Predictors of scoliosis in school-aged children

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Abstract

Background: *Spinal disorders and obesity are increasing and are an important cause for concern among healthcare and educational bodies. This work is intended to take a further step and study in detail the presence of scoliosis hump in schoolchildren with obesity.* **Objective:** *To determine the relationship between the presence of scoliotic posture/hump and sociodemographic, anthropometric, lateral dominance and functional types of variables.* **Methods:** *The sample was comprised by 2,822 schoolchildren from Spain, with a mean age of 8.5 years (SD: 1.792), who were analyzed in 2010. They were assessed using Adams test, the body mass index (BMI), the Edinburgh Inventory, the deep flexion test and a sociodemographic questionnaire; the SPSS 20.0 software was used (descriptive variables and multivariate binary logistic regression).* **Results:** *There were 1,023 (36.3%) subjects with scoliosis; obesity was present in 359 (12.7%) cases and, after the regression, associations were found between scoliotic posture and gender (adjusted odds ratio [OR]: 2.044 [1.731-2.413]), age (adjusted OR: 1.121 [1.070-1.174]), presence of obesity (adjusted OR: 0.676 [0.518-0.882]) and flexibility (adjusted OR: 1.015 [1.001-1.029]).* **Conclusions:** *Female participants had twice the risk of developing a hump; prevalence with regard to age indicated that any schoolchild with one more year of chronologic age had 1.12-fold more risk of having scoliotic posture/hump and subjects carrying school supplies using a backpack were at lower risk of developing a hump.* (Gac Med Mex. 2014;150:524-30)

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Introduction

In the healthcare setting, the study of the spinal column, the back or spinal deformities is a topical issue, as reflected by numerous studies indicating the importance of preventing and taking action upon the onset of several conditions at early ages[1-3]. Spinal alterations and specifically scoliosis, are deformities that alter the spinal column three-dimensionally (the hump is represented by vertebral rotation). These alterations can occur at any stage of life, from the neonatal period, as in congenital scoliosis, to adulthood. Most cases occur during childhood and adolescence, and usually they evolve asymptomatically[4,5].

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To detect spinal alterations, Fernández-Sánchez[5] indicates that several bodies, such as the American Association of Orthopedic Surgeons (AAOS), which in 2006 proposed performing physical exams on girls aged 11 and 13 years and in boys aged 13 or 14 years; the Scoliosis Research Society (SRS), which in 2006 advised on annual examination of all children between 10 and 14 years of age, and the American Academy of Pediatrics (AAP), which in 2001 recommended screening schoolchildren between 10 and 16 years of age, regardless of gender, using Adams test[4], and the convenience of screening children at ages prior to adolescence was indicated. Despite all these indications, the optimal age to perform scoliosis screening studies is currently a subject of debate in numerous forums[6,7]. Although these societies and authors acknowledge the limitations of population-based scoliosis

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screening, they emphasize on the benefits of receiving an early diagnosis and treatment of spinal deformities, thus avoiding future surgical interventions[8]. In the past few decades, the study of obesity and, more specifically, of its deleterious effects, has also focused on its effects on spinal conditions[9,10]. In this sense, in a schoolchildren population, subject to numerous physiological changes, it becomes necessary to prepare these children to confront and prevent possible spinal and nutritional abnormalities that may happen to be produced in subsequent years. Studies performed on the relationship between obesity and scoliosis are limited; conversely, there is more research that has looked into the relationship between scoliosis and hand dominance, the method of transporting school supplies or spine flexibilization[11-13]. We must not overlook that teachers, school doctors and physiotherapists are primary responsible on how screenings are carried out and on early detection of any abnormality.

This work is intended to take a further step and study more specifically the presence of scoliotic posture/hump in schoolchildren with obesity, since at these ages, interventions of bodies taking care of children are highly determinant.

The purposes of the work are: to determine the prevalence of scoliasis hump in schoolchildren of Almería (Spain) aged 6-12 years, adjudicate if a certain level of obesity, type of hand dominance, spine flexibility and method of transporting school supplies influence on the development of lateral spinal deviation and to determine the risk of developing scoliotic posture/hump as a function of obesity, lateral dominance and different functional and sociodemographic variables.

