Faulty posture: Prevalence and its relationship with Body Mass Index and Physical Activity among female adolescents

Dina Golalizadeh, Vahideh Toopchizadeh, Azizeh Farshbaf-Khalili, Yaghoub Salekzamani, Neda Dolatkhan, Ali Pirani

Physical Medicine and Rehabilitation Research Center, Faculty of Medicine, Tabriz University of Medical Science, Tabriz, Iran

Summary

Study aim: The aim of this study was to determine the prevalence of postural disorders and their associated risk factors among high school girls in the city of Tabriz, Iran.

Material and methods: A cross-sectional study was conducted on 400 female students aged 14 to 18 years. Students were examined using a scoliometer, a Debrunner kyphometer, and a flexible ruler, and were directly studied for genu varum/valgum. The information about possible risk factors such as age, BMI, school bag, study time, use of social networks, and physical activity was collected through demographic survey and the International Physical Activity Questionnaire. Data were analyzed by SPSS ver. 22 through independent t-test, chi-square, and logistic regression.

Results: 181 participants (45%) had one or more abnormalities such as scoliosis (4%), kyphosis (5%), genu varum (5.7%), genu valgum (9.7%), hyperlordosis (11.2%), and asymmetrical shoulder (24.5%). The risk of hyperlordosis increased with increase in weight (OR: 1.08, 95%CI: 1.02 to 1.15; $p = 0.014$) and BMI (OR: 1.37, 95%CI: 1.13 to 1.67; $p = 0.002$). Moreover, the odds for genu valgum increased with increase in weight (OR: 1.07, 95%CI: 1.01 to 1.13; $p = 0.045$) and BMI (OR: 1.84, 95%CI: 1.29 to 2.62; $p < 0.001$); but it decreased with increase in age (OR: 0.62, 95%CI: 0.39 to 0.98; $p = 0.039$) and not using a study table (OR: 0.31, 95%CI: 0.12 to 0.78; $p = 0.013$).

Conclusions: Forty-five percent of female students had one or more postural abnormalities. Asymmetrical shoulder was the most common disorder. Weight and BMI were associated with genu valgum and hyperlordosis.

Keywords: Female adolescents – Posture – Body Mass Index – Physical activity

Introduction

Normal posture is a status of the body in which the minimum effort and maximum support are provided to the individual. In children, the posture of the body is associated with their physical growth. Most adult postural disorders are rooted in childhood and are prevalent in a number of age groups. Diagnosis of these disorders is highly important because children's skeletal system is mutable and easily gets modified [1].

Postural disorders in adolescence are subject to the influence of various factors including age, nutrition, genetic, environmental factors, behavioral factors such as immobility and lifting heavy objects, socioeconomic status and body mass index (BMI). Given that these disorders often occur in children at school age and last until adulthood,

school ages are the critical time period for the diagnosis, prevention and correction of these disorders [1, 5, 8].

According to many studies on a similar subject matter, the prevalence rate of these disorders is estimated to be 50% in healthy children [1].

For the special condition of high school course that usually causes physical and psychological stresses in adolescents, this age-educational period is of high importance. In adolescents, neck, shoulder, and back pain can cause postural abnormalities, or, conversely, can be caused by these abnormalities [2].

One of the detectable disorders during school screening is scoliosis. In adolescents, its most common type is idiopathic scoliosis (80–90% of all cases of scoliosis), which can progress in the absence of treatment during the rapid growth phase of puberty, leading to significant abnormalities including pulmonary dysfunctions, reduced

quality of life (QOL), heart failure, mental and psychological problems, back pain, and limitation in physical and motor activities [6, 15, 32].

In many countries its prevalence has been scrutinized and several rates have been reported in various studies ranging from 0.25% in Turkey to 3.26% in Korea [6].

Screening idiopathic scoliosis is a key factor to determine the timely diagnosis of appropriate conservative management and, to some extent, to prevent exacerbation of deformity, and probably reduce the need for surgery [29].

The second most common spinal disorder, with a 1–8% prevalence rate in different communities, is kyphosis. The most rigid type occurs in adolescents. The thoracic type is more common and is associated with lumbosacral and cervical hyperlordosis. Early and timely diagnosis of this disorder can be effective in its elimination and modification [11].

