 | 1,981 | 80 | 18.4 | 44.4 |
|  | Mauritania | 2010 | 1,285 | 70 | 16.4 | 39.2 |
|  | Mongolia | 2013 | 3,707 | 88 | 11.4 | 39.8 |
|  | Morocco | 2010 | 2,405 | 92 | 17.0 | 25.9 |
|  | Pakistan | 2009 | 4,998 | 76 | 11.9 | 7.6 |
|  | Philippines | 2015 | 6,162 | 79 | 15.1 | 30.5 |
|  | Samoa | 2011 | 2,200 | 79 | 23.1 | 37.5 |
|  | Solomon Islands | 2011 | 925 | 85 | 12.0 | 27.8 |
|  | Sri Lanka | 2008 | 2,504 | 89 | 7.3 | 33.4 |
|  | Syria | 2010 | 2,929 | 97 | 12.7 | 25.6 |
|  | Tonga | 2010 | 1,946 | 80 | 15.6 | 28.3 |
|  | Tunisia | 2008 | 2,549 | 83 | 17.0 | 24.1 |
|  | Vanuatu | 2011 | 852 | 72 | 7.4 | 20.0 |
|  | Yemen | 2014 | 1,553 | 75 | 14.2 | 19.4 |
| Upper middle | Antigua & Barbuda | 2009 | 1,235 | 67 | 11.8 | 53.7 |
|  | Argentina | 2012 | 21,528 | 71 | 8.5 | 49.1 |
|  | Botswana | 2005 | 1,397 | 95 | 14.4 | 35.7 |
|  | Costa Rica | 2009 | 2,265 | 72 | 5.5 | 43.1 |
|  | Fiji | 2016 | 1,537 | 79 | 12.1 | 24.4 |
|  | Grenada | 2008 | 1,299 | 78 | 13.4 | 41.4 |
|  | Iraq | 2012 | 1,533 | 88 | 15.9 | 25.6 |
|  | Lebanon | 2011 | 1,982 | 87 | 11.8 | 47.0 |
|  | Malaysia | 2012 | 16,273 | 89 | 6.8 | 42.6 |
|  | Namibia | 2013 | 1,936 | 89 | 12.5 | 36.9 |
|  | Peru | 2010 | 2,359 | 85 | 9.9 | 27.4 |
|  | St. Lucia | 2007 | 1,072 | 82 | 13.6 | 53.5 |
|  | St. Vincent & the Grenadines | 2007 | 1,188 | 84 | 15.4 | 39.7 |
|  | Suriname | 2009 | 1,046 | 89 | 13.7 | 39.1 |
|  | Thailand | 2015 | 4,132 | 89 | 9.8 | 51.0 |
|   | Tuvalu | 2013 | 679 | 90 | 8.3 | 15.4  |

a N is based on those aged 12-15 years.

b Leisure-time sedentary behavior of ≥3 hours/day.

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| **Table 2** Association between leisure-time sedentary behavior and loneliness estimated by multivariable logistic regression |
|   | Overall |   | Male |   | Female |   |
| Hours spent sedentary | OR | 95%CI | OR | 95%CI | OR | 95%CI |
| <1 hour/day | 1.00 |  | 1.00 |  | 1.00 |  |
| 1-2 hours/day | 1.01 | [0.92,1.11] | 0.94 | [0.80,1.09] | 1.09 | [0.99,1.21] |
| 3-4 hours/day | 1.31\*\* | [1.18,1.45] | 1.11 | [0.94,1.31] | 1.46\*\* | [1.28,1.66] |
| 5-8 hours/day | 1.43\*\* | [1.25,1.65] | 1.46\* | [1.16,1.84] | 1.42\*\* | [1.22,1.64] |
| >8 hours/day | 1.72\*\* | [1.47,2.01] | 1.65\*\* | [1.28,2.12] | 1.75\*\* | [1.45,2.12] |

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, food insecurity, anxiety-induced insomnia, number of friends, physical activity, and country. The model based on the overall sample is additionally adjusted for sex.

\* p<0.01, \*\* p<0.001

**Figure 1** Prevalence of loneliness by hours of leisure-time sedentary behavior per day

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**Figure 2** Country-wise association between leisure-time sedentary behavior of ≥3 hours/day (exposure) and loneliness (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval.

Models are adjusted for age, sex, food insecurity, anxiety-induced insomnia, number of close friends, and physical activity.

Overall estimate was calculated by meta-analysis with fixed effects.

**References**

Aalbers, G., McNally, R.J., Heeren, A., de Wit, S., Fried, E.I.J.J.o.E.P.G., 2018. Social media and depression symptoms: A network perspective.

