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ORIGINAL PAPER

Angle of trunk rotation in children suffering from growth hormone deficiency

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ABSTRACT

Introduction: Growth hormone deficiency (GHD) can lead to musculoskeletal system defects. Treatment with recombinant human growth hormone (rhGH) in children suffering from GHD increases muscle mass and improves bone structure.

The purpose of this study was to evaluate the angle of trunk rotation (ATR) in patients diagnosed with GHD treated with rhGH and to observe the incidence of scoliosis.

Material and methods: The study was conducted among 50 children diagnosed with GHD. The group consisted of 11 girls and 39 boys, aged 6–16 years. The study group included 10 children who had recently qualified for the rhGH treatment and 40 patients undergoing this treatment, with different therapy durations. The angle of trunk rotation was measured using a Bunnell scoliometer. For the purposes of the study, each patient was measured at 5 levels: C7/Th1, Th6, Th12/L1, L3, and L5/S1.

Results: It was noted that in 10% of patients the ATR at the Th6 level was in the range 4-6°, at the Th12/L1 level 10% of children presented abnormalities in the range of 4-6° and at the L3 level 8% of patients, while at the L5/S1 level it was 5% of respondents. One person in the analyzed group (2%) presented ATR above 7° at the Th12/L1 level. Other levels tested in the research group remained within normal range. Girls had greater asymmetries compared to boys. There were no statistically significant differences in ATR comparing patients before hormonal treatment and patients undergoing rhGH treatment. The age of the beginning of the therapy, the duration of rhGH therapy, and body mass index (BMI) had no effect on ATR. Sport activities had a positive impact on the results obtained by scoliometer assessment.

Conclusions: The angle of trunk rotation is higher in growth hormone-deficient females. Weight, height, BMI, the time of growth hormone therapy beginning, and the duration of this therapy do not influence ATR. The more sports activities undertaken, the lower the value of the angle of trunk rotation. Treatment with rhGH does not increase the incidence of scoliosis.

KEY WORDS:

scoliosis, growth hormone deficiency, Bunnell scoliometer, recombinant human growth hormone.

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TABLE 1. Characteristics of the research group

Parameters	Girls (±SD)	Boys (±SD)	Total (±SD)
Numer of patients, *n* (%)	11 (22)	39 (78)	50
Body weight [kg]	31.7 ±12.2	35.5 ±14.6	34.7 ±14.1
Height [cm]	134.6 ±14.0	138.8 ±17.9	137.9 ±17.1
BMI [kg/m^2]	16.84 ±3.23	17.64 ±3.03	17.46 ±3.06
Age at the beginning the treatment (years)	8.64 ±2.59	8.03 ±2.49	8.16 ±2.5
The length of growth hormone treatment (years)	1.80 ±1.85	3.05 ±2.14	2.78 ±2.13
Sport (h)	3.09 ±3.33	3.43±4.08	3.36 ±3.89

BMI – body mass index

INTRODUCTION

Growth hormone affects the composition of the human body. People with growth hormone deficiency (GHD) present increased body fat mass and reduced lean body mass, including muscle mass [1]. The increase in muscle mass and bone structure improvement is observed, during the use of recombinant human growth hormone therapy (rhGH), which increases the patient's quality of life [2]. The other known effect of rhGH therapy was shown also in the psychoemotional sphere [3]. Thus, growth hormone plays a vital role in the composition and function of the body. It affects the skeletal system, stimulates bone growth and skeletal mineralization, and stimulates protein metabolism by the anabolic effect on skeletal muscles [4]. It also affects fat metabolism by stimulating lipolysis and reducing the percentage of fat in body composition. Growth hormone is also involved in carbohydrate metabolism and water-electrolyte balance [5].

Growth hormone therapy may be associated with some side effects in children [6, 7]. Several studies indicated that rhGH treatment might contribute to the worsening of scoliosis due to rapid, accelerated growth in a short time [8–12]. However, another study showed that the incidence of scoliosis in children treated with rhGH is similar to the prevalence of idiopathic scoliosis in the general population [13]. Whether growth hormone therapy may cause the risk of scoliosis is still discussed. Analysis of the literature does not show precisely whether the recombinant growth hormone is a risk factor for the occurrence of scoliosis.

The purpose of this study was to observe the incidence of scoliosis in patients diagnosed with GHD and treated with rhGH, and to evaluate the angle of trunk rotation. The next stage of the research will be the reassessment of the patients after 1.5 years of rhGH treatment with analysis of the changes that may appear in body posture.

MATERIAL AND METHODS

The study was approved by the Local Ethics Committee of the University of Medical Sciences (consent ref. no. 1107/17, 9 November 2017), and written consent was obtained before the procedure from all the parents or legal guardians.

