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Prevalence of Spinal Deformities among School Age Children in Iran: A Systematic Review and Meta-Analysis

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Abstract

Background: Postural disorders and spinal deformities are one of the common conditions in children and adolescents. The aim of this systematic review and meta-analysis was to study the prevalence of spinal deformities among school age children in Iran.

Methods: The search strategy was developed using keywords relating to kyphosis, lordosis, scoliosis, child and Iran in the databases of Medline, Scopus, CINAHL, Psycinfo as well as Persian local databases up to January 2020. Articles were appraised by two reviewers using the checklist of Joanna Briggs Institute (JBI) and data was extracted in the designed tables and analyzed using R software with a random effects model. The heterogeneity and dispersion of data was presented in Forest plots.

Results: Eighteen studies were included in the meta-analysis. The total population included 84195 students consisting of 39202 boys and 45947 girls. The mean age of the participants was 12.71±1.18 years. The total prevalence of kyphosis was 13.06% [95% CI 0.07; 0.22], the total prevalence of scoliosis was 2.61% [95% CI 0.014; 0.045] and the total prevalence of lordosis was 32.59% [95% CI 0.23; 0.43]. The prevalence of deformities was higher in girls. Kyphosis and scoliosis was more frequent in elementary school children but lordosis was more frequent in middle school students. Confirmation of diagnosis with radiology as well as clinical examination yielded a lower prevalence compared to diagnosis only made by clinical examination.

Conclusion: The prevalence of spinal deformities in school age children in Iran is on the average level compared to the other countries and lordosis is more common in girls. Designing further studies to evaluate etiology and risk factors of this condition is recommended.

Key Words: Child, Kyphosis, Lordosis, Meta-analysis, Prevalence, Postural disorders, School age, Scoliosis, Screening, Spinal deformities, spinal deviations, Systematic review.

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1- INTRODUCTION

The quality of the human body posture is of great importance, as the changes and disorders in it affect other human functions. The spine as the main axis of the body plays a vital role in maintaining posture and body alignment (1). Postural disorders and spinal abnormalities are common in children and adolescents (2). Since childhood, posture undergoes significant changes, most of which occur at school age, especially in primary school (3). Due to the quiet onset, slow course and poor manifestations of clinical symptoms in children, diagnosis and treatment are delayed (4). Early prevention, early diagnosis, adequate treatment and rehabilitation, and proper exercises can prevent the side effects of motor consequences and spinal abnormalities and ensure the proper functioning of children at older ages (5). However Most of these deformities do not require surgery or the use of braces and can be treated with simple posture correction and exercise training and require regular monitoring of children for the development of symptoms (6). Thus promoting knowledge about proper posture and screening in order to timely detect deviations is recommended (5).

Main spinal deformities in children include deviation in frontal plane called scoliosis (lateral curvature of the spine) and kyphosis (increase in convexity of the spine (hump)) and lordosis (increase in concavity of lumbar spine), which both are deviations in sagittal plane and kyphoscoliosis (a combination of increased convexity and lateral curvature of the spine) (7, 8). Further studies on spinal abnormalities are of great importance due to the increase in postural disorders among students in recent years. Different studies have been conducted with different target communities in different parts of the world, but according to different contexts and regional risk factors, the prevalence and causes of spinal abnormalities are different in any distinct region. In our country, Iran, cross-sectional studies have been conducted to investigate the prevalence of this problem among school-age children in different cities. Since identifying the magnitude of the problem is the first step to encounter it, we decided to design the first systematic review and meta-analysis on the available literature with the aim of studying prevalence of spinal deformities including kyphosis, scoliosis and lordosis in Iranian school age children, to pool the data within a larger sample size and reach more robust conclusion, which can help health planners and policy makers to prepare appropriate programs to prevent, treat and control the disorder and its complications.

2- MATERIALS AND METHODS

This study is a systematic and meta-analytical review of Iranian studies. The registered code in the regional ethics committee of Tabriz University of Medical Sciences was IR.TBZMED.REC.1398.633.

2-1. Inclusion and Exclusion Criteria:

Observational studies (cross-sectional) were included in this study with the following criteria:

a) Inclusion criteria:

- Studies in the general population without any certain pathologic diseases.

