Pain 138 (2008) 11–21

PAIN

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Research papers

The frequency, trajectories and predictors of adolescent recurrent pain: A population-based approach

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Received 22 April 2007; received in revised form 28 October 2007; accepted 30 October 2007

Abstract

Recurrent pains are a complex set of conditions that cause great discomfort and impairment in children and adults. The objectives of this study were to (a) describe the frequency of headache, stomachache, and backache in a representative Canadian adolescent sample and (b) determine whether a set of psychosocial factors, including background factors (i.e., sex, pubertal status, parent chronic pain), external events (i.e., injury, illness/hospitalization, stressful-life events), and emotional factors (i.e., anxiety/depression, self-esteem) were predictive of these types of recurrent pain. Statistics Canada's National Longitudinal Survey of Children and Youth was used to assess a cohort of 2488 10- to 11-year-old adolescents up to five times, every 2 years. Results showed that, across 12–19 years of age, weekly or more frequent rates ranged from 26.1%–31.8% for headache, 13.5–22.2% for stomachache, and 17.6–25.8% for backache. Chi-square tests indicated that girls had higher rates of pain than boys for all types of pain, at all time points. Structural equation modeling using latent growth curves showed that sex and anxiety/depression at age 10–11 years was predictive of the start- and end-point intercepts (i.e., trajectories that indicated high levels of pain across time) and/or slopes (i.e., trajectories of pain that increased over time) for all three types of pain. Although there were also other factors that predicted only certain pain types or certain trajectory types, overall the results of this study suggest that adolescent recurrent pain is very common and that psychosocial factors can predict trajectories of recurrent pain over time across adolescence.

Keywords: Recurrent pain; Pediatric pain; Headache; Stomachache; Backache; Longitudinal; Psychosocial predictors; Adolescence

1. Introduction

Recurrent pains, such as headaches, stomachaches, and backaches, are a complex set of chronic pain conditions that cause great discomfort and impairment. Pediatric chronic pain is also associated with frequent use of medication and the medical system [43,44], difficulties in academic achievement, emotional well-being, as well as peer and family functioning [27,41].

School- and population-based studies show that chronic pain is common [e.g. 6,15,18,21–25,31,32,45,50] affecting 25% of children [42]. Although rates range, many studies show steep increases during adolescence.

It is important to understand pain *trajectories*[1] and their psychosocial predictors. In the present study, psychosocial factors investigated included background factors, external events, and emotional factors (see Fig. 1). In terms of background factors, in some research, girls have been found to have higher rates of recurrent pain

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[1] In this study, a trajectory refers to an individual's changes in pain frequency overtime.

0304-3959/$34.00
doi:10.1016/j.pain.2007.10.032

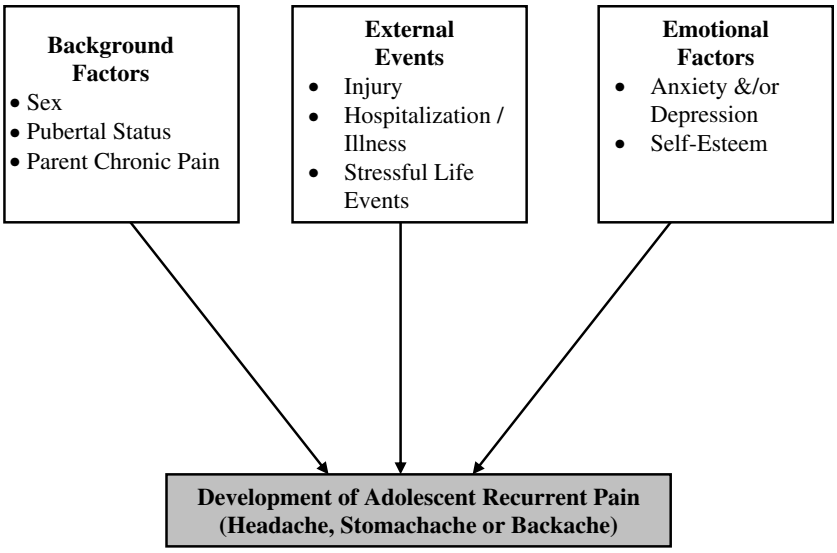

Fig. 1. Psychosocial factors investigated in relation to the development of adolescent recurrent pain (headache, stomachache or backache).

[e.g. 16,24,31,32,45]. Pubertal status, via hormonal changes [49], may underlie increases during adolescence. Children whose parents have chronic pain are more likely to report abdominal pain and use pain medication [28]. In terms of external events, Turk [48] considers injury to be important in adult chronic pain development, although a 4-year study found that children with trauma-induced lower-extremity pain had better long-term prognoses than children with pain not due to trauma [17]. Boey and Goh [5] found higher rates of recurrent abdominal pain (RAP) in 9- to 15-year-olds who had been hospitalized in the past year. Stressful-life events have also been associated with RAP [4,5]. An overall measure of social-emotional and behavioral problems was predictive of new-onset widespread body pain [29] and low-back pain [30] in school children after 12 months. Specifically, depression and anxiety are emotional factors that have been shown to be related to pediatric recurrent pain in both cross-sectional and longitudinal studies [e.g. 14–16,18,22,31,32,39,51]. Self-esteem has also been associated with adolescent headaches [14,22]. Mulvaney and colleagues [39] considered trajectories of pediatric functional abdominal pain and found that the group of children with high levels of symptoms and impairment over 5 years was characterized by higher levels of anxiety, depression, and exposure to negative life events at baseline. This study illustrates the importance of better understanding pediatric pain trajectories and their psychosocial predictors.