CHARACTERISTICS OF THE STUDY GROUP

The study involved 50 children with short stature due to GHD. The group consisted of 11 girls and 39 boys, aged 6–16 years. The study group included 10 children recently qualified for the rhGH treatment and 40 patients undergoing this treatment, with different therapy durations. Data describing the group are presented in Table 1. The examination of the body posture was performed by the same person with a masters degree in physiotherapy, who completed specialized, international courses in diagnosing posture defects including scoliosis and having professional experience in working with patients.

Children diagnosed with GHD were qualified for the study. Patients with neurological deficits, genetic defects, orthopedic diseases or after invasive surgery, as well as patients with traumatic perinatal history were excluded.

Table 1 presents the characteristics of the group without age division and by gender, taking into account the average values of parameters such as body weight, height, body mass index (BMI), the age of starting treatment with recombinant growth hormone, duration of treatment, and the number of hours per week spent on sports.

THE RESEARCH

At the start of the study the parent/legal guardian was asked to complete a questionnaire in which personal data was provided and a perinatal interview completed, which included information regarding the number of hours spent on sporting activities, and the child's current state of health, such as chronic diseases, previous operations, and vision or hearing defects.

Weight and height were measured using a weighted medical height meter (Radwag 2006). Height measurement was made with an accuracy of 0.1 cm and body weight measurement up to 0.01 kg.

The angle of trunk rotation (ATR) was measured using a Bunnell scoliometer. This simple tool allows objective measurements to be made quickly and simply

TABLE 2. The number and percentage of children who presented different trunk rotation angles at the described trunk levels

Assessed level	Angle (°)	Total *N* = 50 (%)	Girls *n* = 11 (%)	Boys *n* = 39 (%)
C7	0–3	50 (100)	11 (100)	39 (100)
	4–6	0 (0)	0 (0)	0 (0)
	7 and more	0 (0)	0 (0)	0 (0)
TH6	0–3	40 (80)	8 (73)	32 (82)
	4–6	10 (20)	3 (27)	7 (18)
	7 and more	0 (0)	0 (0)	0 (0)
TH12/L1	0–3	39 (78)	7 (64)	32 (82)
	4–6	10 (20)	3 (27)	7 (18)
	7 and more	1 (2)	1 (9)	0 (0)
L3	0–3	42 (84)	8 (73)	34 (87)
	4–6	8 (16)	3 (27)	5 (13)
	7 and more	0 (0)	0 (0)	0 (0)
L5/S1	0–3	45 (90)	9 (82)	36 (92)
	4–6	5 (10)	2 (18)	3 (8)
	7 and more	0 (0)	0 (0)	0 (0)

[14, 15]. This plastic device contains a tube filled with liquid in which an indicator moves, similar to a spirit level. The graduated scale makes it possible to read the angle of trunk rotation. In the middle of the lower edge of the scoliometer there is a depression, which is placed in the level of the spinous process of the vertebra.

The spine was assessed in the transverse plane in a free-standing position, without shoes. The lower limbs were straight at the knee joints, and the feet were placed the width of the hips apart. During the examination, the patient bent forward at the trunk. The scoliometer was placed perpendicular to the long axis of the spine. The scoliometer was placed on the trunk without pressure [15, 16]. When the spine is symmetric, the scoliometer indicates a value of 0 degrees. The angle of trunk rotation can be measured at the largest asymmetry sphere of the spine or at different levels of the spine, which are, for example, the most common location for scoliosis [17]. For the purposes of the study, each patient was measured at 5 levels: C7/Th1, Th6, Th12/L1, L3, and L5/S1 according to the recommendations of the Functional Individual Therapy of Scoliosis (FITS) method. A scoliometer is a reliable tool for measuring vertebral rotation [18], which is recommended for scoliosis screening.

The following ranges of ATR were included:

- 0–3°– physiological asymmetry of the torso,
- 4–6° – necessity to repeat the test after 3-4 months,
- > 7° – may suggest scoliosis, an X-ray is recommended and a visit to an orthopaedist [19].

STATISTICAL ANALYSIS

Statistical analysis was performed using the statistical package Statistica 10 PL. The Mann-Whitney *U* test was used to determine the difference in the angle trunk rotation in the C7, Th6, Th12/L1, L3, and L5/S1 levels. Correlations between variables were determined by the significance test of Spearman's rank correlation coefficient. A p-value < 0.05 was considered statistically significant.

RESULTS

The children's angle trunk rotation was measured using a Bunnel scoliometer at C7/TH1, Th6, Th12/L1, L3, and L5/S1. The results are presented in Table 2. Only one girl had ATR above 7° at the thoracolumbar level. All children presented a normal level of the axial region of the cervical spine (ATR between 0 and 3°). A minority of the children presented ATR between 4 and 6°, especially in thoracolumbar and Th6 levels, which meant that they needed repetition of the examination between 3 and 4 months.

