Original Research Article

Hamstrings muscles tightness in adolescences with a thoracic hyperkyphosis: Comparison of muscles flexibility and joint mobility in patients with scheuermann juvenile kyphosis versus postural thoracic hyperkyphosis

P Janusz[1*], K Politarczyk[1], M. Kozinoga[1], T Kotwicki[2]

[1]Spine Disorders Unit, Spine Disorders and Pediatric Orthopedics Department, Poznan University of Medical Sciences, 61-654 Poznan, ul. 28.Czerwca 1956r nr 135-147, Poland,
[2]Spine Disorders and Pediatric Orthopedics Department, Poznan University of Medical Sciences, 61-654 Poznan, ul. 28.Czerwca 1956r nr 135-147, Poland
Email: mdpjanusz@gmail.com

Abstract

Background: Thoracic hyperkyphosis is classified as non-structural or structural. The Scheuermann's disease (SD) is one of the most common structural spine hyperkyphosis in adolescents while postural hyperkyphosis (PHK) is non-structural. The tight hamstring muscles (HS) were reported in SD. **Aim:** The aim of this study was to evaluate the difference in muscles tightness and generalized joint hypermobility between the SD and PHK patients. **Material and methods:** The study group consisted of 40 SD patients (29 boys and 11 girls) in the age of 13.9 ±1.8 years. The control group consisted of 30 PHK patients (9 boys and 21 girls) in age of 13.0 ±2.1 years. The diagnosis was confirmed radiologically. The following measures were performed in clinical examination: sacral slope, lumbar lordosis, thoracic kyphosis, proximal thoracic kyphosis Th1-Th6, distal thoracic kyphosis Th6-Th12, popliteal angle (PA), fingertip-to-floor test (FTF), modified Thomas test, the gastrocnemius and the pectoralis major muscles flexibility tests. The angles were measured with Saunders digital inclinometer. The occurrence of generalized joint hypermobility (GJH) was evaluated using the Beighton scale. **Observations and results:** There were no significant differences of the sagittal spine alignment parameters. There were 2 cases of GJH in the PHK patients vs. 0 in SD patients, p=0.4906. The differences between SD patients vs. PHK patients were as follows: PA 51.9 ±8.3° vs. 46.7 ±11.6°, p=0.0262, FTF distance 13.1 ±11.3 vs. 6.8 ±10.1 cm, p=0.0189, Thomas test 57.8 ±6.2° vs. 58.6 ±7.1°, p=0.3205. The decreased flexibility of the pectoralis major and the gastrocnemius muscle was found in 60% vs. 53.3% and in 65% vs. 53.3%, p=0.6253 and p=0.2814, respectively. **Conclusions:** Patients with Scheuermann`s disease reveal more significant tightness of the hamstring muscles, than patients with postural hyperkyphosis. The generalized joints hypermobility is not common in patients with Scheuerman's disease.

Key Word: Scheuermann's disease, postural hyperkyphosis, hamstring muscles tightness, generalized joint hypermobility Scheuermann juvenile kyphosis

***Address for Correspondence:**
Dr. Piotr Janusz, Spine Disorders Unit, Spine Disorders and Pediatric Orthopedics Department, Poznan University of Medical Sciences, Poland 28 Czerwca 1956r nr 135, 61-545 Poznan, Poland
Email: mdpjanusz@gmail.com

Received Date: 04/01/2019 Revised Date: 23/01/2019 Accepted Date: 12/02/2019
DOI: https://doi.org/10.26611/1020924

Access this article online

Quick Response Code:

Website: www.medpulse.in

Accessed Date: 19 February 2019

INTRODUCTION

Good posture is a state of equilibrium of body segments, in a position of least effort and maximum support[1]. The most common disturbance of body posture in adolescence concerns the spine sagittal alignment[2,3]. Thoracic hyperkyphosis (increase in thoracic curve greater than normal range of 40°) is one of prevalent spinal disorders[2]. Biomechanical analysis reveals that an increase of thoracic kyphosis is associated with significantly higher spinal loads in upright stance. This might accelerate degenerative