Subjects and method

Design and participants

This was a cross-sectional, descriptive, observational study. A total of 2,822 schoolchildren aged 6 to 12 years (x = 8.5 years; SD ± 1.792); they were attending to 13 schools, with a 0.05 sampling error over the entire population of schools in Almería and province. The sample selection was made using random sampling by clusters in a stage, with schools considered as the sampling unit. Out of all participants, 2,800 (98.1%) were boys and girls aged from 6 to 11 years; the remaining 22 (1.9%) were 12-year schoolchildren (they were repeating students who had failed some course and whose chronological age did not belong to primary school). The number of male pupils was 1,463 (51.8%), whereas analyzed girls were 1,359 (48.2%).

Measuring instruments

Several validated instruments were employed to assess scoliotic attitude, BMI, flexibility, laterality and sociodemographic issues:

- Adams' test is one of the most widely used maneuvers for the detection of orthopedic spinal alterations, which differentiates between scoliotic attitude and structured scoliosis. It has been employed by multiple scientists[4,14-16]. For its evaluation, the assessor sits behind the child, who is in the standing position, and asks him/her to make a 50 to 65º forward flexion of the trunk; to detect the hump or prominence, an increase of the relief lateral to the spinal axis will be produced; if it is found, it will be qualified as being present (positive) and if, conversely, no relief is observed, it is regarded as being absent (negative).
- To determine the obesity indices, the BMI value was initially calculated and checked against the En Kid tables, which establish a different BMI from that in adults, since in children it has to be adjusted by age and sex[17]. Four categories are established: low weight, normal weight, overweight and obesity. To calculate this index (weight divided by squared height) body weight and height in the standing position have to be previously obtained. For this, the SECA 881 scale, with a maximal capacity of 200 kg and sensitivity of 50 g, was used, as well as the SECA 206 measuring tape, with a measuring range of 0-220 cm and precision of 1 mm[17-19].
- To establish hand laterality, the hand laterality Edinburgh inventory, as employed by Oldfield[20] and modified by Bryden[21], was applied. This instrument assesses hand preference based on 10 items, and by establishing the corresponding summations[5], three categories are established: right handed, left handed and ambidextrous. This test has been employed by numerous authors[19].
- To determine spinal flexibility, the deep trunk flexion test was performed, which has been widely used in studies similar to ours, such as those by Delgado et al.[11] and Zurita et al.[22]. The subject was instructed to squat on marks indicated on the floor, legs separated by a distance equivalent to the shoulder's width, and to try sliding both hands

held together by the palms as far as possible between the legs in the backwards direction pushing a marker within a millimetric ruler that reflected the reached distance.

- The sociodemographic questionnaire recorded age, gender, center of belonging, method of transporting school supplies (backpack or trolley).

Procedure

Collaboration of the sampling-selected schools to participate in the research was asked through the University of Almería (Spain) and the Delegation of Education (Andalucía Board), which sent a letter to each educational center briefly describing the objective of the study and asking for the school's collaboration; an authorization form was also attached for the legal guardians of the children, asking for their informed consent. This way, together with the protocol approved by the Torrecárdenas de Almería (Spain) Hospital Complex Local Clinical Trials Ethics Committee, all the engaged bodies were implied.

The tests were performed from January through April 2010, following the implementation protocol steps and indicating that the answers were completely anonymous. The survey takers (physicians, physiotherapists and the physical education teacher) were present during the data collection in order to confirm the correct execution of the tests. The collection developed without any type of abnormality and, once the test was finished, the pupils returned to their class routine. At the end, the people responsible were thanked for their collaboration and informed on the future reception of the final report on the results obtained at the conclusion of the study.

Statistical analysis

It was carried out using the SPSS 20.0 software for Windows. The participation index was 80.20%, with a total of 653 invalidated questionnaires due to inattendance the day of data collection or incorrect fulfillment of the tests. The statistical techniques used were of the descriptive type (frequencies and means), contingency tables by means of the chi-square test and a multivariate binary logistic regression analysis, with scoliosis as a dependent variable and age as independent variable. In this model, the sex, BMI, flexibility and transporting of supplies variables were included. Introduction of variables was done manually, with the clinical significance and importance criterion of these. Goodness of fit of the model was verified using the Hosmer-Lemeshow test.