Other major disorders of this period are genu valgum and genu varum, which may occur in the second and third decade of life, and may last to adulthood and affect the QOL of the individuals by causing pain or other musculoskeletal disorders [12].

A limited number of studies on postural disturbances in adolescents and children of school age and related risk factors have been performed in the Iranian setting. So, determination, modification or elimination of these factors can be effective in decreasing these disorders [2, 33]. Due to the higher prevalence rate of some of these disorders in girls (e.g., scoliosis 3.7 to 2.1 in girls to boys, respectively), the present investigation was performed aiming to determine the prevalence rate of postural disorders and their associated factors among high school girls in the city of Tabriz in Iran.

Material and methods

The present cross-sectional study was carried out to determine the prevalence rate of the postural disorder among 400 female high school students in the city of Tabriz. The age range of participants was 14 to 18 years old. Exclusion criteria consisted of neuromuscular disorders, cardiopulmonary diseases, metabolic disorders, congenital anomalies, any history of skeletal surgery, and other chronic disease in past history. Odds for postural disturbances among probable risk factors in female high school students were examined. The study was approved by the Committee of Ethics of Tabriz University of Medical Sciences (TUOMS) (code: IR.TBZMED.REC.1395.773).

The sample size was calculated to be 385 individuals based on the Cho study [2] using the formula:

$$n = \frac{z^2 p(1-p)}{d^2},$$

$z = 1.96$, $p = 0.36$, $d = 13.5\%$. Considering probable drop out, it was considered to be 400 students.

Three-stage clustered sampling was adopted in this study. First, the researcher received a list of all educational districts of Tabriz city along with the number of schools in each district by referring to the Education Department. Then lists of education districts were written and two districts were chosen as samples using the *www.randomizer.org* website at the first stage of cluster sampling. Then, all the schools from each district were listed with a specific row number and in the second step of cluster sampling, using the mentioned randomizer website, two schools were selected from each district (a total of 4 schools) as the sample and finally, at the third step, students studying at each grade were listed with a row number considering 20% dropout (120 students for each school), and finally we selected 100 students randomly from each school (a total of 400 students). Informed parents' consent as well as the assent of the participating students was obtained. The researcher identified and examined the selected students. Subsequently, all 400 students were asked to complete an International Physical Activity Questionnaire (IPAQ) and a risk factor questionnaire which contained age, height, weight, bag weight, bag type (shoulder bag or backpack), the time of study based on hour/day, time of using social networks (such as Instagram, Telegram, WhatsApp,...) during their free times, and the use of a study table (some people do not use a study table in Iran). The IPAQ questionnaire was developed by H Lee et al. [16]. Also, the Persian translation has been validated [20]. This questionnaire has been applied on girl adolescents in Iran and its reliability was confirmed with Cronbach's alpha 0.90 and the intraclass correlation coefficient (ICC) 0.83 [23].

The questionnaire consists of seven domains that include items on the amount and type of physical activity in the last 7 days. In this questionnaire, three types of physical activities (severe, moderate and low) and the metabolic equivalent of task (MET) is calculated, which is equivalent to the person's energy consumption in the rest time. According to the questionnaire, walking is MET3, average activity is MET4, and intense activity is MET8. A student's total activity was calculated based on the MET and in the form of minutes per week (MET minutes/week). The level of physical activity (low, moderate and severe) in the last week, on the basis of minutes, was entered into the following formula:

$$(\text{intense activity} \times 8) + (\text{average activity} \times 4) + (\text{low activity} \times 3) = \text{MET-min/week}.$$

If the student's activity reached 600 MET-min/week, her activity would be moderate, if ≥ 1500 , it was considered to be severe, and if ≤ 600 , the activity would be low [19, 31]. All examinations were done by a physician.

In order to perform examinations and calculate height and weight, the student was asked to wear minimal clothes, and take off her shoes, remain motionless, and stand in the normal position against the grid panel mounted on the wall. To check the symmetry of the shoulders, the anterior and posterior views were observed. A posture assessment grid (grid panel with 2.5 cm grid lines) was used for assessment of asymmetric shoulder. Posture grid is a useful tool for visual posture assessment. This method has adequate validity and reliability. The students stood with feet 8 cm apart and arms at their sides. Shoulder tips and acromioclavicular joints were marked and transferred to the grid panel and deviations between both sides measured with a caliper [7, 8].