- School children aged 7-15 years (elementary and middle school)

b) Exclusion criteria:

- Studies where the age of people is out of the range of 7-15 years

- Articles that did not have the required quality (scored below 3 in JBI appraisal)

- Articles that used the duplicated sample information

- Review articles, letters to the editor or suggestions

- Studies that did not target the general population

2-2. Searching Strategy

Searching was performed up to January 2020. Keywords (using MeSH terms and free keywords) were determined and a searching strategy was developed by an expert in this field (ND) (**Fig. 1** and **Table 1**). Databases including Medline, Scopus, CINAHL, Psycinfo, The Cochrane Library, Proquest and local databases for Persian articles, including Iranmedex, SID, IranDoc and Magiran were searched with the below mentioned keywords. Besides, the references of selected studies were manually searched and reviewed for the possibly missed relevant studies.

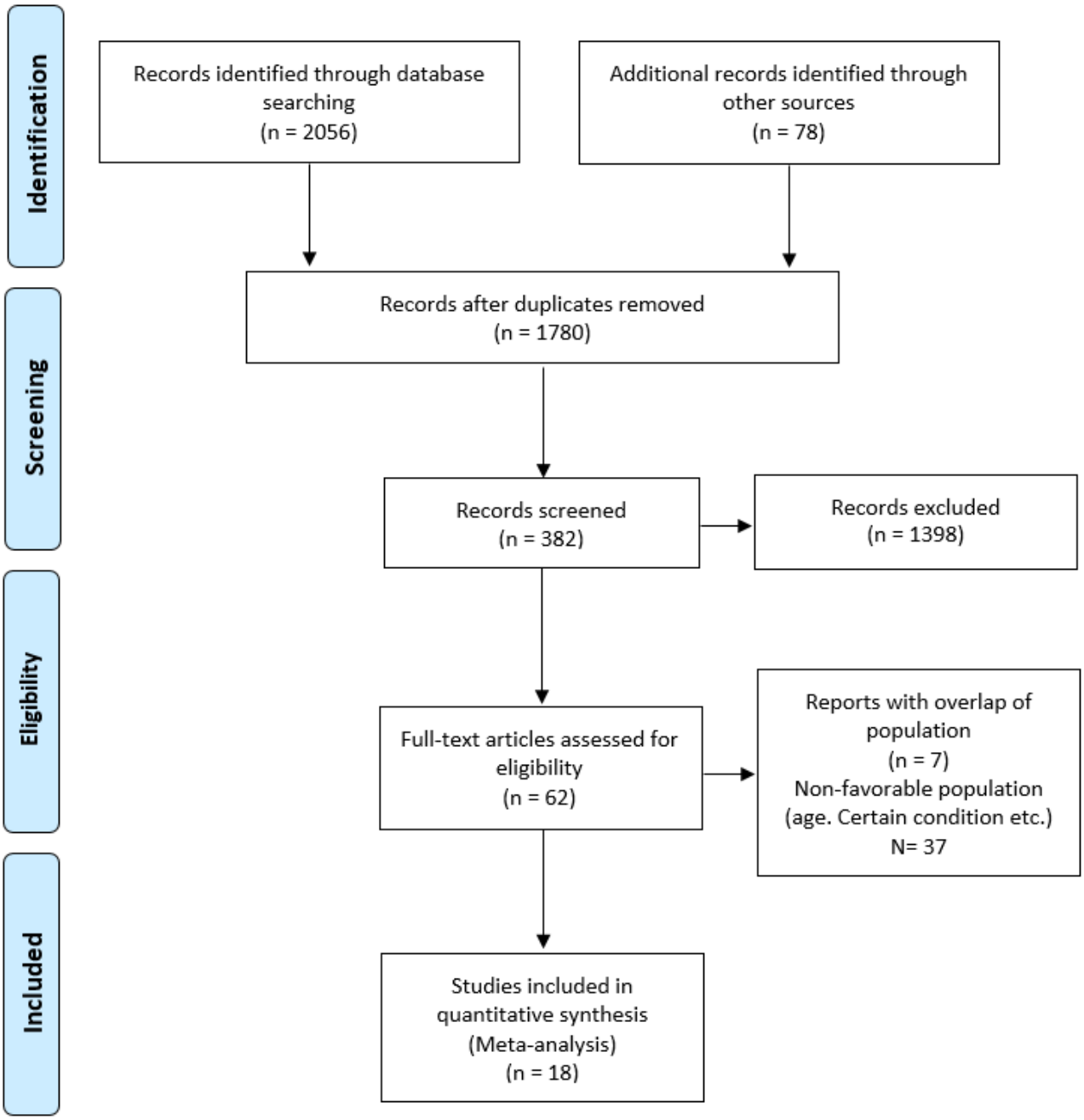

Fig. 1: PRISMA flowchart for search results and study selection (43)