Addiction, N.C.o., Abuse, S., 2011. Adolescent substance use: America's# 1 public health problem. CASA New York, NY.

Alley, S., Wellens, P., Schoeppe, S., de Vries, H., Rebar, A.L., Short, C.E., Duncan, M.J., Vandelanotte, C.J.H.P.J.o.A., 2017. Impact of increasing social media use on sitting time and body mass index. 28, 91-95.

Arat, G., Wong, P.W.-C., 2017. The relationship between physical activity and mental health among adolescents in six middle-income countries: A cross-sectional study. Child & Youth Services, 1-16.

Balogun, O., Koyanagi, A., Stickley, A., Gilmour, S., Shibuya, K., 2014. Alcohol consumption and psychological distress in adolescents: a multi-country study. J Adolesc Health 54, 228-234.

Brener, N.D., Collins, J.L., Kann, L., Warren, C.W., Williams, B.I., 1995. Reliability of the Youth Risk Behavior Survey Questionnaire. American journal of epidemiology 141, 575-580.

Brown, E.G., Gallagher, S., Creaven, A.M.J.P., 2018. Loneliness and acute stress reactivity: A systematic review of psychophysiological studies. 55, e13031.

Cacioppo, J.T., Cacioppo, S., Capitanio, J.P., Cole, S.W.J.A.r.o.p., 2015a. The neuroendocrinology of social isolation. 66, 733-767.

Cacioppo, J.T., Patrick, W., 2008. Loneliness: Human nature and the need for social connection. WW Norton & Company.

Cacioppo, S., Grippo, A.J., London, S., Goossens, L., Cacioppo, J.T.J.P.o.P.S., 2015b. Loneliness: Clinical import and interventions. 10, 238-249.

Cart, L.R.S.M., 2012. Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours”. Applied Physiology Nutrition and Metabolism 37, 540.

Carvalho, A.F., Stubbs, B., Vancampfort, D., Kloiber, S., Maes, M., Firth, J., Kurdyak, P.A., Stein, D.J., Rehm, J., Koyanagi, A., 2018. Cannabis use and suicide attempts among 86,254 adolescents aged 12-15 years from 21 low- and middle-income countries. Eur Psychiatry 56, 8-13.

Choi, Y.J., Matz-Costa, C.J.T.G., 2017. Perceived neighborhood safety, social cohesion, and psychological health of older adults. 58, 196-206.

de Oliveira, R.G., Guedes, D.P.J.P.O., 2016. Physical activity, sedentary behavior, cardiorespiratory fitness and metabolic syndrome in adolescents: systematic review and meta-analysis of observational evidence. 11, e0168503.

Donchi, L., Moore, S.J.B.C., 2004. It's a boy thing: The role of the Internet in young people's psychological wellbeing. 21, 76-89.

Farren, G.L., Zhang, T., Gu, X., Thomas, K.T.J.J.o.s., science, h., 2018. Sedentary behavior and physical activity predicting depressive symptoms in adolescents beyond attributes of health-related physical fitness. 7, 489-496.

Glozah, F.N., Oppong Asante, K., Kugbey, N., 2018. Parental involvement could mitigate the effects of physical activity and dietary habits on mental distress in Ghanaian youth. PloS one 13, e0197551.

Gross, E.F.J.J.o.a.d.p., 2004. Adolescent Internet use: What we expect, what teens report. 25, 633-649.

Guthold, R., Cowan, M.J., Autenrieth, C.S., Kann, L., Riley, L.M., 2010. Physical activity and sedentary behavior among schoolchildren: a 34-country comparison. J Pediatr 157, 43-49.e41.

Higgins, J.P., Thompson, S.G., 2002. Quantifying heterogeneity in a meta-analysis. Stat Med 21, 1539-1558.

Hoare, E., Milton, K., Foster, C., Allender, S., 2016. The associations between sedentary behaviour and mental health among adolescents: a systematic review. International journal of behavioral nutrition and physical activity 13, 108.

Holt-Lunstad, J., Smith, T.B., Baker, M., Harris, T., Stephenson, D.J.P.o.P.S., 2015. Loneliness and social isolation as risk factors for mortality: a meta-analytic review. 10, 227-237.

Horgan, A., Sweeney, J., 2010. Young students' use of the Internet for mental health information and support. Journal of psychiatric and mental health nursing 17, 117-123.

Janssens, K.A., Oldehinkel, A.J., Bonvanie, I.J., Rosmalen, J.G., 2014. An inactive lifestyle and low physical fitness are associated with functional somatic symptoms in adolescents. The TRAILS study. Journal of psychosomatic research 76, 454-457.