For scoliosis examination a scoliometer, an effective and commonly used device for screening of scoliosis in the forward bending position (in which the person bends forward and the palms are pressed together between the knees), was used and the deviation was considered when it was ≥ 5 positive degrees [6, 29]. Coelho et al. indicated a maximum sensitivity of 87% and a specificity of 90% at the Cobb angle of 10° [19].

To determine the thoracic kyphosis, the most accurate and acceptable method to demonstrate Cobb angle uses radiological studies, but it is preferable to use a Debrunner kyphometer to prevent radiation exposure of adolescents in screening methods. In the previous study, the validity of the kyphometer was 96–98% and its reliability was 62–69% [9]. In this method, the 4th and the 12th thoracic vertebra were marked, then a kyphometer stand was placed on the 4th vertebra and another on the 12th thoracic vertebra and an angle more than 44 degrees was recorded as indicating a kyphosis disorder [14, 24].

To calculate lumbar lordosis, a highly reliable and valid (89% and 92%) flexible ruler was used to determine lumbar lordosis. In this method, while the person is standing upright and facing the wall, the space between her feet is about 10 to 15 cm, a flexible ruler on the spine was placed from the spinous process of the T12 vertebra to the spinous process of the S2 vertebra and, after shaping, it was placed on a white paper sheet, the width and length of the arc were drawn and the angle was calculated via the following formula. Angles greater than 40 degrees were considered to indicate hyperlordosis [8, 28]. Here, H is equal to the width of the arc and L represents arc length.

$$\theta = 4 \operatorname{Arctan} (2H/L)$$

To calculate BMI, we used the formula of weight in kilograms divided by height in meters squared (kg/m^2) [12, 18]. BMI for age and sex was classified using the World Health Organization (WHO) percentile charts. BMI was defined as underweight (a BMI percentile below the 5th percentile), normal weight (BMI percentile between 5–85th) overweight (a BMI percentile between

85–95th) and obesity (a BMI percentile above the 95th percentile) [25].

In order to calculate the genu valgum, students were asked to stand upright. Then, the interval between the medial malleolus was measured. More than 6 cm intervals were considered as genu valgum. Moreover, to evaluate genu varum, the intercondylar space in the knees area was measured and the spaces greater than 6 cm were recorded as genu varum [12].

Statistical analysis

Data were analyzed by SPSS software (version 22). Data distribution was initially analyzed using the Kolmogorov-Smirnov test. The distribution of the bag weight variable was abnormal ($p < 0.05$). For other variables, the distribution was normal ($p > 0.05$). In order to compare two groups with and without the disorders, variables with normal distribution were analyzed by the independent samples t-test. Chi-square test and Fisher's exact test were used to analyze nominal variables. Logistic regression was implemented to investigate the odds for postural abnormalities among risk factors. $P < 0.05$ was considered as the significance level.

Results

In this study which was conducted on four girls' high schools, 400 students aged 14 to 18 years old were included; among them, 219 (55%) did not have scoliosis, kyphosis, genu varum, genu valgum, asymmetrical shoulder and hyperlordosis, whereas 181 participants (45%) had one or some of these disorders. Out of 400 studied students, 16 (4%) had scoliosis, 20 (5%) had kyphosis, 45 (11.2%) had lordosis, 98 (24.5%) had asymmetrical shoulder, 23 (5.7%) had genu varum and 39 (9.7%) had genu valgum.

The most common disorder was the asymmetrical shoulder (24.5% of the total students). The age in the group with no disorder was 16.37 ± 0.14 and in the group with the disorder 16.32 ± 0.14 , so no difference was seen in age between the groups ($P > 0.05$).

There was no significant difference in mean weight between the groups with at least one disorder and no disorder ($P = 0.847$). The mean weight in both groups was 55 kg.

More than half of students in the group without the disorders (68.0%) and with the disorders (55.2%) had normal BMI. The mean $\pm$ SD of BMI in groups without and with disorders were $20.63 \text{ kg}/\text{m}^2 \pm 0.52$ and $21.75 \text{ kg}/\text{m}^2 \pm 0.74$, respectively, while no significant difference was observed between the two groups ($p > 0.05$).