Table 1. Descriptive analysis of study variables

Descriptive variable		
Scoliosis	Absence	1,799 (63.7%)
	Presence	1,023 (36.3%)
BMI	Low weight	174 (6.2%)
	Normal weight	1,980 (70.2%)
	Overweight	309 (10.9%)
	Obese	359 (12.7%)
Hand laterality	Right-handed	2,562 (90.8%)
	Left-handed	251 (8.9%)
	Ambidextrous	9 (0.3%)
Method of transporting supplies	Backpack	1,781 (63.3%)
	Trolley	1,036 (36.7%)
Flexibility	x = 20.25	SD: 6.558

Results

One thousand and twenty-three (36.3%) participants were detected with a positive Adams test (presence of scoliotic posture). Schoolchildren with obesity, according to the BMI, were 359 (12.7%). Most participants were right-handed (90.8%; n = 2,562). Flexibility mean was 20.25 cm. As to the method of transporting school supplies, 63.3% (n = 1,781) used a backpack, as shown in table 1 of descriptive variables.

Table 2 shows statistically significant differences ($p < 0.005$) found in all cases for the relationship between scoliotic attitude and study variables, except for laterality, where a p-value of 0.673 was obtained. Of note, in this table, scoliosis was present mostly in girls (44%; n = 598), it increased with age (higher prevalences in schoolchildren aged 11 and 12 years [44.3 and 41.5%]) and was more present in low and normal weight individuals (37.9 and 37.6%); at the level of hand dominance, values were similar (~36%); trolley was used more by participants with scoliosis hump (37.7%) and mean flexibility was higher in participants with presence (x = 20.76 cm) than with absence.

Associations were found ($p < 0.005$ in the adjusted linear regression model) between scoliotic posture and

Table 2. Relationships between the scoliosis variable and the remaining parameters

Variables		Frequencies and percentages	χ^2 (p =)
Gender	Male	425 (29%)	68,167 (p < 0.001)
	Female	598 (44%)	
Age	6 years	152 (29.8%)	25,731 (p < 0.001)
	7 years	158 (33.8%)	
	8 years	156 (34.3%)	
	9 years	150 (37.1%)	
	10 years	179 (38.2%)	
	11 years	206 (44.3%)	
	12 years	22 (41.5%)	
Obesity	Low weight	66 (37.9%)	8,977 (p = 0.003)
	Normal weight	745 (37.6%)	
	Overweight	105 (34%)	
	Obese	107 (29.8%)	
Laterality	Right handed	931 (36.3%)	0,792 (p = 0.673)
	Left handed	90 (35.9%)	
	Ambidextrous	2 (22.2%)	
Transporting of supplies	Backpack	632 (30.6%)	10,043 (p = 0.007)
	Trolley	391 (37.7%)	
Flexibility	Presence	x = 20.76 cm; SD: 6.484	(p = 0.001)
	Absence	x = 19.94 cm; SD: 6.581	

gender (adjusted OR: 2.044 [1.731-2.413], age (adjusted OR: 1.121 [1.070-1.174], obesity (adjusted OR: 0.676 [0.518-0.882] and flexibility (adjusted OR: [1.001-1.029]), as shown in table 3.

Discussion

In this screening study, similar to others conducted in children populations[23-26], more than a third of the children were found to have positive sign on the Adams test (scoliosis hump), which placed this population within similar values to those in other European and worldwide zones[27,28]. Accordingly, we must consider that in many of the studies on scoliosis that use screening techniques, almost 40% of subjects classified as positive do not show any abnormality when they undergo thorough radiologic and orthopedic testing[4]. Due to this fact, our values differ from other studies in the reviewed literature[12,26,29,30], where spinal lateral alteration figures are decreased with respect to our obtained prevalence, with values that in most cases do not exceed 10%.

The population of Almería showed similar obesity prevalence to that in other works with similar characteristics[31-34]. Most participants were right-handed, with identical values to those found in other studies[35-37]. The same happened with data collected in relation with the functional-type variable and flexor capability, which showed figures similar to those found by Martínez-López[38] and Zurita[39]. The data obtained indicated that our participants had indentical values to other school-aged populations and that these parameters do not contaminate possible associations of the study. However, it should be mentioned that discordance was found with the study by Delgado et al.[11], whose participants had a higher mean flexibility, as a result of the excessive number of sportspersons in the sample. It should be pointed out that flexor capability is induced

Table 3. Hosmer-Lemeshow test (p = 0.172)

