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ORIGINAL ARTICLE

Risk factors of non-specific spinal pain in childhood

Julia Szita[1,2] · **Sara Boja**[1] · **Agnes Szilagyi**[1] · **Annamaria Somhegyi**[1] · **Peter Pal Varga**[1] · **Aron Lazary**[1]

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Abstract

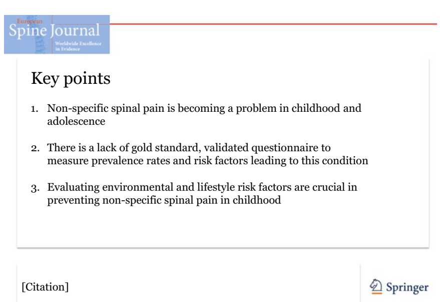
Purpose Non-specific spinal pain can occur at all ages and current evidence suggests that pediatric non-specific spinal pain is predictive for adult spinal conditions. A 5-year long, prospective cohort study was conducted to identify the lifestyle and environmental factors leading to non-specific spinal pain in childhood.

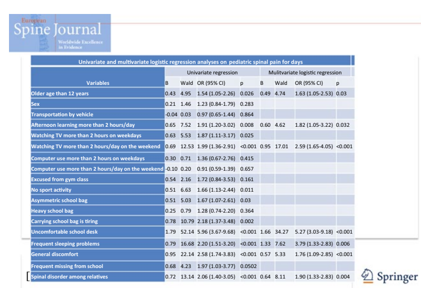
Materials and methods Data were collected from school children aged 7–16 years, who were randomly selected from three different geographic regions in Hungary. The risk factors were measured with a newly developed patient-reported questionnaire (PRQ). The quality of the instrument was assessed by the reliability with the test–retest method. Test ($N = 952$) and validity ($N = 897$) datasets were randomly formed. Risk factors were identified with uni- and multivariate logistic regression models and the predictive performance of the final model was evaluated using the receiver operating characteristic (ROC) method.

Results The final model was built up by seven risk factors for spinal pain for days; age > 12 years, learning or watching TV for more than 2 h/day, uncomfortable school-desk, sleeping problems, general discomfort and positive familiar medical history ($\chi^2 = 101.07$; $df = 8$; $p < 0.001$). The probabilistic performance was confirmed with ROC analysis on the test and validation cohorts (AUC = 0.76; 0.71). A simplified risk scoring system showed increasing possibility for non-specific spinal pain depending on the number of the identified risk factors ($\chi^2 = 65.0$; $df = 4$; $p < 0.001$).

Conclusion Seven significant risk factors of non-specific spinal pain in childhood were identified using the new, easy to use and reliable PRQ which makes it possible to stratify the children according to their individual risk.

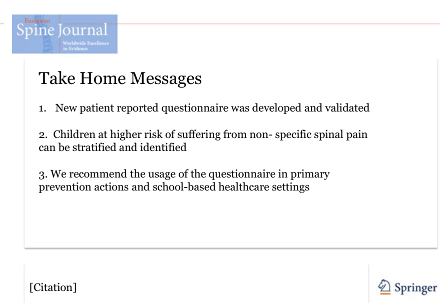
Graphical abstract These slides can be retrieved under Electronic Supplementary Material.





Univariate and multivariate logistic regression analyses on pediatric spinal pain for days