Based on the IPAQ questionnaire completed by 400 students, students' physical activity in the last week was divided into three groups: low, moderate and severe. There

was no significant difference between the level of activity and the presence of the disorder ($P = 0.278$)

No significant difference was found between the use of a study table and bag type with the presence of the disorder ($p > 0.05$) (Table 1).

Analysis of the relationship between each disorder and the investigated risk factors

There was no statistically significant association of scoliosis, kyphosis, asymmetric shoulders, and genu varum disorders with age, type of bag, social networks, weight, BMI, time of reading, study table, or physical activity ($P < 0.05$) (Tables 2, 3).

The risk of hyperlordosis increased with increase in weight (OR: 1.08, 95%CI: 1.02 to 1.15; $p = 0.014$) and BMI (OR: 1.37, 95%CI: 1.13 to 1.67; $p = 0.002$) (Table 2). Moreover, the odds for genu valgum increased with increase in weight (OR: 1.07, 95%CI: 1.01 to 1.13; $p = 0.045$) and BMI (OR: 1.84, 95%CI: 1.29 to 2.62;

$p < 0.001$), but decreased with increase in age (OR: 0.62, 95%CI: 0.39 to 0.98; $p = 0.039$) and not using a study table (OR: 0.31, 95%CI: 0.12 to 0.78; $p = 0.013$) (Tables 2, 3). No statistically significant association was observed between hyperlordosis and genu valgum with other variables (Tables 2, 3).

Discussion

The present study showed that 45% of the studied students had one of the skeletal disorders. The most common disorder was the asymmetrical shoulder (24.5%), which had no significant relation with any of the risk factors. The risk of hyperlordosis and genu valgum increased with increase in weight and BMI. The odds of genu valgum decreased with increasing age and not using a study table.

In the study carried out by Nery et al. in Brazil among more than 1300 children, the researchers found a relation

Table 1. Comparison of the studied variables in subjects with and without postural disorder

Variable	Group without disorder (n = 219)	Group with at least one disorder (n = 181)	p-value
Age [year]	16.37 $\pm$ 0.14	16.32 $\pm$ 0.14	0.276*
Weight [kg]	55.39 $\pm$ 1.56	55.86 $\pm$ 1.87	0.847*
Height [cm]	163.63 $\pm$ 0.70	162.18 $\pm$ 0.98	0.248*
BMI [kg/m ²]	20.63 $\pm$ 0.52	21.75 $\pm$ 0.74	0.273*
Study time [hour/day]	3.06 $\pm$ 0.34	3.88 $\pm$ 0.32	0.085**
Using social networks [hour/day]	2.37 $\pm$ 0.33	2.72 $\pm$ 0.42	0.525*
Mean bag weight [kg]	3.33 $\pm$ 0.33	3.22 $\pm$ 0.36	0.872*
Bag type			0.473 [‡]
Shoulder bag	16 (8.7%)	18 (11.2%)	
Backpack	168 (91.3%)	143 (88.8%)	
Using Study table	49 (26.2%)	40 (27.0%)	0.901 [‡]
BMI			0.065 [§]
Underweight	30 (13.7%)	30 (16.6%)	
Normal	149 (68.0%)	100 (55.2%)	
Overweight	35 (16.0%)	43 (23.8%)	
Obese	5 (2.3%)	8 (4.4%)	
Physical activity			0.278 [§]
Low	102 (47.9%)	98 (56.0%)	
Moderate	49 (23.0%)	35 (20.0%)	
Severe	62 (29.1%)	42 (24.0%)	

Variables were reported as Mean $\pm$ SD or Number (percent). There were nonresponse variables. Therefore, valid percent was reported for categorical variables. * – Independent sample-t test, [‡] – Fishers exact test, [§] – Chi square.

