ORIGINAL ARTICLE

Spinal pain in childhood: prevalence, trajectories, and diagnoses in children 6 to 17 years of age

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Abstract

This study aimed to investigate the trajectories of spinal pain frequency from 6 to 17 years of age and describe the prevalence and frequency of spinal pain and related diagnoses in children following different pain trajectories. First through fifth-grade students from 13 primary schools were followed for 5.5 years. Occurrences of spinal pain were reported weekly via text messages. Children reporting spinal pain were physically evaluated and classified using International Classification of Disease criteria. Trajectories of spinal pain frequency were modeled from age 6 to 17 years with latent class growth analysis. We included data from 1556 children (52.4% female, mean (SD) baseline age = 9.1 (1.9) years) and identified 10,554 weeks of spinal pain in 329,756 weeks of observation. Sixty-three percent of children reported one or more occurrences of spinal pain. We identified five trajectories of spinal pain frequency. Half the children (49.8%) were classified as members of a "no pain" trajectory. The remaining children followed "rare" (27.9%), "rare, increasing" (14.5%), "moderate, increasing" (6.5%), or "early-onset, decreasing" (1.3%) spinal pain trajectories. The most common diagnoses in all trajectory groups were non-specific (e.g., "back pain"). Tissue-specific diagnoses (e.g., muscle strain) were less common and pathologies (e.g., fracture) were rare.

Conclusion: From childhood through adolescence, spinal pain was common and followed heterogeneous courses comprising stable, increasing, and early-onset trajectories. These findings accord with recommendations from adult back pain guidelines that most children with spinal pain can be reassured that they do not have a serious disease and encouraged to stay active.

What is Known:
- *Spinal pain imposes a large burden on individuals and society.*
- *Although many people first experience the condition in childhood, little is known about the developmental trajectories of spinal pain from childhood to adolescence.*

What is New:
- *Data from 1556 children and 329,756 participant weeks showed five unique spinal pain trajectories from 6 to 17 years: most children rarely reported spinal pain, while one in five followed increasing or early-onset trajectories.*
- *Most pain occurrences were non-specific; pathological diagnoses were rare.*

Abbreviations

CHAMPS study-DK   Childhood health, activity, and motor performance school study Denmark
ICD   International Classification of Diseases

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Introduction

Spinal pain imposes a large burden on individuals and society. For many, spinal pain develops in childhood; for example, the 12-month period prevalence of back pain in children ranges from 17.4 to 60.3% [1]. Back pain experienced in childhood tracks into adulthood [2], when it becomes the single largest source of years lived with disability [3].

Despite evidence of spinal pain's burden, traditional clinical wisdom suggests that spinal pain in childhood is rare, and when present, stems from a pathological etiology (e.g., tumor,

infection) [4]. However, current evidence shows spinal pain to be a common and usually benign condition in children, even when pain is persistent [5]. Thus, it may be the nature of symptoms and their developmental trajectories that distinguish different types of spinal pain rather than etiology. Life-course epidemiology emphasizes the importance of change in health-related features over time (i.e., health trajectories) [6]. Trajectory modeling has been used to understand the development of spinal pain, with models identifying discrete subgroups of adults who follow unique courses of pain over time [7]. Studies to date have focused on the trajectories of spinal pain in adult populations, leading researchers to highlight the development of spinal pain in youth as a priority [7, 8].

However, few studies to date have investigated the occurrence of spinal pain from adolescence to early adulthood. One study modeled the 3-year trajectories of low back pain in adolescents from ages 11 to 14 [9]. While 78% of participants had a very low probability of low back pain, the others followed trajectories showing an increasing (8%), decreasing (10%), early increase (2%), or persistently high (1%) probability of pain [9]. Another prospective study of individuals aged 14 to 22 found that most participants experienced impactful low back pain (i.e., pain resulting in care-seeking or interruption in activities) that followed an increasing (44%) or decreasing (10%) probability trajectory over the 8-year period [10].

There remains a lack of evidence regarding the developmental patterns of spinal pain in childhood as well as other fundamental aspects of pain, such as frequency and diagnostic characteristics. This knowledge is necessary to understand the development of spinal pain in the earlier life course. Therefore, the first aim of this study was to describe the trajectories of spinal pain frequency from 6 to 17 years of age. The second aim was to describe the prevalence and frequency of spinal pain and related diagnoses experienced by children following different pain trajectories.