2. Method

This study aimed to (a) use a population-based sample to create individual trajectories of adolescent recurrent headache, stomachache and backache frequencies over an 8-year assessment period, and (b) determine whether psychosocial factors, including background factors, external events, and emotional factors, were predictive of these trajectories.

2.1. Participants

This study builds upon work by Holly and Chambers [25] that used cross-sectional data from the National Longitudinal Survey of Children and Youth (NLSCY); [47] to describe the frequency and correlates of recurrent pain in 12- to 13-year-old adolescents. In contrast to the study by Holly and Chambers [25], the present study used longitudinal methods to consider reports from adolescents and their parents across the entire adolescent period. The participants for the present research study were a cohort of 2488 adolescents in the NLSCY, a longitudinal-sequential survey [47].[2] The NLSCY sample was chosen to be representative of the Canadian population in terms of geographic location, family socioeconomic status (SES), ethnicity, etc. This project received ethical approval from Statistics Canada/Social Sciences Research Council of Canada and the University of British Columbia Behavioural Research Ethics Board.

In this project, national longitudinal survey weights from Cycle 1, 1994–1995 (either non-normalized for descriptive analyses, or normalized for inferential analyses) were applied during data analytic procedures, with exceptions made only when it was desirable to provide descriptive information about the unweighted cohort.

The present study drew its cohort from the group of 10- to 11-year-olds included in NLSCY Cycle 1 (1994–1995), and who were studied every 2 years, up to five times (i.e., across Cycles 1–5, from ages 10–11 years to ages 18–19 years; unweighted N at Cycle 1 = 2488). After Cycle 1, adolescents

[2] The research and analysis are based on data from Statistics Canada and the opinions expressed do not represent the views of Statistics Canada.

Table 1
Cohort size, age in years and percent female across the five survey cycles

Cycle	Unweighted cohort size	Weighted cohort size	Mean age (SD)	Percent female
1	2488	792,192	10.50 (0.50)	48.7
2	2271	703,703	12.46 (0.57)	48.4
3	1919	671,383	14.35 (0.65)	48.5
4	1655	585,123	16.43 (0.64)	49.8
5	1415	514,250	18.27 (0.64)	48.9

Note. Other than in the column labelled 'unweighted cohort size', all results reflect the application of the Cycle 1 non-normalized national longitudinal survey weight.

in the cohort could miss any of the four subsequent cycles of data collection. The weighted Cycle 1 sample represented 792,192 children (48.7% girls). See Table 1 for cohort age and sex statistics at the five data collection cycles. The cohort was 91.1% Caucasian, 2.4% South Asian, 1.4% Black, 1.6% Native, and 2.5% Arab, Latin American or another ethnicity. Primary caregivers for adolescents in the cohort were: 89.9% birth mothers, 7.9% birth fathers, 2.1% step-parents, adoptive parents, or other related females. The mean yearly household income, in thousands of dollars, of families included was 50.60 (weighted $N = 792{,}192$; SD = 24.02), and the mean number of years of education for mothers and fathers was 12.40 (weighted $N = 769{,}419$; SD = 2.36) and 12.69 (weighted $N = 645{,}359$; SD = 2.84), respectively.

2.2. Procedure

At each NLSCY cycle, computer-assisted interviews were conducted with children's primary caregiver and children over 16 years. Children aged 10 years and older were administered a self-report questionnaire. Children's school principals and classroom teachers also completed questionnaires.

2.3. Measures

The Canadian Research Institute for Social Policy (CRISP) NLSCY files [53] were used to complete this research. Only variables pertaining to the present study will be described further.[3] All psychosocial factor data (i.e., background factors, external events, emotional factors) were obtained from Cycle 1, when the cohort was 10–11 years old, making it temporally precedent to the recurrent pain trajectory data that were used from Cycles 2–5, when the cohort was between the ages of 12–13 years and 18–19 years.

2.3.1. Demographic variables

Cohort ethnicity, caregiver relationship to the adolescent, caregiver education and family income were derived from caregiver-report variables.

2.3.2. Frequency of recurrent pain

Recurrent pain frequency was assessed via adolescent-report in Cycles 2–5 (cohort ages = 12–13 years − 18–19 years) using items derived from a draft of the World Health Organization's survey: health behaviours in school-age children [12]. Adolescents were asked: "In the past six months, how often have you had or felt the following: (a) headache…, (a) stomachache…, (a) backache…?" Adolescents responded using a 5-point Likert-type ordinal scale that included: 1 (seldom or never), 2 (about once a month), 3 (about once a week), 4 (more than once a week) and 5 (most days).

2.3.3. Background factors

Adolescent *sex* was measured via parent-report and coded: (girls = 1) and (boys = 0). Sex proportions for the cohort at each cycle/age group are found in Table 1.

For *pubertal status*, boys were asked about body hair, voice deepening, and facial hair development. Girls were asked about body hair and breast development. Reponses were indicated using a 4-point Likert-type scale ranging from 1 (has not started) to 4 (seems completed). Girls were also asked a yes/no question about the onset of menstruation. A mean score for pubertal status, ranging from 0.0 to 1.0, was created similar to the method used by Holly and Chambers [25] where higher scores indicated more advanced pubertal development. Adolescents had to provide responses on at least two of their items in order to obtain a mean score, because missing data analyses indicated that this would capture 100% of the sample. This variable had an overall mean of 0.49 and a standard deviation of 0.31.