Table 2. Logistic regression analysis on the selected variables in subjects with and without disorder

Spinal disorder	Age [year]	Weight [kg]	BMI [kg/cm ²]	Physical activity		
				Low	Moderate	Severe ^R
Scoliosis						
With (n = 16)	16.22 ± 0.27	53.04 ± 1.3	20.3 ± 0.74	10 (66.7%)	2 (13.3%)	3 (20.0%)
Without (n = 384)	16.36 ± 0.11	56.02 ± 1.38	21.36 ± 0.52	193(51.2%)	82(21.8%)	102 (27.1%)
p-value*	0.801	0.123	0.473	0.793	0.925	R
OR (CI 95%)	0.90 (0.41 to 1.99)	1.05 (0.99 to 1.12)	1.16 (0.77 to 1.76)	1.25 (0.23 to 6.74)	1.10 (0.14 to 8.41)	—
Kyphosis						
With (n = 20)	17.63 ± 0.63	55.58 ± 4.12	22.16 ± 2.15	9 (47.4%)	7 (36.8%)	3 (15.8%)
Without (n = 380)	16.29 ± 0.09	55.64 ± 1.29	21.15 ± 0.47	194 (52.2%)	77 (20.7%)	101 (27.2%)
p-value*	0.914	0.604	0.432	0.557	0.207	R
OR (CI 95%)	1.04 (0.53 to 2.02)	1.01 (0.96 to 1.07)	0.84 (0.55 to 1.28)	0.62 (0.13 to 3.01)	2.59 (0.59 to 11.37)	—
Hyperlordosis						
With (n = 45)	15.88 ± 0.2	55.67 ± 3.39	22.02 ± 1.4	27 (62.8%)	6 (14.0%)	10 (23.3%)
Without (n = 355)	16.41 ± 0.11	55.63 ± 1.32	21.10 ± 0.49	175 (50.3%)	78 (22.4%)	95 (27.3%)
p-value*	0.740	0.014	0.002	0.420	0.454	R
OR(CI 95%)	0.93 (0.61 to 1.41)	1.08 (1.02 to 1.15)	1.37 (1.13 to 1.67)	1.48 (0.57 to 3.81)	0.62 (0.18 to 2.17)	—
Asymmetric shoulder						
With (n = 98)	16.42 ± 0.16	54.51 ± 2.63	21.20 ± 0.96	57 (60.6%)	13 (13.8%)	24 (25.5%)
Without (n = 302)	16.31 ± 0.13	56.12 ± 1.35	21.23 ± 0.53	146 (49.0%)	71 (23.8%)	81 (27.2%)
p-value*	0.099	0.550	0.118	0.895	0.178	R
OR(CI 95%)	1.33 (0.95 to 1.86)	0.13 (1.03 to 0.99)	0.89 (0.79 to 1.03)	1.05 (0.52 to 2.11)	0.54 (0.22 to 1.33)	—
Genuvarum						
With (n = 23)	16.0 ± 0.26	48.18 ± 2.86	17.90 ± 0.91	12 (54.5%)	6 (27.3%)	4 (18.2%)
Without (n = 377)	16.39 ± 0.11	56.60 ± 1.29	21.65 ± 0.48	100 (27.2%)	78 (21.2%)	190 (51.6%)
p-value*	0.529	0.745	0.179	0.254	0.080	R
OR(CI 95%)	0.79 (0.36 to 1.63)	0.98 (0.89 to 1.08)	0.66 (0.36 to 1.21)	3.58 (0.40 to 31.87)	7.45 (0.79 to 70.44)	—
Genuvalgum						
With (n = 39)	16.10 ± 0.17	62.30 ± 4.93	25.47 ± 1.64	22 (56.4 %)	8 (20.5%)	9 (23.1%)
Without (n = 361)	16.38 ± 0.11	54.53 ± 1.13	20.51 ± 0.41	181 (51.3%)	76 (21.5%)	96 (27.2%)
p-value*	0.039	0.045	<0.001	0.961	0.603	R
OR(CI 95%)	0.62 (0.39 to 0.98)	1.07 (1.01 to 1.13)	1.84 (1.29 to 2.62)	0.97 (0.33 to 2.87)	0.71 (0.19 to 2.58)	—

Note: Variables were reported as Mean ± SD or Number (percent). There were nonresponse variables. Therefore, valid percent was reported for categorical variables. * – Logistic regression, R – reference, Sever activity was considered as reference class for physical activity (as nominal variable).