Methods

Study design and participants

We analyzed prospective spinal pain data from the Childhood Health, Activity and Motor Performance School Study Denmark (CHAMPS Study-DK) collected between October 2008 and April 2014. The CHAMPS Study is a school-based health study; the study sample and procedures have been described in detail previously [11, 12]. In brief, CHAMPS Study-DK is a dynamic cohort in which some schools and participants entered the study at different times. In total, 19 public primary schools were invited, and 10 schools agreed to participate. A central feature of the original study design involved the comparison of outcomes between students attending schools implementing

either usual or supplemented physical education. Because our study objectives were not concerned with the effects of physical education curriculum, we combined all data into a common cohort comprising students registered to attend grades one through five. We excluded children with serious chronic diseases and three children were excluded based on this criterion: one child with a congenital heart malformation, 1 child with cerebral palsy, and 1 child with dwarfism.

The study protocol was approved by the Regional Scientific Ethical Committee of Southern Denmark (ID S-20080047) and registered with the Danish Data Protection Agency (J.nr. 2008–41-2240). All participating children gave verbal assent and parents provided written informed consent prior to enrollment.

Spinal pain measurements

Weekly pain data were collected via short-message-service text messaging, except during the six-week summer and one-week Christmas holiday periods. Each week, the child's parent or guardian was sent a text message inquiring about any occurrence of pain experienced by the child in different bodily regions over the preceding seven days: "Has (child's name) had pain for the last week?". Potential answers included "neck, back, or lumbar spine," "shoulder, arm, or hand," "hip, leg, or foot," and "no, my child has not had any pain." In this study, we limited our outcome to neck, back, or lumbar pain (i.e., spinal pain).

When spinal pain was reported by text message, a healthcare provider followed up with the parent by telephone within the week. If the pain continued to be present at the time of telephone interview, the child was scheduled for physical evaluation within 7 days. If the pain had resolved by the time of follow-up, the child continued to be monitored by text messaging as before. The evaluation comprised a standardized physical examination performed by study investigators who were registered physiotherapists or chiropractors. An orthopedic surgeon trained the examiners to ensure a standard examination approach, and the procedures were piloted by co-evaluating the first 20 children examined. The examiners maintained close contact with the orthopedic surgeon and each other throughout the study, discussing challenging cases and reinforcing examination procedures. When clinically indicated, children were referred for additional diagnostic investigation (e.g., blood tests, diagnostic imaging), orthopedic evaluation, or both. When children received medical evaluation or treatment outside of the study (e.g., emergency care), we obtained information through linked medical records.

All children who underwent physical examination with or without diagnostic testing were diagnosed using

International Classification of Diseases (ICD-10) coding [13]. When more than one code was assigned for the same episode, we identified the primary diagnosis as the one most likely to be directly responsible for the child's pain. Diagnostic codes were classified as either traumatic or non-traumatic. We considered four spinal pain outcomes: (i) self-reported spinal pain, (ii) diagnosed spinal pain, (iii) non-traumatic spinal pain, and (iv) traumatic spinal pain. Self-reported spinal pain included all pain reports. Diagnosed spinal pain was a subcategory of self-reported spinal pain comprising pain episodes for which the child underwent a physical evaluation and received a diagnosis. In this way, reports of diagnosed spinal pain indicated episodes lasting approximately 1 week or longer. Non-traumatic and traumatic spinal pain were subcategories of diagnosed pain and determined by ICD codes.

Anthropometric measurements and pubertal development

Height was measured to the nearest 0.5 cm with a portable stadiometer (SECA 214, Seca Corporation, Hanover, MD, USA) and weight to the nearest 0.1 kg using a calibrated Tanita BWB-800S digital scale (Tanita Corporation, Tokyo, Japan). Body mass index was calculated as weight(kg)/height(m)^2. We classified BMI outcomes as normal, overweight, or obese according to age- and sex-specific criteria from the International Obesity Task Force [14].

Pubertal development was determined using Tanner stages [15]. During a structured interview that included explanatory text and visual diagrams of pubic hair development in boys and breast development in girls, participants self-assessed their Tanner stage on a 1 to 5 scale, with higher scores indicating later pubertal stages [16]. Tanner stage 1 represents prepubertal status, stages 2 to 4 denote increasing levels of adolescent development, and stage 5 indicates adult development. We collapsed Tanner stages 4 and 5 into a common category owing to their low prevalence in the sample population.

