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ORIGINAL ARTICLE

Back pain in children and adolescents: a cross-sectional study

Nelson Azevedo[1] · José Carlos Ribeiro[2] · Leandro Machado[3]

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Abstract

Purpose Back pain is a growing problem worldwide, not only in adults but also in children. Therefore, it is becoming increasingly important to investigate and understand the factors that influence the early onset of back pain. The aim of this study was to determine the prevalence of back pain in children and adolescents and to identify predisposing risk factors and protective factors.

Methods A cross-sectional study was conducted between October and December 2019 in schools from northern Portugal, evaluating 1463 students aged 9 to 19 years, of both genders. The instruments used were the Spinal Mouse® to assess posture, the Inbody 230® to assess body composition, an online questionnaire to characterize the sample and back pain, and the FITescola® battery test to access physical fitness.

Results Half of the subjects experienced back pain at least once in their lifetime. The most frequently mentioned were lumbar spine and thoracic spine, mostly with mild or moderate pain intensities. Age, female gender, percent body fat, prolonged smartphone and computer use, hyperkyphosis, and the lateral global spine tilt to the left side are all factors with higher relative risk of back pain. Practicing physical activity or sports regularly and video games have a protective effect.

Conclusion The prevalence of back pain in children and adolescents is very high: The study enhances the case for protective factors such as physical activity habits or video games while reinforcing risk factors such as percent body fat, prolonged smartphone or computer use, and posture.

Keywords Back pain · Children · Adolescents · Prevalence · Risk factors · Physical activity

Introduction

Back pain is a clinical condition that affects a wide spectrum of the world's population and has implications for public health, as well as economic and social concerns [1]. There are several factors associated with the development of back pain, including repetitive activities or a sedentary lifestyle [2]. Symptoms do not always reflect structural changes in the spine [3], and it is important to find the cause of symptoms as early as possible [4]. Recent studies focused on how early in human life back pain sets in and how common it is [5, 6].

Back pain in children and adolescents is a clinical condition that in recent years has seen increased attention from parents and the appropriate medical support services because of its early onset [6] but also due to a better understanding of the risk factors [7]. To better characterize this condition, several studies have been conducted recently in several countries, including Portugal [8, 9].

The prevalence of back pain is high among young students [5], with a higher representation of female children [10], but the precipitating factors have not been fully elucidated. A recent meta-analysis studied the relationship between physical fitness and back pain, but the results were inconclusive [11].

This study aims to characterize the prevalence of back pain in children and adolescents from Portugal and the possible protective and risk factors associated with this clinical condition.

✉ Nelson Azevedo
nelson.azevedo@docente.isave.pt

José Carlos Ribeiro
jribeiro@fade.up.pt

Leandro Machado
lmachado@fade.up.pt

1 CICS, ISAVE, Faculdade de Desporto da Universidade do Porto, 4200-450 Porto, Portugal

2 CIAFEL, ITR, Faculdade de Desporto da Universidade do Porto, 4200-450 Porto, Portugal

3 CIFI2D, LABIOMEP, Faculdade de Desporto da Universidade do Porto, 4200-450 Porto, Portugal

Materials and methods

Study design and participants

A cross-sectional study was carried out with children from a school cluster in northern Portugal (Fig. 1), between October and December 2019.

The study was explained to the physical education teachers at the school cluster. Subsequently, a description of the study was given to all students in these schools, and written informed consent was obtained from their parents or guardians after attending a presentation of the project, during which all doubts were resolved. All participants were given the opportunity to decline participation.

Exclusion criteria included students with acute musculoskeletal injuries or serious medical problems that prevented data collection.

This study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving human participants were approved by the Ethics Committee of FADEUP—University of Porto (CEFADE 50, 2019). The directors of the participating schools gave their ethical approval and written consent.

The elaboration of the manuscript was based on the STROBE statement guidelines.

