Pain and learning in primary school: a population-based study

Silja Kosola MD PhD [1,2,3,4], Lisa K. Mundy PhD [1,2,5], Susan M. Sawyer MD [1,2,5], Louise Canterford MBiostat [1,2], Danielle A. van der Windt PhD [6], Kate M. Dunn PhD [6], George C. Patton MD [1,2,5]

Affiliations

[1] Centre for Adolescent Health, The Royal Children's Hospital, Melbourne, Victoria, Australia

[2] Murdoch Children's Research Institute, Melbourne, Victoria, Australia

[3] School and Student Healthcare, City of Helsinki, Finland

[4] Children's Hospital, Helsinki University Central Hospital and University of Helsinki, Helsinki, Finland

[5] Department of Paediatrics, University of Melbourne, Melbourne, Victoria, Australia

[6] Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Staffordshire, England

Number of text pages: 13

Number of figures and tables: 1 figure, 3 tables

Corresponding author:

Dr Silja Kosola (ORCID 0000-0002-2881-8299)

Address: Researchers of the Helsinki Children's Hospital, Biomedicum 2 C, 6th floor; Tukholmankatu 8, 00029 HUS, Finland

Email: silja.kosola@fimnet.fi

Telephone: +358 9 4717 5725

Conflicts of interest: The authors have no conflicts of interest to declare.

Previous presentation of abstract: European Public Health Conference, Vienna, November 2016

Pain and learning in primary school: a population-based study

ABSTRACT

Despite the frequency of pain among children, little is known about its effects on learning and school outcomes. The objective of this study was to quantify the association of pain and academic achievement while taking into account the presence of co-occurring emotional symptoms.

A population-based stratified random sample of 1239 students aged 8 to 9 years from primary schools in Melbourne, Australia was recruited for the Childhood to Adolescence Transition Study. Children indicated sites of pain that had lasted for a day or longer in the past month using a pain manikin. Depressive and anxiety-related symptoms were assessed using child-reported items. National assessment results for reading and numeracy were used to measure academic achievement.

Sixty-five percent of children reported pain in at least one body site and 16% reported chronic pain. Increasing number of pain sites was associated with poorer reading scores in a dose-response fashion (β = -3.1; 95% confidence interval -4.9 to -1.3; $p < 0.001$). The association was only partly attenuated when adjusting for emotional symptoms (β = -2.6; 95% confidence interval -4.5 to -0.8; $p < 0.001$) and was not moderated by emotional symptoms. Children with chronic pain were a year behind their peers in both reading and numeracy.

Among primary school students, pain was associated with lower reading scores even after adjusting for the presence of emotional symptoms. Although population-based longitudinal studies will be required to ascertain consistency and possible causality, grounds exist for considering pain and emotional symptoms in the assessment of children with reading difficulties.

INTRODUCTION

Pain is a frequent complaint in school-aged children.[28,42] Published prevalence rates of any pain lasting for at least a day during the past three to six months in the general population range from 58% to 86%, tend to be higher in girls and increase with age.[28,42] Headaches and abdominal pain are most commonly reported [20,28,35,42] although children often report pain in more than one site.[26,29] The prevalence of pain has increased in recent decades among both 8-year-old children as well as adolescents aged 12 to 18 years.[9,34] Pain could affect learning through its effects on emotional wellbeing, poor concentration, decreased classroom participation and increased absence from school. Despite high pain prevalence research regarding possible pathways is still limited.[7]

Chronic pain has been associated with school absences in cross-sectional studies from tertiary care settings.[5,23,25,33,41] Studies from the United States, the Netherlands and Germany have also found associations between abdominal pain, headache or pain intensity and self-reported or parent-reported school absences.[32,35,42] None of these studies included an objective measure of academic achievement. In a Brazilian study of students attending one school, headache severity was correlated with a lower grade point average but the effect sizes were very small.[31] These reports have several weaknesses such as small sample size, varied age ranges of participants, poor methods of pain measurement as well as the use of self-reported absences as the only measure of academic achievement.[7]

Besides absenteeism and concentration, pain might influence academic achievement through its connection with emotional wellbeing. Pain has been associated with anxiety and depression in both clinical and population-based samples of children and adolescents.[4,26,31,35,39,41] As anxiety and depression can be independently associated with school absence and poor academic achievement,[12,15] studies investigating the impact of pain on academic achievement should also account for the potentially confounding or moderating effect of common emotional symptoms.

