Prevalence of joint hypermobility in children and adolescents: A systematic review and meta-analysis

Amir Sobhani-Eraghi[1], Mohsen Motalebi[2], Siavash Sarreshtehdari[1], Borzooyeh Molazem-Sanandaji[1], Zahra Hasanlu[1]

[1]Department of Orthopaedics Surgery, Rasoul Akram Hospital, Iran University of Medical Sciences, Tehran, Iran, [2]Department of Medicine, Trauma Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran

Background: The inconsistent results of different studies regarding the prevalence of joint hypermobility (JH) or joint laxity in children and adolescents made us conduct a meta-analysis on the prevalence of JH in this age group. **Materials and Methods:** We searched electronic databases including Trip, Scopus, Medline, Embase, PubMed, and Google Scholar; some Iranian databases including Iran Medex and Magiran; and Scientific Information Database to find studies in which the prevalence of JH in children and adolescents had been reported since January 1990 to April 2017. In this process, two researchers evaluated the articles separately while they were not aware of each other's method, and they extracted and matched the information. **Results:** Necessary data of twenty studies (15,097 boys and 6048 girls) were entered into this meta-analysis. The age range in these studies was 3–19 years. According to the meta-analysis conducted on the twenty studies, it was determined that the total prevalence of JH among children and adolescents was 34.1% (95% confidence interval [CI]: 33.3%–34.8%). Based on the results obtained from the studies, a significant heterogeneity (I_2 index equals to 99,415 and $P \leq 0.001$) was shown, so we used random-effects model; moreover, the overall assessment of studies showed a statistically significant publication bias ($P = 0.02$). In total, the prevalence in girls was equal to 32.5% (95% CI: 31.4%–33.7%), and in boys, it was equal to 18.1% (95% CI: 17.2%–19.1%). **Conclusion:** According to this meta-analysis, studies showed high heterogeneity, and the prevalence of JH in children and adolescents around the world was equal to 34.1% (95% CI: 33.3%–34.8%) in total, whereas it was higher in girls and lower in older ages.
Level of evidence: 1.

Key words: Child, joint laxity, meta-analysis

INTRODUCTION

Excessive mobility of joints was first described by Hippocrates in members of a tribe living in the south of Russia, but the term "hypermobility" was first used in the 19th century to explain Marfan and Ehlers–Danlos syndromes.[1]

Hypermobility refers to excessive joint movement and can be symptomatic or asymptomatic. Hypermobility syndrome in fact refers to the excessive movement of joints (without accompanying other syndromes) with symptoms such as pain and instability.[2] Headache, back pain, joint pain, and intervertebral disc prolapse are the hallmarks of hypermobility syndrome.[3] Despite the high prevalence of this syndrome among children and adolescents, final results are not very comprehensive and reliable due to performing studies on little samples, different methods for evaluation of joint hypermobility (JH), and different methods for pain evaluation. Nevertheless, the studies conducted on children, especially at school level, show that JH range from 30% to 50%.[4,5] This high prevalence leads ligamentous laxity to be referred to as the variation among the general population in different reviews.

Address for correspondence: Dr. Mohsen Motalebi, Department of Medicine, Baqiyatallah University of Medical Sciences, Baqiyatallah Hospital, Vanaq Square, Tehran, Iran. E-mail: dr.motalebi@ymail.com

The report about JH in children between 6 and 15 years old ranged from 8.8% to 64.6%,[6,7] which is very high. It seems that the reason for the above-mentioned range is that these studies have been carried out among different societies and races with different age groups. Moreover, the sample size has been extremely wide ranging so that the sample size varies from 364[8] to 2432 cases.[6] In addition, there is no consensus on whether the incidence of JH is the same or different in joints of both sides so that there are some reports confirming the differences and some emphasizing on the similarity of the involvement of both sides.[9,10] There is a controversy about the relationship between JH and body weight.[11,12] Although there is agreement that younger children are more likely to show JH than teens and young people,[13] there is little evidence in this regard. For example, a study on 1845 Swedish children and adolescents[14] showed that in all age groups, girls experience higher levels of JH than boys. In addition to that, JH in boys decreases with age, whereas this trend is quite the opposite in girls. On the contrary, in some studies, there was no relationship between age and severity of JH.[15] Overall, it seems that there are significant gender- and age-related differences in the incidence of JH in children and adolescents, and these statistics are strongly influenced by the characteristics of the population under evaluation, race, geographical area, sample size and method of study design, JH evaluation methods, and genetic tendencies. Considering the high prevalence of JH, and its association with osteoarthritis, and the above-mentioned symptoms on the one hand and these different and widespread statistics about it on the other hand, it is essential to determine a global statistics for the management of this condition, hence we decided to gather all information about JH from all around the world and reanalyzed them to determine its actual prevalence and associations to do better management of this population and develop better health policies.