Table-1: Research strategy in PubMed

#1 "Pediatrics"[Mesh] OR Pediatric[Title/Abstract] OR "Child"[Mesh] OR Children[Title/Abstract] OR Childhood[Title/Abstract] OR Adolescents[Title/Abstract] OR Adolescence[Title/Abstract]
#2 "Epidemiology"[Mesh] OR Prevalence[Title/Abstract] OR incidence[Title/Abstract] OR Rate[Title/Abstract] OR Amount[Title/Abstract]
#3 "Spinal curvatures"[Mesh] OR "Kyphosis"[Mesh] OR "Lordosis"[Mesh] OR "Scoliosis"[Mesh] OR "Round back "[Title/Abstract] OR Swayback [Title/Abstract] "Spinal Deformity"[Title/Abstract] OR "Spinal Abnormality"[Title/Abstract] OR "Spinal curvature disease"[Title/Abstract] OR "Spinal Curvature Disorder"[Title/Abstract] OR "Postural Abnormality"[Title/Abstract] OR "Postural Disorder"[Title/Abstract] OR "Postural Defect"[Title/Abstract]
#4 "Iran"[Title/Abstract] OR Iranian[Title/Abstract] OR Persian[Title/Abstract] OR Persia[Mesh] OR "Islamic republic of Iran" [Title/Abstract]
#5 #1 AND #2 AND #3 AND #4

2-3. Study selection

First, the titles were screened and irrelevant studies were dropped out. In the next step, the abstracts and full texts of the selected articles were studied in order to identify the articles meeting inclusion criteria. The articles were reviewed by two independent reviewers (NTT and MZP) and in the case of discrepancy at any stage the final judgment was made by the third reviewer (SD).

2-4. Critical Appraisal

The selected studies were evaluated by the two assessors (MZP, NTT) using the JBI (Australian Joanna Bridges Institute) Prevalence Study Checklist (9); and in the case of discrepancy between the two assessors were referred to a third party (SD). Based on the scores of the checklist (0 to 9), the articles were divided into three groups: good quality (7-9), medium quality (4-6) and low quality (0-3). There was no low quality study according to JBI scoring to be excluded from the meta-analysis. The scores of articles are shown in detail in **Table 2**.

2-5. Data Extraction and Meta-Analysis

After the final selection of studies, the required information was extracted by two authors (NTT and BE), and summarized within the designed table (Extraction table) in Excel software environment. Endnote X8 resource management software was also used to organize study titles and abstracts, and identify duplicates. Meta-analysis and interpretation of data was conducted by author FA. Due to the sufficient number of studies, R software was used for meta-analysis. To report the pooled prevalence, Forest plot diagrams with a 95% confidence interval by Random Effects method were used. I^2 statistics was used to assess heterogeneity of the studies. The heterogeneity rate in this study was reported to be 99%, which is at the highest level of heterogeneity. Subgroup analysis was performed for the type of spinal disorder, sex and age (educational level) and diagnostic criteria (clinical or radiological). The final report of the manuscript was written by NTT and FA and revised by MZP and BE.

3- RESULTS

Eighteen studies were included in the meta-analysis. Characteristics of the selected studies are presented in **Table 3**. The studies were widely distributed among Iranian cities. The total population included in the meta-analysis was 84195 people consisting of 39202 boys and 45947 girls. The mean age of the subjects was 12.71±1.18 years. Analysis was performed by the random effects model in

four subgroups of kyphosis, scoliosis, lordosis and kyphoscoliosis. The number of studies included was as follows: kyphosis 11, scoliosis 13, lordosis 6 and kyphoscoliosis one study.

3-1. Kyphosis

The total number of students was 37945, among whom the pooled prevalence of kyphosis was estimated to be 13.06% [95% CI 0.07; 0.22], I^2=99.5% p<0.0001 (**Fig. 2**).

3-1.1. Gender

In girls, the prevalence was 14.87% [95% CI 0.07; 0.28], I^2 = 99.5%, p<0.0001 and in boys 11.50% [95% CI 0.05; 0.24], I^2 = 99.1% p<0.0001)

3-1.2. School level

In two studies, the prevalence among elementary school students was 15.06% [95% CI 0.12; 0.18], I^2 = 0.0% p = 0.16 and in 8 studies in middle school, the prevalence of kyphosis was calculated as 10.83% [95% CI 0.04; 0.22], I^2 = 99.2% p<0.0001. In a cross-sectional study, the prevalence of kyphosis was reported to be 35.14% [95% CI 0.27; 0.43].

3-1.3. Basis of diagnosis

Prevalence of kyphosis in the diagnoses based on clinical examination was 18.36% [95% CI 0.12; 0.25], I2 = 98.6%, p<0.0001, and diagnosis based on both radiologic and clinical examination yielded a prevalence of 3.1% [95% CI 0.002; 0.26], I2 = 97.4%, p<0.0001.