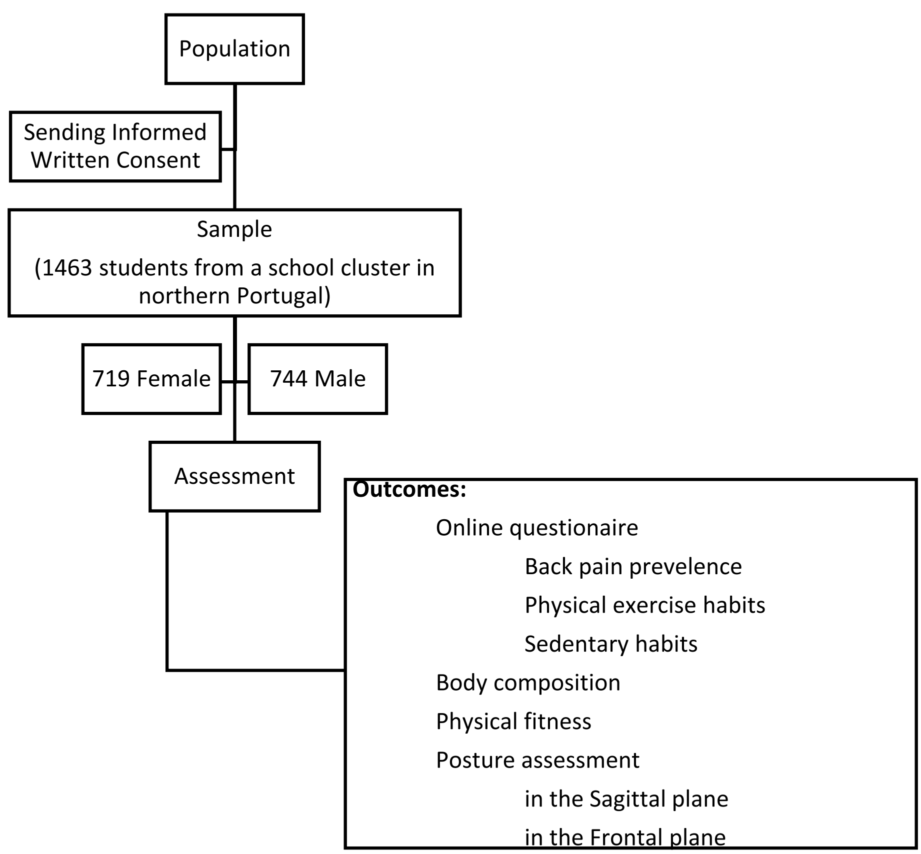
Instruments

An online questionnaire (Google Forms) was used to characterize the sample in terms of anthropometric data, physical activity and sedentary habits, as well as presence of back pain, its prevalence, and location (more than a region could be indicated). Back pain intensity was quantified by an 11-point numeric rating scale (NRS-11), associated with Faces Pain Scale—Revised [12]. Pain classification was based on the study by Tsze et al. [13].

Physical fitness was analyzed using the FITescola® test protocol [14], where the tests are divided into three sections: aerobic condition, evaluated by the 20-m shuttle run; body composition, evaluated by body mass index (BMI); and neuromuscular fitness assessed in three components: trunk neuromuscular condition through abdominal strength (number of curl-ups), upper body neuromuscular condition through the maximal number of push-ups in one series, and lower body neuromuscular condition through the long jump. Flexibility was assessed with the sit and reach test. The test results were divided into three categories according to the reference values, namely low profile, normal profile, and high profile [14].

Body mass index (BMI) and percentage body fat (PBF) composition were assessed using the InBody 230 (InBody,

Fig. 1 Study diagram



Cerritos, California, USA) scoring system [15], a body analysis system based on the bioimpedance of the body. BMI and PBF were divided into three categories, namely low, normal, and high, adjusted for age and gender [16, 17].

Posture was assessed through spinal evaluation performed using the Spinal Mouse® (Idiag, Voletswil, Switzerland), with proprietary software IDIAG M360pro® version 7.6. Spinal Mouse (SM) is a computerized wireless telemetry device, consisting of two wheels, sensors, and controllers in a protective casing, acquiring at 150 Hz, that is manually guided on the skin along the spine, from the seventh cervical vertebrae to the sacrum to quantify posture and spine mobility [18].