MATERIALS AND METHODS

We searched electronic databases including Trip, Scopus, Medline, Embase, PubMed, and Google Scholar; some Iranian databases including Iran Medex and Magiran; and Scientific Information Database to find studies which have reported the prevalence of JH and ligamentous laxity in children and adolescents since January 1990 to April 2017. We also made a separate search in Cochrane library and all relating references, in order to decrease the publication bias. We used the following keywords and their synonyms in title and abstract: child, hypermobility, joint laxity, and ligamentous laxity. All searching stages were carried out by two researchers, and any disagreement between them was solved by a third researcher. All final articles were evaluated qualitatively by STROBE questionnaire.[16] The questionnaire evaluates 22 questions about the quality of descriptive articles, with each item having 1 score and a

total of 22 scores. A score <12 indicates that the article lacks quality. We limited our search to human studies and did not consider the limitations of the language of studies.

Eligible studies

Studies had to have the following conditions to enter this meta-analysis: (1) reviewing the prevalence of hypermobility in children and adolescents under 20 years old; (2) using Beighton score[17,18] to diagnose hypermobility; (3) having score 12 or higher in STROBE analysis; and (4) having article formats in cross-section, case–control, clinical trial, and cohort. Articles with these conditions were entered into this meta-analysis regardless of the country and the language in which they were done. On the contrary, articles studying on people with musculoskeletal disorders, those who had pain or lesion at the reviewed site of the Beighton score, and people with known syndromic diseases were discarded.

Data extraction

We extracted the following information from the eligible articles entered into the meta-analysis: original writer, publication year, country in which the study was carried out, number of sample volume, boy-to-girl ratio, age range, prevalence of hypermobility, and differences in genders and age ranges. In this meta-analysis, we first analyzed the prevalence of hypermobility in total population, and then we did it in boys and girls separately because of significant differences of hypermobility in both genders according to the meta-regression test.

Definitions

Hypermobility is defined as excessive movement of joints beyond the normal range. All studies in this analysis were based on the criteria of Beighton *et al*., which were conducted on 1083 children and adults in South Africa,[17] with all those being almost identical to the Carter and Wilkinson scoring system in 1960.[19] Based on the Beighton scoring system, a person gets 1 score for doing each of these moves (the first four moves will be performed on both sides and will score 1 for each side): (1) passive extension of the fifth metacarpo-phalangeal joint past 90°, (2) passive opposition of the thumb to the forearm, (3) hyperextension of the elbow joint past 10°, (4) hyperextension of the knee joint past 10°, and (5) trunk flexion allowing the palms to be placed flat on the floor. The maximum score in this system will be 9 and the score ≥4 is known as hypermobility.

Data analysis

We used STATA ver. 13.2 (StataCorp Inc., Cary, NC, USA) to conduct this analysis. The heterogeneity level of the study was determined based on I_2 and *P* value by Q test ($P \leq 0.05$ and high I_2 was considered significant) in evaluating the odds pooled ratio; a random-effects model (based on significant heterogeneity of the study) was used from

various studies. Moreover, publication bias was determined according to funnel plot diagram and Egger test.

RESULTS

Search results

In total, 3874 studies were found from different databases, of which there were 1031 repetitive studies that were deleted. By reviewing the title of 2843 remaining articles, 1796 unrelated studies were identified and removed. Abstract of the 1047 remaining articles were studied, of which 936 were unrelated to our analysis and were omitted. Full text of the 111 remaining studies was evaluated and 91 articles were excluded because of our inclusion criteria. The final twenty studies that were entered into this analysis were evaluated by the STROBE questionnaire. No items were identified as poor-quality articles. Eventually, all the twenty studies[4,5,7,8,15,20-34] were entered into this analysis [Figure 1].

Characteristics of studies

The total number of patients evaluated in these twenty studies was 21,145 cases (including 15,097 boys and 6048 girls), which included a wide range of children aged between 3 and 19. Studies were carried out in different countries including Asian countries (40%) (Iran, India, Turkey, Pakistan, and Hong Kong), European countries (45%) (England, Denmark, Sweden, Italy, Poland, Spain, Iceland, and the Netherlands), Africa (5%) (Egypt), South America (5%) (Brazil), and Australia (5%). In some studies, the incidence of JH was reported in total population, and, in others, separately in boys and girls. Complete data based on the extracted ones from articles including age range, overall and gender prevalence, and the prevalence regarding age and total sample size of each study are specified in Table 1.

Meta-analysis

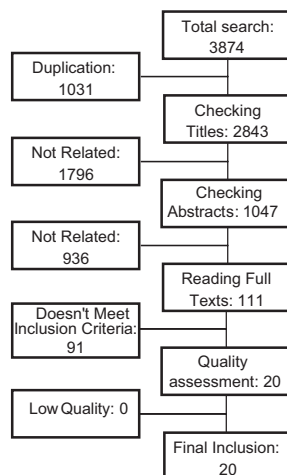Based on the meta-analysis performed on the twenty studies, it was found that the overall prevalence of JH in children and adolescents was 34.1% (95% confidence interval [CI]: 33.3%–34.8%) [Figure 2]. Based on the analysis done with respect to the I_2 index of 99.415 and $P < 0.001$, the results of the studies have had a significant heterogeneity. In addition, according to $P = 0.02$ in the Egger regression test and Funnel plot, there was a significant publication bias in this analysis [Figure 3].