3-2. Scoliosis

The total population was 81043 in the studies of scoliosis. The total prevalence was estimated to be 2.61% [95%CI 0.014; 0.045], I^2=98.8% p<0.0001 (**Fig. 3**). The only study on kyphoscoliosis was conducted by Moezzi et al. Among 5224 female middle school students, in which 73 cases were diagnosed with kyphoscoliosis, with a prevalence of 1.39 % (10).

3-2.1. Gender

In girls, the prevalence was 2.3% [95% CI 0.013; 0.042], I^2 = 98.3%, p<0.0001 and in boys 1.17% [95% CI 0.007; 0.037], I^2 = 98.2% p<0.0001.

3-2.2. School level

In two studies, the prevalence was estimated as 3.51% [95% CI 0.024; 0.049], I2 = 0.0% p = 0.14 in primary schools and prevalence of scoliosis was 3% [95% CI 0.013; 0.063], I2 = 99.3% p<0.0001. in middle school the In two studies which did not separate primary or middle school, the incidence of scoliosis was reported to be 2.8% [95% CI 0.01; 0.072].

3-2.3. Basis of diagnosis

Prevalence of scoliosis in diagnosis based on clinical examination 3.6% [95% CI 0.028; 0.045], I2 = 73.6%, p<0.001, and based on two studies that combined a clinical examination and radiographic criteria 1.8% [95% CI 0.007; 0.042], I2 = 98.1%, estimated p<0.0001.

3-3. Lordosis

According to 6 studies on lordosis, the total population was 29,758. The overall prevalence was calculated to be 32.59% [95% CI 0.23; 0.43], I2 = 98.6% p<0.0001 (**Fig. 4**).

3-3.1. Gender

Among girls, the prevalence was 41.03% [95% CI 0.25; 0.58], I2 = 98%, p<0.0001 and in boys 25.18% [95% CI 0.16; 0.36], I2 = 98.2% p<0.0001.

3-3.2. School level

In a single study, the prevalence of lordosis in primary schools was 24.8% [95% CI 0.2; 0.29] and in middle school its prevalence was calculated as 29.02% [95% CI 0.21; 0.37], I2 = 97.9% p<0.0001.

3-3.3. Basis of diagnosis

The prevalence of lordosis within 5 studies using diagnosis based on clinical examination was 34.83% [95% CI 0. 24; 0. 47], I2 = 97%, p<0.0001.

Table-2: Methodological assessment of the included studies according to JBI checklist

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Overall score
Daneshmandi et al. (26)	Unclear	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	No	5
Mirzatolouei et al. (27)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8
Rezaei et al. (32)	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	Yes	6
Moezzi et al. (10)	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	No	6
Torkaman (33)	Unclear	Yes	Unclear	Yes	Yes	Yes	No	Yes	No	5
Homayouni et al. (34)	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	No	5
Arti et al. (35)	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	Unclear	5
Safikhani (36)	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	Unclear	5
Zakeri et al. (13)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8
Ghorbani et al. (37)	Unclear	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	5
Fathi et al. (31)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8
Behruzi et al. (38)	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	No	Unclear	6
Siavashi et al. (39)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9
Eivazi et al. (40)	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	5
Lasjouri et al.(22)	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	6
Karimian et al.(41)	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	5
Eslami et al. (42)	Unclear	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	6
Moalej et al. (18)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	7