Variables	Univariate regression				Mulitvariate logistic regression			
	B	Wald	OR (95% CI)	p	B	Wald	OR (95% CI)	p
Older age than 12 years	0.43	4.95	1.54 (1.05-2.26)	0.026	0.49	4.74	1.63 (1.05-2.53)	0.03
Sex	0.21	1.46	1.23 (0.84-1.79)	0.283				
Transportation by vehicle	-0.04	0.03	0.97 (0.65-1.44)	0.864				
Afternoon learning more than 2 hours/day	0.65	7.52	1.91 (1.20-3.02)	0.008	0.60	4.62	1.82 (1.05-3.22)	0.032
Watching TV more than 2 hours on weekdays	0.63	5.53	1.87 (1.11-3.17)	0.025				
Watching TV more than 2 hours/day on the weekend	0.69	12.53	1.99 (1.36-2.91)	<0.001	0.95	17.01	2.59 (1.65-4.05)	<0.001
Computer use more than 2 hours on weekdays	0.30	0.71	1.36 (0.67-2.76)	0.415				
Computer use more than 2 hours/day on the weekend	-0.10	0.20	0.91 (0.59-1.39)	0.657				
Excused from gym class	0.54	2.16	1.72 (0.84-3.53)	0.161				
No sport activity	0.51	6.63	1.66 (1.13-2.44)	0.011				
Asymmetric school bag	0.51	5.03	1.67 (1.07-2.61)	0.03				
Heavy school bag	0.25	0.79	1.28 (0.74-2.20)	0.364				
Carrying school bag is tiring	0.78	10.79	2.18 (1.37-3.48)	0.002				
Uncomfortable school desk	1.79	52.14	5.96 (3.67-9.68)	<0.001	1.66	34.27	5.27 (3.03-9.18)	<0.001
Frequent sleeping problems	0.79	16.68	2.20 (1.51-3.20)	<0.001	1.33	7.62	3.79 (1.33-2.83)	0.006
General discomfort	0.95	22.14	2.58 (1.74-3.83)	<0.001	0.57	5.33	1.76 (1.09-2.85)	<0.001
Frequent missing from school	0.68	4.23	1.97 (1.03-3.77)	0.0502				
Spinal disorder among relatives	0.72	13.14	2.06 (1.40-3.05)	<0.001	0.64	8.11	1.90 (1.33-2.83)	0.004



Keywords Back pain · Risk factor · Risk assessment · Questionnaires and surveys · Prevention

Introduction

Spinal pain is common in most modern societies thereby increasing overall healthcare costs. Neck pain and low back pain together represent the fourth most common cause of disability globally [1] thus having a significant impact on

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Aron Lazary
aron.lazary@bhc.hu

Extended author information available on the last page of the article

quality of life. Low back pain (LBP) is also referred to as a "western epidemic" that primarily affects the working age population [2].

The most recent review on the epidemiologic aspect of LBP reported a point prevalence of LBP up to 58.1% in the adult population [3]. Life-time prevalence of LBP is over 70% in the industrialized countries [4] and that of neck pain (NP) is similarly high: 22–70% [5, 6], with most of the cases classified as non-specific.

Recently published data show that the epidemiologic features of pediatric spinal pain are almost as high as seen in the adult population [7]. Judging from these studies, it is clear that NP and LBP may well start in early childhood and at the end of adolescence their prevalence is likely to reach the prevalence rate in adulthood [4, 8]. Aartun et al. found that mild, infrequent neck, mid back and low back pain are common in children aged 11–15 and after a 2-year follow-up, regardless of location, a clear progression of the condition is apparent [9]. A Danish study showed that 8% of all 13-year-olds sought healthcare and this number rises to 34% by the age of 15 [8]. Jones et al. [10] interviewed 500 schoolchildren aged between 10 and 16 years and found that 13% of the investigated group experienced disabling recurrent low back pain, 23.1% needed medical care, 26.2% had been absent from school, and 30.8% experienced diminished physical activity. Typically, pain intensity is lower compared with adult LBP intensity and it also lasts for a shorter time [11]. Hestbaek et al. [12] conducted a large population-based study on twins and found a clear correlation between back pain in childhood/adolescence and low back pain in adulthood. Based on these findings, adult non-specific low back pain primary prevention measures should be advocated in childhood or adolescence [13, 14].

