Increases in Sleep Difficulties and Psychological Symptoms are Associated with the Increase of Chronic Back Pain in Adolescents: The HBSC Study 2002-2018

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Original Article

Running title: Psychological symptoms, sleep difficulties, and pain

Abstract

Cross-national research using data from the Health Behavior in School-aged Children (HBSC) survey showed an increase in the prevalence of chronic back pain from 2002 to 2014. However, it is unknown if this trend has persisted beyond 2014. The aims of this study were to: (1) determine if the prevalence of chronic back pain in girls and boys aged 11, 13, and 15 continued to increase from 2014 to 2018; and if this was the case, to (2) examine whether this increase in the prevalence of chronic back pain between 2002 and 2018 was explained indirectly by increases in sleep difficulties and in psychological symptoms. Data from 789,596 adolescents retrieved from five waves of the HBSC survey conducted in 2002, 2006, 2010, 2014, and 2018 in 32 countries/regions were used. Logistic regressions and path analyses were conducted. Results showed an overall increase of 0.5% in the prevalence of chronic back pain between 2014 and 2018, ranging from 0.4% for 15-year-old girls to 1.3% for 11-year-old boys, indicating a continued overall increase in chronic back pain in adolescents beyond 2014. For 13-year-old girls and for 15-year-old girls and boys, the increase in the prevalence of chronic back pain between 2002 and 2018 was partially mediated by increases in sleep difficulties which in turn were associated with increases in psychological symptoms. The findings provide important information that may aid stakeholders enhancing public health initiatives to prevent or reduce the increasing trend in the prevalence of chronic back pain in adolescents.

Perspective

This study shows that chronic back pain prevalence continues to increase among adolescents, with sleep difficulties and psychological symptoms contributing significantly to this trend. The findings provide insights that may inform strategies to prevent or reduce the increasing trend of chronic back pain in adolescents.

Keywords: *Chronic back pain; prevalence; adolescents; sleep difficulties; psychological symptoms.*

INTRODUCTION

Back pain can have negative effects in everyday functioning of adolescents [7,47]. Furthermore, back pain in adolescents can take a chronic course, which incurs in a significant negative economic impact [28,50] and is associated with a greater risk of impairment into adulthood [33].

Research has shown that the prevalence of chronic back pain among adolescents has increased over the past few decades. For example, a study conducted by Roy et al.[60] using data from the Health Behavior in School-Aged Children (HBSC) study, reported an increase of 3% in the prevalence of chronic back pain among adolescents from 2002 to 2014. This increase was especially higher in girls and older adolescents [60]. However, it is not known if the increasing trend in the prevalence of chronic back pain has persisted beyond 2014. Providing updated estimates of chronic back pain is important given its association with disability, decreased quality of life, and increased healthcare costs both in adolescents and adults [7,27,36,46–48,59,62,69]. Furthermore, if the prevalence of chronic back pain has increased since 2014, then it would be important to identify the factors that are contributing to this increase. This knowledge could be used by policymakers and other stakeholders interested in the development and implementation of preventive and treatment strategies of chronic back pain in this population.

In a recent study, we found that increases in time spent in sedentary screen-based activities (e.g., playing computer games or using a smart phone) and obesity between 2002 and 2014 were significantly associated with the increase in the prevalence of chronic back pain across the twelve-year period [58]. However, these increases in sedentary screen-based

activities and obesity only accounted for a 5% of the variance of the increase in back pain prevalence. There are clearly other factors that are playing a role in this increase. Two possible factors could be an increase in sleep disturbances and in psychological symptoms. In relation to this, research has shown that both sleep difficulties [25] and psychological symptoms (e.g., psychological distress; [18,19,23]) have increased over the last few decades. Furthermore, a substantial body of evidence suggests that sleep disturbance is a robust predictor of future pain-related issues [1,3,9,38,41], and that psychological symptoms could mediate this relationship [5,13,54,66,68]. It is important to test whether increases in sleep difficulties and psychological symptoms are associated with increases in chronic back pain prevalence given that both factors are potentially amenable to interventions. Furthermore, to fully understand these relationships, it is essential to examine these associations while considering the variations in prevalence of these problems by sex and age [22,37,42,49].