Independent variables	Adjusted OR (95% CI)	p-value
Sex (reference category: boys)	2.044 (1.731-2.413)	p < 0.001
Age (reference category: 6 years)	1.121 (1.070-1.174)	p < 0.001
BMI (reference category: normal weight)		
Low weight	0.966 (0.690-1.352)	p = 0.839
Overweight	0.859 (0.658-1.121)	p = 0.263
Obese	0.676 (0.518-0.882)	p = 0.004)
Flexibility	0.015 (1.001-1.029)	p = 0.039
Transporting of supplies (reference category: trolley)		
Backpack	0.955 (0.800-1.140)	p = 0.608

CI: confidence interval.

by two parameters: sex and age[38,40-42]; there is higher mean flexibility in girls in the physical fitness dimension and increases on the test with increasing age, until maturational development onset is reached. As for scoliosis and gender, statistically significant differences were found ($p < 0.001$); female participants showed higher scoliosis indices than males, similar to other studies[43-45], which refer larger proportions of curves greater than 20° in girls. Likewise, with increasing age, the development of scoliotic posture is higher, and this is based on the theory that scoliotic process appears in the middle or by the end of the childhood period and is increased upon puberty arrival[46].

In our study, obese subjects showed lower scoliotic posture figures than in other categories, which indicated that having a higher overweight and obesity index resulted in less spinal lateral deviations. These data are opposed to those in the reviewed literature[47,48], which, in spite of not establishing comparisons with scoliosis, indicates that in obese participants presenting sedentary habits and bad ergonomic attitudes, abnormalities in spinal postures are generated, but no study provides concrete figures, since only associated factors are mentioned.

No statistically significant correlation was found between scoliotic posture and hand laterality, and this is why, unlike to what some authors propose[49,50], indicating a higher predisposition of left-handed individuals to develop scoliosis hump, our work confirms that, at early ages, left-handedness does not affect the onset of scoliosis[12,25].

Flexor capability was found to be higher in individuals with scoliotic tendency; we suspect that this finding could have been driven by the mean increase observed in female participants who had started the puberal growth spurt period (around 11 years), moment at which flexor capability reaches the highest values.

As for the relationship between scoliotic posture variables and the way school supplies are carried, statistically significant differences were determined ($p = 0.007$). In this sense, we perceived that subjects who carried their backpack obtained higher absence values than those who used the trolley. These data are opposed to what other investigations indicate[2,47,51].

Finally, with regard to the multivariant binary logistic regression analysis, where scoliosos hump was taken as a dependent variable, similar to what other scientists indicate[52-54], girls were found to have a two-fold higher risk of developing a hump compared with boys, at similar age, BMI category and school supplies transporting modality. Regarding age, any schoolchld with one more years of chronological age had a 1.12-fold higher risk of developing scoliosis hump at similar gender, BMI category, flexibility and school supplies transporting method, which confirmed findings by Álvarez et al.[46] and Franco et al.[52]. As to BMI categories, obese subjects had 32.4% less risk of developing scoliosis hump than those with normal weight. And with regard to flexibilty degree, any schoolchild with 1 cm more of flexibility had 1.02 higher probabilities of developing a hump at similar gender, age, BMI category and school

supplies transporting method. It could be assumed that higher flexibility would stabilize the spine to a lesser extent, and that this would result in more deformity. Subjects who carry school supplies using a backpack are at lower risk of developing a hump, namely, 37% less than a subject with the same gender, age, BMI and flexibility who uses a trolley; these results are opposed to those proposed by Kovacs et al[2].

From the point of view of clinical application, this work presents a simple method for possible detection of spinal-type deformities, applicable to large samples, that allows for screening prior to arrival to the medical center; moreover, it serves as an indicator to guide the performance of strategies, programs and interventions intended to prevent the development of scoliosis hump.

In the development of this research, we have detected some limitations, such as not having used any confirmatory instrument for possible positives, which would have further complemented the employed technique, although we have to remember that in school populations this large (close to 3,000 subjects) it would entail an economic excess and thus, we recommend that participants with detected hump should first be seen by their pediatrician to confirm the diagnosis, and adequate measures to be taken for their recovery.

Conclusions

The main conclusions extracted from the conducted research are that approximately one third part of the analyzed schoolchildren population gave positive on the Adams test (scoliosis hump) and that, according to the obtained data, being female, chronologically older, having normal weight and using a trolley confere higher risk for the development of scoliosis hump attitude.

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