To identify those children at risk, the likely risk factors for non-specific spinal pain need to be determined and assessed. Although the risk factors in adulthood are well investigated, they cannot automatically be applied to children. Moreover, there is also a lack of standardized, validated, patient-reported questionnaires (PRQ) that can be applied to pediatric spinal conditions and their risk factors.

The majority of studies on this issue use a self-developed questionnaire to investigate the risk factors of spinal pain development, but generally speaking the reliability or validity of such questionnaires is not reported. This is probably why there is an inconsistency in previously published studies concerning the risk factors for spinal pain in children [15–17]. Comparison of multicenter data is not possible, and the carrying out of prospective studies is also encumbered by the absence of validated gold standard PRQs.

The rationale for a new questionnaire was identified from the literature. We, therefore, aimed at—and succeeded in—developing and validating a multivariate probabilistic model PRQ capable of measuring non-specific spinal pain prevalence in childhood and the possible environmental factors leading to this condition.

Materials and methods

Questionnaire development

The three-stage method for questionnaire development published by Wilson and Cleary was followed (1. conceptual model-conceptualisation, 2. development, 3. testing) [18]. With the participation of physiotherapists, school teachers, a rheumatologist, a prevention expert and spine surgeons an expert group was formed to select the possible risk factors based on a careful literature review. The items of the questionnaire were drafted and finalized after several iteration cycles among the group members. The final consensus version of the PRQ is registered in Hungarian language and consists of 20 items divided into three sections. Section 1 contains the questions about the physical activity and mechanical load in terms of lifestyle factors (sports activity level, time spent in front of TV and computer, type and whether the school bag is perceived as heavy, physical comfort of the school environment, sleeping disturbances). Section 2 covers non-specific spinal pain prevalence, the child's health care seeking behaviour and general well-being. Section 3 is addressed to the parents whether they or a family member have had any type of spinal disorder and finally, they give their written consent. Considering the age and reading comprehension of the target group the parents were advised to supervise or help the children during the completion of the PRQ. No missing item was accepted for the questionnaire.

Subjects/study population

The schools participating in the study were selected from three different geographic regions of the country representing a general population sample. The research protocol was designed and implemented regarding the Helsinki Declaration on human subjects testing and the study was approved by the Scientific and Research Ethics Committee of the Medical Research Council (431/PI/2007).

A random subgroup of children in fifth and sixth grades filled out the questionnaire at home two times with 1-week interval to assess the reliability. A larger group of schoolchildren were recruited into a 5-year long prospective study between 2009 and 2014 in six elementary schools. Second to eight graders have completed the questionnaire, most of the students twice in a 3-year interval. All subjects were healthy volunteers without any known disabling musculoskeletal or other chronic disease or functional limitation. The test

($N = 952$) and the validity datasets ($N = 897$) were generated by the random selection of the participant school–classes.

Statistical analysis

Reliability

For testing the reliability, the test–retest method was used. Particularly, in this study the questionnaire was refilled 1 week after the first completion. Given the nominal type of data in the newly developed PRQ, kappa statistic was chosen for the analysis [19]. As a measure of reliability, kappa value should be statistically significant and as proposed by Landis and Koch [20] values below 0.4 were interpreted as poor, 0.41–0.75 as fair to good, and 0.75–1 were interpreted as excellent agreement.

Risk factor analysis and model validation

The prospective study data was analysed by uni- and multivariate logistic regression models to identify significant risk factors for non-specific pediatric spinal pain. Stepwise multivariate logistic regression model was built from the test cohort data by entering all the variables with $p < 0.1$ in univariate analyses. Multicollinearity was assessed with Spearman's rank correlation ($r > 0.8$). The predictive performance of the final multivariate model was calculated and validated applying the receiver operating characteristics (ROC) method. The association between the simplified risk scoring system and spinal pain probability was analysed using Chi-Square test. Sample size for the psychometric analyses was determined based on recommendations in the literature [19, 21]. All statistical analyses were performed with IBM SPSS 20.0 software and p values of less than 0.05 were considered significant.