According to the meta-regression test about gender ($P = 0.01$), only 12 of the 20 studies reported the prevalence of JH based on boys and girls. By assessing these studies, it was found that the prevalence of JH among boys was 18.1% (95% CI: 17.2%–19.1%) [Figure 4]. According to I_2 index of 976/806 and $P < 0.001$, the results of these 12 studies have had a significant heterogeneity. Furthermore, the overall evaluation of the publication bias was statistically significant in these 12 studies ($P = 0.01$) [Figure 5]. Moreover, the prevalence of JH among females, children, and adolescents was 32.5% (95% CI: 31.4%–33.7%) [Figure 6]. Accordingly, the results of the studies showed a statistically significant heterogeneity (I_2 index: 988/405, $P < 0.001$). There was a statistically significant publication bias in these 12 studies ($P = 0.01$) [Figure 7].

DISCUSSION

As we have already mentioned, various studies have been published with different outcomes regarding the prevalence of JH, as well as the gender and age differences in this disorder in different parts of the world, which have reached a different prevalence. Obviously, due to the different prevalence in this regard, there will be significant heterogeneity among different communities. This significant difference is resulted by two categories of factors, including community- and the study environment-related factors and factors associated with the type and design of the study. Regarding the first category, race, geographic location, and genetic tendencies will all be effective in the occurrence of this difference in JH. In contrast, the second category which are related to the study itself include sample size, different criteria and cutting points in the definition of JH, criteria for entering and leaving the study, selection process of the samples, and, most importantly, the different age ranges entered in the study. Considering all these factors and also the need for developing health policies to prevent the occurrence of disease in this group and reduce the cost of treatment, designing and conducting a systematic review and meta-analytic study aimed to achieving a pooled prevalence and determining the factors associated with it was absolutely necessary. In this study, we included all articles regardless of their language for reduction of publication bias and the most generalizability of the result and also searched Cochrane library especially for Clinical Trials Registry to ensure minimum publication bias. In

Figure 1: Results of searching strategy

Table 1: Details of evaluative studies in systemic review and meta-analysis

Author, published year	Research population	Number of sample volume	Girls/boys	Age range	Prevalence (*n*)	Sexuality	Age difference
Cheng *et al.*, 1991[20]	Hong Kong	2360	1180/1180	3-13	65% (1534)	More prevalence in girls than boys	As age increases, score decreases
Lamari *et al.*, 2005[7]	Brazil	1120	586/534	4-7	64.6% (723)	More prevalence in girls than boys	As age increases, score decreases
Subramanyam and Janaki, 1996[21]	India	1000	500/500	6-10	65% boys, 35% girls) (175-325)	More prevalence in boys. Under 10 years old: more prevalence in girls. Higher than 10 years old	As age increases, score decreases in boys
Seçkin *et al.*, 2005[22]	Turkey	861	431/428	13-19	7.2% boys, 16.2% girls (31-70)	More prevalence in girls	As age increases, the score decreases
Gyldenkerne *et al.*, 2007[8]	Denmark	364	164/200	12-13	3.3% boys, 16.6% girls (6-27)	More prevalence in girls	As age increases, the score decreases
Remvig *et al.*, 2013[23]	Denmark	315	159/156	-	21.2% (67)	-	-
Romeo *et al.*, 2016[24]	Italy	284	138/146	-	7% (20)	There is no sexual difference	There is no age difference
El-Garf *et al.*, 1998[4]	Egypt	997	497/500	-	14.4% boys, 18% girls (72-89)	There is no sexual difference	As age increases, the score decreases
Butt *et al.*, 2014[25]	Pakistan	500	200/300	8-17	29.0% boys, 33.5% girls (87-67)	There is no sexual difference	As age increases, the score decreases in girls
Morris *et al.*, 2017[26]	Australia	1584	769/815	14	36.7% boys, 60.6% girls (300-466)	More prevalence in girls	-
Gocentas *et al.*, 2016[27]	Poland	778	378/400	7-12	19.2% (149)	-	-
Öhman *et al.*, 2014[28]	Sweden	138	58/80	5-8	12% (16)	More prevalence in girls	As age increases, the score decreases
Clinch *et al.*, 2011[29]	The UK	6022	3061/2961	7-18	10.6% boys, 27.5% girls (314-841)	More prevalence in girls	There is no age difference
Viswanathan and Khubchandani, 2008[30]	India	433	214/219	3-9	40.8% (177)	There is no sexual difference	There is no age difference
Hasija *et al.*, 2008[31]	India	829	309/520	3-19	58.7% (487)	There is no sexual difference	As age increases, the score decreases
Qvindesland and Jónsson, 1999[5]	Iceland	267	167/100	12	12.9% boys, 40.5% girls (13-68)	More prevalence in girls	-
Rikken *et al.*, 1997[15]	The Netherlands	910	449/461	4-17	10.2% boys, 18.7% girls (47-84)	More prevalence in girls	There is no age difference
Verd, *et al.*, 1991[32]	Spain	1136	444/692	11-14	13.0% boys, 21.0% girls (90-94)	More prevalence in girls	There is no age difference
Ziaee and Moradinejad, 2008[33]	Iran	252	132/120	6-16	10.0% boys, 13.6% girls (12-18)	More prevalence in girls	As age increases, the score decreases
Jamshidi *et al.*, 2004[34]	Iran	1005	501/504	6-19	14.1% boys, 33.7% girls (71-169)	More prevalence in girls	As age increases, the score decreases