Data analysis

Missing spinal pain data were imputed with random hot deck multiple imputations [17] across five datasets. This approach involved the matching of missing data with observed records, generating probabilities for matched records, and sampling records based on the probability of each outcome. Covariates incorporated into the random hot deck imputations were sex and pain for the individuals with missing data in the surrounding weeks. Additional details have been reported previously [18]. To support the modeling procedure, the weekly pain data were collapsed into 11 six-month study periods. To contribute data to a study period,

we required that participants were enrolled and responding to the text messages for at least 60% of that period.
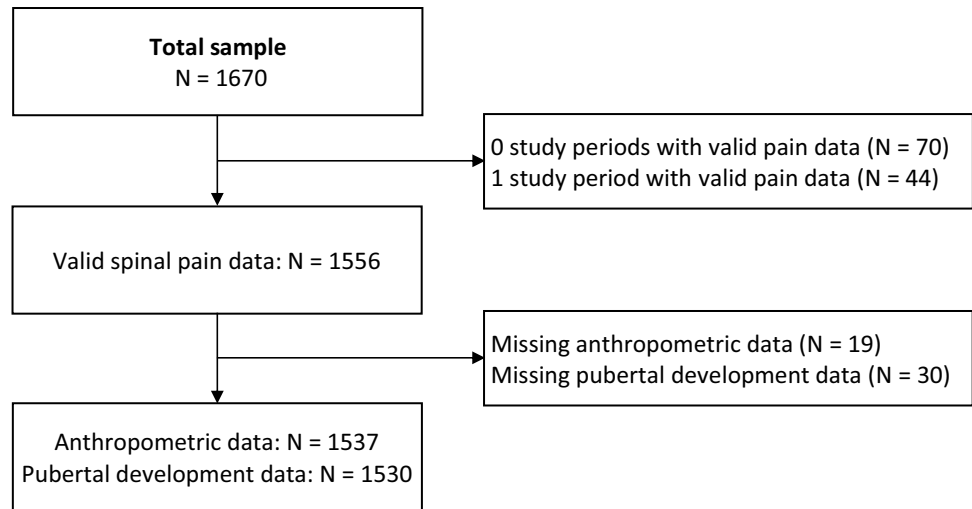
All analyses were conducted with Stata 16.1 software (StataCorp, College Station, TX, USA). We described continuous variables as means and standard deviations (SD) and categorical variables as counts and percentages for the entire sample and stratified by trajectory subgroup. We modeled trajectories of self-reported spinal pain frequency (weeks with pain), as a function of age, with latent class growth analysis. This approach is a specialized application of finite mixture modeling used to identify meaningful trajectory subgroups (latent classes) within otherwise heterogeneous data [19; 20]. These models use maximum likelihood estimation to approximate trajectory distributions without assuming that trajectory classes comprise distinct populations; features that distinguish this approach from similar techniques such as growth mixture modeling [19]. We applied a zero-inflated Poisson distribution and applied equal weights across the five imputed datasets to generate a common model.

We first constructed a single-class model and then increased the number of latent classes, the complexity of the polynomial distributions (e.g., linear, quadratic, cubic) and zero-inflation patterns until an optimal model was identified. We used several criteria to define the optimal model as fit decisions should not hinge on a single metric [19]. Initial decisions were made using the Bayesian information criterion and judgment to identify clinically meaningful subgroups. We subsequently tested models with four a priori diagnostic criteria: (i) a minimum average posterior probability of group membership ≥ 0.7, (ii) minimum odds of correct classification > 5, (iii) precision of confidence intervals around estimates of group membership probabilities, and (iv) close correspondence between the estimated group membership probability and the proportion of participants assigned to each group based on the posterior probability [19, 20]. We explored for sex-specific differences in the spinal pain trajectories by analyzing data from boys and girls separately. The resulting models were very similar (data not shown), and we therefore elected to report one common model.

Results

In total, 1670 children were enrolled in the study. We excluded 114 (6.8%) children as they only had spinal pain data for one study period. Therefore, data from 1556 children (baseline age = 9.1 (1.9) years, 52.4% female) comprising 329,756 weeks of observation were included in the trajectory model (Fig. 1). The average weekly response rate over the course of the study was greater than 96% [21, 22];

Fig. 1 Participant flow diagram

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                    ┌─────────────────────────┐
                    │      Total sample       │
                    │        N = 1670         │
                    └─────────────────────────┘
                                 │
                                 │         ┌──────────────────────────────────────────────┐
                                 ├────────▶│ 0 study periods with valid pain data (N = 70) │
                                 │         │ 1 study period with valid pain data (N = 44)  │
                                 ▼         └──────────────────────────────────────────────┘
                    ┌─────────────────────────┐
                    │ Valid spinal pain data: N = 1556 │
                    └─────────────────────────┘
                                 │
                                 │         ┌──────────────────────────────────────────────┐
                                 ├────────▶│ Missing anthropometric data (N = 19)          │
                                 │         │ Missing pubertal development data (N = 30)     │
                                 ▼         └──────────────────────────────────────────────┘
                    ┌─────────────────────────┐
                    │ Anthropometric data: N = 1537 │
                    │ Pubertal development data: N = 1530 │
                    └─────────────────────────┘
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in total, valid responses were received for 94.8% of weeks prior to imputation. The mean number of 6-month study periods with valid spinal pain data was 8.0 (2.8). Therefore, participating children contributed approximately four years of weekly spinal pain data on average. Precise age data were unavailable for 19 children (1.2%) who provided spinal pain data via text messaging but did not participate in the measurement sessions; we estimated their ages using average values from children at the same grade level.