Results

The testing phase was performed through a pilot study including 30 children. Their answers and remarks were analysed and the PRQ was finalized by the final expert group discussion (Suppl. Material 1).

Test–retest study

A total of 146 children fully completed the PRQ twice in 1-week interval. The mean age was 10.73 ± 0.8 years and the gender distribution were 53% boys ($n = 78$) and 47% girls ($n = 68$). Results of the reliability analysis are shown on Table 1. In Sect. 1, the item about the "transportation to school" achieved the highest kappa value ($\kappa = 0.95$), while the question about "how tiring carrying the school bag is" showed the least reliability ($\kappa = 0.39$). "Missing days' from school because of any health problem" ($\kappa = 0.75$) and "spinal pain for days" ($\kappa = 0.8$) in sect. 2 proved to be highly reliable among the items about the spinal pain. The questions about the location of the pain did not perform so well,

Table 1 Results of the reliability analysis

Item	Content	Kappa value
1	Transportation type to school (car, bus or by foot)	0.95
2	Hours spent studying/day	0.61
3	Hours spent watching TV weekday/weekend	0.65/0.76
4	Hours spent using the computer weekday/weekend	0.76/0.81
5	Type of gym class	0.6
6	Regular sport activities	0.82
7	Type of school bag	1
8	Weight of school bag perceived	0.63
9	How tiring is it to carry the school bag	0.39
10	How comfortable is the school desk	0.74
11	How well does the child sleep	0.74
12	General well being	0.52
13	Missing days from school because of any health problem	0.75
14	Low back pain in the last month	0.23
15	Back pain in the last month	0.39
16	Neck pain in the last month	0.43
17	Spinal pain for days	0.8
18	Missed school because of spinal pain	Insuff. number
19	Doctor visit because of spinal pain	0
20	Spinal pain among first degree relatives/second degree relatives	0.74/0.84

all these items' kappa value was below 0.75. The questions about "missing school because of spinal pain" and "doctor's visit because of spinal pain" could not be evaluated in the test–retest cohort because of the insufficient number of positive answers. The analysis of Sect. 3, the item about family spinal pain history achieved a good to excellent agreement ($\kappa = 0.74$ and 0.84).

Prevalence of back pain

Age and gender distribution were similar in the test and the validation dataset (11.8 ± 1.8 vs. 11.0 ± 1.8 years old and 48 vs. 45% boys). The highly reliable "spinal pain for days" item was dichotomised for prevalence analysis purposes. The descriptive analysis showed (Table 2) a "spinal pain for days" prevalence of 12.9% in the full cohort. Out of the children 19.4% had experienced non-specific low back pain, 24.9% back pain, 25% neck pain in the last month and 4.1% had already visited a doctor because of spinal pain.

Risk factors for non-specific spinal pain

Further analyses were performed using the "spinal pain for days" item as the dependent variable which was the most reliable symptom feature. To develop a simplified multivariate risk estimation model, the categorical variables of the PRQ were dichotomized based on the deeper analysis of the results of the first run of univariate logistic regression models. The dichotomized variables were analysed again in univariate models and variables with $p < 0.1$ entered into the multivariate model (Table 3). The final multivariate predictive model ($\chi^2 = 101.07$; $df = 8$; $p < 0.001$) achieved by logistic regression analysis was built up by seven risk factors. A good prediction power of the multivariate probabilistic model was confirmed on the test and validation cohort for "spinal pain for days" (AUC = 0.76 and 0.71, respectively) (Fig. 1a, b).

A simplified risk scoring system was developed based on the number of the above-mentioned risk factors. In the total cohort, children having one risk factor had a possibility of 8.5% to suffer from "spinal pain for days" while the risk for that was 50% in the case of four or more risk factors ($\chi^2 = 65.0$; $df = 4$; $p < 0.001$) (Fig. 2).