For *parent chronic pain*, parents responsed to whether or not they experienced a set of conditions typically associated with chronic pain that were long-term (lasting 6 months or longer) and that had been diagnosed by a health professional. Conditions considered were: "arthritis or rheumatism", "back problems, excluding arthritis", "migraine headaches", "sinusitis", "cancer", and "stomach or intestinal ulcers". A mean total score for parental chronic pain, ranging from 0.0 to 1.0, was obtained, where higher scores indicated a higher number of chronic pains experienced by parents. Missing data analyses indicated that 99.7% of parents had reported on all items and the remaining 0.3% had not responded to any. The "migraine headaches" item was also included as a single-variable predictor in the adolescent recurrent headache development model. The same was done for "stomach or intestinal ulcers" in the adolescent recurrent stomachache development model, and for "back problems, excluding arthritis" in the adolescent recurrent backache development model. Means and standard deviations for these variables were: overall parent chronic pain $M = 0.07$, SD = 0.12, parent headache $M = 0.12$, SD = 0.32, parent stomachache $M = 0.03$, SD = 0.17, and parent backache $M = 0.12$, SD = 0.32.

2.3.4. External events

The frequency of *injury* was obtained by calculating the number of times caregivers reported that their adolescent had injuries in the past year that required medical attention. The injury variable had an overall mean of 0.20 and a standard deviation of 0.59. For acute *illness/hospitalization* ($M = 0.03$, SD = 0.17), caregivers stated whether or not their child had stayed overnight in the hospital in the past year (0 = no, 1 = yes). Inpatient stays due to injury were excluded. For adolescents' experiences with *stressful-life events*, caregivers indicated the number of events their child had experienced that "caused him/her a great amount of worry or unhappiness".

[3] Specific NLSCY variable names used are available from the authors upon request.

Examples from the list parents responded to included death of a parent, parental divorce, and alcoholism or mental health disorder in the family. A mean score, ranging from 0.0 to 1.0, was created where higher scores indicated more stressful-life experiences. Missing value analyses indicated that 99.2% of parents had completed all items in the mean score, and the remainder had completed none at all. The stressful-life events variable had an overall mean of 0.04 and a standard deviation of 0.07.

2.3.5. Emotional factors

The presence of *anxiety and/or depression* was measured via adolescent-report on the eight-item emotional disorder scale within the Feelings and Behaviours Questionnaire. The reliability and validity of the questionnaire has been shown previously [7]. Sample items from this scale include: "I am not as happy as other children", "I am too fearful or anxious", and "I cry a lot". Adolescents responded on a 3-point Likert-type scale that ranged from 1 (never true) to 3 (very or very often true). A mean score, ranging from 1.0 to 3.0, was created where higher scores indicated higher anxiety/depression. Because missing data analyses showed that 80.4% of adolescents responded to all of the items, adolescents had to respond to all eight items in order to obtain a mean score. Cronbach's alpha was 0.77. The same items were also administered to parents and teachers. Both parents and teachers were required to have completed all eight items in order to receive an anxiety/depression mean score. Cronbach's alpha was 0.83 for the parent-report and 0.87 for the teacher-report. Adolescent-report ($M = 1.49$, SD = 0.37), parent-report ($M = 1.37$, SD = 0.36), and teacher-report ($M = 1.39$, SD = 0.39) anxiety/depression scores were included as separate predictors to determine if the different reports related in different ways to the development of adolescent recurrent pain [26].

Self-esteem was measured using the four-item general self-scale of the Self Description Questionnaire [35]. A sample item from the scale is: "In general, I like the way I am". Adolescents responded on a 5-point Likert-type scale that ranged from 1 (false) to 5 (true). This questionnaire has been previously shown to have strong reliability and validity [e.g. 36]. A mean self-esteem score, ranging from 1.0 to 5.0, was created where higher scores indicated higher self-esteem. Missing data analyses indicated that 83.6% of adolescents responded to all four items, and that 14.6% did not respond to any item. Adolescents needed to have completed all four items in order to receive a mean score. Cronbach's alpha was 0.76, mean was 4.33 and standard deviation was 0.62.

2.4. Data analysis

2.4.1. Recurrent pain frequency

The first major objective of this research was to create trajectories of recurrent pain frequency across adolescence. The frequency of recurrent headache, stomachache and backache in the cohort was determined by examining the three recurrent pain variables across Cycles 2–5. The rates for adolescents experiencing more than one type of recurrent pain on a weekly basis were also determined. Chi-square tests were performed to determine whether there were significant differences in patterns of pain frequency data between girls and boys.

2.4.2. Recurrent pain trajectories and psychosocial predictors

The second major objective of this research was to determine whether psychosocial factors for adolescent recurrent pain development were predictive of adolescents' recurrent headache, stomachache and backache trajectories.[4] Necessary precursors to this second major aim were to determine (a) the shape of individuals' headache, stomachache and backache trajectories, (b) whether individuals varied across their trajectory components, and (c) whether the modeled trajectories were a good fit to the data. Trajectory components considered included the trajectory start- and end-point intercepts (i.e., pain level at the beginning and end of the trajectory) and the trajectory slopes (i.e., the change in pain level over time).