Over the course of the study, 63.2% of children reported one or more occurrences of spinal pain and 27.5% of children experienced one or more pain occurrences of sufficient duration to allow for physical examination and diagnosis (diagnosed spinal pain). In total, spinal pain was reported in 10,554 participant weeks, among which 4,823 (45.7%) were weeks with diagnosed spinal pain. The large majority of diagnosed spinal pain weeks were categorized as non-traumatic (4342 weeks; 90.0%).

Spinal pain trajectories

The final trajectory model identified a five-class solution comprising zero-order, linear, and quadratic polynomials (Fig. 2). All predefined diagnostic criteria were met: posterior probabilities were 0.80 or greater, odds of correct classification exceeded 5.0, confidence intervals were relatively precise, and differences between the estimated group membership probability and the proportion of participants assigned to the group were small (Table 1).

Latent trajectory subgroups were labeled according to the average frequency of weeks with spinal pain and the shapes of their distributions. Approximately half the children (49.8%) were classified as members of a trajectory defined by the absence or minimal occurrence of spinal pain (i.e., "no pain"). Although we received rare reports of pain from approximately one-third of children following the "no pain" trajectory (approximately 0.4 weeks per four years on

Fig. 2 Trajectories of self-reported spinal pain and their prevalence (N = 1556)[1]. [1]Points represent weeks with spinal pain in each 6-month period. Dotted lines represent 95% confidence intervals
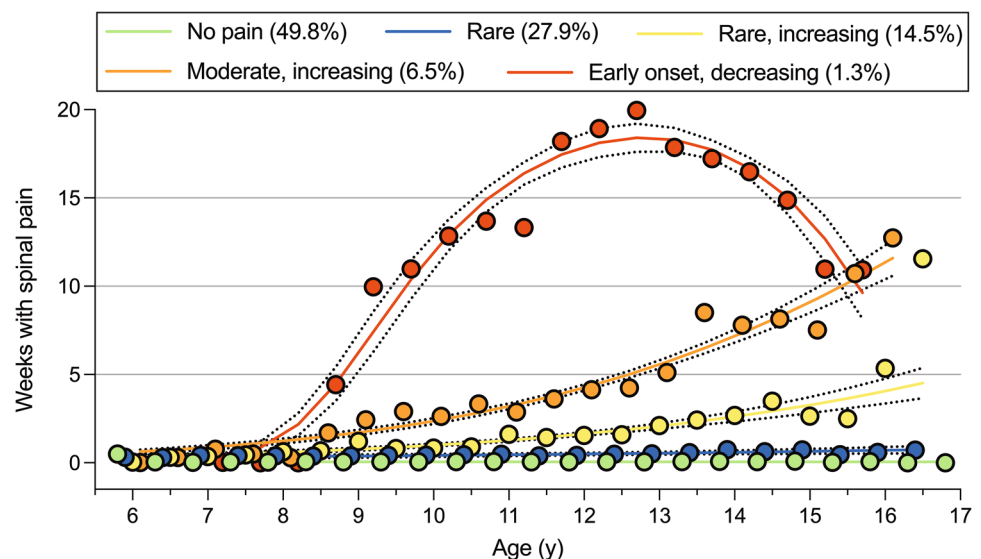
Table 1 Latent class growth model diagnostics

	Average posterior probability[1]	Odds of correct classification[2]	Assigned membership[3]	Estimated membership (95% CI)
Trajectory subgroup				
"No pain"	0.84	5.31	56.3%	49.8 (46.3 to 53.2)%
"Rare"	0.80	10.15	23.8%	27.9 (24.8 to 31.1)%
"Rare, increasing"	0.85	34.54	12.3%	14.5 (12.7 to 16.3)%
"Moderate, increasing"	0.91	141.15	6.2%	6.5 (5.6 to 7.4)%
"Early-onset, decreasing"	0.98	3535.60	1.3%	1.3 (1.0 to 1.6)%

[1]Minimum threshold = .70

[2]Minimum threshold = 5.0

[3]Percentages do not total to 100 due to rounding

average), the pain was nearly always transient and resolved prior to physical examination. Remaining children were assigned to a "rare" (27.9%), "rare, increasing" (14.5%), "moderate, increasing" (6.5%), or an "early-onset, decreasing" (1.3%) spinal pain trajectory. Baseline demographic, anthropometric, and pubertal development data for each trajectory subgroup are presented in Table 2.