Discussion

Seven risk factors for significant pediatric non-specific spinal pain have been identified and validated in this large-scale cohort study. Older age, time spent with learning or watching TV, uncomfortable school desk, sleeping problems, general discomfort and positive familiar medical history are associated with "spinal pain for days" in schoolchildren. Risk factors can be divided into environmental or lifestyle and biological aspects.

The most plausible biological risk factor is age and gender. Consistent with the evidence we found that the chance of experiencing any kind of "spinal pain for days" and health care seeking behaviour increases with age [8, 22, 23]. To convert age into an easily identifiable risk factor and feasible for the postliminary analysis, age was dichotomised into older or younger than 12 years old following and supporting the findings of Trevelyan et al. [24] who published that children older than 12 years had an increased risk for the development of spinal pain. Gender was not significantly associated with spinal pain for days in our uni- or multivariate models which corresponds with the findings of several publications investigating the relationship between prevalence rates of spinal pain and sex [22, 25, 26]. On the contrary Balague et al. and MacDonald et al. reported that female gender is associated with LBP [14, 17, 27]. Kovacs et al. [17] published a population based study investigating LBP in adolescents and adults and one of their key findings was that gender related risks increase with age, other authors found female gender to be a predictor for spinal pain but only in the cases of more severe and frequent LBP or having pain in more than one spinal area [11, 28]. The mean age in our longitudinal cohort was younger than in these published studies and we did not differentiate between the intensity of spinal pain, therefore, a careful comparison should be made between the results.

Table 2 Prevalence of spinal pain symptoms

	Test cohort ($N = 952$)	Validity cohort ($N = 897$)
Low back pain (last month)	190 (20.1%)	164 (18.5%)
Back pain (last month)	228 (24.1%)	227 (25.6%)
Neck pain (last month)	233 (24.6%)	224 (25.3%)
Spinal pain (for days)	127 (13.4%)	109 (12.4%)
Missing school because of spinal pain	23 (2.4%)	13 (1.5%)
Doctor's visit because of spinal pain	40 (4.3%)	34 (3.8%)

Table 3 Results of univariate and multivariate logistic regression analyses on pediatric spinal pain for days

Variables	Univariate regression				Multivariate logistic regression			
	B	Wald	OR (95% CI)	*p*	*B*	Wald	OR (95% CI)	*p*
Older age than 12 years	***0.43***	***4.95***	***1.54 (1.05–2.26)***	***0.026***	***0.49***	***4.74***	***1.63 (1.05–2.53)***	***0.03***
Sex	0.21	1.46	1.23 (0.84–1.79)	0.283				
Transportation by vehicle	− 0.04	0.03	0.97 (0.65–1.44)	0.864				
Afternoon learning more than 2 h/day	***0.65***	***7.52***	***1.91 (1.20–3.02)***	***0.008***	***0.60***	***4.62***	***1.82 (1.05–3.22)***	***0.032***
Watching TV more than 2 h on weekdays	*0.63*	*5.53*	*1.87 (1.11–3.17)*	*0.025*				
Watching TV more than 2 h/day on the weekend	***0.69***	***12.53***	***1.99 (1.36–2.91)***	***< 0.001***	***0.95***	***17.01***	***2.59 (1.65–4.05)***	***< 0.001***
Computer use more than 2 h on weekdays	0.30	0.71	1.36 (0.67–2.76)	0.415				
Computer use more than 2 h*/day on the weekend*	− 0.10	0.20	0.91 (0.59–1.39)	0.657				
Excused from gym class	0.54	2.16	1.72 (0.84–3.53)	0.161				
No sport activity	*0.51*	*6.63*	*1.66 (1.13–2.44)*	*0.011*				
Asymmetric school bag	*0.51*	*5.03*	*1.67 (1.07–2.61)*	*0.03*				
Heavy school bag	0.25	0.79	1.28 (0.74–2.20)	0.364				
Carrying school bag is tiring	*0.78*	*10.79*	*2.18 (1.37–3.48)*	*0.002*				
Uncomfortable school desk	***1.79***	***52.14***	***5.96 (3.67–9.68)***	***< 0.001***	***1.66***	***34.27***	***5.27 (3.03–9.18)***	***< 0.001***
Frequent sleeping problems	***0.79***	***16.68***	***2.20 (1.51–3.20)***	***< 0.001***	***1.33***	***7.62***	***3.79 (1.33–2.83)***	***0.006***
General discomfort	***0.95***	***22.14***	***2.58 (1.74–3.83)***	***< 0.001***	***0.57***	***5.33***	***1.76 (1.09–2.85)***	***< 0.001***
Frequent missing from school	*0.68*	*4.23*	*1.97 (1.03–3.77)*	*0.0502*				
Spinal disorder among relatives	***0.72***	***13.14***	***2.06 (1.40–3.05)***	***< 0.001***	***0.64***	***8.11***	***1.90 (1.33–2.83)***	***0.004***