How to site this article: P Janusz, K Politarczyk, M. Kozinoga, T Kotwicki. Hamstrings muscles tightness in adolescences with a thoracic hyperkyphosis: Comparison of muscles flexibility and joint mobility in patients with scheuermann juvenile kyphosis versus postural thoracic hyperkyphosis. *MedPulse International Journal of Orthopedics.* February 2019; 9(2): 41-46.
https://www.medpulse.in/Orthopedies/

process within the spine[4,6]. The disturbances of human posture can be classified as non-structural or structural[3]. The Scheuermann's disease (SD) is one of the most common causes of structural spine hyperkyphosis in adolescents[7]. The prevalence of SD is 0.4%–8% of growing population[8,10]. In the typical manifestation, the SD is localized in thoracic region of the spine and results in a stiff structural hyperkyphosis[10] by wedging of the anterior aspect of vertebral bodies[11]. The etiology is unclear even if several theories have been published[11]. One of the hypothetical etiological factor is the weakness of the vertebral endplate, possibly due to predisposing genetic background that influences the quality of matrix components (collagen types II and IX)[8,12]. Other authors describe abnormalities of cartilage, collagen fibrils and irregularity of mineralization and ossification of the vertebral endplates[13,14]. These observations suggest that genetic and/or metabolic predisposition together with mechanical stress of the anterior part of vertebral bodies may cause vertebral body deformation[15,16]. The diagnosis of SD is established and based on clinical and radiological presentation of the disease[11]. Most authors use the diagnostic criteria introduced by Sorensen [17] however, there exist other diagnostic classifications, differing by the number of affected vertebrae and additional findings, such as irregularities of the vertebral endplates, Schmorl nodes, narrowing of the disc spaces, and lengthening of the vertebral bodies in the sagittal plane[11]. Non-structural thoracic hyperkyphosis is more common in adolescents than the structural hyperkyphosis. It is often described as a postural hyperkyphosis (PHK) or „round back". The reported prevalence of PHK differs around the world. It is found in 7.5%-30% depending on the measures criteria and age of children[1,18,19]. The pathology usually consists of combination of an incorrect postural habit and muscles' hypo- or hyperactivity[3]. Radiographs reveal normal vertebral structure, however the thoracic kyphosis angle is increased[20]. At early stage the PHK can be corrected voluntarily by the patient and disappears spontaneously in the supine position. It may become stiffer with time[1,20,21]. PHK may be found in combination with increased lumbar lordosis. The clinical presentation of children with non-structural versus structural hyperkyphosis may be similar[3]. the tight hamstring muscles (semitendinous, semimembranous, and femoral biceps muscles) were reported in SD with the prevalence of 30% to 85%[20,22,24]. Fisk *et al*. suggested possible causative role of this finding in SD. According to Czaprowski *et al*. the hamstring muscles are not involved in PHK patomechanism or should be even lengthened in the PHK combined with increased lumbar lordosis[3].

AIM

The aim of this study was to evaluate the difference in muscles tightness and generalized joint hypermobility between SD and PHK patients.