Results from preliminary modeling using HLM 6 software [46] determined that there were no differences in recurrent pain trajectories when the exact age at each assessment versus the assessment number was used to index time [see 2,38]. Thus, latent variable structural equation modeling (SEM) in Mplus version 3.13 software [40] was used with time indexed by assessment and scaled at yearly intervals (e.g., for models examining initial status, Cycle 2 was coded as time = 0 and Cycle 3 was coded as time = 2 which corresponded to 2 years later). Responses to recurrent pain were modeled as ordinal with the delta parameterization to provide the scaling for the measurement of the ordinal variables. Full information maximum likelihood procedures, using numerical integration, were applied to handle missing data. Mplus version 3.13 uses the Likelihood Ratio Chi-square test to assess overall model fit for ordinal data. Mplus version 3.13 does not produce goodness-of-fit indices when numerical integration procedures are applied to data that contain a combination of continuous and categorical/ordinal data, as was the case in the present study.

Separate trajectories were created for headache, stomachache and backache, using pain data across the four time points (Cycles 2–5, cohort ages 12–13 years – 18–19 years). The basic shapes of the trajectories (e.g., testing whether the slopes had quadratic components) and their variances were determined. Then, psychosocial predictors were added to the basic trajectory models. By comparing the results from the start-point intercept models to the models where time coding had been reversed (i.e., end-point intercept models), predictors that were associated with both the start- and end-points of trajectories could be interpreted as factors likely to be important for adolescents who maintain high frequencies of recurrent pain over time. Factors that were associated with the slope of the trajectories could be interpreted as factors likely to be important for adolescents who have recurrent pain that changes in frequency over the course of adolescence. Psychosocial factors were tested separately, as well as simultaneously.

Sex-by-predictor interactions were also tested, given that some previous literature has found that girls have higher rates of many types of recurrent pain than boys [e.g. 16,24,31,32,45]. Interactions were tested by running models that included sex, the predictor and the sex-by-predictor interaction variable. Only significant interactions were included in models where all psychosocial factors were tested simultaneously.

[4] Correlations among psychosocial factors were also calculated and can be provided by the authors upon request.

Model testing results are presented below in terms of standardized parameter estimates and p values. The standardized parameter estimates can be interpreted in the same way as Beta values are in the context of regression analyses and will be abbreviated as Beta (β).

3. Results

3.1. Recurrent pain frequency

High rates of recurrent pain were seen across adolescence. Overall, headaches were the most common type of recurrent pain. Rates for headaches experienced weekly or more frequently ranged from 26.2% to 31.8% across the age groups (see Fig. 2). Rates for weekly backaches and stomachaches ranged from 17.6% to 25.8% (see Fig. 2) and 13.5% to 22.2% (see Fig. 2), respectively. There was a subgroup of adolescents that experienced pairs of recurrent pains on a weekly or more frequent basis (headache and stomachache: 11.8% at 12–13 years, 14.7% at 14–15 years, 8.0% at 16–17 years, 7.3% at 18–19 years), (headache and backache: 10.1% at 12–13 years, 14.4% at 14–15 years, 10.2% at 16–17 years, 10.5% at 18–19 years), (stomachache and backache: 8.1% at 12–13 years, 11.6% at 14–15 years, 5.7% at 16–17 years, 6.1% at 18–19 years). There were also a substantial number of adolescents who experienced all types of recurrent pain on a weekly basis (6.3% at 12–13 years, 8.6% at 14–15 years, 3.6% at 16–17 years, 3.6% at 18–19 years).

The 4 (about once a week) and 5 (almost every day) Likert responses were collapsed in order to maintain sufficient cell sizes for analyses (a Statistics Canada data security regulation). Chi-square analyses indicated that for all types of pain and at all cycles of data collection, girls reported higher frequencies of pain than boys (headache: 12–13 years: χ^2 (3, $N = 1932.76$) = 25.73, $p < 0.001$; 14–15 years: χ^2 (3, $N = 1711.89$) = 150.73, $p < 0.001$; 16–17 years: χ^2 (3, $N = 1544.88$) = 128.32, $p < 0.001$; 18–19 years: χ^2 (3, $N = 1605.72$) = 151.28, $p < 0.001$; stomachache: 12–13 years: χ^2 (3, $N = 1920.85$) = 44.24, $p < 0.001$; 14–15 years: χ^2 (3, $N = 1712.03$) = 114.16, $p < 0.001$; 16–17 years: χ^2 (3, $N = 1544.88$) = 145.22, $p < 0.001$; 18–19 years: χ^2 (3, $N = 1608.16$) = 122.94, $p < 0.001$; backache: 12–13 years: χ^2 (3, $N = 1923.81$) = 11.02, $p = 0.012$; 14–15 years: χ^2 (3, $N = 1699.50$) = 45.48, $p < 0.001$; 16–17 years: χ^2 (3, $N = 1544.88$) = 27.34, $p < 0.001$; 18–19 years: χ^2 (3, $N = 1608.16$) = 47.65, $p < 0.001$).

3.2. Recurrent pain trajectories and psychosocial predictors

Trajectories were created separately for headache, stomachache and backache across the four time points (Cycles 2–5, cohort age = 12–13 years – 18–19 years).