Table3. Logistic regression analysis on the selected variables in subjects with and without disorder

Spinal disorder	Study time [hour/day]	Using social networks [hour/day]	Using study table		Bag type	
			YesR	No	Shoulder bagR	Backpack
Scoliosis						
With (n = 16)	3.7 ± 0.46	2.55 ± 0.68	1(7.1%)	13 (92.9)	2 (15.4%)	11 (84.6%)
Without (n = 384)	3.4 ± 0.26	2.56 ± 0.3	88 (27.1%)	237(72.9%)	32 (9.5%)	304(90.5%)
p-value*	0.952	0.637	R	0.997	R	0.693
OR(CI 95%)	1.01 (0.76 to 1.33)	1.08 (0.79 to 1.48)	—	—	—	0.62 (0.06 to 6.73)
Kyphosis						
With (n = 20)	3.2 ± 1.03	3.2 ± 0.80	3 (18.8%)	13(81.3%)	2 (11.1%)	16 (88.9%)
Without (n = 380)	3.53 ± 0.24	2.51 ± 0.29	86 (26.7%)	236(73.3%)	32 (9.7%)	298 (90.3%)
p-value*	0.310	0.787	R	0.487	R	0.278
OR (CI 95%)	1.14 (0.89 to 1.46)	0.96 (0.72 to 1.28)	—	1.76 (0.36 to 8.69)	—	0.39 (0.07 to2.14)
Hyperlordosis						
With (n = 45)	4.77 ± 0.75	2.11 ± 0.42	8 (21%)	30(78.9%)	1 (2.4%)	41 (97.6%)
Without (n = 355)	3.31 ± 0.24	2.63 ± 0.31	81 (27.0%)	219(73.0%)	33 (10.8%)	273(89.2%)
p-value*	0.639	0.660	R	0.188	R	0.200
OR(CI 95%)	1.04 (0.88 to 1.24)	0.96 (0.80 to 1.15)	—	2.02 (0.71 to 5.79)	—	3.93 (0.48 to 32.0)
Asymmetric shoulder						
With (n = 98)	4.10 ± 0.46	2.95 ± 0.64	16 (21.1%)	60(78.9%)	10 (11.4%)	78 (98.6%)
Without (n = 302)	3.26 ± 0.26	2.39 ± 0.28	73 (27.8%)	190(78.2%)	24 (9.2%)	237 (90.8%)
p-value*	0.366	0.101	R	0.480	R	0.833
OR(CI 95%)	1.06 (0.93 to 1.22)	1.11 (0.98 to 1.26)	—	1.30 (0.63 to 2.69)	—	0.89 (0.32 to 2.50)
Genuvarum						
With (n = 23)	4.37 ± 0.94	2.25 ± 0.64	4 (23.5%)	13 (76.5%)	2 (11.8%)	15 (88.2%)
Without (n = 377)	3.39 ± 0.23	2.60 ± 0.30	85(26.6%)	235 (73.4%)	32 (9.7%)	298 (90.3%)
p-value*	0.636	0.246	R	0.619	R	0.070
OR(CI 95%)	1.07 (0.82 to 1.39)	0.79 (0.55 to 1.17)	—	1.54 (0.28 to 8.43)	—	0.19 (0.03 to 1.14)
Genuvalgum						
With (n = 39)	3.80 ± 0.46	3.80 ± 1.11	17 (48.6%)	18(51.4%)	5 (15.6%)	27 (84.4%)
Without (n = 361)	3.46 ± 0.26	2.35 ± 0.25	72 (23.7%)	232 (76.%)	29 (9.1%)	288 (90.9%)
p-value*	0.714	0.481	R	0.013	R	0.749
OR(CI 95%)	0.96 (0.76 to 1.20)	1.07 (0.89 to 1.28)	—	0.31 (0.12 to 0.78)	—	0.81 (0.22 to 3.02)

Variables were reported as Mean ± SD or Number (percent). There were nonresponse variables. Therefore, valid percent was reported for categorical variables.* – Logistic regression , R – reference.

between overweight and the incidence of asymmetry of shoulders and scalene muscles, so they suggested that body weight control is necessary for shoulder balance [22]. Also, in a study conducted by Wyszynska et al. (2016) in Poland, there was a correlation between BMI and asymmetrical shoulders. Additionally, the prevalence of postural disturbances was associated with physical activity [33]. However, in this study, children's puberty, which is a factor that affects the maximum rate of physical growth and body fat, was not taken into account, and the results of the investigation by Nery et al. are more reliable due to the larger sample sizes.

In our study, there was no significant correlation between the level of physical activity of the individual (according to the IPAQ questionnaire) with postural disorders such as asymmetrical shoulder, genu varum, genu valgum, and hyperlordosis.