MATERIAL AND METHODS

Retrospective analysis of patients attending physical therapy in one outpatient clinic from January 2016 to December 2018 was performed. Consecutive patients treated due to thoracic hyperkyphosis were evaluated. Patients underwent clinical and radiological examination. The Scheurmann group (SD group) consisted of 40 patients with radiologically confirmed SD and with thoracic kyphosis Th1-Th12 angle of more than 40°. The diagnosis of SD was made by an experienced orthopedic surgeon according to Sorensen`s criteria (wedging of at least 5° of three or more consecutive vertebral bodies) with additional findings such as irregularities of the vertebral endplates, Schmorl's nodes, narrowing of the disc spaces, and lengthening of the vertebral bodies in the sagittal plane[11,25].The postural hyperkyphosis group (PHK group) consisted of patients with kyphosis Th1-Th12 angle of more than 40°. The diagnosis of PHK was made by an experienced orthopedic surgeon. All patients included to the PHK group were free of radiological signs of SD or any other structural deformities of vertebral column (eg. congenital malformations, post-traumatic, idiopathic scoliosis, spondylolisthesis, tumors, tuberculosis). Clinical examination was performed by two observers (K.P. and M.K.) using structured charts for each patient. The sagittal spinal curvatures were measured in a spontaneous standing position, shoeless. The measures were performed using Saunders digital inclinometer (Baseline Digital Inclinometer, The Saunders Group Inc, Chaska, MN, USA). Sacral slope, lumbar lordosis, thoracic kyphosis, proximal thoracic kyphosis Th1-Th6 and distal thoracic kyphosis Th6-Th12 were evaluated as described by Czaprowski *et al.*[26]. The occurrence of the generalized joint hypermobility (GJH) was evaluated with the Beighton scale. The examination of the joint hypermobility at the wrist, fifth metacarpal phalangeal joint, elbow, knee and the lumbo-sacral spine was performed according to original description[27]. The Beighton scale is a nine-score rating and the cut-off of 5/9 or greater indicates GJH[28]. The muscles tightness was evaluated in:[1] hamstring, [2] iliopsoas,[3] pectoralis major and[4] gastrocnemius muscles. The measures were performed according to following description: - popliteal angle (PA) - was measured in a supine position with the one hip flexed to 90° and second leg extended. After assuming the position, the leg was slowly passively straightened. The angle missing to the full extension was measured in degrees. - Fingertip-to-floor test (FTF) - was performed according to description

provided by Czaprowski *et al.*[29] with the patient standing on a measurement box, shoeless. Then the patient bent forward with the knee joints extended. The distance from the fingertips to the level of the box was measured in cm. When the patients could not reach the level of the box negative values were noted, otherwise the result was positive. - the ilipsoas muscle tightness was evaluated with the modified Thomas test as described by Clapis *et al.*[30]. The results were described in degrees. - the gastrocnemius muscle tightness - was evaluated with the Silverskiold method. The test was performed in supine position. The dorsiflexion of the ankle joint was measured with the lower limbs extended. Than the same measurement was performed with the hip and the knee joints flexed to 90°. The test result was interpreted as positive when the ankle dorsiflexion with knee extended was <5° and improved to 10° with knee flexed, and negative otherwise[31]. the pectoralis major muscle tightness was evaluated in a supine position with fully flexed, externally rotated the shoulder joints and fully extended the elbow joints. The lumbar spine was lying flat on the table and knees flexed. The examiner pressed patient`s lower rib cage down. In this position the patient drops the arms down to the table level and remain in this position. If the patient was able to drop arms down to the table level and remain in this position, the result of the test was negative, otherwise it was positive[1]. In all bilateral tests the mean value was calculated. For each parameter, the mean values, standard deviation and the limit values were established. Normal distribution of data was analyzed with the Kolomogorov-Smirnov test. The data was compared with the Mann-Whithey test or the t-test were used to compare means and Chi^2 test was used to compare the distribution. The p-level of 0.05 was considered significant. The data was analyzed using the GraphPad In Stat software 3.06 (Graph Pad Software, San Diego, CA, USA).

OBSERVATIONS AND RESULTS

Forty patients were included to the SD group. There were 29 boys and 11 girls in the mean age of 13.9±1.8 years. Thirty patients were included to the PHK group. There were 9 boys and 21 girls in the mean age of 13.0±2.1 years, Table 1. There was not statistical significant difference for the sagittal spine alignment parameters, Table 1.

Table 1: Anthropometric description and the spinal sagittal parameters of the patients with Scheuermann`s disease vs. the patients with postural hyperkyphosis.