Based on our clinical experience and previous literature, we hypothesized that pain would be associated with lower academic achievement and that this association would be pronounced in children with concurrent emotional problems. The aims of this study of a population-based sample of primary school children were to establish the extent of association between pain and poorer academic achievement and to measure to what degree the association is moderated by co-occurring depressive and anxiety-related symptoms.

METHODS

Study population and design

Data for this study were collected in 2012 in the first wave of the Childhood to Adolescence Transition Study (CATS), a cohort study which has a broad focus on health, education and social adjustment. The detailed study design has been published previously.[27] In brief, children were recruited from a stratified random sample of 43 primary schools in metropolitan Melbourne, Australia (Government, Catholic and Independent strata). All grade 3 students (aged 8 to 9 years) were invited to participate. Based on active, informed parental consent, 1239 of 2289 invited children (54%) participated in the study. The most common reason for not participating was that parents failed to return the consent form.

Procedure

The Royal Children's Hospital Human Research Ethics Committee granted approval for the study (#31089). The Victorian Department of Education and Training and the Catholic Education Office Melbourne each granted permission to recruit through their schools. Trained research assistants visited schools during school hours and administered questionnaires to students in a class setting. The research assistants read out the questions to facilitate completion by children with lower literacy levels and children used an iPad application to respond. Teachers completed a short questionnaire about each participating student. Parents completed two questionnaires (part one was paper-based and was completed at the time of consent; part two was completed after the child's data collection session, using either a paper or online version). Academic achievement scores were provided by the Victorian Curriculum and Assessment Authority for children whose parents allowed data linkage. Consent for data linkage was provided by 1147 (93%) parents and linkage was achieved for 1141 (92%) children.

Measures

Pain symptoms

Students were first asked whether they had experienced any pain in the past month that lasted for a whole day or longer. Children who responded positively to this question were then asked whether their pain had lasted less than or longer than three months.[39] All children reporting pain were provided with a pain manikin[16] representing both the front and back of the body on which they were asked to indicate the sites of pain. The manikin was assumed to be blank for those children who reported no experiences of pain within the last month. Pain manikins are a reliable method to identify pain sites in children from the age of 8 years [3,18,36] with prevalence estimates of pain based on manikins or written questions being similar across age groups.[18,40] Graphic-based pain location tools have also shown good test-retest reliability in left/right reversals, front/back reversals and the location of pain sites. [11] A standardized template was used to score the manikins according to the following sites: head, neck/throat, thoracic spine, upper back, lumbar spine, lower back, chest, abdomen, shoulders, elbows, forearms, hands, buttocks, thighs, knees, shins/calves, and feet. The total number of pain sites (maximum 26) was calculated for each child and used as a continuous variable. In adults, the number of pain sites is strongly associated with reduced physical functioning, anxiety, depression and sleeping problems, providing evidence for the number of pain sites as a marker of the impact of pain.[19,21] Binary pain variables included abdominal pain (yes/no), headache (yes/no) and chronic pain (pain duration more/less than three months).