Given these considerations, this study had two aims. First, using data from the international HBSC survey collected during the five most recent waves (2001/2, 2005/6, 2009/10, 2013/14, and 2017/18), we examined if the overall prevalence of chronic back pain in adolescent girls and boys aged 11, 13, and 15 continued to increase from 2014 to 2018. Second, if an increase in the prevalence of chronic back pain was identified, we examined if the increase in the prevalence of chronic back pain from 2002 to 2018 was explained indirectly by the increase in sleep difficulties and increases in psychological symptoms. Based on previous research, we hypothesized that (1) the overall prevalence of chronic back pain among adolescent girls and boys aged 11, 13, and 15 in 2018 would be significantly higher than in 2014 and that (2) over the 16-year time period, increases in sleep disturbance would be associated with increases in psychological symptoms, which in turn would be associated with the increase in prevalence of chronic back pain.

METHOD

Study design, setting and sample

The HBSC study is a collaborative cross-sectional study conducted by the World Health Organization in multiple countries and regions of Europe and North America. The study is conducted at four-year intervals beginning in 1983-1984, with the objective of obtaining data on the health behaviors and well-being of adolescents utilizing a standardized research protocol. Participating countries collect data from independent, nationally representative samples of boys and girls aged 11, 13, and 15 years, using multi-stage stratified random cluster sampling, with school classes or schools as the sampling unit. Participation in the study is voluntary and anonymous, and data are collected through standardized self-administered questionnaires administered in classrooms. The survey was conducted after obtaining approval from an ethics review board or a country/region-specific regulatory body in each participating country. Ethical consent procedures were followed, and institutional consent was obtained based on local requirements from schools, parents, and adolescents, either through active or passive informed consent/assent. Only consenting adolescents whose parents did not object were included in the study. Additional information about the methodology of the HBSC study can be found elsewhere [20,57].

For the purposes of this study, only countries that provided data on back pain, psychological symptoms, and sleep difficulties in each of the five most recent waves of the HBSC study (i.e., 2001/2, 2005/6, 2009/10, 2013/14, and 2017/18) were included. With these restrictions, we were able to use data from 826,563 participants from 32 different countries/regions (including Austria, Belgium Flemish, Belgium French, Canada, Croatia, Czech Republic, Denmark, England, Estonia, France, Germany, Greece, Greenland, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal,

Russia, Scotland, Slovenia, Spain, Sweden, Switzerland, Ukraine, and Wales). Five percent (36,967) of the participants were excluded because of missing data, leaving data from 789,596 children and adolescents available for the current analyses. The characteristics of the sample are presented in Table 1.

[Insert Table 1 about here]

Variables and measures

Independent variable

Survey year. The variable representing the time of assessment was the survey year (i.e., 2001/02, 2005/06, 2009/10, 2013/14, and 2017/18). To create a continuous variable, a value of 1 was assigned to the survey year 2002, and incremented the value by 1 for each subsequent survey year, up to a value of 5 for the survey year 2018.

Dependent variable and mediator variables

Chronic back pain, psychological symptoms, and sleep difficulties. The information regarding the experience of chronic pain back pain, psychological symptoms, and sleep difficulties was extracted from the HBSC symptom checklist (HBSC-SCL) [31]. With the HBSC-SCL, participants are asked to respond to the question "In the last 6 months, how often have you had the following…?" with respect to eight different symptoms using a 5-point scale (1 = "About every day," 2 = "More than once a week," 3 = "About every week," 4 = "About every month," and 5 = "Rarely or never"). Four of the items assess somatic symptoms (i.e., headache, stomachache, backache, and feeling dizzy) and four items assess psychological symptoms (i.e., feeling low, irritability or bad temper, feeling nervous, and sleep difficulties; [24,31,35]). We used responses to the item assessing back pain and the four items assessing psychological symptoms to address the study aims. On the bases of prior research using the HBSC-SCL [58,60], adolescents who reported having back pain weekly or more often over the