Risk factors identified in univariate regression in italic and the risk factors in bold were entered in the multivariate regression model; beta coefficients (*B*), Wald statistics, odds ratios (OR) and its 95% confidence intervals (CI) as well as *p* values are represented

Prolonged time in seated position is widely suggested to be associated with back pain [23, 29] as it is assumed that the structural changes of the intervertebral disc are the underlying mechanism of the development of chronic low back pain [30]. Our study confirmed this concern about the negative impact of the increased amount of time spent in sitting during everyday activities such as watching TV or studying for more than 2 h a day. However, surprisingly computer use of more than 2 h a day did not increase the possibility of spinal pain in our risk assessment model. It could be explained by having an ergonomically seen better environment and seating position compared to watching TV or studying from a book. The tendency of sedentary lifestyle increases with age and in our investigation children over 12 years of age spent significantly longer times seated ($\chi^2 = 32.1$; $df = 5$; $p < 0.001$) compared to the younger population. As a result of recent technological innovations, it is possible, that the growing use of tablets and mobile phones thereby the time spent overall per day in seated position increases compared to previous generations and for future studies this could be a major aspect that cannot be overlooked especially if we consider the typical posture most of these activities are carried out. Sitting position at school can be also associated with the development of spinal pain according to our and others' finding, that uncomfortable school desk increases the risk for back pain or health care seeking behaviour [31, 32], although the Hungarian educational setting is ergonomically seen the most favourable because the sitting direction in relation of the teacher is faced frontal [32].

Carrying heavy objects, carrying school backpacks and transportation to/from school by car were found significant factors in recent publications [23, 32]. Watson et al. [33] found that 94% of the children who were suffering from back pain experienced some disability, with the most common reports being difficulty carrying schoolbags. Asymmetric types of schoolbags and "carrying schoolbag is tiring" were significantly associated with spinal pain for days in our univariate models, but were not entered into the final multivariate regression model. On the other hand, in the reliability analysis the question 'how tiring is to carry the schoolbag is' scored poorly which could be explained by the day to day difference of the weight of the schoolbag (strongly dependent on the classes the child has to attend). In a subsequent analysis, the weight of the back pack played a significant role for LBP ($\chi^2 = 21.84$; $df = 2$; $p < 0.001$), BP ($\chi^2 = 23.69$; $df = 2$; $p < 0.001$) and for NP ($\chi^2 = 16.83$; $df = 2$; $p < 0.001$) which can be explained by the type of mechanical load the spine likely suffers from while carrying a back pack. The type of transportation played a role for LBP, the children who were transported to school by car were more likely to have LBP ($\chi^2 = 21.77$; $df = 2$; $p < 0.001$), however, it was not associated with the clinical relevant spinal pain in our model. This observation could