addition, all of the references of relevant review studies were checked to find further investigations not found previously in primary electronic search. Two investigators separately did all of the searches and quality assessment procedures and any disagreements between them were resolved by the third author. Among all the studies that referred to JH among children and adolescents, twenty studies fulfilled the inclusion criteria and based on them, it was found that the overall prevalence of JH was 34.1%, which is estimated to be 32.5% in girls and 18.1% in boys,
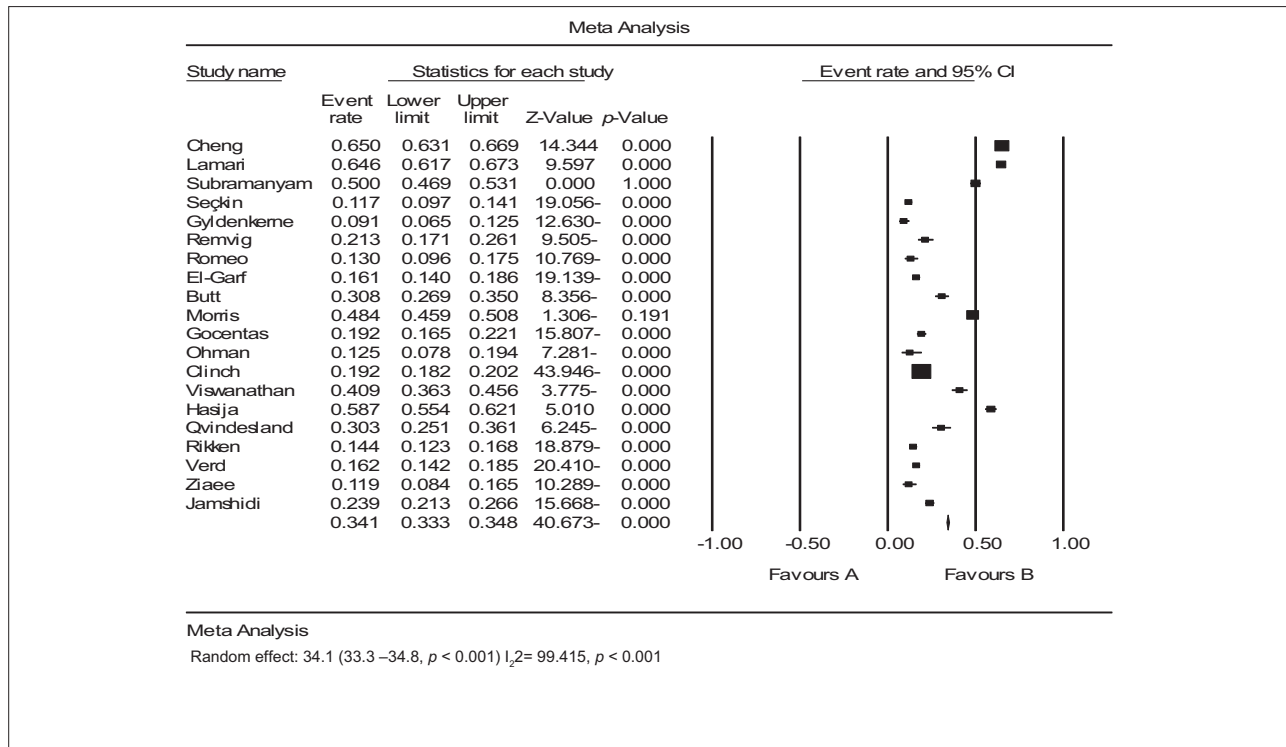
Figure 2: Prevalence of joint hypermobility in the twenty evaluated studies
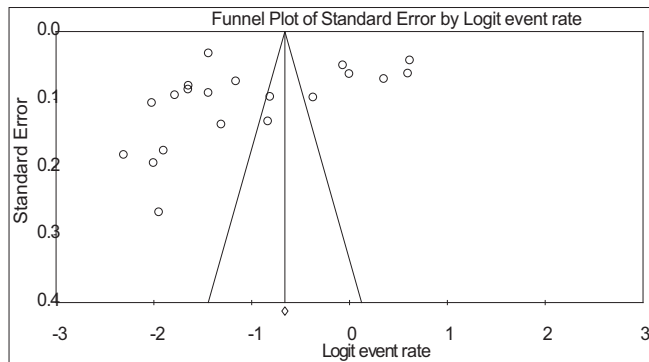

Figure 3: Publication bias in the twenty evaluated studies

which, in general, indicates a higher prevalence of this disorder in girls.