last 6 months were considered to have chronic back pain. In addition, we grouped the items of "feeling low," "irritability or bad temper," and "feeling nervous" as a single, composite measure of psychological symptoms based on prior research showing that these three items, in addition with "sleep difficulties," provide a single valid measure of psychological health in school-aged children [24]. For the purposes of the current study, and following Vandendriessche et al.'s [67] procedure, the item assessing sleep difficulties was left out from the measure of psychological symptoms, allowing sleep to be assessed as a domain distinct from psychological function. In the current sample, the measure of psychological symptoms after leaving out the sleep difficulties item, showed a slightly better internal consistency (as reflected by Cronbach's alpha) moving from $\alpha = .74$ to $\alpha = .76$. Response categories of the items conforming the measures of psychological symptoms (i.e., feeling low, irritability or bad temper, and feeling nervous) and sleep difficulties were reverse recoded (0-4) so that higher scores indicated a higher frequency of each symptom; that is, worse psychological function and more sleep difficulties. A total score for the psychological symptoms measure was created by summing the responses to each item (range 0-12).

Confounders

Socioeconomic status. Socioeconomic status was assessed using the Family Affluence Scale (FAS). This instrument has been updated through survey years of the HBSC study to account for the changing societal patterns of consumption and lifestyles of families and adolescents. In survey years 2002 to 2014, the FAS-II version [21] was used. This version includes 4 items asking about the number of cars and computers in the household, whether adolescents have their own bedroom, and the number of overseas holidays taken. In survey years 2014 and 2018, the FAS-III [64] was used. This version includes two additional items regarding the number of bathrooms and whether adolescents have a dishwasher at home.

For both versions of the FAS, the sum of these scores were transformed into proportional ranks, indicating the relative family affluence of the adolescents in their residential country. By this method, young people were categorized into groups of lowest 20% (low affluence), middle 60% (medium affluence), and highest 20% (high affluence) within each country and region.

School pressure. Participants were asked to respond the question "How pressured do you feel by the schoolwork you have to do?" with response options being 1 = "not at all"; 2 = "a little"; 3 = "some"; and 4 = "a lot." The responses were recoded from 0 to 3, with a higher score indicating more perceived school pressure [19].

Data analyses

We first computed percentages, means, and standard errors of the three variables of interest (i.e., chronic back pain, sleep difficulties and, psychological symptoms) across the five measurement periods (i.e., 2001/2, 2005/6, 2009/10, 2013/14, and 2017/18). We then fitted two linear regression models, one with sleep difficulties as the criterion variable and one with psychological symptoms as the criterion variable, to evaluate the statistical significance of the observed increases between 2002 and 2018 in both conditions. In both, the survey year was introduced as the independent variable. Then, to test the first study hypothesis (i.e., that the prevalence of chronic back pain has continued to increase past 2014), we compared the prevalence of chronic back pain in 2014 with the prevalence of chronic back pain in 2018 using logistic regression analysis. In the event that the first hypothesis was supported, we planned to conduct a path analysis to test if the increase in the prevalence of chronic back pain from 2002 to 2018 was explained indirectly by increases in sleep difficulties which, in turn, may be associated with increases in psychological symptoms (i.e., a serial mediation analysis). This approach is consistent with those taken by

prior studies in this area that have used survey year as a predictor variable in mediation analyses, demonstrating its usefulness in examining trends over time [19,55,58].

Path analysis establishes a structural model by postulating predetermined hypothesized relationships among variables and utilizes a sequence of multiple regression analyses to statistically represent and analyze the specified pathways. Although path analysis suggests the presence of a causal relationship, the directionality of the relationship cannot be established in cross-sectional designs, such as the one used in this study, due to the possibility of causal influence in the opposite direction or the presence of unmeasured third variables. Therefore, the current study used path analysis to test whether the data aligned with the hypothesis, but cannot draw definitive conclusions about the direction or timing of the effects.