Spinal pain prevalence, frequency, and diagnoses

Table 3 and Fig. 3 report descriptive statistics for spinal pain characteristics, stratified by trajectory subgroup. Primary diagnoses, stratified by spinal pain trajectory subgroup, are reported in Table 4. Back pain (non-specific) was the most common diagnosis received by participants in four of five trajectories groups, comprising 18 to 33% of all primary diagnostic codes. Tissue-specific spinal pain diagnoses (e.g., muscle strain, facet syndrome) were less common, and pathological diagnoses (e.g., fracture) were rare.

Discussion

In this study, children were classified as following one of five spinal pain trajectories from 6 to 17 years of age. Most children were classified as never or rarely experiencing spinal pain, while approximately 1 in 5 reported an increasing frequency of spinal pain into adolescence. The increasing trajectories are noteworthy as they may indicate children who suffer for prolonged periods and may also be at risk of developing more frequent or persistent spinal pain later in life. Moreover, a small subgroup of children experienced early-onset spinal pain. While children following the early-onset trajectory improved after about age 13, they reported the greatest number of weeks with pain overall. Most children (63%) reported at least one episode of spinal pain in approximately 4 years (including the few reports of usually transient pain from children in the "no pain" subgroup), and nearly 1 in 3 (28%) were diagnosed with at least one condition related to their pain, which were largely classified as

Table 2 Baseline demographic, anthropomorphic, and pubertal development statistics stratified by spinal pain trajectory subgroup[1]

	n	"No pain"	"Rare"	"Rare, increasing"	"Moderate, increasing"	"Early-onset, decreasing"
Age (years)	1556	9.0 (1.9)	9.2 (1.7)	9.1 (2.1)	9.4 (2.1)	9.8 (2.1)
Height (cm)	1537	136.0 (12.8)	137.9 (11.8)	138.6 (13.3)	139.3 (13.9)	141.8 (14.7)
Weight (kg)	1536	31.7 (9.5)	32.6 (8.8)	33.4 (10.8)	34.4 (11.9)	36.8 (11.9)
BMI (kg/m^2)	1536	16.8 (2.3)	16.9 (2.3)	17.0 (2.7)	17.2 (2.9)	17.6 (4.4)
Overweight (n(%))	1536	93 (10.8%)	54 (14.8%)	21 (10.9%)	15 (15.5%)	2 (10.5%)
Obese (n(%))	1536	20 (2.3%)	5 (1.4%)	5 (2.6%)	1 (1.0%)	1 (5.3%)
Female sex (n(%))	1556	432 (49.3%)	182 (49.1%)	122 (63.5%)	69 (71.1%)	11 (55.0%)
Puberty stage (n(%))	1530	526 (61.4%)	196 (53.7%)	105 (54.7%)	48 (50.0%)	12 (63.2%)
Tanner 1		229 (26.7%)	124 (34.0%)	58 (30.2%)	32 (33.0%)	5 (26.3%)
Tanner 2		75 (8.8%)	35 (9.6%)	22 (11.5%)	12 (12.4%)	2 (10.5%)
Tanner 3		27 (3.2%)	10 (2.7%)	7 (3.7%)	5 (5.2%)	—
Tanner 4/5						

BMI body mass index

[1]Values are mean (SD) unless otherwise indicated

Table 3 Spinal pain outcomes stratified by spinal pain trajectory subgroup ($N = 1556$)

	Total	"No pain"	"Rare"	"Rare, increasing"	"Moderate, increasing"	"Early-onset, decreasing"
Sample size	1556	876	371	192	97	20
Reporting periods[1]	8.0 (2.8)	7.8 (2.9)	8.1 (2.7)	8.4 (2.7)	7.9 (2.8)	7.5 (3.1)
Spinal pain prevalence[2]						
Self-reported pain	984 (63.2%)	304 (34.7%)	371 (100.0%)	192 (100.0%)	97 (100.0%)	20 (100.0%)
Diagnosed pain	428 (27.5%)	34 (3.9%)	168 (45.3%)	140 (72.9%)	73 (75.3%)	13 (65.0%)
Non-traumatic pain	347 (22.3%)	23 (2.6%)	119 (32.1%)	123 (64.1%)	69 (71.1%)	13 (65.0%)
Traumatic pain	127 (8.2%)	12 (1.4%)	60 (16.2%)	41 (21.4%)	12 (12.4%)	2 (10.0%)
Spinal pain frequency[3]						
Self-reported pain	6.8 (17.6)	0.4 (.6)	4.5 (3.1)	14.6 (9.1)	35.3 (22.8)	114.0 (52.3)
Diagnosed pain	3.1 (12.5)	<0.1 (.2)	1.3 (1.9)	6.7 (6.5)	17.7 (18.3)	66.1 (68.8)
Non-traumatic pain	2.8 (12.3)	<0.1 (0.2)	0.9 (1.8)	5.6 (6.5)	16.3 (18.1)	65.7 (68.7)
Traumatic pain	0.3 (1.6)	<0.1 (0.1)	0.4 (0.9)	1.0 (2.6)	1.4 (4.8)	0.4 (1.4)