Table-3: Characteristics of the Studies included in the meta-analysis

Author (Year)	Province (City)	Deformities	Sampling method	Diagnostic Method	Sample size (Number)		Mean age ± SD (years)	Min-Max age (years)	School	Main Conclusion
					Boys	Girls				
Daneshmandi et al. (2006)(26)	Khorasan Razavi (Mashhad)	Kyphosis Lordosis Scoliosis	Clustered randomization	Clinical examination Checkerboard NYPR	616		-	12-15	Middle	The rates of spinal abnormalities including lordosis and scoliosis were higher in girls and kyphosis was higher in boys.
					313	300				
Mirzatolouei et al. (2004) (27)	Western Azerbaijan (Urmia)	Scoliosis	Simple randomization	Clinical examination Adam's test If suspicious Radiography (Cobbs' angle)	38988		-	11-14	Middle	103 people (0.24%) had scoliosis. The prevalence of deviation above 15 degrees in girls was 2.5 times higher than boys and deviation above 20 degrees was 8.5 times higher.
					21374	17614				
Rezaei et al. (2007) (32)	Kermanshah (Kermanshah)	Kyphosis	Stratified-clustered randomization	Clinical examination Plumb line If suspicious Radiography (Cobbs' angle)	2194		13.39±1.05	12-15	Middle	The prevalence of various spinal disorders was 2.01% and the prevalence of kyphosis was 0.68%. Hyperkyphosis was significantly higher in people who carried heavy bags.
					1100	1094				
Moezzi et al. (2014) (10)	Tehran (Tehran)	Kyphosis Kyphoscoliosis Scoliosis	Clustered randomization	Clinical examination Plumb line Checkerboard NYPR Adam's test	5524		13.18±1.24	-	Middle	Of the subjects, 9.6% had kyphosis, 190% had 3.6% scoliosis and 1.4% had kyphoscoliosis. There was a significant relationship between the way of sitting and the type of activity and sports with the above deformities.
					0	5524				
Torkaman (2003) (33)	Kordestan (Sanandaj)	Scoliosis	Stratified-clustered randomization	Clinical examination Plumb line If suspicious Radiography (Cobbs' angle)	1981		13.44±1.13	-	Middle	Prevalence of scoliosis was 55 (2.6%) and it was significantly more prevalent in boys (3.6 vs. 2%)
					981	1000				
Homayouni et al. (2004) (34)	Fars (Shiraz)	Scoliosis	Clustered randomization	Clinical examination Adam's test If suspicious Radiography (Cobbs' angle)	400		-	14-15	Middle	The prevalence of scoliosis was 11 ± 0.03%. No significant relationship was observed between age or improper sitting habits and deviation was found.
					0	400				

Author (Year)	Province (City)	Deformities	Sampling method	Diagnostic Method	Sample size (Number)		Mean age ± SD (years)	Min-Max age (years)	School	Main Conclusion
					Boys	Girls				
Arti et al. (2005) (35)	Chaharmahal-Bakhtiari (Shahrekord)	Scoliosis	Stratified randomization	Clinical examination Adam's test If suspicious Radiography (Cobbs' angle)	936		-	10-14	Middle	Out of 936 students examined, 86 were referred to orthopedic clinics, of which 7 (0.7%) had scoliosis with unknown.
					0	936				
Safikhani et al. (2006) (36)	Khouzestan (Ahvaz)	Scoliosis	Clustered randomization	Clinical examination Plumb line If suspicious Radiography (Cobbs' angle)	2433		-	11-15	Middle	In this study, 42 patients (1.7%) of the study population had scoliosis with a ratio of girls to boys 2: 1. The prevalence of scoliosis in thoracic, lumbar and cervical areas is 50%, 42.86% and 7.14%, respectively.
					1033	1400				
Zakeri et al. (2016) (13) (Eng)	Khouzestan (Abadan)	Kyphosis Lordosis	Clustered randomization	Clinical examination Checkerboard	383		9.87±1.82	7-13	Elementary	There was a significant relationship between skeletal abnormalities and age and sex. The prevalence of kyphosis was 13.6% and lordosis was 24.8%.
					188	195				
Ghorbani et al. (2010) (37)	Hormozgan (BandarAbbas)	Kyphosis Lordosis	Convenience sa mpling	Clinical examination Flexible ruler	188		9.22±1.6 11.98±1.1	-	Elementary Middle	In total, out of 502 samples, 92 had kyphosis and 1 had severe kyphosis. Out of 256 boys, 55 had kyphosis, 21.4%, out of 246 girls, 37 had kyphosis (15%).
					99	99				
Fathi et al. (2011) (31)	Lorestan (KhorramAbad)	Kyphosis Lordosis Scoliosis	Clustered randomization	Clinical examination Plumb line Checkerboard NYPR	26733		-	-	Middle	The prevalence of scoliosis is more common in boys, while shoulder prolapse, kyphosis, and lordosis are more common in girls.
					11131	15602				
Behrouzi et al. (2013) (38)	Arak (Arak)	Scoliosis	Stratified randomization	Clinical examination If suspicious Radiography (Cobbs' angle)	984		11.67±1.36	-	Elementary Middle	The prevalence of scoliosis was 1.52% in all students and 1.21% in girls and 3.21% in boys.
					156	828				
Siavashi et al. (2008) (39)	Lorestan (KhorramAbad)	Scoliosis	Clustered randomization	Clinical examination Plumb line	768		10	10	Elementary	The number of cases screened positively was 97 (12.6%), of