Table 3 shows the number of patients at the beginning of rhGH therapy, which presents a specific range of rotation angle measured at C7/TH1, Th6, Th12/L1, L3, and L5/S1.

Table 4 presents the average and mean value of angle trunk rotation at the 5 examined levels of the spine: C7/TH1, Th6, Th15/L5, L3, and L5/S1.

There were statistically significant differences in the ATR between girls and boys at Th12/L1 ($p = 0.0238$). The girls presented greater ATR comparing to boys (3.36 ±2.11° and 1.90 ±1.60°, respectively). The same difference was noted at the L3 level ($p = 0.0130$) – the ATR value at L3 was higher in girls than in boys (3.09 ±1.38° and 1.74 ±1.63°, respectively) (Table 5).

There were no statistically significant differences in the level of ATR between patients before and during treat-

TABLE 3. The number and percentage of children who presented various values of angle of trunk rotation depending on the age at start of recombinant human growth hormone treatment

Assessed level	Angle trunk rotation (°)	Total $N = 50$ (%)	Treatment before the age of 10 years $n = 26$ (%)	Treatment after the age of 10 years $n = 24$ (%)
C7	0–3	50 (100)	26 (100)	24 (100)
	4–6	0 (0)	0 (0)	0 (0)
	7 and more	0 (0)	0 (0)	0 (0)
TH6	0–3	40 (80)	20 (77)	20 (83)
	4–6	10 (20)	6 (23)	4 (17)
	7 and more	0 (0)	0 (0)	0 (0)
TH12/L1	0–3	39 (78)	21 (81)	18 (75)
	4–6	10 (20)	5 (19)	5 (21)
	7 and more	1 (2)	0 (0)	1 (4)
L3	0–3	42 (84)	21 (81)	21 (87)
	4–6	8 (16)	5 (19)	3 (13)
	7 and more	0 (0)	0 (0)	0 (0)
L5/S1	0–3	45 (90)	22 (85)	23 (96)
	4–6	5 (10)	4 (15)	1 (4)
	7 and more	0 (0)	0 (0)	0 (0)

TABLE 4. The average and mean value of the angle of trunk rotation at C7, Th1/Th6, Th12/L5, L3, and L5/S1

Angle of trunk rotation	*n*	Average value	SD	Mean value	Minimum	Maximum
C7/TH1 (°)	50	0.54	0.95	0.00	0	3
Th6 (°)	50	2.02	1.62	2.00	0	6
Th12/L1 (°)	50	2.22	1.81	2.00	0	8
L3 (°)	50	2.04	1.67	2.00	0	5
L5/S1	50	1.58	1.60	1.50	0	6

TABLE 5. The results of tests of significance in differences between boys and girls referring to the angle of trunk rotation

Angle of trunk rotation	Sex	*n*	Average value	SD	Mean value	Minimum	Maximum	*U*	*p*
C7/TH1 (°)	Girls	11	0.64	0.92	0.0	0	3	184.0	0.4823
	Boys	39	0.51	0.97	0.0	0	3		
Th6 (°)	Girls	11	2.18	1.54	2.0	0	5	196.0	0.6734
	Boys	39	1.97	1.66	2.0	0	6		
Th12/L1 (°)	Girls	11	3.36	2.11	3.0	0	8	117.5	0.0238*
	Boys	39	1.90	1.60	2.0	0	5		
L3 (°)	Girls	11	3.09	1.38	3.0	1	5	108.0	0.0130*
	Boys	39	1.74	1.63	1.0	0	5		
L5/S1 (°)	Girls	11	2.27	1.90	2.0	0	6	154.5	0.1635
	Boys	39	1.38	1.48	1.0	0	6		

p – probability level, SD – standard devision, U – Mann-Whitney U test statistic value
**Statistically significant, $p < 0.05$*

ment: C7/Th1, Th6, Th12/L1, L3, and L5/S1 ($p > 0.05$). No such differences were found after the analysis of the study group by gender.

There are no statistically significant correlations between body weight, height, and BMI and ATR ($p > 0.05$). No such differences were found after the analysis of the study group by gender.

There are no statistically significant correlations ($p > 0.05$) between the growth hormone treatment duration and the angles at C7/TH1, Th6, Th12/L1, L3, and L/S1 in patients. No such differences were found after the analysis of the study group by gender.

There are no statistically significant correlations ($p > 0.05$) between the age at the beginning of growth hormone therapy and ATR at C7-Th1, Th6, Th12/L1, L3, and L5/S1. No such differences were found after the analysis of the study group by gender.

After analyzing the data, it was seen that sporting activities affect body posture. In boys, significant correlations occurred between the number of hours per week spent on sports and ATR at Th6 and Th12/L1 – a negative correlation. The more hours boys spent doing sports, the smaller the ATR at Th6 and Th12/L1. There was no such relationship in the female group. Perhaps this is due to the small number of girls in the study group. In addition, the average number of hours per week spent on sports was higher for boys than for girls. However, this difference was not statistically significant.