In this path analysis, the survey year was entered as the independent variable; sleep difficulties as the first mediator; psychological symptoms as the second mediator; and chronic back pain as the dependent variable. Survey year, sleep difficulties, and psychological symptoms were entered as continuous variables, whereas chronic back pain was entered as a dichotomous variable. A bootstrap estimation approach with 10,000 samples was used to examine the hypothesized indirect pathways. To address the effects of potential confounders, path analyses were adjusted for participants' socioeconomic status and school pressure. All analyses were stratified by sex/age subgroups (i.e., 11-, 13-, and 15-year-olds boys and girls). Cluster robust standard errors (adjusting for adolescents being nested within countries) and survey weights were used to account for the complex sampling method. A 2-tailed significance level of $p < .05$ was defined as statistically significant. Specific model fit indices are reported including the Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Square Residual (SRMR), and the

Comparative Fit Index (CFI). A good fit is typically indicated by RMSEA values less than 0.06, SRMR values less than 0.08, and CFI values greater than 0.90 [43]. List-wise deletion were used to handle missing data. All analyses were conducted using STATA 14 (StataCorp.).

RESULTS

Differences in the prevalence of chronic back pain between 2014 and 2018

Table 2 provides an overview of the prevalence of chronic back pain across the five survey waves. As can be seen, the overall prevalence of chronic back pain in 2018 was slightly higher (22.2%) than the prevalence of chronic back pain in 2014 (21.6%). This increase in the prevalence of chronic back pain between 2014 and 2018, albeit small, was statistically significant across all subgroups considered and ranged from 0.4% for 15-year-old girls to 1.3% for 11-year-old boys.

[Insert Table 2 about here]

Increases in sleep difficulties and psychological symptoms between 2002 and 2018

Table 3 provides an overview of the frequency of sleep difficulties and psychological symptoms across the five survey waves. Results from the linear regression analyses indicated that both the overall frequency of sleep difficulties (b = 0.018, SE = 0.004, t = 4.50, p < .001) and psychological symptoms (b = 0.020, SE = 0.002, t = 10.94, p < .001) increased from 2002 and 2018. The findings showed that whereas the increase in the frequency of sleep difficulties were consistent for all subgroups considered, the increase in the frequency of psychological symptoms was statistically significant only for 13-year-old girls and 15-year-old boys and girls. Based on these results, three path analyses were conducted to test the second study hypothesis: one for 13-year-old girls, one for 15-year-old girls, and one for 15-year-old boys.

[Insert Table 3 about here]

Path analysis

Figure 1 presents paths coefficients of the model for the increase in the prevalence of chronic back pain between 2002 and 2018 for 13-year-old girls and for 15-year-old girls and boys. As can be seen, the path from survey year to sleep difficulties was statistically significant for all subgroups considered (13-year-old girls: $B = 0.024$, $SE = 0.002$, $p < .001$; 15-year-old girls: $B = 0.025$, $SE = 0.002$, $p < .001$; 15-year-old boys: $B = 0.018$, $SE = 0.002$, $p < .001$), indicating a significant increase in sleep difficulties between 2002 and 2018. Furthermore, more sleep difficulties were significantly associated with more frequent psychological symptoms (13-year-old girls: $B = 0.844$, $SE = 0.029$, $p < .001$; 15-year-old girls: $B = 0.854$, $SE = 0.025$, $p < .001$; 15-year-old boys: $B = 0.858$, $SE = 0.034$, $p < .001$) which, in turn, were significantly associated with a higher prevalence of chronic back pain (13-year-old girls: $B = 0.167$, $SE = 0.006$, $p < .001$; 15-year-old girls: $B = 0.155$, $SE = 0.006$, $p < .001$; 15-year-old boys: $B = 0.189$, $SE = 0.006$, $p < .001$). The indirect pathway from survey year to psychological symptoms was statistically significant for all subgroups considered (13-year-old girls: $B = 0.020$, $SE = 0.002$, 95% CI = 0.017 – 0.024, 10,000 bootstrap resamples, $p < .001$; 15-year-old girls: $B = 0.022$, $SE = 0.002$, 95% CI = 0.018 – 0.025, 10,000 bootstrap resamples, $p < .001$; 15-year-old boys: $B = 0.016$, $SE = 0.002$, 95% CI = 0.012 – 0.019, 10,000 bootstrap resamples, $p < .001$), indicating that increases in sleep difficulties mediated the increase in psychological symptoms over time. This mediation effect was found to be total for 13-year-old girls and 15-year-old boys, and partial for 15-year-old girls. The indirect pathway from survey year to chronic back pain through sleep difficulties and psychological symptoms was statistically significant (13-year-old girls: $B = 0.003$, $SE = 0.0003$, 95% CI = 0.003 – 0.004, 10,000 bootstrap resamples, $p < .001$; 15-year-old girls: $B = 0.003$, $SE = 0.0003$, 95% CI = 0.003 – 0.004, 10,000 bootstrap resamples $p < .001$; 15-year-old boys: $B =$