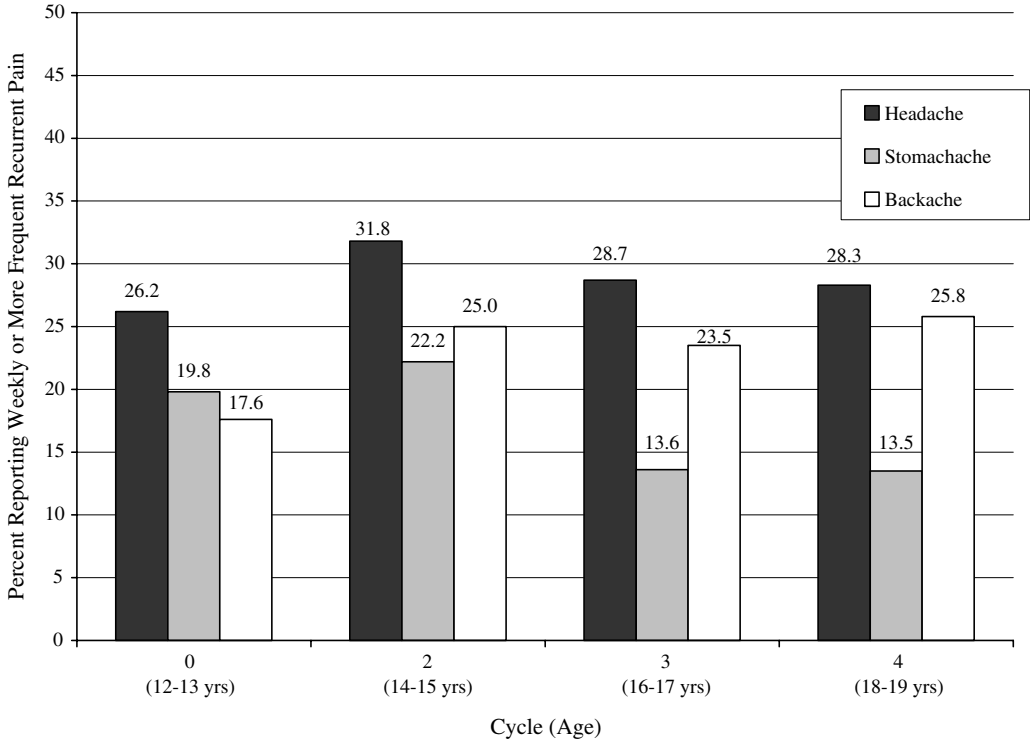

Fig. 2. Weekly or more frequent recurrent pain. *Note.* All data points in the graph above reflect the application of the Cycle 1 non-normalized national longitudinal survey weight. Standard errors for each level of pain frequency ranged across cycles (headache: 0.002–0.013; stomachache: 0.003–0.021; backache: 0.004–0.012).

We aimed to determine (a) the shape of individuals' trajectories, (b) whether there was individual variation in trajectory start- and end-point intercepts, as well as slopes, and (c) whether the trajectories we created were a good fit to the NLSCY data. To determine the shape of the trajectories, preliminary models included both linear and quadratic slope components. Analyses of the mean linear slopes indicated that headache frequencies increased over time (linear mean estimate = 0.23, SE = 0.08, $p < 0.01$). This pattern of general increase was not seen for stomachache, but was seen for backache (stomachache: linear mean estimate = 0.03, SE = 0.08, $p > 0.05$; backache linear mean estimate = 0.57, SE = 0.08, $p < 0.001$). Analyses of the mean quadratic slopes indicated that there were general decelerations in pain frequencies over time for all three types of pain (headache: quadratic mean estimate = −0.10, SE = 0.04, $p < 0.01$; stomachache: quadratic mean estimate = −0.21, SE = 0.06, $p < 0.001$; backache: quadratic mean estimate = quadratic mean estimate = −0.27, SE = 0.06, $p < 0.001$). However, there were no significant individual differences in the quadratic slope component (headache: quadratic slope variance estimate = 0.03, SE = 0.02, $p > 0.05$; stomachache: quadratic slope variance estimate = 0.05, SE = 0.07, $p > 0.05$; backache: quadratic slope variance estimate = 0.10, SE = 0.08, $p > 0.05$). Thus, the quadratic term's variance was fixed at 0 for all further trajectory model analyses. There was significant individual variation for the start- and end-point intercepts, as well as the linear slope component of the trajectories, thus we could proceed to determine which psychosocial factors could predict these variations.

Model fit statistics were then computed as an indicator of how well the derived pain trajectories fit the data. The Likelihood Ratio Chi-square test was non-significant for headache, Likelihood Ratio χ^2 (615) = 626.91, $p > 0.05$, indicating an excellent fit between the headache trajectory model and the data. The Likelihood Ratio Chi-square tests were significant for the stomachache and backache trajectory models, stomachache: Likelihood Ratio χ^2 (615) = 676.74, $p < 0.05$; backache: Likelihood Ratio χ^2 (615) = 771.90, $p < 0.001$. However, given the large sample sizes involved in the analyses, Chi-square/degrees-of-freedom ratios indicated that there was still a good fit between the data and the headache, stomachache and backache models.