Regarding the prevalence of JH in different genders, in 12 out of the 20 studies,[5,7,8,15,20,22,26,28,29,32-34] the prevalence of this disorder in girls was significantly higher than that of boys. In one study in India, <10 years old, the prevalence was higher in boys than girls, whereas over the age of 10 this prevalence was *vice versa*.[21] In the remaining seven studies, there was no statistically significant difference between boys and girls regarding the incidence of JH.[4,23-25,27,30,31]

Concerning the prevalence of JH in different ages, it was also found that in nine studies,[4,7,8,20,22,28,31,33,34] the increasing age was associated with a decrease in the prevalence of JH, and this prevalence was independent of sex, but in one

study, the inverse relationship between age and prevalence of the disorder was only in boys.[21] In another study, this inverse relationship was observed only in girls.[25] On the contrary, in five studies, there was no relationship between the prevalence of JH and age[15,24,29,30,32] and in four studies, there was no mention of age differences.[5,23,26,27] As a result, in the majority of studies, it was found that with increasing age of the patients, the prevalence of JH had significantly reduced. This is due to the tendency of collagen fibers to bind together more as a result of more tissue stiffness with increasing age.[17,35,36]

There are a few important points in relation to this meta-analysis: first, the number obtained for total prevalence or gender-related prevalence is basically not reliable due to the high heterogeneity among studies. This heterogeneity was due to the difference in the sample size of the studies, the different cut scores for diagnosis of the JH, as well as the demographic and racial differences between the studies. In general, it could be mentioned that, first, the sample size of the study varied widely between 128 and 6022, which was very broad. Second, there was a high geographic dispersion between studies, but in a review of studies, it can be concluded that the highest prevalence was observed in Southeast Asian countries (China and Hong Kong) and South Asian (India) as well as South America (Brazil), whereas in the European countries, we have encountered the lowest prevalence of JH. This conclusion can be an emphasis on a favorable life pattern in European countries,
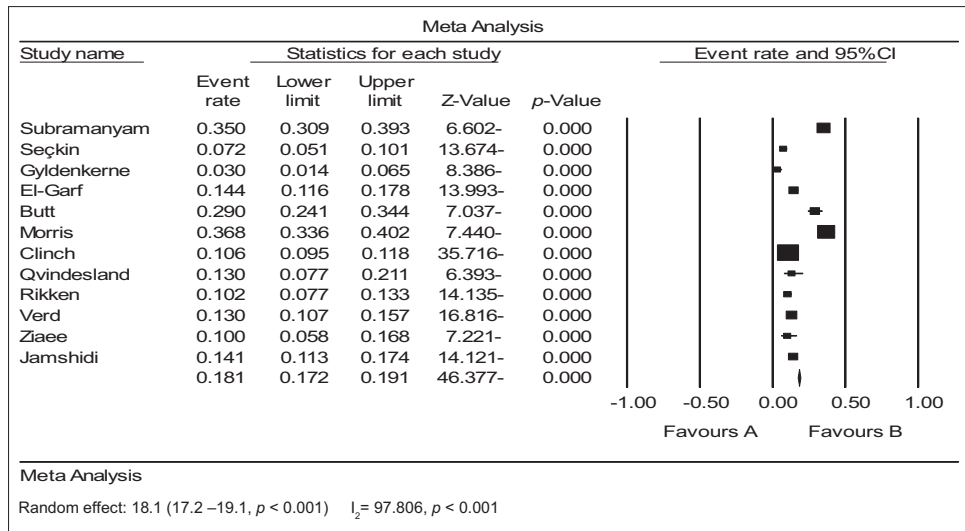
Meta Analysis							
Study name	Statistics for each study					Event rate and 95%CI	
	Event rate	Lower limit	Upper limit	Z-Value	*p*-Value		
Subramanyam	0.350	0.309	0.393	6.602–	0.000		
Seçkin	0.072	0.051	0.101	13.674–	0.000		
Gyldenkerne	0.030	0.014	0.065	8.386–	0.000		
El-Garf	0.144	0.116	0.178	13.993–	0.000		
Butt	0.290	0.241	0.344	7.037–	0.000		
Morris	0.368	0.336	0.402	7.440–	0.000		
Clinch	0.106	0.095	0.118	35.716–	0.000		
Qvindesland	0.130	0.077	0.211	6.393–	0.000		
Rikken	0.102	0.077	0.133	14.135–	0.000		
Verd	0.130	0.107	0.157	16.816–	0.000		
Ziaee	0.100	0.058	0.168	7.221–	0.000		
Jamshidi	0.141	0.113	0.174	14.121–	0.000		
	0.181	0.172	0.191	46.377–	0.000		