0.003, *SE* = 0.0003, 95% CI = 0.002 – 0.004, 10,000 bootstrap resamples $p < .001$), hence supporting the purposed model for the increase in the prevalence of chronic back pain between 2002 and 2018. Overall model fit indices indicated a good fit for all models (13-year-old girls: RMSEA = 0.00, SRMR = 0.00, CFI = 1.00; 15-year-old girls: RMSEA = 0.00, SRMR = 0.00, CFI = 1.00; 15-year-old boys: RMSEA = 0.00, SRMR = 0.00, CFI = 1.00).

[Insert Figure 1 around here]

DISCUSSION

This large cross-sectional study combined data from 789,596 adolescents from 32 countries over 16 years (2002–2018) to determine (1) if there was a continued increase in the overall prevalence of chronic back pain in adolescents from 2014 to 2018 considering sex and age; and (2) if the increase in the prevalence of chronic back pain from 2002 to 2018 was explained indirectly by the increase in the frequency of sleep difficulties and psychological symptoms.

The study findings confirmed a small increase of 0.5% in the prevalence of chronic back pain among adolescents between 2014 and 2018. This increase ranged from 0.4% for 15-year-old girls to 1.3% for 11-year-old boys and indicated that the prevalence of chronic back pain has continued increasing in this population beyond 2014. Overall, the data suggest that the prevalence of chronic back pain in this population has increased by 4% in the last two decades, with 22% of adolescents in 2018 reporting chronic back pain compared to 18% in 2002. This is a concerning finding, given the abundance of evidence that chronic pain conditions – and chronic back pain in particular – in adolescents imposes a significant economic burden on healthcare systems [28,50,65]. Moreover, it is well-documented that back pain or low back pain in adolescents is positively associated with back pain in adulthood [11,34,39] which is the leading cause of disability worldwide [36,69]. Therefore, if the

findings reported here are replicated, it could be anticipated that the negative economic impact associated with this condition both in adolescents and adults will also increase. That said, however, the findings also suggested that the rate of increase in the prevalence of chronic back pain between 2014 and 2018 was lower than increases in prior successive waves of the HBSC study – e.g., from 19.4% to 20.5% between 2006 and 2010; from 20.5% to 21.6% between 2010 to 2014. In any case, the findings support the importance of continuing to monitor the trends in back pain prevalence rates in children, and, if possible, take steps to reduce this prevalence.

Consistent with the second study hypothesis, the findings also showed that for girls aged 13 and for girls and boys aged 15 the increase in the prevalence of chronic back pain between 2002 and 2018 was partially indirectly explained by the increase in the frequency of sleep difficulties, which were associated with increases in the frequency of psychological symptoms. This finding is consistent with research indicating that sleep problems are a prospective predictor of chronic pain problems [1,9,38], and that psychological symptoms may serve as mediators in this association [5,13,54,68]. Moreover, these results provide valuable insights into the potential mechanisms underlying the increase in the prevalence of chronic back pain in adolescents, particularly in girls and older adolescents. However, while the results confirmed the study hypotheses, it is important to exercise caution in interpreting the findings due to the divergent temporal trends observed in chronic back pain, sleep difficulties, and psychological symptoms. While the frequency of sleep difficulties and the prevalence of chronic back pain exhibited a consistent upward trend across survey waves, the frequency of psychological symptoms displayed a different pattern. It is worth noting that psychological symptoms are influenced by various contextual and individual factors that were not measured in the current study. These factors could potentially contribute to

the observed fluctuations or the absence of a steady increase in psychological symptoms. For example, a recent study examining temporal over time bullying victimization – which has been associated with poor mental health outcomes in adolescents [30] – reported a general decrease in bullying victimization rates across several countries over time. This could partially explain the findings of this study. This possibility should be tested in future studies.