Spinal measurements were taken with the students in the orthostatic reference position and with minimal clothing on the trunk (the girls used tape to hold their bras, always accompanied by the researcher and a female teacher; the boys had their torsos unclothed). Postural analysis in the orthostatic position was performed in the sagittal and frontal planes. In the sagittal plane, posture was considered in four regions, each divided into three categories: thoracic spine: hypokyphosis/neutral/hyperkyphosis; lumbar spine: hypolordosis/neutral/hyperlordosis; pelvic tilt: anterior/neutral/posterior; global spinal sagittal tilt: anterior/neutral/posterior. In the frontal plane, posture was also divided into three categories for the different regions studied: right/neutral/left tilt. The reference angles for spinal curvatures in the sagittal plane in children are: thoracic kyphosis (33.3° ± 5.4°) and lumbar lordosis L1–L5 (39.6° ± 5.6°) and in adolescents: thoracic kyphosis (35.4° ± 4.9°) and lumbar lordosis L1–L5 (42.7° ± 4.5°) [19]. The reference values for pelvic tilt in children and adolescents are 7.7° ± 11.3° [20]. In the frontal plane and global spine in the sagittal plane, the reference values for neutral are 0º(± 3º). All the reference values were adjusted by ± 3º according to the value of the SM standard error of measurement (SEM) determined by Mannion et al. [18].

The privacy of the students was maintained by providing a private room for the examination. The average duration of each examination was approximately 5 min per participant.

Statistical analysis

Descriptive statistics were used to characterize the sample. Normality of the data was tested by the Kolmogorov–Smirnov test, and most of the variables did not have a normal distribution. Mann–Whitney U-test was used to estimate differences in the studied variables between the two gender groups. The Chi-squared test was used to estimate the differences between genders and back pain manifestation, as well as the NRS-11 intensity categories and their association with the back regions.

The Phi correlation coefficient test was used to measure the relationship between two binary variables (yes/no; female/male).

For the association between the manifestation of back pain and the variables studied, binary logistic regression was used to calculate the odds ratio (OR). We assumed as a missing value the answer option (I don't know the answer; it depends on the day/week) for those variables including it, because it did not allow to determine a specific answer. Statistical significance was set at $\alpha = 0.05$. SPSS version 26 (IBM Inc., Chicago, IL, USA) was used for the statistical computations.

Results

From all school' students, aged 9 to 19 years, whose caretakers freely signed the informed written consent, 1463 agreed to participate in the study (719 females—49.1%; 744 males—50.9%).

Through descriptive analysis of the data (Table 1), we can observe that there are significant differences between genders in mass, height, BMI, PBF, and NRS-11, but not in age. The largest significant difference relates to PBF and the smallest to pain intensity.

Back pain was present in half the children and adolescents, at least once in their lifetime (Table 2), with higher prevalence for females (57%). Most back pain complains mentioned occurred in the previous month for both genders, with a higher proportion of those occurring only once (30.1%). Females had a slightly higher percentage of limitations originating from back pain complains than males. The regions with the highest pain prevalence were the lumbar region, followed by the thoracic and cervical spine, and the combination of thoracic + lumbar spine, in both genders.

Analysis of the data in Table 3 shows that slight pain is the most prevalent (48.2%), followed by moderate pain.

When analyzing the odds ratio associated with the development of back pain through binary logistic

Table 1 Sample characterization by gender and its association with continuous variables

	Female Mean/SD	Male Mean/SD	*p* value*
Age (yr)	13.98/2.43	13.88/2.37	0.386
Mass (kg)	54.85/13.68	57.17/15.46	0.001
Height (cm)	157.62/8.98	164.03/13.97	0.000
BMI (kg/m^2)	21.89/4.22	20.93/3.64	< 0.001
PBF (%)	29.32/8.06	18.38/8.77	0.000
NRS-11	5.07/2.01	4.61/1.91	0.004

*Mann–Whitney *U* test: (level of significance 95%)