Author (Year)	Province (City)	Deformities	Sampling method	Diagnostic Method	Sample size (Number)		Mean age ± SD (years)	Min-Max age (years)	School	Main Conclusion
					Boys	Girls				
				Adam's test If suspicious Radiography (Cobbs' angle)	0	768				which 30 had spinal scoliosis according to radiographic findings (3.9%).
Eivazi et al. (2012) (40) (Eng)	Eastern Azerbaijan (Turkmenchay)	Kyphosis	-	Clinical examination Plumb line	93		-	11-15	Middle	The prevalence of kyphosis (8.27 vs. 7.7) was significantly higher in girls than boys.
					-	-				
Lasjouri et al. (2005) (22)	Alborz (Karaj)	Kyphosis Lordosis Scoliosis	-	Clinical examination Digital camera photography with software correction	1688		-	11-13	Middle	The prevalence of these disorders was as follows: kyphosis 10.07%, scoliosis 7.58%, lordosis 22.99%
					1688	0				
Karimian et al. (2016)(41)	Fars (Fasa)	Kyphosis Lordosis Scoliosis	Simple randomization	Clinical examination Checkerboard Plumb line	148		-	7-12	Elementary	Lumbar and oblique lordosis had the highest and lowest prevalence in boys, respectively, and lumbar and flat back lordosis had the highest and lowest prevalence in girls, respectively.
					74	74				
Eslami et al. (2013) (42) (Eng)	Lorestan (Nurabad)	Lordosis Kyphosis	Stratified randomization	Clinical examination measuring tape flexible ruler	190		-	11-14	Middle	The prevalence of lordosis between the ages of 11-14 years was 36.6% and kyphosis was 29.8%.
					0	190				
Moalej et al. (2018) (18) (Eng)	Tehran (Tehran)	Scoliosis	Clustered randomization	Clinical examination Adam's test Scoliometer app for iPhone's smartphone If suspicious Radiography (Cobbs' angle)	144		9.5±1.71	7-12	Elementary	Among the participants, 1.4% had obvious scoliosis and 10.4% had suspected deviations, which was estimated to have a relative prevalence of 4.86% using a scoliometer.
					72	72				