3.2.1. Psychosocial factors and recurrent pain intercepts: Headache

When predictors were entered separately, sex, adolescent-report of anxiety/depression, and self-esteem were found to be associated with *both* the start- and end-points of headache trajectories (sex-alone: start-point intercept: $\beta = 0.21$, $p < 0.001$, end-point intercept: $\beta = 0.42$, $p < 0.001$; adolescent-report of anxiety/depression-alone: start-point intercept: $\beta = 0.36$, $p < 0.001$, end-point intercept: $\beta = 0.21$, $p < 0.01$; self-esteem-alone: start-point intercept: $\beta = -0.20$, $p < 0.001$, end-point intercept: $\beta = -0.13$, $p < 0.01$). Girls were more likely to have high frequencies of headache over the course of adolescence (i.e., at age 12–13 years and at age 18–19 years) than boys. Adolescents who reported higher anxiety/depression scores at age 10–11 years were more likely to have higher frequencies of headache over the course of adolescence (i.e., at age 12–13 years and at age 18–19 years) than adolescents who reported lower anxiety/depression scores at age 10–11 years. Finally, adolescents who reported having lower self-esteem scores at age 10–11 years were more likely to have higher frequencies of headache over the course of adolescence (i.e., at age 12–13 years and at age 18–19 years) than adolescents who reported higher self-esteem scores at age 10–11 years.

However, in simultaneous analyses, only sex and adolescent-reports of anxiety/depression were found to be associated with *both* the start- and end-points of headache trajectories (sex: start-point intercept: $\beta = 0.13$, $p < 0.001$, end-point intercept: $\beta = 0.28$, $p < 0.001$; adolescent-report of anxiety/depression: start-point intercept: $\beta = 0.33$, $p < 0.001$, end-point intercept: $\beta = 0.17$, $p < 0.01$). Results were in the same directions as were found in analyses when factors were entered separately.

It also appeared that parental chronic headaches were important for adolescents who maintained high frequencies of headache over time, notably girls. Parent headache was found to be associated with the start-points of headache trajectories (separate model: $\beta = 0.15$, $p < 0.05$; simultaneous model: $\beta = 0.15$, $p < 0.05$), indicating that young adolescents whose parents had chronic headaches were more likely to have headaches at age 12-13 years. The sex-by-parent headache interaction was found to be associated with the end-points of headache trajectories (separate model: $\beta = 0.10$, $p < 0.05$; simultaneous model: $\beta = 0.11$, $p < 0.05$). This interaction indicated that girls who had a parent with recurrent headaches were most likely to have high frequencies of recurrent headaches at the end of adolescence.

3.2.2. Psychosocial factors and recurrent pain intercepts: Stomachache

Slightly different results were found in terms of the predictors of stomachache start- and end-point intercepts. When predictors were entered separately, sex, adolescent-report of anxiety/depression, and self-esteem were found to be associated with *both* the start- and end-points of stomachache trajectories (sex-alone: start-point intercept: $\beta = 0.25$, $p < 0.001$, end-point intercept: $\beta = 0.42$, $p < 0.001$; adolescent-report of anxiety/depression-alone: start-point intercept: $\beta = 0.32$, $p < 0.001$, end-point intercept: $\beta = 0.18$, $p < 0.01$; self-esteem-alone: start-point intercept: $\beta = -0.14$, $p < 0.05$, end-point intercept: $\beta = -0.13$, $p < 0.01$). The directions of

these effects were in the same directions as were seen in the headache start- and end-point intercept analyses.

In the models where predictors were entered simultaneously, there were no psychosocial factors that were associated with both the start- and end-points of the stomachache trajectories. However, results did suggest that anxiety/depression was important across the two time points. Adolescent-reported anxiety/depression was found to be predictive of stomachache trajectory start-points ($\beta = 0.32$, $p < 0.001$). Parent-reported anxiety/depression and the interaction between sex and teacher-report of anxiety/depression were found to be predictive of stomachache trajectory end-points (parent-reported anxiety/depression: $\beta = 0.18$, $p < 0.01$; interaction between sex and teacher-report of anxiety/depression: $\beta = 0.49$, $p < 0.001$). For all of these results, high levels of anxiety were more likely to have higher frequencies of stomachache. The sex by teacher interaction indicated that this pattern occurred for girls.

3.2.3. Psychosocial factors and recurrent pain intercepts: Backache

For backache models where predictors were entered separately, sex, adolescent-report of anxiety/depression, parent-report of adolescent anxiety/depression and self-esteem were found to be associated with *both* the start- and end-point trajectories (sex-alone: start-point intercept: $\beta = 0.16$, $p < 0.01$, end-point intercept: $\beta = 0.22$, $p < 0.001$; adolescent-report of anxiety/depression-alone: start-point intercept: $\beta = 0.32$, $p < 0.001$, end-point intercept: $\beta = 0.16$, $p < 0.001$; parent-report of adolescent anxiety/depression-alone: start-point intercept: $\beta = 0.18$, $p < 0.01$, end-point intercept: $\beta = 0.12$, $p < 0.05$; self-esteem-alone: start-point intercept: $\beta = -0.22$, $p < 0.001$, end-point intercept: $\beta = -0.16$, $p < 0.01$). Again, the direction of effects matched those described previously for the headache start- and end-point intercept analyses.

However, across models where predictors were entered simultaneously, only sex was found to be associated with both the start- and end-points of backache trajectories (start-point intercept: $\beta = 0.10$, $p < 0.05$; end-point intercept: $\beta = 0.15$, $p < 0.001$). Again, girls were more likely to have high frequencies of backache over the course of adolescence (i.e., at age 12–13 years and at age 18–19 years) than boys.

3.2.4. Psychosocial factors and recurrent pain slopes: Headache

As was done when testing intercepts, psychosocial factors were tested separately, as sex-by-factor interactions, and simultaneously in predicting pain slope trajectories. For headache, the models where predictors were run separately and the model where all psychosocial factors were included simultaneously generated the same results. Only sex was found to be a unique significant predictor of headache trajectories (sex-alone model: $\beta = 0.38$, $p < 0.001$; simultaneous model: $\beta = 0.28$, $p < 0.001$). Specifically, adolescent girls were found to have greater increases in headache frequency over time (i.e., steeper slopes) than adolescent boys.