Academic achievement

In this study, the National Assessment Programme – Literacy and Numeracy (NAPLAN) was used as a measure of academic achievement. All Australian students participate in NAPLAN in grades 3, 5, 7 and 9. NAPLAN scores for Reading and Numeracy domains range from 0 to 1000, and scores are scaled across all grades. For grade 3 students, scores below 270 are considered to be below the national minimum standard. A year of learning from grade 3 to grade 4 equals about 40 NAPLAN points.[2]

Emotional symptoms (potential confounder and moderator)

Symptoms of anxiety were assessed using two items derived from the Spence Children's Anxiety Scale[38], "I worry about things" and "I feel afraid". Depressive symptoms were

assessed using two items, “I feel miserable or unhappy” and “I don’t enjoy anything at all”, adapted from the Short Mood and Feelings Questionnaire[37] which has been validated in a community sample of children from the age of 7 years. All four items were rated on a five point scale ranging from “never” to “always”. Responses were assigned numerical values (“never”=0, “always”=4), combined as the sum of symptoms (range, 0-16) and used as a continuous variable. Cronbach’s alpha for this emotional symptom scale was 0.69.

Other potential confounders

Socio-economic status (SES). Family SES was derived from the Australian Bureau of Statistics census-based local neighbourhood Socio-Economic Index for Areas (SEIFA)[1] using the Index of Relative Socio-economic Advantage and Disadvantage. Higher scores indicate higher SES.

Chronic conditions. Parents of 914 children answered questions regarding chronic conditions in their children, of whom 19.3% reported at least one diagnosis that could possibly affect their children’s health perceptions (e.g. asthma), pain symptoms (e.g. migraine) or learning (e.g. attention deficit hyperactivity disorder). No difference was found between groups of healthy and chronically ill children in NAPLAN results nor any of the pain or emotional symptoms. Thus, the results are reported for all of the children in the study.

School absenteeism. Teachers answered a single item regarding absences: “Does this child have frequent absences from school (e.g. has an absence most weeks)?” Answers were simply yes/no. Data was available for 1139 children, of whom 71 (6.2%) had frequent absences. These children scored lower on both NAPLAN Reading and Numeracy domains than children without absences but no difference was found in pain or emotional symptoms.

Statistical analyses

For description of categorical variables, percentages were calculated and compared using chi-squared tests. For continuous variables, means and standard deviations (or in cases with skewed distribution, medians and interquartile ranges, IQR) were calculated and compared using t-tests and Mann-Whitney U tests as appropriate.

We used linear regression analysis to investigate the association between number of pain sites and academic performance. We first estimated unadjusted associations (i.e. without potential confounders) between pain sites and the reading and numeracy scores and tested these for statistical significance. Next, we added emotional symptoms to the model, then SES and gender to adjust the associations for potential confounding by these variables. We finally entered the interaction between pain sites and emotional symptoms to the model in order to investigate whether emotional symptoms moderated the association between pain and academic performance. Generalised estimating equations (GEE) with robust standard errors were used to fit the model to account for the clustering of children in schools.[22] For continuous NAPLAN scores, mean differences (and standard errors, SE) with 95% confidence intervals (CI) are reported. For subgroup analyses, depressive and anxiety-related symptom scores were dichotomized into groups of "low symptoms" (sum of symptoms < 7) and "high symptoms" (sum of symptoms ≥ 7) based on the IQR. A p-value <0.05 was considered significant. Data analyses were performed using Stata 13.0 (Stata Corp, College Station, TX).

RESULTS

Descriptive statistics for the study cohort (n= 1239) are presented in Table 1. Sixty-five percent of children reported pain in at least one body site (range, 0-25). Children suffering from chronic pain (> 3 months) reported more pain sites than children with shorter pain duration (median 3, IQR 2-5 vs. median 1, IQR 0-3; p < 0.001). Girls reported slightly more depressive and anxiety-related symptoms than boys and boys achieved higher NAPLAN Numeracy scores than girls.

Children who reported any pain had higher depressive and anxiety-related symptom scores than pain-free children (median 5, IQR 3-7 vs. 4, IQR 1-5; p<0.001). Children who reported abdominal pain or headaches showed similar levels of emotional symptoms (median 5 for both). Children suffering from chronic pain had the highest depressive and anxiety-related symptom scores (median 6, IQR 3-8; p<0.001).