Eng: Articles in English
NYPR: New York Posture Rating Chart

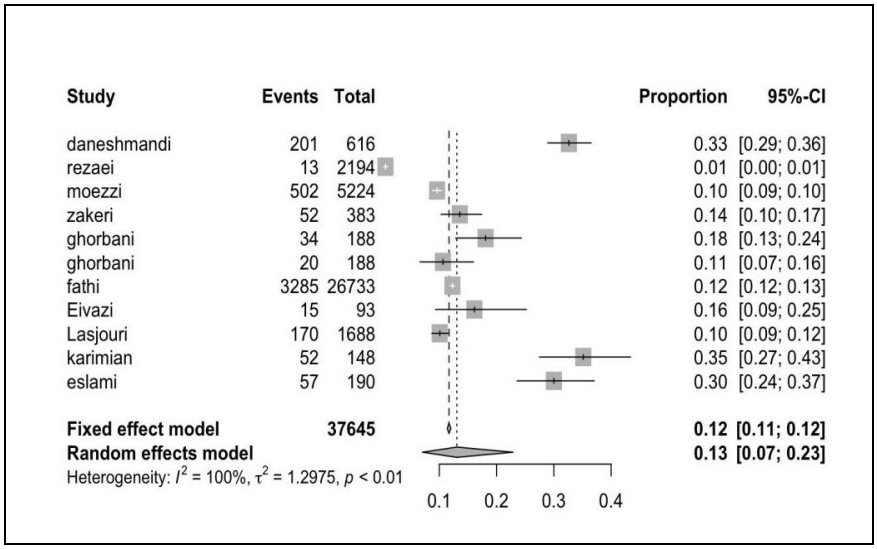

Fig. 2: Prevalence of Kyphosis among the Iranian school age children

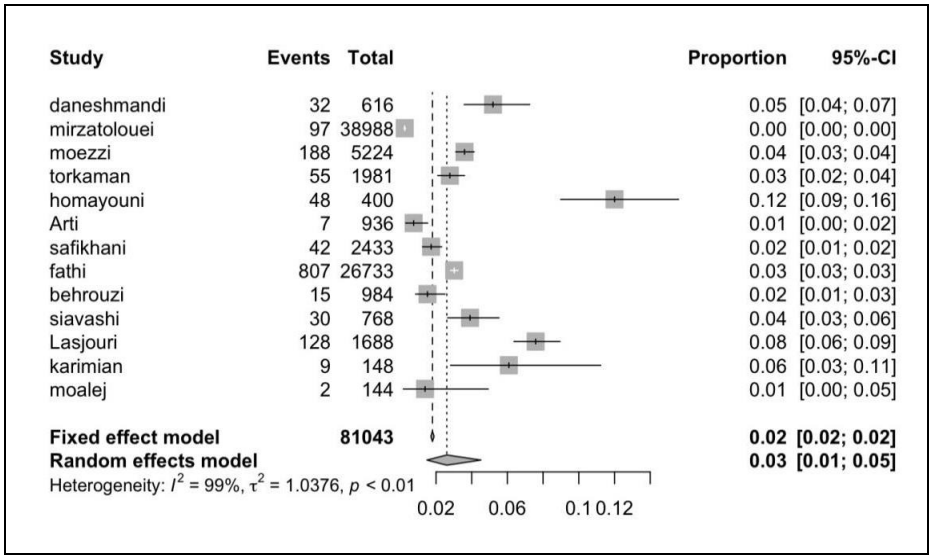

Fig. 3: Prevalence of Scoliosis among the Iranian school age children

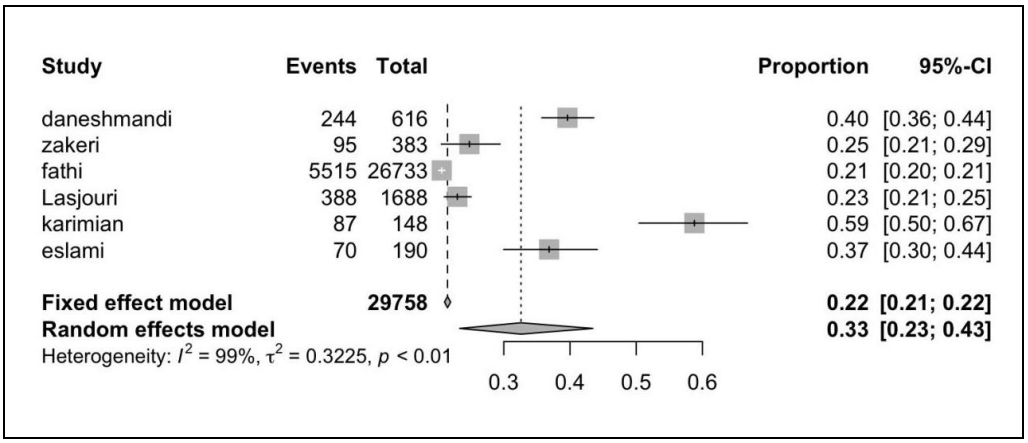

Fig. 4: Prevalence of Lordosis among the Iranian school age children

4- DISCUSSION

The types of spinal abnormalities discussed in this systematic review include kyphosis, scoliosis, and lordosis, which can cause adverse effects in the future if left untreated in children.

It was not possible to present the general prevalence of spinal abnormalities in all articles due to the overlap in the incidence of several abnormalities and the lack of complete reports of these cases, and each disorder was meta-analyzed separately.

In general, in all three subgroups, the prevalence of spinal deformities was higher in girls than boys. The most common disorder was lordosis. The prevalence of kyphosis and sclerosis in primary school was higher than in middle school, but the prevalence of lordosis in secondary school was higher than in primary school.

4-1. Diagnosis

Physical examination is the essential step to diagnose spinal deviation disorders, which is initiated with observation. Most disorders are evident while observation but it is not enough to rely on because of habitual postural attitude or other truncal asymmetries. There are various tests for the evaluation of spinal deviations; here we name some of them which have been used in included studies. One of the tests for stating alignment of different body segments is New York State posture rating scale (NYPR) assessment method (11, 12). Also checkerboards gridded to 5-centimeter square can be used to evaluate different postural skeletal deformities (13) For determining the degrees of thoracic kyphosis and lumbar lordosis Flexible ruler (Flexicurve) (14). Sagittal alignment could be measured using a plumb line (mostly distance from C7 vertebrae) (15). Adam's forward bending test (FBT) is a scoliosis examination (16) to quantify the spinal curve and rotation. A scoliometer, or inclinometer is used to determine the angle of trunk rotation (ATR) or inclination angle (17). Besides, advanced techniques such as digital scoliometer like what was used in the study of Moalej et al. (18) (Scoliometer app for iPhone's smartphone), have shown to be valid for pediatric scoliosis screening (19). Digital camera photographs with software correction such as Digital Image-Based Postural Assessment (DIPA) (20) and Postural assessment software (PAS) (21) are other examples. Among the included studies, only the study of Lasjouri et al. implemented photography based evaluation; the reported prevalence of these disorders was as follows: kyphosis 10.07%, scoliosis 7.58%, lordosis 22.99% (22).