[1] Mean (SD) 6-month periods with valid spinal pain data

[2] N (%) participants reporting ≥ 1 occurrence of spinal pain

[3] Mean (SD) weeks with spinal pain

non-traumatic. The most common diagnoses were descriptive and non-specific (e.g., "back pain"); tissue-specific and pathological diagnoses were less frequent. This means that spinal pain in children is common, often non-specific, and follows a heterogeneous course of pain frequency.

We are unaware of other studies that have modeled the developmental trajectories of spinal pain from childhood through adolescence. However, previous studies have estimated the probability of reporting low back pain during early adolescence [9] or from adolescence to early adulthood [10], with results that also suggest spinal pain to be common in those age groups. The primary differences between the current and previous studies involve the populations and methods of spinal pain measurement. We modeled the trajectories of spinal pain (back and neck pain) frequency over 5.5 years in children aged 6 to 11 years at baseline and covered a larger age span. We measured spinal pain frequency versus pain occurrences and applied shorter sampling windows (1 week versus 3 to 12 months). Despite these methodological differences, there were some similarities in the pain trajectories identified by the different studies.

One prospective study modeled the 3-year trajectories of low back pain experienced by 1336 11- to 14-year-old children from the USA and identified six unique trajectories [9]. Comparable to our study, in which 78% of participants had no pain or rare pain, approximately 3 in 4 participants in the
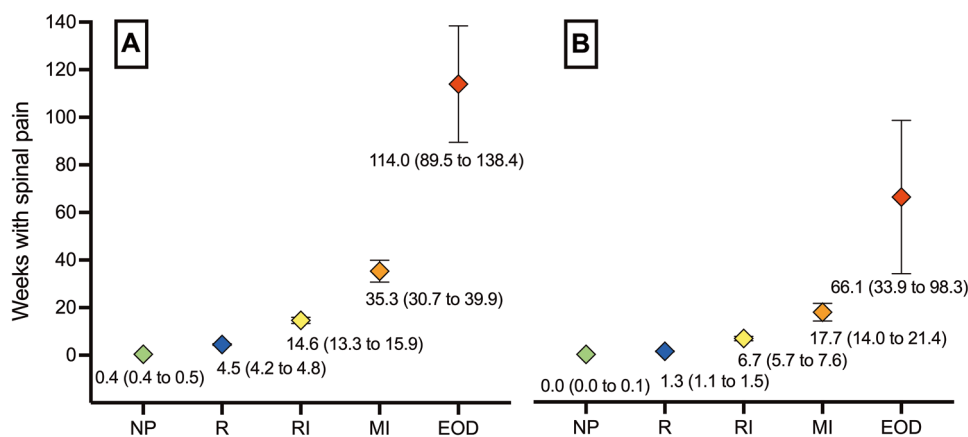
Fig. 3 Average weeks with (A) self-reported spinal pain[1] and (B) diagnosed spinal pain[2], stratified by trajectory subgroup. [1]Self-reported spinal pain includes all pain reports. [2]Diagnosed spinal pain is a subcategory of self-reported spinal pain comprising pain episodes for which the child underwent a physical evaluation and received a diagnosis. Values are means and 95% confidence intervals (some intervals too narrow to visualize). NP, no pain; R, rare; RI, rare, increasing; MI, moderate, increasing; EOD, early-onset, decreasing

Table 4 Diagnoses as a proportion of total diagnoses stratified by spinal pain trajectory subgroup[1,2]