In a study by Latalski, which was performed on 380 14-year-old adolescents, there was a correlation between postural disorders and the rate of physical activity [15]. In this study more than half of the samples were boys aged 14 years (which most boys may not enter the puberty phase) and also physical activity in boys is more frequent and regular than girls). So, these two factors might affect their results.

In our study, BMI and weight were risks factor for disorders such as hyperlordosis and genu valgum, but there was no relationship between mentioned factors and scoliosis. In a study by Matusik, performed on 279 adolescents with scoliosis, there was no correlation between the prevalence of high BMI and scoliosis. However, there was a correlation between higher BMI and scoliosis severity [20]. On the other hand, in the study on scoliosis by Qui et al., they found that longer height, lower BMI and lower body weight were related to adolescent idiopathic scoliosis [26]. Our smaller sample size in terms of scoliosis (16 people against 630 people in Qui's study) may be related to the difference in results.

Cicca et al., in their study conducted in Brazil, found that genu valgum and flatfoot disorder were more prevalent in obese and overweight children [3], as in our study, genu valgum was more prevalent in adolescents with obesity. Overweight and obesity can cause extra load on the knee joints, distort the joint and lead to valgus deformity [12].

Furthermore, in a study by Lataski et al., they found no correlation between high BMI ratio and postural disorders [15]. However, Macialczyk et al. reported that there was a significant relation of postural disorders with obesity and overweight [18]. On the other hand, the Hershkovich et al. study showed that the prevalence of severe spinal deformities in lean men was 3 times higher and in lean women was 6 times higher than in obese and normal weight people, and that these spinal disorders were associated with

lower BMI and taller height [11]. In a Brazilian investigation by Cicca et al., there was a significant difference in the amount of ankle and knee pattern posture between obesity and normal weight among 7–10-year-old children. Thus, similar to our findings, they suggested that genu valgum and flat foot disorders were more frequent in obese and overweight children [3], because obesity increases loading on knees, which can enhance valgus deformity.

Korovessis et al. revealed that the height and age of 9 to 15-year-old adolescents were related to lumbar hyperlordosis and thoracic kyphosis, but there was no relationship between the way of using bags (unilateral or bilateral) and the prevalence of postural disorders. Their results were similar to our findings. Also, many students and their parents worried about the effects of carrying overloaded bags on spinal or skeletal injury, but our study and that of Korovessis' team can not confirm that [13]. Nevertheless, in a cross-sectional study by Grimmer et al., it was established that increasing backpack weight can increase craniovertebral angle and cervical spine disorder in girls more than boys at the age of adolescence [10].

In our investigation, there was no risk factor for spinal kyphosis in evaluated possible factors, but some studies reported taller height and higher body weight as more prevalent in children with spinal kyphosis [17, 27, 30]. However, the associations of kyphosis with BMI and height are controversial in the literature [11].

In our study, no significant correlation was found between the average study time, the type of bag, the use of a study table (a reverse correlation with genu valgum), the weight of the bag, the type of bag, height, physical activity and the use of social networks and postural disorders.

Interestingly, using a table for reading was related to increasing genu valgum in adolescent students, but we did not find any existing literature on this factor, and thus further investigations must be carried out to evaluate their relation because many students in all grades use a table when reading.

This research was conducted on adolescent girls due to the high prevalence of postural disorders in this group of community according to the literature review. It is suggested that a similar study be performed on both sexes in all age groups and with a higher sample size in order to obtain more reliable results. Also, radiological tests, which are definitive diagnostic tests after screening, were not performed in this study because of the possible side effects and high cost.

Moreover, we investigated physical activity using the IPAQ as a standard tool. Physical activity during the previous week is an estimate of one's physical activity. However, we cannot exactly generalize it to life span posture. We suggest using another method for screening physical activity in this regard.

Conclusion

The present study showed that the prevalence of postural disorders in adolescent girls is significantly high, and suggested that screening these disorders in this age group is necessary. Forty-five percent of female students had one or more postural abnormalities. Asymmetrical shoulder was the most common disorder. Weight and BMI were associated with genu valgum and hyperlordosis.

Strategies to control weight and improve life style in female adolescents are needed because BMI and weight were associated with faulty posture. However, further studies are recommended to find other risk factors in this age group.

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