	Scheuermann's Disease	Postural hyperkyphosis	
	N=40 (Mean ±SD Min.-Max.)	N=30 (Mean ±SD Min.-Max.)	P-value
Age (years)	13.9±1.8 10-17	13.0±2.1 7-17	0.0769[1]
Gender female:male	11:29	21:9	**0.00082**[2]
Weight (kg)	57.9+16.5 33-90.5	49.5+14.8 22.5-86	0.0800[1]
Height (cm)	169.3+10.1 144-191	162.1+11.0 132-175	**0.0147**[1]
Kyphosis Th1-Th12 (°)	54.7+8.7 40-72	53.1+10.8 40-88	0.4824[3]
Kyphosis Th1-Th6 (°)	30.6+7.9 10-43	32.7+8.9 18-57	0.3140[3]
Kyphosis Th6-Th12 (°)	22.5+7.2 9-50n	20+9.2 3-42	0.0908[1]
Lordosis L1-S2 (°)	42.7+10.3 20-70	40.6+10.8 24-67	0.4337[3]
Sacral slope (°)	23.7+10.2 6-71n	22.9+7.8 9-38	0.8961[1]
Beighton	1+1.3 0 0-4	1.36+1.8 1 0-7	0.4906[1]
Beighton ≥ 5 points	0:40 (0%)	2:28 (6.6%)	

[1]Mann-Whithey test, [2] Chi^2 test, [3] t-test

Evaluation of the joint hypermobility revealed 2 cases of GJH in the PHK patients and 0 in SD patients. The difference was not significant, Table 1. The SD patients revealed significantly tighter hamstring muscles in PA test. The mean PA was bigger of 5.2° in SD patients, 0.0262, Table 2. The FTF distance was 6.3cm bigger in SD patients than in PK patients, p=0.0189, Table 2. There was no difference in Thomas test between the groups, Table 2.

Table 2: Evaluation of the muscles tightness in patients with Scheuermann`s disease vs. patients with postural kyphosis.

	Scheuermann's Disease	Postural hyperkyphosis	
	N=40 (Mean ±SD Min.-Max.)	N=30 (Mean ±SD Min.-Max.)	P-value
Popliteal angle (°)	51.9 +8.3 24-67	46.7+11.6 11.5-66	**0. 0262[1]**
Fingers-to-floor test (°)	13.1+11.3 (-12 - 41)	6.8+10.1 (-15 -29)	**0. 0189[2]**
Thomas test (°)	57.8+6.2 (30-72)	58.6+7.1 (42-71)	0. 3205[1]

[1]Mann-Whithey test, [2]t-test

The shortening of the pectoralis major muscle was found in 60% of SD patients vs. 53.3% PHK patients, 0.6253. The shortening of the gastrocnemius muscle was found in 65% of SD patients vs. 53.3% PHK patients, 0.2814. The significance of hamstring muscles tightness between the groups depends on the cut-off point value. The difference is insignificant between the groups for the cut-off point of 30° and 60°. However, it is significant for the cut-off point of 40° with p=0.0453 and 50° with p=0.0062, Table 3.

Table 3: Percentage of patients with the tightness of the hamstring muscles depending on cut-off point.

	Scheuermann's Disease	Postural hyperkyphosis	P-value
	N=40	N=30	
Cut-off value			
30°	97.5%	93.3%	0.5725
40°	92.5%	74.4%	**0.0453**
50°	75%	40%	**0.0062**
60°	15%	10%	0.7227