In unadjusted regression analyses, NAPLAN Reading scores were three points lower for each additional pain site (95% CI -4.9 to -1.3; p < 0.001; Figure 1), which roughly correlates to one month of learning. Adding emotional symptoms to the model and adjusting for SES and gender resulted in a very slight change in the effect of pain on NAPLAN Reading scores. The

interaction between the number of pain sites and depressive and anxiety-related symptoms was non-significant, suggesting that the association between pain and NAPLAN Reading scores was not moderated by the presence of emotional symptoms (Table 2). In the total study population, NAPLAN Numeracy scores showed no significant association with the number of pain sites (β = -1.1; 95% CI -2.4 to 0.1; p=0.07).

In subgroup analyses, children with more than four pain sites and high depressive and anxiety-related symptom scores (n=122) were almost 12 months behind their symptom-free peers in NAPLAN Reading scores (β = -33; 95% CI -15 to -52; $p < 0.001$). Children with chronic pain and high depressive and anxiety-related symptoms (n=85) were roughly 12 months behind their peers in both NAPLAN Reading and Numeracy scores (Table 3). Children who reported either abdominal pain or headache in combination with high depressive and anxiety-related symptoms were six months behind symptom-free children, as were children with no pain but with high emotional symptom scores.

DISCUSSION

Two thirds of primary school students had experienced pain that lasted longer than a day within the last month and one in six students suffered from chronic pain. Each additional pain site was associated with decreased reading scores that roughly correlated to one month of learning so that the reading scores of those with both multiple pain sites and depressive and anxiety-related symptoms were almost 12 months behind their symptom-free peers. The interaction between pain sites and emotional symptoms failed to reach statistical significance, suggesting that depressive and anxiety-related symptoms did not moderate the association of pain and academic achievement. Pain and emotional symptoms only showed significant associations with numeracy scores in subgroup analyses which should be interpreted with caution.

To the best of our knowledge, this is the first population-based study to quantify the association of pain with reliable measures of academic achievement. Both the 65% prevalence rate of overall pain and 16% prevalence of chronic pain found here are in line with previous international reports.[28,35,42]

The strengths of the study include the comprehensive assessment of pain sites using a manikin as well as inclusion of child-reported emotional symptoms as a possible confounder

or effect moderator. Researchers from specific disciplines may primarily focus on a particular part of the body, [3,11] whereas we aimed at a more holistic understanding of pain. Our greatest limitation is the cross-sectional study setting which inhibits assessments of causality. The participation rate of 54% of the original invited sample raises the possibility of selection bias. However, SES among participants was close to the Australian population mean and NAPLAN scores of participants were similar to those of the sampling area.[2] Our study included no measure of pain intensity but according to previous studies,[28,32] pain intensity shows a strong correlation with the number of pain sites reported. We used only a crude measure of school absences. Responses were, however, acquired from teachers which decreases the chance of bias compared with self-reported absenteeism. As in other population studies, the presence of other potential confounders is impossible to eliminate.

Our main finding was that pain and emotional symptoms were associated with poorer reading scores, while numeracy scores showed less significant associations. This result may be due to chance or confounders that were not assessed. We do not know whether anxiety and depressive symptoms were the consequence of pain or were already present prior to the onset of pain, and whether or not pain and emotional symptoms preceded poor academic achievement. Emotional problems have previously been associated with poorer school grades, memory function and school attainment.[30] Theoretically, struggling with school work or problems in the wider school community may cause stress and anxiety which the child may interpret as somatic symptoms.[8,14] Pain may in turn heighten the risk for poor academic achievement through several mechanisms, e.g. the accumulation of school absences or sleep disturbances which might affect academic performance.[35,42] On a shorter time span, pain may interfere with a child's attention and concentration, thus hindering both daily classroom participation and achievement within formal tests.[8,13] Speculatively, pain could be a greater impediment to reading tasks that require longer concentration and rely more on working memory than what is necessary to solve mathematical problems at this age. The consistency and directionality of the associations found in this study should be investigated in future longitudinal studies. In the meantime, for children to reach their full academic potential, child-reported pain deserves attention in its own right.