3.2.5. Psychosocial factors and recurrent pain slopes: Stomachache

Unlike headache, several psychosocial factors predicted the slope of stomachache trajectories. The stomachache models where predictors were run separately indicated that sex, parent-report of child anxiety/depression, and injury were significant predictors of stomachache trajectories (sex-alone model: $\beta = 0.27$, $p < 0.001$; injury-alone: $\beta = -0.17$, $p < 0.05$; parent-report of child anxiety/depression-alone: $\beta = 0.20$, $p < 0.05$). Girls, adolescents whose parents reported that they had fewer injuries at age 10–11 years, and adolescents whose parents reported that they had higher anxiety/depression at age 10–11 years were found to have greater increases in stomachache frequency over time (i.e., steeper slopes) than boys, adolescents whose parents reported that they had more injuries at age 10–11 years, and adolescents whose parents reported that they had lower anxiety/depression at age 10–11 years. The interaction between sex and teacher-report of child anxiety/depression was also a significant predictor of stomachache slope ($\beta = 0.60$, $p < 0.01$). Girls whose teachers reported that they had higher anxiety/depression at age 10–11 years were the most likely to have increases in stomachache frequency over time (i.e., steeper slopes).

When all the psychosocial predictors and the sex-by-teacher-report of child anxiety/depression interaction were included simultaneously, a slightly different set of factors emerged as predictors of stomachache slope. Injury, parent-report of adolescent anxiety/depression, and the interaction between sex and teacher-report of child anxiety/depression were found to be unique predictors of stomachache slopes, in the same directions as were found in the models where they were entered separately (puberty: $\beta = -0.15$, $p < 0.05$; injury: $\beta = -0.18$, $p < 0.05$; adolescent-reported anxiety/depression: $\beta = -0.20$, $p < 0.05$; parent-reported anxiety/depression: $\beta = 0.27$, $p < 0.01$; sex × teacher-reported anxiety/depression: $\beta = 0.68$, $p < 0.01$). The results from the full model indicated that puberty and adolescent-report of anxiety/depression were also unique predictors of stomachache slope. Adolescents with lower pubertal development at age 10–11 years were more likely to have an increasing frequency of stomachache over time. Interestingly, though adolescents who reported *less* anxiety/depression were more likely to have an increasing frequency of stomachache over time.

3.2.6. Psychosocial factors and recurrent pain slopes: Backache

For backache, no psychosocial factors were found to significantly predict backache trajectories either separately or in simultaneous analyses.

4. Discussion

4.1. Recurrent pain frequency

This study used a longitudinal population-level approach to determine the frequency of recurrent pain and psychosocial predictors of recurrent pain trajectories across adolescence. Overall, high frequencies of recurrent pain were seen during adolescence (weekly or more frequent pain across adolescence: headache = 26.2–31.8%, stomachache = 13.6–22.2%, backache = 17.6–25.8%) and a subgroup of adolescents experienced multiple types of recurrent pain. The rates in this study were higher than those found in some studies [e.g. 6,23,31,32]. School-based sampling and/or more specific recurrent pain diagnostic classification used in other research could help explain discrepancies.

4.2. Recurrent pain trajectories and psychosocial predictors

4.2.1. Background factors

The present study considered sex, pubertal status, and parent chronic pain as possible factors predictive of recurrent pain trajectories during adolescence. Data indicated that girls reported higher frequencies of recurrent pain than boys across adolescence. In trajectory analyses, girls were more likely than boys to have high persistent levels of headaches, stomachaches and backaches (as indicated by high levels at both the start and end of adolescence), as well as increasing levels of headaches, stomachaches and backaches across adolescence (as indicated by steeper, positive trajectory slopes). Girls have been noted in some studies to have higher rates of headache [e.g. 31,32], backache [e.g. 24] and stomachache [e.g. 23]. However, the mechanisms that are responsible for high levels of recurrent pain in adolescent girls are not well known. Research on pain expression and assessment has shown that young girls tend to express distress in response to pain more frequently [19], as well as rate higher levels of pain than boys [9]. Specific hormonal and biochemical mechanisms may contribute to these sex differences.

Parent chronic pain was only predictive in the case of adolescent headache, such that high parent chronic pain when children were aged 10–11 years predicted persistently high levels of adolescent headache over time (as indicated by high start- and end-point intercepts), particularly in girls. These findings may suggest a shared genetic vulnerability for headaches and/or the effects of parental pain modeling. Other research supports the connection between parent pain and pediatric abdominal pain (e.g., recurrent abdominal pain [3]) and further research is needed to explore the connections between specific types of pain shared between parents and children.

Adolescents with lower pubertal development at age 10–11 years were found to be more likely to develop higher frequencies of recurrent stomachaches over the course of adolescence (had steeper slope trajectories over time). For young adolescents, the stress of lagging behind their peers in terms of pubertal development may manifest as recurrent stomachaches. Again, the connection between pubertal status and specific types of adolescent recurrent pain needs to be explored in future research.