The gold standard for identifying and monitoring scoliosis is standing frontal and lateral full spinal radiographic image and calculating Cobb's angle; however it is not recommended for patients with negative Adam's test and ATR below 5 degrees (23). A measurement of 10 degrees or greater needs X-ray for Cobb angle determination which is the most commonly used method for curvature evaluation (16). In subgroup analysis, diagnostic approaches were divided into two general groups: clinical diagnosis and clinical diagnosis along with the use of radiography in suspicious cases to confirm the diagnosis. In studies that also used radiological methods, the prevalence in all three groups of kyphosis, scoliosis and lordosis was significantly lower than in the clinical diagnosis group, indicating that clinical examination itself can lead to over diagnosis.

4-2. Kyphosis

The overall prevalence of kyphosis was 13.06%, which was higher in girls than in boys (16.87% vs. 11.5%). The highest prevalence reported in the study BY Daneshmandi et al. in Mashhad (26) was 32.63% and the lowest was 0.68% in the study By Rezaei et al. (32) in Kermanshah.

The overall prevalence of kyphosis in developed countries is estimated approximately 0.3 to 10% (24) But in countries such as Brazil, in a study by Bueno et al. (2013), the prevalence of dorsal kyphosis was estimated to be about 16.6%(25). A comprehensive meta-analysis study was not found to examine the prevalence of kyphosis in different communities. However, the prevalence of kyphosis is high in our study and requires attention to promote training of correct sitting posture and early diagnosis.

4-3. Scoliosis

The overall prevalence of scoliosis in our meta-analysis was estimated about 2.61%., which was 2.30% in girls and 1.17% in boys; again more common in girls. The highest prevalence is related to the Daneshmandi study in Mashhad (5.19%) (26) and the lowest prevalence is reported in a study by Mirza Tolouei in Urmia (0.24%) (27).

A systematic review was conducted by Karimian et al., on the prevalence of scoliosis and its related factors from 2000 to 2014, in which three Iranian studies and 12 studies from other countries were included. The results of this systematic review indicated that the prevalence of scoliosis in children and adolescents had been reported between 0.19 and 11.03 percent, and girls were more than boys (28). In a meta-analysis conducted by Zhang (2015), the prevalence of scoliosis among primary and secondary school students in China including 38 articles and 697043 samples was reported to be 1.02 with a 95% confidence interval [0.85-1.18] (29). The prevalence of scoliosis in this study was lower than what found in our study. In Zhang's study, the ratio of women to men in the prevalence of scoliosis was 1.54 and with increasing age, the rate of scoliosis increased from 0.73% to 1.42%. According to our study, the prevalence was higher in girls but decreased with the increase in age. It was lower in middle school; however, there was no significant difference between primary and middle school ages.

An extensive cross-sectional epidemiological study in Korea on one million school-age children between 2000 and 2008 in the age ranges of 10-12 years and 13-14 years yielded that the overall prevalence of scoliosis was in boys 3.26% and 4.64% in girls (30). The prevalence in this study was higher than in ours. In general, according to the findings of other studies, the prevalence of scoliosis in Iran has been within the moderate limits.

4-4. Lordosis

The number of studies on lordosis was lower than the other two deformities (6 studies with a population of 29,758 people). Lumbar lordosis has had a prevalence of 32.59% and is significantly higher in girls than boys (41.03% of girls versus 25.18% in boys, $p<0.0001$). The highest prevalence was reported in Mashhad (39.61%) (26) and the lowest prevalence in Lorestan province in the Fathi's study (20.63%) (31). A study in the Republic of Czech screening 35,000 school children, estimated the prevalence of lordosis to be 32%, which is consistent with the findings of our meta-analysis (4).

In general, there are differences in the prevalence of spinal deformities between girls and boys in different studies. A possible rationale to explain the higher rates of deformities in girls, especially lordosis, can be the way Iranian girls stand and sit due to special cultural conditions.

The findings were wide-ranging in different cities and, as noted in the results, the heterogeneity in most entities was high. One of the causes of this high discrepancy is the nature of epidemiological studies due to different underlying and etiological factors. Another factor is the differences in measurement criteria of clinical versus adding radiologic

findings to confirm the diagnosis as discussed above.

5- CONCLUSION

In general, the prevalence of spinal abnormalities in Iranian elementary and middle school students is moderate, as compared to other countries. In cases of kyphosis and lordosis this level is slightly higher. All deformities were more common in girls. It is suggested that future reviews and meta-analyses should focus on the causes of congenital or acquired abnormalities and etiologies, as well as their risk factors, in order to take steps to prevent disorders by identifying risk factors. It is recommended to conduct epidemiological studies with precise methodologies and large sample sizes.

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