Meta Analysis

Random effect: 18.1 (17.2 –19.1, $p < 0.001$) $I_2 = 97.806$, $p < 0.001$

Figure 4: Prevalence of joint hypermobility in boys in the 12 evaluated studies
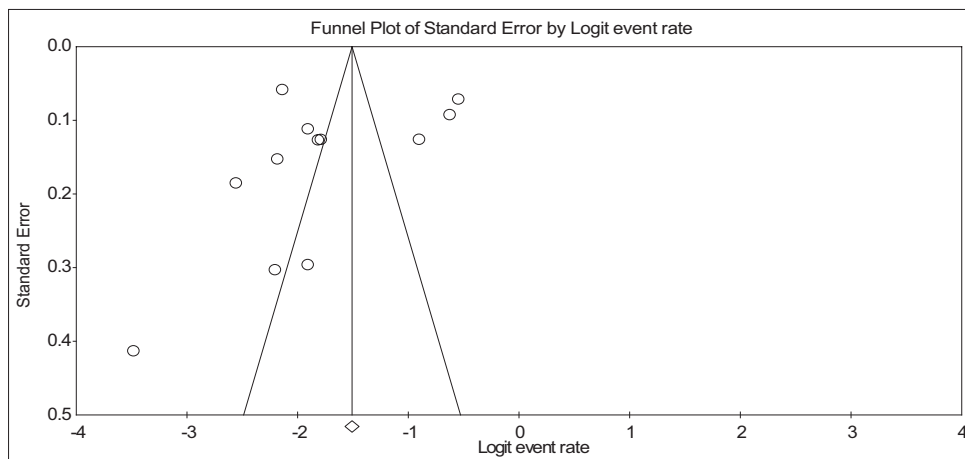
Figure 5: Publication bias in the 12 evaluated studies about prevalence in boys

Meta Analysis							
Study name	Statistics for each study					Event rate and 95%CI	
	Event rate	Lower limit	Upper limit	Z-Value	p-Value		
Subramanyam	0.650	0.607	0.691	6.602	0.000		
Seçkin	0.162	0.131	0.200	12.561–	0.000		
Gyldenkerne	0.165	0.115	0.229	7.713–	0.000		
El-Garf	0.179	0.148	0.215	13.015–	0.000		
Butt	0.335	0.273	0.403	4.577–	0.000		
Morris	0.606	0.571	0.640	5.833	0.000		
Clinch	0.275	0.259	0.291	23.973–	0.000		
Qvindesland	0.407	0.335	0.483	2.385–	0.017		
Rikken	0.187	0.154	0.226	12.140–	0.000		
Verd	0.212	0.176	0.252	11.317–	0.000		
Ziaee	0.136	0.088	0.206	7.278–	0.000		
Jamshidi	0.337	0.297	0.380	7.146–	0.000		
	0.325	0.314	0.337	27.485–	0.000		

Meta Analysis

Random effect: 32.5 (31.4 –33.7, p < 0.001) $I_2 = 98.405$, p < 0.001

Figure 6: Prevalence of joint hypermobility in girls in the 12 evaluated studies

as well as a more consistent implementation of screening and preventive programs for encountering connective tissue disorders as well as musculoskeletal disorders in these communities.
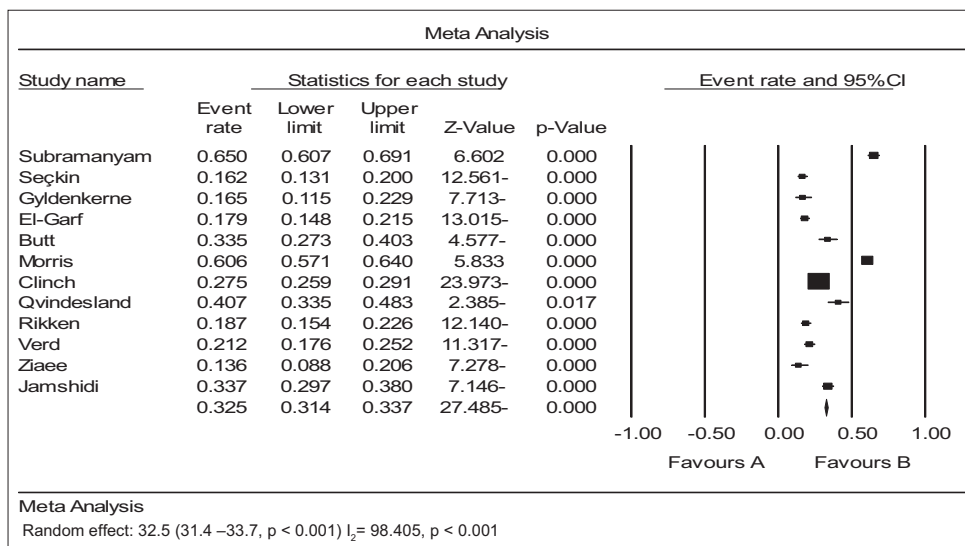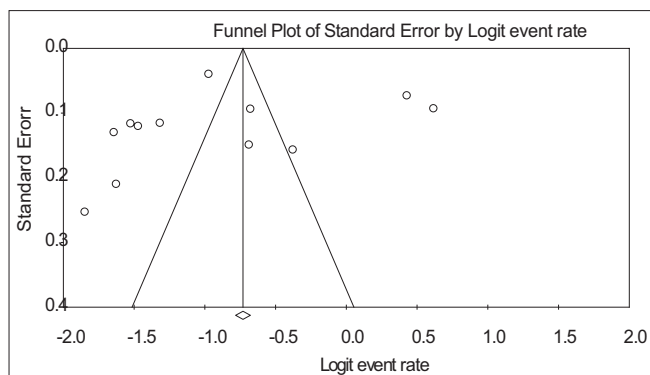
Figure 7: Publication bias in the 12 evaluated studies about prevalence in girls