[1]Chi Square test

DISCUSSION

The hamstring muscles tightness is an important issue in SD treatment. It has negative effect on the conservative treatment as well as on the surgical treatment results. In both cases stretching therapy is needed to improve the treatment results[23,32,33]. The occurrence of this phenomenon is observed in SD; however, the reason of coexistence of the structural kyphosis and the hamstring muscles tightness remains unclear. This phenomenon was noticed in the in the thirties of the twentieth century and described by Lambrinudi[34]. Fisk *et al.* was the first who suggested that thigh hamstring muscles might be important factor in SD etiology. They performed a pilot study on 20 patients and the incidence of the hamstring muscles contractures was 85%[24]. In the other study, they revealed that 56% of males and 30% of females with the tight hamstring muscles presented signs of SD[35]. Murray *et al.* found the hamstring muscles tightness in 29% of examined patients witch SD. What is more, they found correlation of back pain with the hamstring muscles tightness[22.] Hoseman *et al.* described occurrence of the hamstring muscles tightness in 48.5% of SD patients. They associated the tight hamstring muscles with higher risk of the post-surgical imbalance in SD[23]. They proved, that the tightness of the hamstring muscles is not just an accompanying phenomenon, but it also may have important impact on the patients' health and the treatment results. Avanzi *et al.* evaluated group of 20 SD and 18 PHK patients. They found the hamstring muscles tightness in 85% of SD patients and in 83.3% of PHK patients[20]. All mentioned studies describe occurrence of the hamstring muscles tightness in SD patients based on the occurrence of the PA values above the cut-off point measured with a classical goniometer[20,22,24]. In this study we performed more comprehensive evaluation of the generalized muscles tightness and GJH. We do not only focus on the occurrence of the muscles tightness, but also we stratified it using angles measures. We have added FTF test which evaluate the hamstring muscle together with the spine and the gastrocnemius muscle flexibility [29,36] In the evaluation of the mean values of PA and FTF we have found significantly tighter the hamstring muscles in SD than in

PHK patients in each test. An interesting result revealed analysis of the occurrence of the hamstring muscles tightness. A high percentage of the muscle tightness in both groups was found when the most commonly used cut-off value of 30°[20,22,24]. It was much higher then described by Murray *et al*. or Hoseman *et al*. and close to results described by Fisk *et al*. or Avanzi *et al*.[20,22,24]. The difference was not significant between the groups for this cut-off value. Similar results were described by Avanzi *et al*., the high occurrence rate of the hamstring muscles in both groups without significant difference in the occurrence distribution[20]. However, when we decreased the cut-off point the significant difference in the distribution was noted. We have evaluated other muscles potentially involved in the postural control except the hamstring muscles. We did not found significant differences between the groups of the other evaluated muscles tightness. What is interesting, the occurrence of the gastrocnemius muscle and pectoralis major contractures were high in the both groups. The study revealed, that in the SD group there was no patient with GJH, when in the PHK group there were 2 cases (6.6%). The reports of the GJH differ significantly among publications from 7% to 36%, depending on gender, ethnicity, age and cut-off point[37]. The prevalence of GJH in the similar age group in this region is reported at the level of 9.5% of the population for a cut-off 5 points or more of the Beighton score[38]. In this study PHK patients revealed 2.9% lower prevalence of the GHJ, than is presented in the published data for the evaluated region for children in similar age[38]. The patients form the evaluated groups were in comparable age. It was important due to fact that muscles flexibility changes with age[20,37]. The weight was also similar, however, the patients from the SD group were taller, than the patients from the PHK group. The most important difference was noted in a gender distribution between the evaluated groups. In the SD group there was 2.6:1 in favor of males, whereas, the gender ratio was 1:2.3 in favor of females in the PK group. Murray *et al*. and Fisk *et al*. reported the similar ratio for the genders (around 2:1) in SD[22,24]. The groups did not differ significantly in the spinal sagittal parameters. Although, we have expected some differences, such a similarity makes the comparison more significant. It was not planed to select the patients according to in the spinal sagittal parameters at the study design stage. It confirms the opinion that the clinical presentation of children with non-structural versus structural disturbances of body posture may be similar[3]. The strong side of this study is that it is comprehensive analysis of the muscles tightness in SD. It gives additional information of the other muscles than the hamstring muscles, that were not evaluated yet. To our knowledge, this is the first study evaluating GJH in SD patients. The limitation of this study is the retrospective design. However, based on this study prospective study may be designed. What is more, the comparison with the healthy peers group would be interesting.

CONCLUSIONS

Patients with Scheuermann`s disease reveal more significant tightness of the hamstring muscles than patients with postural hyperkyphosis. High occurrence of the gastrocnemius muscle tightness was noted. The generalized joints hypermobility is not common in patients with Scheuerman`s disease.

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Source of Support: None Declared
Conflict of Interest: None Declared