Our study highlights the importance of talking directly with children about pain, anxiety and other symptoms from an early age. This has great implications for parents, schools and healthcare professionals, including paediatricians, given that pain at age 7 predicted pain at age 45 in the longitudinal 1958 British Birth Cohort Study[17] and pain at age 8 predicted

antidepressant medication use at age 24 in the longitudinal Finnish Nationwide 1981 Birth Cohort Study.[24] Parental responses to their children's pain also play a pivotal role in the maintenance of pain behaviour.[6] According to a recent systematic review, poor mental health in adolescence is associated with inferior education and employment outcomes in adulthood.[10] Our results suggest that physical pain may also be associated with academic achievement and that this association is already evident by mid-primary school. Given the high prevalence of both pain and depressive and anxiety-related symptoms, whole school approaches to enhance student wellbeing are warranted. Our findings also support the concept of school-based health and wellbeing services, which offer the potential for close collaboration of parents and healthcare personnel with teachers and other school staff to provide individual students with early assessment and interventions when necessary, and vice versa, for health issues to be taken into account in students' tuition. We encourage paediatricians and school nurses who assess children presenting with common pain symptoms to take the child's description seriously, while seeking to understand the social and emotional context of the child's experiences at home and at school.

ACKONWLEDGEMENTS

The authors wish to thank all of the families and schools who participated in this study, as well as all staff and volunteers involved in data collection and processing. This research was supported by a National Health and Medical Research Council project grant (#1010018). MCRI research is supported by the Victorian Government's Operational Infrastructure Program. SK is supported by grants from the Foundation for Pediatric Research, Biomedicum Helsinki Foundation and Orion Research Foundation. LM receives funding from the Invergowrie Foundation. GP is supported by a Senior Principal Research Fellowship from Australia's National Health and Medical Research Council.

The authors declare that they have no conflicts of interest.

REFERENCES

1. Australian Bureau of Statistics. Socio-Economic Indexes for Areas (SEIFA) 2011. Canberra, ACT, Australia.

2. Australian Curriculum Assessment and Reporting Authority. NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy: National Report for 2012. Sydney, Australia.
3. von Baeyer CL, Lin V, Seidman LC, Tsao JC, Zeltzer LK. Pain charts (body maps or manikins) in assessment of the location of pediatric pain. *Pain Manag* 2011;1:61-68.
4. Blaauw BA, Dyb G, Hagen K, Holmen TL, Linde M, Wentzel-Larsen T, Zwart J-A. The relationship of anxiety, depression and behavioral problems with recurrent headache in late adolescence - a Young-HUNT follow-up study. *J Headache Pain* 2015;16:10.
5. Breuner CC, Smith MS, Womack WM. Factors related to school absenteeism in adolescents with recurrent headache. *Headache* 2004;44:217-222.
6. Claar RL, Simons LE, Logan DE. Parental response to children's pain: the moderating impact of children's emotional distress on symptoms and disability. *Pain* 2008;138:172-179.
7. Gorodzinsky AY, Hainsworth KR, Weisman SJ. School functioning and chronic pain: a review of methods and measures. *J Pediatr Psychol* 2011;36:991-1002.
8. Grills-Taquechel AE, Fletcher JM, Vaughn SR, Stuebing KK. Anxiety and reading difficulties in early elementary school: evidence for unidirectional- or bo-directional relations? *Child Psychiatry Hum Dev* 2012;43:35-47.
9. Hakala P, Rimpela A, Salminen JJ, Virtanen SM, Rimpelä M. Back, neck, and shoulder pain in Finnish adolescents: national cross sectional surveys. *BMJ* 2002;325:743.
10. Hale DR, Bevilacqua L, Viner RM. Adolescent health and adult education and employment: A systematic review. *Pediatrics* 2015;136:128-140.
11. Hamill JK, Lyndon M, Liley A, Hill AG. Where it hurts: a systematic review of pain-location tools in children. *Pain* 2014;155:851-858.
12. Hawkrigg S, Payne DN. Prolonged school non-attendance in adolescence: a practical approach. *ADC* 2014;99:954-957.
13. Heathcote LC, Lau JYF, Mueller SC, Eccleston C, Fox E, Bosmans M, Vervoort T. Child attention to pain and pain tolerance are dependent upon anxiety and attention control: an eye-tracking study. *Eur J Pain* 2017;21:250-263.
14. Helgeland H, Van Roy B, Sandvik L, Markestad T, Kristensen H. Paediatric functional abdominal pain: significance of child and maternal health. A prospective study. *Acta Paediatr* 2011;100:1461-1467.
15. Ingul JM, Nordahl HM. Anxiety as a risk factor for school absenteeism: what differentiates anxious school attenders from non-attenders? *Ann Gen Psychiatry* 2013;12:25.