DISCUSSION

The study presents, for the first time, the measurement of the ATR in children with diagnosed GHD. The measurement was performed at 5 levels: C7/Th1, Th6, Th12/L1, L3, and L5/S1. It was noted that in 10% of patients, ATR at the Th6 level was in the range 4-6°, and for the same values at the Th12/L1 level 10% of children presented abnormalities in the range of 4-6°, at the L3 level 8% of patients, and at the L5/S1 level 5% of respondents. One person in the analyzed group (2%) presented ATR above 7° at the Th12/L1 level – this result suggests scoliosis and requires a further therapeutic approach. Other levels tested in the research group remained within the normal range (0–3°). According to interviews with parents, no one reported scoliosis.

It is estimated that idiopathic scoliosis occurs in about 4% of healthy children. It seems that the treatment with recombinant growth hormone does not increase the incidence of scoliosis but may affect its progression [20]. However, the present study did not show the progression of scoliosis during GHD. There was no correlation between the time of start of growth hormone treatment and the value of the angle of trunk rotation. Perhaps this was because of the small group of examined children and the presence of posture control by doctors and physiotherapists in the examined group. The authors plan to control body posture in the examined patients in order to monitor if the ATR progresses.

Available publications show that patients with Turner's syndrome (Ts) who also suffer from short stature are particularly at risk for scoliosis. The National Cooperative Growth Study conducted a study on patients with Ts on the safety of using recombinant growth hormone therapy and found that scoliosis was more common in growth hormone-treated patients compared to other patients without Ts [21]. Other authors examined 43 girls with Ts and found scoliosis in 11.6% of the girls, which is definitely a higher frequency than in the healthy population [22]. Patients suffering from Prader-Willi syndrome are also at increased risk of scoliosis [23, 24].

Yun *et al*. conducted observations to investigate the effect of recombinant growth hormone therapy on the spine. The study group consisted of patients with idiopathic short stature, while the control group consisted of patients with idiopathic scoliosis. Using the X-ray image, among others, Cobb angle. An annual increase in the angle of 1° was observed in patients from the study group, while in the control group no significant changes were noted during the year. Girls showed a larger Cobb angle compared to boys. Studies showed that growth hormone therapy in patients with idiopathic short stature might affect the progression of the Cobb angle. It should be a broadened procedure to control posture as an important element of typical examination in patients undergoing rhGH treatment [8].

In the study group, a higher ATR was noted in girls compared to boys. A similar relationship is described by Yun *et al.* [8].

Gender may influence the appearance of scoliosis, as researches from Poland also showed. There is an interdependence between the concentration of oestradiol and the development of scoliosis [25, 26]. These showed the coincidence of scoliosis in the female population in general.

There were no statistically significant differences in ATR between patients before treatment and patients during the treatment reagrding C7-Th1, Th6, Th12/L1, L3, and L5/S1. According to data analysis, also the age at the beginning of growth hormone treatment did not affect the size of the ATR measured in patients. The literature shows that the growth rate can influence the progression of scoliosis [27].

There are also no statistically significant correlations between body weight, height, and BMI and angles at C7/Th1, Th6, Th12/L1, L3, and L5/S5. Similar relationships regarding the occurrence of scoliosis and the BMI were observed by Wilczyński [28].

The authors showed the relationship between the number of hours per week spent on sports and ATR values, especially in the male group. The more time boys devoted to sport, the smaller the observed values of ATR in the thoracic and lumbar-thoracic levels. It seems advis-

able to promote physical activity in children with GHD treated with rhGH, as in some other health disorders during childchood [29, 30].

There is a need to control body posture in short-stature patients treated with rhGH and also in the general population. We plan to re-examine the ATR among our study group after 1.5 years of growth hormone therapy to analyze the changes in body posture together with anterior-posterior spinal curvatures [31]. We plan to make the further examination in a larger group of patient, which we will divide into age ranges in order to check how the rhGH works before and after puberty.

CONCLUSIONS

The angle of trunk rotation is higher in growth hormone-deficient females than in males. Weight, height, and BMI do not influence the angle of trunk rotation in children with GHD. It also does not depend on the time of start of growth hormone therapy and the duration of this therapy. The more sporting activities are undertaken, the lower the ATR, especially in boys. It seems advisable to promote physical activity in this group of patients.

The obtained results support the thesis that treatment with rhGH does not increase the incidence of scoliosis. Nonetheless, it is necessary to re-examine the same patients after long-term growth hormone therapy to clearly verify whether this treatment causes changes in the angle of trunk rotation.

DISCLOSURE

The authors declare no conflict of interest.

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