"No pain" (N = 876, 144 diagnoses)		"Rare" (N = 371, 325 diagnoses)		"Rare, increasing" (N = 192, 299 diagnoses)		"Moderate, increasing" (N = 97, 152 diagnoses)		"Early-onset, decreasing" (N = 20, 40 diagnoses)	
Soft tissue pain	*41%*	*Back pain*	*18%*	*Back pain*	*25%*	*Back pain*	*30%*	*Back pain*	*33%*
Muscle strain	*16%*	*Soft tissue pain*	*17%*	*Facet syndrome (L)*	*16%*	*Facet syndrome (TL)*	*16%*	*Neck pain*	*13%*
Enthesopathy	*15%*	*Muscle strain*	*13%*	*Muscle strain*	*11%*	*Neck pain*	*13%*	**Muscle strain**	**10%**
Back pain	*12%*	**Neck pain**	**10%**	*Soft tissue pain*	*11%*	**Muscle strain**	**7%**	**Soft tissue pain**	**10%**
Neck pain	*3%*	**Facet syndrome (TL)**	**10%**	**Neck pain**	**8%**	**Facet syndrome (C)**	**7%**	**Idiopathic scoliosis**	**5%**
Contusion thorax	*3%*	**Contusion**	**8%**	**Facet syndrome (C)**	**5%**	**Soft tissue pain**	**5%**	**Enthesopathy**	**5%**
Unspecified joint disorder	*2%*	**Enthesopathy**	**7%**	**SI syndrome**	**5%**	**SI syndrome**	**5%**	**Facet syndrome (C)**	**5%**
Neck sprain/strain	*2%*	**Facet syndrome (C)**	**4%**	**Contusion**	**5%**	**Sprain/strain (C)**	**3%**	**Facet syndrome (TL)**	**5%**
Facet syndrome (T)	*1%*	**Neck sprain/strain**	**4%**	**Head pain**	**3%**	**Head pain**	**3%**	**Head pain**	**3%**
SI syndrome	*1%*	**SI syndrome**	**2%**	**Idiopathic scoliosis**	**2%**	**Idiopathic scoliosis**	**3%**	**Sprain/strain (C)**	**3%**
Torticollis	*1%*	**Head pain**	**2%**	**Enthesopathy**	**2%**	**Disc protrusion (L)**	**2%**	**Sprain /strain (T)**	**3%**
Biomechanical lesion	*1%*	**Idiopathic scoliosis**	**1%**	**Neck sprain/strain**	**2%**	**Contusion**	**2%**	**Contusion pelvis**	**3%**
Juvenile arthritis	*1%*	**Other joint disorder**	**1%**	**Unspecified joint disorder**	**1%**	**Enthesopathy**	**1%**	**SI syndrome**	**3%**
Facet syndrome (C)	*1%*	**Biomechanical lesion**	**1%**	**Postural kyphosis**	**1%**	**Postural kyphosis**	**1%**	**Superficial injury**	**3%**
Lumbar fracture	*1%*	**Sprain /strain (T)**	**1%**	**Disc protrusion (L)**	**1%**	**Spinal osteochondrosis**	**1%**		
		Postural kyphosis	**<1%**	**Facet syndrome (C)**	**<1%**	**Spondylolysis**	**1%**		
		Torticollis	**<1%**	**Lumbago with sciatica**	**<1%**	**Coccygodynia**	**1%**		
		Disc degeneration (C)	**<1%**	**Thoracic fracture**	**<1%**	**Dorsopathy, unspecified**	**1%**		
		Disc protrusion (L)	**<1%**	**Thoracic sprain / strain**	**<1%**	**Biomechanical lesion**	**1%**		
		Muscle/tendon injury(C)	**<1%**	**Sprain/dislocation (L)**	**<1%**	**Sprain/strain (T)**	**1%**		
		Coccyx fracture	**<1%**	**Soft tissue injury**	**<1%**				
		Dislocation, sprain/ strain (LP)	**<1%**						
		Sprain and strain (SI)	**<1%**						
		Soft tissue injury	**<1%**						

Bold-italics < 5% prevalence; bold 5 to 10% prevalence; italics > 10% prevalence

L lumbar, *T* thoracic and lumbar, *C* cervical, *T* thoracic, *LP* lumbopelvic, *SI* sacroiliac

[1]Individuals could receive multiple primary diagnoses if more than 1 pain episode was reported

[2]Percentages do not total to 100 due to rounding

other cohort had a very low probability of reporting pain. The remaining participants in that study followed trajectories whose probabilities of pain increased (8%), decreased (10%), peaked early (2%), or remained persistently high (1%) over time. We identified a greater proportion of participants who followed increasing spinal pain trajectories, which may reflect the larger age range of our population and the later stage of pubertal development for some participants, a potential risk factor for spinal pain [23, 24]. However, the early peak trajectory reported in that study included children whose probability of pain increased until around age 13 and sharply decreased thereafter, a pattern similar to the early-onset, decreasing frequency trajectory experienced by 1.3% of the participants in the current study. While most pain

trajectories identified by the current and previous studies followed a course of consistent or increasing pain frequency or probability, this finding shows that some children with early-onset pain do experience a favorable prognosis.