Higher prevalence of JH in girls than boys can be attributed to the difference of their body structure, as well as hormonal effects before and during puberty in both sexes. On the other hand, decreasing incidence of JH with aging may be due to the physical growth and development of individuals following getting older, especially when they reach adulthood. Finally, the important point to mention is that only two comprehensive studies have been published in Iran that are inadequate for systemic analysis in our society, especially considering racial and geographical diversity in our country.[33,34] Nevertheless, findings related to JH in Iranian studies (prevalence in the study of Ziaee was 10% in boys and 13.6% in girls, and in the study of Jamshidi was 14.1% in boys and 33.7% in girls) showed that the prevalence in girls was higher than that in boys, and, as the age increases, the disease's prevalence decreases.[33,34] In both studies, the prevalence in girls was higher than that in boys, and, as the age increases, the disease's prevalence decreases, which is closer to the findings of European studies, which indicates that screening and management of this problem is desirable in our country, but there is still a long way to go in comparison to the developed countries.

Limitation

Our limitations in this analysis were as follows: First, many studies used scores other than the Beighton score to diagnose JH so that we could not include these studies in our work. Second, there are many unreliable reports about the prevalence of JH all around the world, of which none are valid. Third, there was a significant publication bias in our study, indicating that some studies have not been published by researchers for unknown reasons, and these studies are out of reach. However, it seems that in this situation, the results of this meta-analysis would be countable.

CONCLUSION

Regarding this analysis, it can be concluded that, first, the global prevalence of JH was estimated to be 34.1%, which was more prevalent in girls than in boys and lower in younger ages. Second, the results of studies have had a high heterogeneity. Third, the results of limited studies in Iran show a prevalence of 10%–14.1% in boys and 13.6%–33.7% in girls.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Walker BA, Beighton PH, Murdoch JL. The marfanoid hypermobility syndrome. Ann Intern Med 1969;71:349-52.
2. Kirk JA, Ansell BM, Bywaters EG. The hypermobility syndrome. Musculoskeletal complaints associated with generalized joint hypermobility. Ann Rheum Dis 1967;26:419-25.
3. Russek LN. Examination and treatment of a patient with hypermobility syndrome. Phys Ther 2000;80:386-98.
4. El-Garf AK, Mahmoud GA, Mahgoub EH. Hypermobility among Egyptian children: Prevalence and features. J Rheumatol 1998;25:1003-5.
5. Qvindesland A, Jónsson H. Articular hypermobility in Icelandic 12-year-olds. Rheumatology (Oxford) 1999;38:1014-6.
6. Vougiouka O, Moustaki M, Tsanaktsi M. Benign hypermobility syndrome in Greek schoolchildren. Eur J Pediatr 2000;159:628.
7. Lamari NM, Chueire AG, Cordeiro JA. Analysis of joint mobility patterns among preschool children. Sao Paulo Med J 2005;123:119-23.
8. Gyldenkerne B, Iversen K, Roegind H, Fastrup D, Hall K, Remvig L. Prevalence of general hypermobility in 12-13-year-old school children and impact of an intervention against injury and pain incidence. Adv Physiother 2007;9:10-5.
9. Lin HC, Lai WH, Shih YF, Chang CM, Lo CY, Hsu HC. Physiological anterior laxity in healthy young females: The effect of knee hyperextension and dominance. Knee Surg Sports Traumatol Arthrosc 2009;17:1083-8.
10. Verhoeven JJ, Tuinman M, Van Dongen PW. Joint hypermobility in African non-pregnant nulliparous women. Eur J Obstet Gynecol Reprod Biol 1999;82:69-72.
11. Kannus P, Järvinen M. Age, overweight, sex, and knee instability: Their relationship to the post-traumatic osteoarthrosis of the knee joint. Injury 1988;19:105-8.
12. Engelbert RH, Bank RA, Sakkers RJ, Helders PJ, Beemer FA, Uiterwaal CS. Pediatric generalized joint hypermobility with and without musculoskeletal complaints: A localized or systemic disorder? Pediatrics 2003;111:e248-54.
13. Beighton PH, Grahame R, Bird H. Hypermobility of Joints: Springer Science & Business Media; 2011.
14. Jansson A, Saartok T, Werner S, Renström P. General joint laxity in 1845 Swedish school children of different ages: Age- and gender-specific distributions. Acta Paediatr 2004;93:1202-6.
15. Rikken-Bultman DG, Wellink L, van Dongen PW. Hypermobility in two Dutch school populations. Eur J Obstet Gynecol Reprod