Table 2 Gender differences in the manifestations of back pain

	Female		Male		Total (F+M)		*p* value
	N	%	*N*	%	*N*	%	(F/M)
Presence of back pain anytime in the past							
Yes	410	57.0	330	44.4	740	50.6	<0.001*
No	309	43.0	414	55.6	723	49.4	
Total	719	100.0	744	100.0	1463	100.0	
If 'Yes', how long have you had back pain?							
From 1 day to 1 month	214	52.2	159	48.2	373	50.4	0.475**
From 1 to 3 months	78	19.0	52	15.8	130	17.6	
From 4 to 6 months	34	8.3	35	10.6	69	9.3	
From 7 to 9 months	17	4.1	13	3.9	30	4.1	
From 10 to 12 months	22	5.4	19	5.8	41	5.5	
From 13 to 18 months	12	2.9	12	3.6	24	3.2	
From 19 to 24 months	7	1.7	8	2.4	15	2.0	
From 25 to 30 months	6	1.5	12	3.6	18	2.4	
31 months or more	20	4.9	20	6.1	40	5.4	
Total	410	100.0	330	100.0	740	100.0	
How often did back pain occur?							
Just one time	102	24.9	121	36.7	223	30.1	0.004**
Once per month	46	11.2	41	12.4	87	11.8	
Once a week	58	14.1	46	13.9	104	14.1	
2 to 3 times a week	41	10.0	19	5.8	60	8.1	
4 times or more per week	39	9.5	30	9.1	69	9.3	
I don't know how to answer.	124	30.2	73	22.1	197	26.6	
Total	410	100.0	330	100.0	740	100.0	
This back pain prevents or prevented you from activities from your normal life?							
Yes	98	23.9	56	17.0	154	20.8	<0.001**
No	268	65.4	257	77.9	525	70.9	
Didn't know	44	10.7	17	5.2	61	8.2	
Total	410	100.0	330	100.0	740	100.0	
What is/was the region of your back pain?							
C alone	53	12.9	16	4.8	69	9.3	<0.001**
T alone	102	24.9	99	30.0	201	27.2	
L alone	178	43.4	163	49.4	341	46.1	
P alone	6	1.5	7	2.1	13	1.8	
C+T	13	3.2	10	3.0	23	3.1	
T+L	21	5.1	21	6.4	42	5.7	
L+P	2	0.5	3	0.9	5	0.7	
C+L	20	4.9	1	0.3	21	2.8	
C+T+L	10	2.4	7	2.1	17	2.3	
C+T+L+P	3	0.7	2	0.6	5	0.7	
T+L+P	2	0.5	0	0.0	2	0.3	
T+P	0	0.0	1	0.3	1	0.1	
Total	410	100.0	330	100.0	740	100.0	

C cervical; *T* thoracic; *L* lumbar; *P* pelvic

*Phi correlation coefficient test: (level of significance 95%)

**Chi-squared test: (level of significance 95%)

Table 3 Number and percentage of subjects accordingly to NRS-11 pain intensity categories and their association with the back regions

NRS-11 intensity categories	No pain (0–2)		Slight pain (3–5)		Moderate pain (6–7)		Intense pain (8–10)		Total NRS-11		p value*
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	
C alone	10	10.2	39	10.9	17	7.9	3	4.2	69	9.3	< 0.001
T alone	37	37.8	100	28.0	52	24.3	12	16.9	201	27.2	
L alone	40	40.8	169	47.3	99	46.3	33	46.5	341	46.1	
P alone	3	3.1	2	0.6	5	2.3	3	4.2	13	1.8	
C + T	3	3.1	9	2.5	8	3.7	3	4.2	23	3.1	
T + L	3	3.1	17	4.8	13	6.1	9	12.7	42	5.7	
L + P	0	0.0	1	0.3	3	1.4	1	1.4	5	0.7	
C + L	1	1.0	11	3.1	8	3.7	1	1.4	21	2.8	
C + T + L	0	0.0	7	2.0	6	2.8	4	5.6	17	2.3	
C + T + L + P	1	1.0	0	0.0	3	1.4	1	1.4	5	0.7	
T + L + P	0	0.0	1	0.3	0	0.0	1	1.4	2	0.3	
T + P	0	0.0	1	0.3	0	0.0	0	0.0	1	0.1	
Total across spine regions	98	100	357	100	214	100	71	100	740	100	
	%	13.2		48.2		28.9		9.7		100.0	

C cervical; *T* thoracic; *L* lumbar; *P* pelvic

*Chi-squared test: (level of significance 95%)

regression (Table 4), we found that females have a 71% higher risk compared to males (OR 1.71). The risk of developing back pain also increases strongly with age and with PBF.