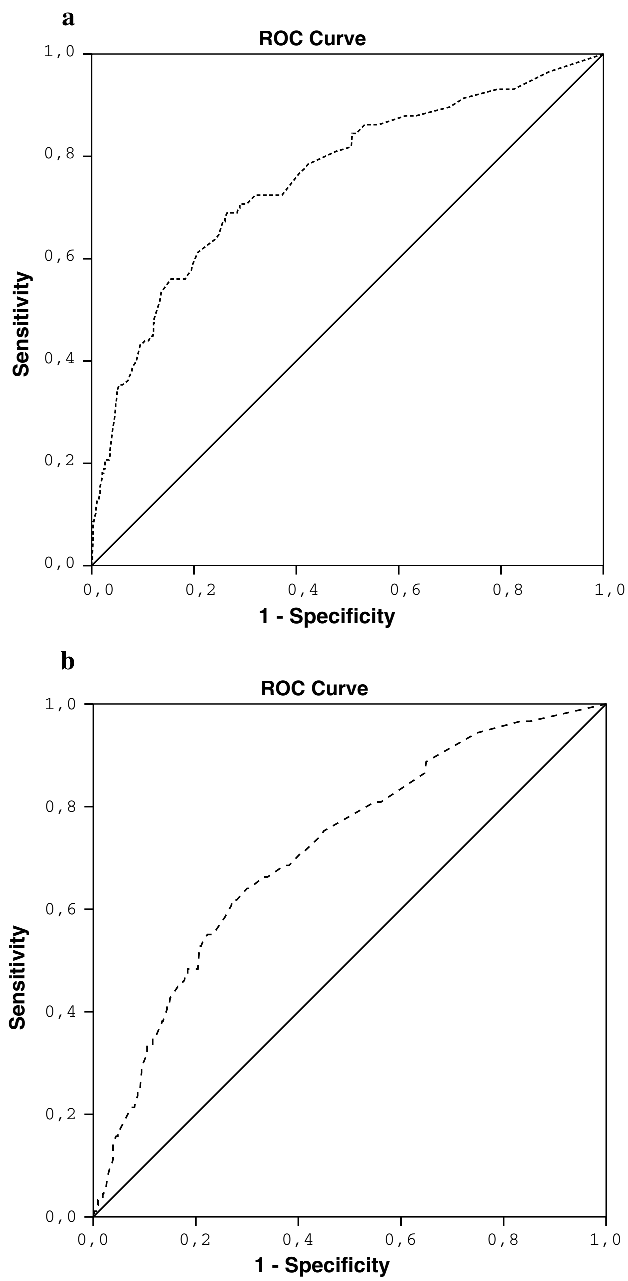

Fig. 1 ROC analysis for having 'spinal pain for days' in the test (**a**) and validity cohort (**b**)

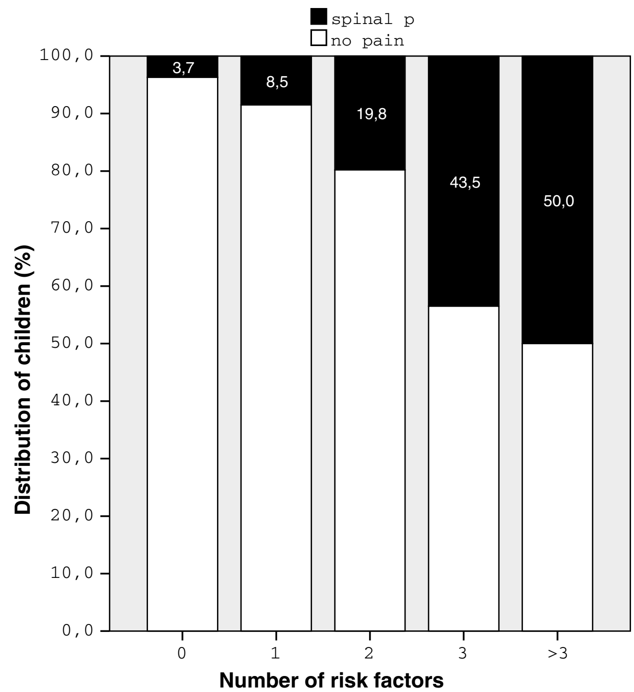

Fig. 2 Frequency of children in pain according to the number of risk factors

be associated with the increased time spent seated and the decrease of the amount of physical activity per day.