16. Jones GT, Silman AJ, Macfarlane GJ. Predicting the onset of widespread body pain among children. *Arthritis Rheum* 2003;48:2615-2621.
17. Jones GT, Silman AJ, Power C, Macfarlane GJ. Are common symptoms in childhood associated with chronic widespread body pain in adulthood? Results from the 1958 British Birth Cohort Study. *Arthritis Rheum* 2007;56:1669-1675.
18. Jones GT, Watson KD, Silman AJ, Symmons DPM, Macfarlane GJ. Predictors of low back pain in British schoolchildren: a population-based prospective cohort study. *Pediatrics* 2003;111:822-828.
19. Kamaleri Y, Natvig B, Ihlebaek CM, Benth JS, Bruusgaard D. Number of pain sites is associated with demographic, lifestyle, and health-related factors in the general population. *Eur J Pain* 2008;12:742-748.
20. King S, Chambers CT, Huguet A, MacNevin RC, McGrath PJ, Parker L, MacDonald AJ. The epidemiology of chronic pain in children and adolescents revisited: a systematic review. *Pain* 2011;152:2729-2738.
21. Lacey RJ, Strauss VY, Rathod T, Belcher J, Croft PR, Natvig B, Wilkie R, McBeth J. Clustering of pain and its associations with health in people aged 50 years and older: cross-sectional results from the North Staffordshire Osteoarthritis Project. *BMJ Open* 2015;5:e008389. doi: 10.1136/bmjopen-2015-008389.
22. Liang K-Y, Zeger, S.L. Longitudinal data analysis using generalized linear models. *Biometrika* 1986;73:13-22.
23. Logan DE, Simons LE, Carpino EA. Too sick for school? Parent influences on school functioning among children with chronic pain. *Pain* 2012;153:437-443.
24. Luntamo T, Sourander A, Gyllenberg D, Sillanmäki L, Aromaa M, Tamminen T, Kumpulainen K, Moilanen I, Piha J. Do headache and abdominal pain in childhood predict suicides and severe suicide attempts? Finnish nationwide 1981 birth cohort study. *Child Psychiatry Hum Dev* 2014;45:110-118.
25. Mackner LM, Bickmeier RM, Crandall WV. Academic achievement, attendance, and school-related quality of life in pediatric inflammatory bowel disease. *J Dev Behav Pediatr* 2012;33:106-111.
26. Mikkelsson M, El-Metwally A, Kautiainen H, Auvinen A, Macfarlane GJ, Salminen JJ. Onset, prognosis and risk factors for widespread pain in schoolchildren: a prospective 4-year follow-up study. *Pain* 2008;138:681-687.
27. Mundy LK, Simmons JG, Allen NB, Viner RM, Bayer JK, Olds T, Williams J, Olsson C, Romaniuk H, Mensah F, Sawyer SM, Degenhardt L, Alati R, Wake M, Hacka F,

Patton GC. Study protocol: the Childhood to Adolescence Transition Study (CATS). *BMC Pediatr* 2013;13:160.

28. Perquin CW, Hazebroek-Kampschreur AA, Hunfeld JA, Bohnen AM, van Suijlekom-Smit LWA, Passchier J, van der Wouden JC. Pain in children and adolescents: a common experience. *Pain* 2000;87:51-58.