Competitively performing physical exercise reduces the probability of having back pain by 36% (OR 0.637) compared to this practice noncompetitively. However, for those performing physical exercise competitively or not, performing 2–3 h per day of physical exercise increases the risk by 58% (OR 1.579) compared to performing 0–1 h per day. Analysis of days and hours spent in physical activity, separated between competitive and noncompetitive, is presented in Table 5.

The use of smartphone or computer shows an increased risk of presenting back pain compared to not using them. A surprising finding is the use of video games for 2 to 3 h per day that significantly reduces the risk of developing back pain by 50% (OR 0.50), although based in a small number of students (56 in 1463).

In the analysis of posture, in the sagittal plane, hyperkyphosis showed a 44% (OR 1.437) increased risk of the manifestation of back pain. In the frontal plane, the lateral spine tilt (left side) is associated with an increased risk of developing back pain (OR 2.257), although only 52 students showing this lateral tilt.

Table 5 shows that most participants who performed competitive physical activity did so 2–3 h/day and 3–4 days/week, while those performing it noncompetitively spend 0–1 h/day and 1–2 days/week.

Discussion

The aim of this study was to investigate back pain in children and adolescents and factors that influence it.

In Portugal, some studies have been conducted, especially by Minghelly et al. [8], presenting disturbing data on the high prevalence of low back pain in adolescents (62.1% have had low back pain at least once in their lives). Our study shows that half of the students experienced back pain at least once in their lifetime (50.6%), and half of these students reported having had at least one episode of back pain in the previous month. Of the students who reported having back pain, 20.8% had a functional limitation related to that pain.

We considered different regions of the spine to better characterize back pain. The lumbar spine was the most commonly cited, accounting for nearly half of the complaints, followed by the thoracic spine, the cervical spine, and finally the pelvis, which is consistent with other studies [5, 7]. In our data, the greatest difference between genders was found in the cervical spine, with females representing 77% (53/69) of the total students complaining about this region. The most common pain intensities were "slight pain" and "moderate pain," with the female gender having a slightly higher mean score in NRS-11 (5.07 vs. 4.61).

Analyzing the influence of gender, females showed a higher prevalence of back pain and a higher risk of developing it than males. Age is another significant factor in the manifestation of back pain, especially by comparing the older adolescents to younger children. These two results are

Table 4 Binary logistic regression for the variable back pain and its relationship with the studied variables

	N	Odds ratio	95% CI		*p* value*
			Lower bound	Upper bound	
Gender (*reference: male*)	744				
Female	719	1.708	1.382	2.111	< 0.001
Age (*reference: under 12 years*)	307				
Between 12 and 17 years	1118	2.842	2.152	3.705	< 0.001
Over 17 years	38	5.475	2.593	11.558	< 0.001
Body composition					
BMI (*reference: normal BMI*)	971				
Low BMI	42	0.958	0.510	1.802	0.895
High BMI	450	0.798	0.608	1.046	0.102
PBF (*reference: normal PBF*)	659				
Low PBF	207	0.926	0.673	1.273	0.635
High PBF	597	1.402	1.078	1.824	0.012
Physical exercise habits					
Do you practice physical activity or sport regularly (*reference: no*)	568				
Yes	895	0.844	0.684	1.042	0.115
Practice physical activity or sport competitively (*reference: no*)	316				
Yes	579	0.637	0.467	0.869	0.004
How many days do you practice this physical activity or sport per week (*reference: 1 to 2 days*)	318				
3–4 days a week	453	1.060	0.773	1.454	0.716
5 or more per week	83	1.317	0.782	2.218	0.301
I don't know how to answer	41	1.418	0.707	2.844	0.325
How many hours do you practice this physical activity or sport per day (*reference: 0 to 1 h*)	352				
2–3 h a day	426	1.579	1.157	2.153	0.004
4 to 5 h a day	11	1.416	0.413	4.858	0.580
I don't know how to answer	106	1.358	0.860	2.143	0.189
Sedentary habits					
How many hours a day do you sit using the computer (*reference: I don't use computer*)	428				
0 to 1 h a day	216	1.427	1.008	2.019	0.045
2–3 h a day	83	1.905	1.135	3.197	0.015
4–5 h a day	31	2.240	0.950	5.280	0.065
6 or more per day	381	1.181	0.882	1.582	0.265
I don't know how to answer	324	0.874	0.645	1.184	0.384
How many hours a day to use the mobile phone (*reference: I don't use mobile phone*)	187				
0 to 1 h a day	473	2.066	1.436	2.974	< 0.001
2–3 h a day	320	3.198	2.162	4.730	< 0.001
4–5 h a day	128	3.843	2.365	6.246	< 0.001
6–7 h a day	106	4.070	2.428	6.825	< 0.001
More than 8 h a day	192	2.401	1.564	3.684	< 0.001
I don't know how to answer	57	1.340	0.707	2.538	0.369
How many hours a day do you play video games (*reference: I don't play video games*)	189				
0 to 1 h a day	133	0.816	0.511	1.302	0.394
2–3 h a day	56	0.501	0.262	0.959	0.037
4–5 h a day	17	0.535	0.185	1.551	0.250
6–7 h a day	16	0.489	0.156	1.532	0.219
More than 8 h a day	232	0.952	0.633	1.433	0.814