Luhmann, M., Hawkley, L.C.J.D.P., 2016. Age differences in loneliness from late adolescence to oldest old age. 52, 943.

Maes, M., Van den Noortgate, W., Fustolo-Gunnink, S.F., Rassart, J., Luyckx, K., Goossens, L.J.J.o.p.p., 2017. Loneliness in children and adolescents with chronic physical conditions: a meta-analysis. 42, 622-635.

McKinnon, B., Gariepy, G., Sentenac, M., Elgar, F.J., 2016. Adolescent suicidal behaviours in 32 low- and middle-income countries. Bulletin of the World Health Organization 94, 340-350f.

Mielke, G.I., Brown, W.J., Nunes, B.P., Silva, I.C., Hallal, P.C.J.S.M., 2017. Socioeconomic correlates of sedentary behavior in adolescents: systematic review and meta-analysis. 47, 61-75.

Mutschler, C., Naccarato, E., Rouse, J., Davey, C., McShane, K.J.S.r., 2018. Realist-informed review of motivational interviewing for adolescent health behaviors. 7, 109.

Naar, S., Safren, S.A., 2017. Motivational Interviewing and CBT: Combining Strategies for Maximum Effectiveness. Guilford Publications.

Neergheen, V.L., Topel, M., Van Dyke, M.E., Sullivan, S., Pemu, P.E., Gibbons, G.H., Vaccarino, V., Quyyumi, A.A., Lewis, T.T.J.B., behavior,, immunity, 2019. Neighborhood social cohesion is associated with lower levels of interleukin-6 in African American women. 76, 28-36.

Oliveira, A.J., Lopes, C.S., de Leon, A.C.P., Rostila, M., Griep, R.H., Werneck, G.L., Faerstein, E., 2011. Social support and leisure-time physical activity: longitudinal evidence from the Brazilian Pró-Saúde cohort study. International Journal of Behavioral Nutrition and Physical Activity 8, 77.

Perlman, D., Peplau, L.A.J.P.r., 1981. Toward a social psychology of loneliness. 3, 31-56.

Prochaska, J.J., Sallis, J.F., Long, B., 2001. A physical activity screening measure for use with adolescents in primary care. Archives of pediatrics & adolescent medicine 155, 554-559.

Qualter, P., Hurley, R., Eccles, A., Abbott, J., Boivin, M., Tremblay, R.J.J.o.y., adolescence, 2018. Reciprocal Prospective Relationships Between Loneliness and Weight Status in Late Childhood and Early Adolescence. 47, 1385-1397.

Raudsepp, L., Vink, K.J.J.o.P.A., Health, 2019. Longitudinal Associations Between Sedentary Behavior and Depressive Symptoms in Adolescent Girls Followed 6 Years. 1-6.

Sandercock, G.R., Alibrahim, M., Bellamy, M.J.P.m.r., 2016. Media device ownership and media use: Associations with sedentary time, physical activity and fitness in English youth. 4, 162-168.

Shapiro, L.A.S., Margolin, G., 2014. Growing up wired: Social networking sites and adolescent psychosocial development. Clinical child and family psychology review 17, 1-18.

Stack, S.J.S.p., 1998. Marriage, family and loneliness: A cross-national study. 41, 415-432.

Stickley, A., Koyanagi, A., Koposov, R., Blatný, M., Hrdlička, M., Schwab-Stone, M., Ruchkin, V.J.B.p., 2016. Loneliness and its association with psychological and somatic health problems among Czech, Russian and US adolescents. 16, 128.

Stickley, A., Koyanagi, A., Koposov, R., Schwab-Stone, M., Ruchkin, V.J.B.p.h., 2014. Loneliness and health risk behaviours among Russian and US adolescents: a cross-sectional study. 14, 366.

Teppers, E., Luyckx, K., Klimstra, T.A., Goossens, L.J.J.o.a., 2014. Loneliness and Facebook motives in adolescence: A longitudinal inquiry into directionality of effect. 37, 691-699.

UNICEF, 2015. Fixing the broken promise of educaiton for all.

Victor, C.R., Burholt, V., Martin, W.J.J.o.c.-c.g., 2012. Loneliness and ethnic minority elders in Great Britain: an exploratory study. 27, 65-78.

Wu, X.Y., Han, L.H., Zhang, J.H., Luo, S., Hu, J.W., Sun, K.J.P.o., 2017. The influence of physical activity, sedentary behavior on health-related quality of life among the general population of children and adolescents: A systematic review. 12, e0187668.