Biol 1997;73:189-92.

16. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, *et al*. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. PLoS Med 2007;4:e296.

17. Beighton P, Solomon L, Soskolne C. Articular mobility in an African population. Ann Rheum Dis 1973;32:413.

18. Bulbena A, Duró JC, Porta M, Faus S, Vallescar R, Martín-Santos R. Clinical assessment of hypermobility of joints: Assembling criteria. J Rheumatol 1992;19:115-22.

19. Carter C, Wilkinson J. Persistent joint laxity and congenital dislocation of the hip. Bone Joint J 1964;46:40-5.

20. Cheng JC, Chan PS, Hui PW. Joint laxity in children. J Pediatr Orthop 1991;11:752-6.

21. Subramanyam V, Janaki KV. Joint hypermobility in south Indian children. Indian Pediatr 1996;33:771-2.

22. Seçkin U, Tur BS, Yilmaz O, Yağci I, Bodur H, Arasil T. The prevalence of joint hypermobility among high school students. Rheumatol Int 2005;25:260-3.

23. Remvig L, Kümmel C, Kristensen JH, Boas G, Juul-Kristensen B. Prevalence of generalized joint hypermobility, arthralgia and motor competence in 10-year-old school children. Intern Musculoskelet Med 2013;33:137-45.

24. Romeo DM, Lucibello S, Musto E, Brogna C, Ferrantini G, Velli C, *et al*. Assessing joint hypermobility in preschool-aged children. J Pediatr 2016;176:162-6.

25. Butt HI, Tarar SH, Choudhry MA, Asif A, Mehmood S. A study of joint hypermobility in school children of Rawalpindi/Islamabad, Pakistan: Prevalence and symptomatic features. PJMHS 2014;8:372-5.

26. Morris SL, O'Sullivan PB, Murray KJ, Bear N, Hands B, Smith AJ. Hypermobility and Musculoskeletal Pain in Adolescents. J Pediatr 2017;181:213-0.

27. Gocentas A, Jascaniniene N, Pasek M, Przybylski W, Matulyte E, Mieliauskaite D, *et al*. Prevalence of generalised joint hypermobility in school-aged children from east-central European region. Folia Morphol (Warsz) 2016;75:48-52.

28. Öhman A, Westblom C, Henriksson M. Hypermobility among school children aged five to eight years: The Hospital del Mar Criteria gives higher prevalence for hypermobility than the Beighton score. Clin Exp Rheumatol 2014;32:285-90.

29. Clinch J, Deere K, Sayers A, Palmer S, Riddoch C, Tobias JH, *et al*. Epidemiology of generalized joint laxity (hypermobility) in fourteen-year-old children from the UK: A population-based evaluation. Arthritis Rheumatol 2011;63:2819-27.

30. Viswanathan V, Khubchandani RP. Joint hypermobility and growing pains in school children. Clin Exp Rheumatol 2008;26:962-6.

31. Hasija RP, Khubchandani RP, Shenoi S. Joint hypermobility in Indian children. Clin Exp Rheumatol 2008;26:146-50.

32. Verd SV, de Salva Mas J, Arboleda LG. Joint hypermobility in Palma school children. An Esp Pediatr 1991;35:17-20.

33. Ziaee V, Moradinejad M. Joint hypermobility in the Iranian school students. Pediatr Rheumatol 2008;6:P168.

34. Jamshidi AR, Shaeri HR, Akbarian M. Prevalence and features of joint hypermobility among school children in Tehran. Biol 2004;73:189-92.

35. Jindal P, Narayan A, Ganesan S, MacDermid JC. Muscle strength differences in healthy young adults with and without generalized joint hypermobility: A cross-sectional study. BMC Sports Sci Med Rehabil 2016;8:12.

36. Larsson LG, Baum J, Mudholkar GS. Hypermobility: Features and differential incidence between the sexes. Arthritis Rheum 1987;30:1426-30.