General discomfort and sleeping problems increased the risk of clinical spinal pain in the present study, similarly to the findings of Wirth et al. They investigated more than 400 adolescents and found that sleep disorder is a significant predictor for pain in more than one spinal area and also a trend for frequent pain [11]. Adverse psychological factors such as distress or dissatisfaction caused by the educational system and pre-existing somatic pain can also can increases the risk of musculoskeletal symptoms, especially LBP in children who initially were pain free [16, 34]. The effect of parents' spinal pain conditions in terms of the behavioural and biological consideration on the potential development of pediatric spinal pain has been expansively researched in the last decade. Our analysis reinforces the recent results that low back pain in one or both parents may lead to spinal pain in childhood [35] and these children are at increased risk of developing a chronic pain condition in adulthood [36]. Children whose parents or relatives have had any type of spinal pain were more likely to suffer from NP, BP, LBP and spinal pain of any type in the present study. These children were also at higher risk to take sick leave caused by spinal pain and showed a greater extent of health care seeking behaviour ($\chi^2 = 190.35$; $df = 2$; $p < 0.001$; $\chi^2 = 281.73$; $df = 2$; $p < 0.001$). The exact roles of the possible genetic and behavioural factors as well as the effective mitigation strategies of these "familiar" risks need further investigations.

The study has got some possible limitations. Age limit for the questionnaire was not defined and tested. Generally, children in the age of 8–9 years old are able to read and write alone but it does not mean that young children are ready to fill out a PRQ by themselves. There can be also a difference among countries because of the different schooling systems, therefore, each system needs to identify the age limit of these types of questionnaires which primarily target children. We generally advised the children to fill out the questionnaire themselves with the supervision of their parents; therefore, there is a chance of possible bias in terms of parental influence on the given answers. Pain intensity scale which is an important progression modality, therefore, also crucial factor in the prognosis of the disease, however, it was not included in our PRQ by the reason that our main purpose was the development of a risk scoring tool and the initiation of primary prevention actions for non-specific spinal pain. Time spent seated was investigated and identified as an important factor for non-specific spinal pain but the quality as in postural disturbance was not explored in our analysis. Another limitation of our study is that the risk assessment scoring system has not yet been externally validated.

In conclusion, a new PRQ that is capable to identify the children who are at greater risk of experiencing non-specific spinal pain was developed and validated on a large sample size prospective cohort study and by that it is filling a gap in the primary prevention actions for adult low back pain. Our study allowed us to determine and validate a number of risk factors that can lead to the development of pediatric spinal pain. Having a highly reliable dependent variable in the center of the risk assessment model gives a great value to our results compared to previous investigations which do not consider the reliability issues of each spinal area. The risk scoring system is a reliable and easily applied tool for everyday preventative actions and we highly suggest the use of it in school healthcare systems.

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Compliance with ethical standards

Conflict of interest None of the authors have any potential conflict of interest.

Ethical approval The study was approved by Hungary's Scientific and Research Ethics Committee of the Medical Research Council (431/PI/2007).

Informed consent All participants' parents/legal guardians received study information and signed an informed consent form.

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Affiliations

Julia Szita[1,2] · Sara Boja[1] · Agnes Szilagyi[1] · Annamaria Somhegyi[1] · Peter Pal Varga[1] · Aron Lazary[1]

[1] National Center for Spinal Disorders, Kiralyhago u. 1-3, Budapest 1126, Hungary

[2] School of Ph.D. Studies, Semmelweis University, Budapest, Hungary