Based on these findings as a group, it is possible that if the upward trends in sleep difficulties and psychological symptoms continue [18,19,23,25], the prevalence of chronic back pain is likely to increase. This is particularly relevant in light of the recent coronavirus disease 19 (COVID-19) pandemic, as studies have shown an increase in sleep problems [10,12,61] and mental health problems such as anxiety and depressive symptoms [29,32,52] in children and adolescents. Furthermore, as a result of the COVID-19 pandemic, there has been changes in daily routines, such as increased time spent in screen time activities [14], which has been associated with multiple health complaints in adolescents, including back pain [8,40,45,58]. Taken together, the findings raise the possibility that the prevalence of chronic back pain may have increased during the years of COVID-19 lockdown measures [17,53], and underscore the importance of continuing to monitor back prevalence rates.

The study findings reinforce the importance of implementing public health interventions to promote mental health and prevent sleep problems in adolescents. Considering that adolescents spend most of their waking time in school, educational institutions are well-positioned to play a significant role in delivering such interventions. In this regard, whole-school interventions -i.e., comprehensive programs or strategies that are implemented across an entire school with collaboration and coordination among all stakeholders within the school community, including teachers, administrators, students, and

parents- aimed at enhancing students' development of social and emotional skills have shown promising results for improving emotional well-being and reducing internalizing symptoms [26]. Furthermore, school-based sleep education programs have been shown to be effective at increasing adolescents' sleep knowledge [56] and produce short-term benefits on sleep-related outcomes such as sleep duration [16]. However, the extent to which these interventions prevent the development of back pain and chronic back pain or their impact in adolescents needs to be systematically studied.

The results of this study should be considered in light of several limitations. First, the HBSC study data are cross-sectional at each time point, allowing only for tests of concurrent associations among variables; these data cannot be used to test for and confirm causal relationships. For example, although insufficient sleep can precede and maintain pain, pain can also interfere with the ability to initiate and maintain sleep [44]. Therefore, and in support of the increasing body of research suggesting a bidirectional relationship between sleep disturbance and chronic pain [2,3,66], it could be argued that increases in sleep difficulties are a possible consequence of the increase in the prevalence of chronic back pain. Longitudinal research is needed to evaluate the potential for causal relationships between sleep, psychological function, and chronic back pain. Second, the study was limited to the measures that were used for the HBCS study, which only include a subset of the many factors that are thought to contribute to the complex experience of chronic back pain. Moreover, the HBSC collects self-report data which is based, at least in part, on the respondents' memories. Although this is the most commonly used method in chronic pain survey studies, it may lead to overestimation of rates and associations among study variables [63]. The utilization of objective measures of sleep such as actigraphy and polysomnography, and inclusion of measures of psychological symptoms reported by

multiple sources (e.g., parents) would have enhanced the rigor of the study findings. Furthermore, our study would also have benefitted from incorporating other more specific measures of psychological symptoms such as depressive symptoms or anxiety. Future research should include additional sources of data for assessing the variables assessed here when possible. Additionally, while our path analysis accounted for confounding variables associated with chronic back pain, sleep difficulties, and psychological symptoms, it is important to note that potential confounding effects of unmeasured factors, including the influence of the delay in sleep phase/chronotype, may still exist. The delay in sleep phase/chronotype, which is particularly prominent during adolescence, has been previously linked to psychological symptoms, sleep difficulties, and pain in existing studies [4,6,51]. Therefore, the impact of this particular factor on the observed relationships should be studied in future research, if possible. Future research should also consider the potential moderating role of adolescents' sex when investigating the effects of sleep disturbance on pain, rather than considering it solely as a confounding variable; there is a growing body of evidence indicating that these effects may differ between boys and girls [15]. Finally, the HBSC survey does not collect data on self-identified race and ethnicity which may prevent the generalizability of our findings to populations with different racial and ethnic backgrounds.