29. Ramchandani PG, Hotopf M, Sandhu B, Stein A, ALSPAC Study team. The epidemiology of recurrent abdominal pain from 2 to 6 years of age: results of a large, population-based study. *Pediatrics* 2005;116:46-50.

30. Riglin L, Petrides KV, Frederickson N, Rice F. The relationship between emotional problems and subsequent school attainment: a meta-analysis. *J Adolesc* 2014;37:335-346.

31. Rocha-Filho PA, Santos PV. Headaches, quality of life, and academic performance in schoolchildren and adolescents. *Headache* 2014;54:1194-1202.

32. Roth-Isigkeit A, Thyen U, Stoven H, Schwarzenberger J, Schmucker P. Pain among children and adolescents: restrictions in daily living and triggering factors. *Pediatrics* 2005;115:152-162.

33. Rousseau-Salvador C, Amouroux R, Annequin D, Salvador A, Tourniaire B, Rusinek S. Anxiety, depression and school absenteeism in youth with chronic or episodic headache. *Pain Res Manag* 2014;19:235-240.

34. Santalahti P, Aromaa M, Sourander A, Helenius H, Piha J. Have there been changes in children's psychosomatic symptoms? A 10-year comparison from Finland. *Pediatrics* 2005;115:434-442.

35. Saps M, Seshadri R, Sztainberg M, Schaffer G, Marshall BM, Di Lorenzo C. A prospective school-based study of abdominal pain and other common somatic complaints in children. *J Pediatr* 2009;154:322-326.

36. Savedra MC, Tesler MD, Holzemer WL, Wilkie DJ, Ward JA. Pain location: validity and reliability of body outline markings by hospitalized children and adolescents. Res Nurs Health. 1989;12:307-314.

37. Sharp C, Goodyer IM, Croudace TJ. The Short Mood and Feelings Questionnaire (SMFQ): a unidimensional item response theory and categorical data factor analysis of self-report ratings from a community sample of 7-through 11-year-old children. *J Abnorm Child Psychol* 2006;34:379-391.

38. Spence SH, Barrett PM, Turner CM. Psychometric properties of the Spence Children's Anxiety Scale with young adolescents. *J Anxiety Disord* 2003;17:605-625.

39. Treede RD, Rief W, Barke A, Aziz Q, Bennett MI, Benoliel R, Cohen M, Evers S, Finnerup NB, First MB, Giamberardino MA, Kaasa S, Kosek E, Lavand'homme P, Nicholas M, Perrot S, Scholz J, Schug S, Smith BH, Svensson P, Vlaeyen JW, Wang SJ. A classification of chronic pain for ICD-11. *Pain* 2015;6:1003-1007.
40. van den Hoven LH, Gorter KJ, Picavet HS. Measuring musculoskeletal pain by questionnaires: the manikin versus written questions. *Eur J Pain* 2010;14:335-338.
41. Varni JW, Bendo CB, Nurko S, Shulman RJ, Self MM, Franciosi JP, Saps M, Pohl JF. Health-related quality of life in pediatric patients with functional and organic gastrointestinal diseases. *J Pediatr* 2015;166:85-90.
42. Vervoort T, Logan DE, Goubert L, De Clercq B, Hublet A. Severity of pediatric pain in relation to school-related functioning and teacher support: an epidemiological study among school-aged children and adolescents. *Pain* 2014;155:1118-1127.

FIGURE LEGEND

Figure 1. Unadjusted mean NAPLAN Reading scores (with 95% confidence intervals) according to the number of pain sites.

TABLES

Table 1. Summary of demographic characteristics, pain and mental health symptoms and academic achievement among grade 3 children (n = 1239), stratified by sex.