The current study adds to the evidence that spinal pain in children rarely results from a pathological etiology. Of the 1556 participants enrolled in this study, we identified few cases of pathological spinal pain such as idiopathic scoliosis (12 cases; 0.8%), disc protrusion (6 cases; 0.4%), fractures (3 cases; 0.2%), inflammatory arthritis (1 case; 0.1%), and spondylolysis (1 case; 0.1%). In comparison, non-specific diagnoses such as back pain (211 cases; 13.6%), soft tissue pain (159 cases; 10.2%), and neck pain (86 cases; 5.5%) were more common. This finding accords with evidence from adult populations showing the vast majority (approximately 90%) of low back pain to be non-specific [25]. Given the implications of overdiagnosis, clinicians are encouraged to embrace non-specific labels when appropriate and avoid potentially harmful diagnostic labels during a formative period when one's perceived vulnerability to spinal pain is poorly understood [26].

The number of children meeting our criteria for diagnosed spinal pain (27.5%) was less than half that of those with self-reported spinal pain (63.2%), indicating that many pain occurrences resolved within one week. However, previous findings have shown spinal pain to be episodic and recurrent for many [7, 27], and contemporary perspectives view spinal pain as a long-term condition with a variable course of symptoms and not a series of unrelated and self-limiting pain events [28, 29].

Clinical decision-making for children with spinal pain is a challenge. There have been few trials published on the treatment of spinal pain in the pediatric population and guideline recommendations are almost exclusively underpinned by evidence from adult studies of low back pain [30]. The current study results show concerning causes of spinal pain to be rare. This finding accords with guideline recommendations for clinicians to (1) reassure patients without clinical "red flags" that they do not have a serious disease, (2) encourage normal activities, and (3) avoid bed rest [31].

Study strengths and limitations

The strengths of this prospective study include the frequent and repeated measurements of spinal pain in a representative cohort of children from the general population. The 1-week sampling window likely reduced the potential for recall bias, and the integration of clinical examination and diagnostic information advances our understanding of spinal pain classification in the pediatric population.

Trajectory modeling is a person-centered approach, and our a priori statistical criteria suggested a high likelihood that participants were correctly classified. However, statistical models do not represent the individual experiences of all participants. For example, longitudinal evaluations show that some adults follow an episodic or "fluctuating" course of back pain in which intervals with minimal symptoms are separated by painful episodes that recur with time [7, 27]. These patterns are difficult to model, as the timing of the episodes can be unpredictable. Trajectory model outcomes "smooth" the course of symptoms and therefore represent the average experience of people assigned to a particular trajectory subgroup.

In the current study, participants contributed approximately 4 years of spinal pain data on average. Because we sought to understand the development of spinal pain as a function of age, we modeled pain trajectories from ages 6 to 17 years. This approach assumes that the participating children would follow similar trajectories at a given age, irrespective of their age at baseline and duration of participation. The validity of diagnostic criteria to identify specific pain-generating tissues such as joints, intervertebral discs, or muscles is unclear. Therefore, some diagnoses may be misclassified. Similarly, pain occurrences were reported by parents, and surrogate reporting is a potential source of bias, particularly with minor occurrences that may not be communicated from children to their parents [32]. The current study focused on the trajectories of spinal pain frequency, which is key to understanding the burden of this condition. However, investigating additional person-centered and societal outcomes (e.g., pain intensity, cost, school absenteeism, reduced physical activity participation) in future studies could provide important context to understanding the burden of spinal pain in children. Finally, while we attempted to recruit all 19 regional primary schools in Svendborg, nine schools elected not to participate in this study. Although our study sample represents approximately half of all primary school students in the region, there may be differences between the study and target populations.

Data science tasks in epidemiology can be classified as description, prediction, and causal inference [33], and future research is needed to investigate these aspects of spinal pain in children. For example, the trajectories described in this study can be extended to see if they predict persistent pain states in adulthood. Identifying baseline predictors of the different pain trajectories will help identify those children at risk of future spinal pain. Finally, the discovery of modifiable causes of spinal pain will be central to the development and testing of future interventions.

Conclusion

Spinal pain is common, often non-specific, and follows a heterogeneous course in children. Most children were classified as members of a no pain or rare spinal pain trajectory subgroup. About 1 in 5 children followed trajectories of increasing pain frequency, while a small subgroup of followed an early-onset, decreasing spinal pain trajectory. Children with early-onset pain reported the most weeks with spinal pain overall, while those following an increasing trajectory were tracking to experience the most pain in late adolescence. Pathological diagnoses were rare in all subgroups.

Declarations

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