Despite the study's limitations, the findings provide important new information regarding the rising trend in the prevalence of chronic back pain among adolescents. Moreover, the finding that increases in sleep difficulties and psychological symptoms significantly linked with the increasing rates of chronic back pain in this population, particularly in girls and older adolescents, provides important information that may aid policymakers, healthcare professionals, and researchers in assessing and enhancing public

health initiatives that aim to reduce the occurrence and effects of chronic back pain in adolescents.

Acknowledgements

Health Behaviour in School-aged Children is an international study carried out in collaboration with World Health Organization Regional Office for Europe. The International Coordinator was Jo Inchley (University of Glasgow) for the 2018 survey and Candace Currie (Glasgow Caledonian University) for the 2002 to2014 surveys. The Data Bank Manager was Professor Oddrun Samdal (University of Bergen). The survey data included in this study were conducted by the following principal investigators in the 32 countries: Austria (Rosemarie Felder-Puig and Wolfgang Dür), Flemish Belgium (Bart De Clercq, Carine Vereecken, Anne Hublet, and Lea Maes), French Belgium (Katia Castetbon and Danielle Piette), Canada (William Pickett, Wendy Craig, John Freeman, and William Boyce), Croatia (Ivana Pavic Simetin and Marina Kuzman), Czech Republic (Michal Kalman and Ladislav Csemy), Denmark (Mette Rasmussen and Pernille Due), England (Fiona Brooks, Ellen Klemera, and Antony Morgan), Estonia (Leila Oja, Katrin Aasvee, and Mai Kaser), France (Emmanuelle Godeau), Germany (Matthias Richter, Petra Kolip, Ulrike Ravens-Sieberer, and Klaus Hurrelmann), Greece (Anna Kokkevi), Greenland (Birgit Niclasen), Hungary (Ágnes Németh and Anna Aszmann), Ireland (Saoirse Nic Gabhainn), Israel (Yossi Harel-Fisch), Italy (Franco Cavallo), Latvia (Iveta Pudule), Lithuania (Kastytis Smigelskas and Apolinaras Zaborskis), North Macedonia (Lina Kostarova Unkovska), the Netherlands (Gonneke Stevens, Saskia van Dorsselaer, Wilma Vollebergh, and Tom de Bogt), Norway (Oddrun Samdal), Poland (Joanna Mazur and Barbara Woynarowska), Portugal (Margarida Gaspar de Matos), Romania (Adriana Baban), Russia (Anna Matochkina, Oleg Churganov, and Alexander Komkov), Scotland (Jo Inchley and Candace Currie), Slovenia(Helena Jericek and Eva Stergar), Spain

(Carmen Moreno), Sweden (Petra Löfstedt, Lilly Augustine, and Ulla Marklund), Switzerland (Marina Delgrande-Jordan, Hervé Kuendig, Emmanuel Kuntsche, and Holger Schmid), Ukraine (Olga Balakireva), and Wales (Chris Roberts).

Disclosures

The authors declare no financial or other relationships that might lead to a conflict of interest related to this study.

This work was partly funded by grants from the Spanish Ministry of Economy, Industry and Competitiveness (RED2022-134869-T), the European Regional Development Fund (ERDF), and the Government of Catalonia (AGAUR; 2021SGR-730). JR-J is supported by a doctoral grant from MINECO (PRE2019-089283). JM's work is supported by ICREA-Acadèmia. The Chair in Pediatric Pain is supported by Fundación Grünenthal.

Figure captions

Path analysis testing whether the increase in the prevalence of chronic back pain from 2002 to 2018 was explained indirectly by the increase in the frequency of sleep difficulties which, in turn, were associated with increases in the frequency of psychological symptoms for 13-year-old girls (A) and for 15-year-old girls (B) and boys (C). Black solid lines indicate significant direct paths ($p < .05$). The gray dotted line indicates nonsignificant direct path ($p > .05$).

Note. ¶Regression coefficients are on a log-odds metric.

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