Measure	Males [a]	Females [b]	p-value [c]
Demographic background			
Child characteristics			
Mean age, years (SD)	9.0 (0.4)	9.0 (0.4)	.27
Born in Australia, n (%)	481 (87.1)	574 (88.3)	.54
Family SES			
SEIFA score (mean, SD)	1017 (65)	1013 (69)	.26
Pain and emotional symptoms			
Number of pain sites, median (IQR)	2 (0-4)	2 (0-3)	.28
Abdominal pain, n (%)	113 (20.7)	178 (27.7)	.005
Headache, n (%)	123 (22.5)	114 (17.7)	.04
Pain > 3 months, n (%)	87 (15.9)	105 (16.3)	.86
Emotional symptom score, median (IQR)	4 (2-7)	5 (2-7)	.001
Academic achievement			
NAPLAN score, mean (SD)			
Reading	437 (90)	446 (82)	.09
Numeracy	430 (74)	411 (69)	<.001

[a] Sample size ranged from 463 to 572. [b] Sample size ranged from 561 to 667.

[c] Chi square tests were used to compare categorical variables (e.g. Born in Australia). T-tests were used in comparison of mean age, SEIFA score and NAPLAN scores, and the Mann-Whitney U test was used to compare the number of pain sites and emotional symptoms scores.

SD = standard deviation; SES = socio-economic status; SEIFA = Socio-economic Index for Areas; IQR = interquartile range; NAPLAN = National Assessment Programme – Literacy and Numeracy

Table 2. Regression analyses between the number of child-reported pain sites, emotional symptoms and NAPLAN Reading.

	β (SE)	95% CI	p-value
Unadjusted regression			
Pain > Reading	-3.1 (0.9)	-4.9 to -1.3	<0.001
Added emotional symptoms			
Pain > Reading	-2.6 (0.9)	-4.5 to -0.8	0.005
Emotional > Reading	-3.1 (0.9)	-4.8 to -1.5	<0.001
Adjusted for SES & gender			
Pain > Reading	-2.7 (0.9)	-4.5 to -0.9	0.004
Emotional > Reading	-2.9 (0.8)	-4.5 to -1.3	0.001
Interaction: pain × emotional			
Pain × emotional > Reading	0.2 (0.2)	-0.2 to 0.7	0.27

NAPLAN = National Assessment Programme – Literacy and Numeracy; SE = standard error; CI = confidence interval; SES = socioeconomic status

Table 3. Academic achievement (mean, SE) in children with different types of pain and high emotional symptoms (≥ 7 points) and children with only emotional symptoms compared with symptom-free children.

Subgroup	NAPLAN Reading			NAPLAN Numeracy		
	Score	Reference score [a]	Adjusted mean difference (95% CI)	Score	Reference score [a]	Adjusted mean difference (95% CI)
Other pain	421 (5.1)	458 (5.3)	-13 (-17 to -8)**	401 (5.0)	430 (4.3)	-9 (-13 to -6)**
Abdominal pain	426 (8.4)	456 (3.8)	-28 (-44 to -11)**	402 (8.4)	432 (3.1)	-25 (-41 to -8)*
Headache	418 (9.0)	453 (3.7)	-31 (-49 to -13)**	402 (10.6)	428 (3.0)	-24 (-43 to -5)*
Chronic pain	413 (8.1)	452 (3.5)	-39 (-57 to -22)**	388 (8.6)	427 (2.9)	-40 (-56 to -24)**
No pain, emotional	428 (6.0)	452 (3.6)	-23 (-38 to -9)**	405 (5.4)	426 (3.0)	-21 (-34 to -9)*

SE = standard error; NAPLAN = National Assessment Programme – Literacy and Numeracy; CI = confidence interval.

[a] Reference scores presented for children without the respective pain and with low emotional symptom scores (< 7 points). Mean differences estimated from multivariate generalised estimating equations adjusted for socio-economic status, school clustering and gender. A year of learning from grade 3 to grade 4 equals roughly 40 NAPLAN points.

Group sizes (n with symptoms/reference group): other pain besides abdominal or headache (267/333), abdominal pain (101/635), headache (83/669), chronic pain (85/717), emotional symptoms only (212/663). Only children with all relevant data available were included in analyses.

** p values ≤ 0.001; * p values ≤ 0.01.