Table 4 (continued)

	N	Odds ratio	95% CI Lower bound	Upper bound	*p* value*
I don't know how to answer	820	1.508	1.081	2.104	0.016
Physical fitness					
Aerobic capacity (20-m shuttle run) (*reference: normal profile*)	701				
Low profile	361	1.278	0.976	1.675	0.075
High profile	283	0.917	0.685	1.227	0.560
Abdominal strength (curl-up) (*reference: normal profile*)	845				
Low profile	229	0.763	0.559	1.042	0.089
High profile	271	0.996	0.749	1.324	0.976
Upper body muscular fitness (push-up) (*reference: normal profile*)	583				
Low profile	534	0.858	0.670	1.099	0.226
High profile	228	0.760	0.554	1.043	0.089
Lower-body muscular fitness (long jump) (*reference: normal profile*)	958				
Low profile	322	1.017	0.774	1.336	0.906
High profile	65	1.228	0.733	2.059	0.435
Flexibility (sit and reach) (*reference: normal profile*)	465				
Low profile	669	1.033	0.810	1.316	0.795
High profile	211	1.212	0.870	1.688	0.256
Posture–sagittal plane					
Pelvic tilt *(reference: neutral)*	883				
Posterior tilt					
Anterior tilt	580	1.204	0.938	1.545	0.146
Lumbar posture (*reference: normal lordosis*)	290				
Hypolordosis	1120	0.981	0.725	1.326	0.899
Hyperlordosis	53	1.266	0.693	2.312	0.442
Thoracic posture (*reference: normal kyphosis*)	289				
Hypokyphosis	56	1.124	0.632	1.999	0.691
Hyperkyphosis	1118	1.437	1.103	1.872	0.007
Global spine tilt *(reference: neutral)*	624				
Posterior tilt	8	1.713	0.401	7.310	0.467
Anterior tilt	831	1.048	0.842	1.304	0.673
Posture–frontal plane					
Lateral pelvic tilt (*reference: neutral*)	1025				
Left side tilt	83	0.699	0.389	1.255	0.231
Right side tilt	355	1.151	0.881	1.503	0.303
Lateral lumbar tilt (*reference: neutral*)	631				
Left side tilt	713	1.226	0.952	1.577	0.114
Right side tilt	119	1.691	0.944	3.030	0.077
Lateral thoracic tilt (*reference: neutral*)	798				
Left side tilt	126	1.079	0.677	1.720	0.750
Right side tilt	539	0.955	0.755	1.208	0.698
Lateral global spine tilt (*reference: neutral*)	1397				
Left side tilt	52	2.257	1.234	4.127	0.008
Right side tilt	14	0.668	0.226	1.972	0.465

*Binary logistic regression: (level of significance 95%)

consistent with a systematic review by Calvo-Muñoz et al. [7].