4.2.2. External events

Experiences with injury, illness/hospitalization, and stressful-life experiences were considered as possible external events predictive of recurrent pain trajectories during adolescence. Adolescents with fewer injuries at age 10–11 years were more likely to develop higher frequencies of recurrent stomachaches over time (as indicated by steeper slopes). Perhaps anxious adolescents who avoid danger and are therefore less likely to be injured may develop stomachaches as physical manifestations of their worry. The specific connection between injury and stomachaches, versus other types of recurrent pain needs to be explored. Illness/hospitalization and stressful-life events were not found to be predictive of adolescent recurrent pain trajectories, although longitudinal research considering functional abdominal pain trajectories did find negative life events at baseline to be predictive of a profile of long-term symptom and impairment maintenance [39]. Future research is needed to further assess the role of these factors in the development of recurrent pain.

4.2.3. Emotional factors

This study tested anxiety/depression and self-esteem as emotional factors potentially predictive of recurrent pain trajectories during adolescence. Anxiety/depression was found to be an important predictor of recurrent headache, stomachache and backache trajectories. Children who were more anxious/depressed at age 10–11 years exhibited high persistent levels of pain over time (as indicated by high start- and end-point intercepts), as well as increasing levels of pain over time (as indicated by more positive slopes). Previous cross-sectional and longitudinal research has shown relationships between recurrent pain and emotional factors, such as anxiety and depression [e.g. 14–16,22,51]. Results of the present study supports findings of previous longitudinal work showing that anxiety/depression predicts recurrent pain [31,32,39]. Once developed, recurrent pains and anxiety/depression may interact reciprocally to worsen each other over the course of adolescence.

Low self-esteem at age 10–11 years predicted high start- and end-point intercepts for all types of recurrent pain in models where it was considered separately. These findings support previous work suggesting that self-

esteem/sense of mastery is a key variable in relation to child health [10] and longitudinal research on functional abdominal pain trajectories by Mulvaney and colleagues [39]. It is likely that adolescents with low self-esteem feel less able to manage recurrent pain when it occurs and this causes it to be experienced at consistently high levels over time. Further research is needed to explore these hypotheses.

4.2.4. Generality versus specificity

Overall, sex and anxiety/depression appeared to have a broad impact on the development of headaches, stomachaches and backaches across adolescence. Nevertheless, different types of recurrent pain do not seem to develop from completely overlapping psychosocial processes, as indicated by the fact that several variables were associated with only one type of pain. Further, there seems to be a need to consider adolescents who have high frequency of pain throughout the course of adolescence somewhat distinctly from adolescents who are developing increasing frequencies of recurrent pain over time. These could represent two different types of vulnerable subgroups of adolescents, with potentially different psychosocial experiences.

4.3. Limitations and future research

Future research that is able to obtain additional details about recurrent pain intensity, duration, quality and impairment will be important for refining our understanding of predictors of pain trajectories. Future population-level research should also employ narrower sampling windows and predictor data should be drawn from time periods that range from early childhood, right up to the time when recurrent pain trajectories start to be tracked. More detailed, in-depth measures may increase the predictive validity of the constructs investigated in the present study.

It is possible that other predictors, such as temperament [e.g. 49]; other types of psychopathology, such as conduct disorder and attention deficit hyperactivity disorder [e.g. 15,16]; health behaviors, such as sleep and activity [e.g. 31,34,41,52], family functioning (e.g. [1,8]), peer social activities [e.g. 37], and school success/attendance [e.g. 14,20,22,31], may play a role in the trajectories of recurrent pain over the course of adolescence and should be investigated further. Neighborhood and socioeconomic variables would also be interesting to include in future studies, as these factors have been shown to relate to other negative child developmental and well-being outcomes [e.g. 13,33]. Further, it will be important for future research to explicitly study the role of culture and ethnicity. Despite placing theoretical importance on the role of culture in pain, there is little research exploring how culture influences children's experiences of pain [11]. Finally, survey data does not facilitate the study of biological mechanisms. Other types of research designs, such as experimental approaches, may shed greater light on the possible biological underpinnings of adolescent pain trajectories. Comprehensive models for recurrent pain development should be developed and tested based on this future research.

4.4. Conclusions

The results of this study not only advance knowledge about predictors of longitudinal trajectories of pain in adolescence, but also demonstrate the need for future research to identify the causes and mechanisms that affect recurrent pain trajectories. Girls are an important vulnerable subgroup to study in future prevention and treatment research. Future research on recurrent pain prevention and treatment programs should target adolescent anxiety, depression and self-esteem as important emotional constructs, using detailed measures and multiple reporters. The ultimate goal of this research is to use this knowledge to effectively treat adolescents suffering from recurrent pain and to prevent the development of recurrent pain in at-risk adolescents.

Acknowledgements

This study was completed in order to fulfil partial requirements for E.A. Stanford's Doctor of Philosophy in Psychology at the University of British Columbia.

The authors thank Dr. Charlotte Johnston, Dr. Geoff Hall, Dr. Lawrence Walker for their thoughtful and constructive comments regarding this research and previous drafts of this paper. The authors are indebted to Dr. Ken Craig for his wonderful mentorship in the area of pediatric pain.

The authors thank Dr. Michael Papsdorf and Ekin Blackwell for their invaluable statistical consultation and Kelly Hayton for her excellent editorial work on this project. The authors thank Lee Grenon, James Croal and Cheryl Fu, of the University of British Columbia Research Data Centre, for their tremendous support with the NLSCY data files.

This project received support from the Canadian Institutes of Health Research, the Michael Smith Foundation for Health Research, the Human Early Learning Partnership, and the William T. Grant Foundation. C.T. Chambers was supported by a Canada Research Chair.

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