Body mass index showed no significant association with the risk of manifestation of back pain. However, our data suggest that children and adolescents with higher PBF have a 40% higher risk of developing back pain than those with normal PBF. These findings are consistent with studies showing the influence of excess body fat on the manifestation

Table 5 Detail of the entry for "physical exercise habits" presented in Table 4

	Hours of physical activity or sport practice per day				
	0 to 1 h	2–3 h	4 to 5 h	I don't know how to answer	Total
	N	*N*	*N*	*N*	*N*
Days of physical activity or sport practice per week					
Competitive physical activity					
1–2 days	78	55	0	11	144
3–4 days	95	220	3	42	360
5 or more	4	55	3	6	68
I don't know how to answer	0	5	0	2	7
Total	177	335	6	61	579
Noncompetitive physical activity					
1–2 days	113	44	0	17	174
3–4 days	47	34	3	9	93
5 or more	4	9	1	1	15
I don't know how to answer	11	4	1	18	34
Total	175	91	5	45	316

of musculoskeletal pain in children and adolescents [21]. Furthermore, a recent review found an association between increased body fat and lower levels of moderate to vigorous physical activity [22].

The association between posture and back pain has been highlighted in some studies [8, 10], particularly in children. Minghelly et al. [8] found a relationship between posture (assessed with a scoliometer) and the occurrence of low back pain, especially when sitting in poor posture. In our study, a greater association with the manifestation of back pain showed only in the thoracic hyperkyphosis and the lateral global spine tilt (left side). We also see a large number of students with abnormal postures in the sagittal plane, such as anterior tilt of the spine and pelvis and hypolordosis, and in the frontal plane, right tilt of the pelvis and thoracic spine and left tilt of the lumbar spine. Although they are not significant risk factors for back pain, they may have an impact on adult life, and the consequences are often underestimated. These changes were also observed in other studies [23]. Are we seeing the onset of a health problem of future generations? Considering the results for the sagittal and frontal planes, more studies are needed to clarify this question.

We did not find any association between physical fitness (assessed by the FITescola tests) and pain, a result in disagreement with a recent systematic review that found moderate evidence for this association [24].

Sports and physical activity in general acted as protective factors for the development of back pain. However, physical activity for 2–3 h/day increased the risk of developing back pain compared with 0–1 h/day. This increase in risk is related to the growth in the number of hours of physical activity, also present at over 4 h/day, although not significant statistically. These data suggest that practice of sport or physical activity for more than 1 h consecutively may increase the likelihood of developing back pain in children and adolescents. Sedentary habits are also associated with back pain [8], and in our case, the link with new technologies is particularly emphasized. The use of computers, but especially of smartphones by students, shows a higher risk of the manifestation of back pain. Smartphone use of 4 to 7 h per day increases the risk of developing back pain by four times. These results contrast with a study in which smartphone or computer use did not increase the likelihood of developing back pain [25].

Limitations

This study has natural limitations that are characteristic of cross-sectional studies when trying to understand a complex and multifactorial phenomenon. Thus, although we can establish associations between factors, we cannot establish direct causality between them. Although the study has a large sample, the fact that it was conducted in a limited geographical area is also a limitation.

For younger children, the limited understanding of the questionnaires and questions was overcome with the help of parents and teachers who kindly helped in a fundamental way in this process.

Conclusion

The prevalence of back pain is very high in children and adolescents, with some factors such as higher age, female gender, and sedentary habits contributing negatively to this phenomenon. The posture of the thoracic spine, namely hyperkyphosis, and the lateral global spine tilt (left side) are also important factors in back pain prevalence. There are also protective factors such as sports and physical exercise practice and video games.

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Author contributions NA and LM were involved in conceptualization, methodology, and investigation; JCR and LM were involved in validation and formal analysis; NA, JCR, and LM were involved in resources, writing—review and editing, and visualization; NA was involved in data curation and writing—original draft preparation; LM and JCR were involved in supervision and project administration. All authors have read and agreed to the published version of the manuscript.

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Data, materials and code availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the ethics committee of FADEUP—University of Porto (2019/CEFADE 50).

Informed consent Informed consent was obtained from all subjects participating in the study. Informed consent was obtained from parents or guardians for study participants younger than 18 years of age. Adult participants (18 or 19 years old) gave their own informed consent.

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