The correlation between the pelvic movement symmetry during motion, as well as body mass and the alignment of the knees of schoolchildren

Symetria i zakres ruchu miednicy w chodzie a status masy ciała i ustawienie kolan u dzieci w wieku szkolnym

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C – przeprowadzenie analizy statystycznej
D – interpretacja wyników
E – przygotowanie manuskryptu
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Abstract

Introduction: Body posture, including the alignment of the knees, as well as being overweight or obese, has a measurable influence on the way one moves. Most of the somatic and motor dysfunctions, which are often a problem for adults, originated in their childhood. Ailments regarding motor functions among adults are often a consequence of a previously overlooked or untreated dysfunction. Children and teenagers are a large group of patients suffering from dysfunctions of such type. The goal of this research was to assess the degree of influence being overweight or obese and having valgus knees has over children's pelvic movement symmetry during motion.
Materials and methods: 192 primary school students, aged 11-13, from Tarnow and its surrounding areas took part in the study. The alignment of their lower limbs was realised through measuring the distances between their medial malleoli, while standing up, with legs joined at knees. The pelvic movement symmetry while walking was tested with the BTS G-Walk device.
Results: Boys have been diagnosed with having excessive body weight and valgus knees alignment more often than girls. A crucial correlation between being overweight or obese and having valgus knees was noted. A notable difference in the pelvic movement symmetry during motion between overweight or obese children and those with correct body weight, as well as between children with valgus and correct knees alignment has been determined. Studying the correlation coefficient has shown that BMI is more relevant than knee alignment to the problem in question.
Conclusion: Gait re-education should be a part of kinesitherapy both for the children with valgus knees and those with excessive body weight.

Keywords: knees misalignment, excessive body weight, pelvic movement, gait

Introduction

Most of the somatic and motor dysfunctions that are often a problem for adults originated in their childhoods. The pain in the motor system some adults feel is often an effect of undiagnosed or untreated faulty body posture and movement disorders. Unfortunately, faulty posture and the associated movement dysfunctions are common among children and teens. Misalignment of the lower limbs are a large part of faulty postures.

Currently, common sedentary lifestyle, hypokinesia, and the lack of proper posture habits, e.g. while sitting down, have a negative influence on the performance of a locomotor system. In consequence, the body posture deteriorates, the muscles weaken, the general body fitness lowers, the drive for physical activity vanishes and the fat tissue increases [1–3].

The correlated and frequently co-occurring faulty posture and excessive body weight negatively influence the motoric

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abilities, e.g. the gait pattern. Gait is described as *the rhythmic losing and regaining of balance in the altering phases of bracing and relocating* [4]. Correct gait should be regular, aesthetic, and dynamic, with a moderate energy use [5, 6].

The goal of the study and the research questions

The main goal of the study was an analysis of the correlation between the pelvic movement symmetry during motion and the status of body mass, as well as the knee alignment of schoolchildren. The following research questions were asked:

1. What is the frequency of overweightness and obesity among the studied population?
2. What is the frequency of genu valgum (knock knees) and genu varum (bandy-legs, bowlegs) among the studied population?
3. Are there any notable correlations between body weight, BMI, and the alignment of the knees?
4. Is the pelvic movement symmetry during motion largely affected by the improper body weight or the abnormal alignment of knees?

Materials and methods

192 children (108 girls and 84 boys), aged 11–13, from Tarnow and its surrounding areas, participated in the study. It was conducted in the first quarter of 2019. Each of the children was healthy and had no contraindications towards physical activity. The study was affirmed by written consent from all the parents and headmasters of the schools attended by the children. The measurements were made in accordance with the guidance provided by World Health Organisation with special care towards the participants' comfort, as well as reliability of the measurements.

Body height has been measured using a calibrated anthropometer accurate to within 1mm, and body mass with a TANITA scale accurate to within 0.1kg. The collected data have been used to calculate BMI and allowed to estimate the status of body mass according to threshold values of excessive weight and obesity diagnosis among children devised by Cole et al. [7].

The alignment of the knees was measured with a centimetre tape. Genu valgum has been diagnosed when the intermalleolar distance (IMD), measured in the standing position with the knees joined, was longer than 5cm. None of the participants has been diagnosed with genu varum (intercondylar distance (ICD), measured in the standing position with the feet kept together, did not exceed 5cm).

The symmetry of the movement of the pelvis while walking has been examined using BTS G-Walk device, which is an easy-to-use, an objective tool that allows obtaining quantitative information about the movement of the right and left side of the pelvis in three planes. G-Walk is a small device placed on the patient's body at L5 height (Fig. 1). A description of the device can be found on the website of its distributor, Technomex: https://technomex.pl/ru/analiza-ruchu/bts-g-sensor-komputer

A statistical analysis has been conducted in the Statistica v13 program. Basic descriptive statistics, frequency tables, Shapiro-Wilk test (normal distribution test), t-Student's test for independent samples (for normally distributed variables), Mann-Whitney U test (when the distribution of variables differed from normal), and Spearman's rank order correlation (for estimating the relationship between variables) were used. The significance level was set at $\alpha = 0.05$.

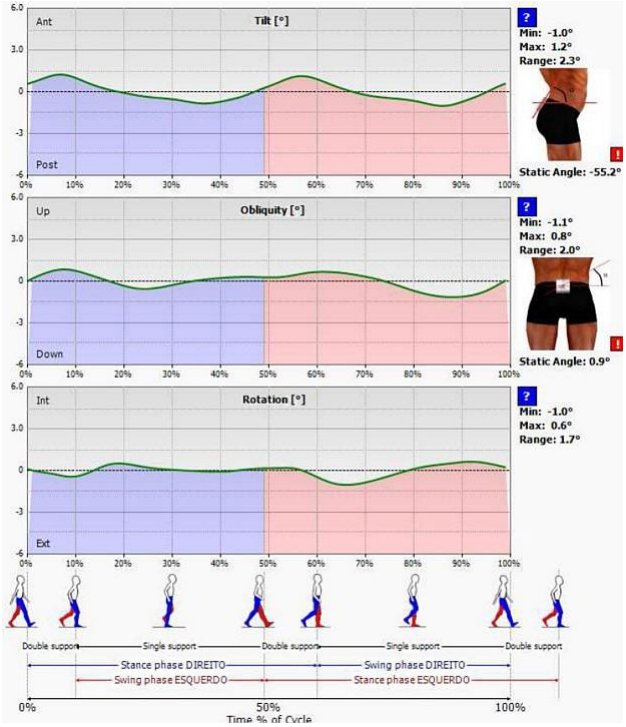

Figure 1. The analysis of the pelvic movement in three planes, the report from the examination with the G-Walk device (source: https://technomex.pl/sprzet-diagnostyczny/analiza-ruchu/g-sensor).

Results

19% of the girls and 38% of the boys that participated in the study have been diagnosed with excess weight (Tab. 1). Genu valgum has also been observed to occur twice as often among boys, but it is more likely to affect overweight children of both genders. A statistically significant difference ($p<0.001$) in BMI has been noted between children with correctly aligned (mean BMI=18.18kg/m^2) and valgus knees (mean BMI=22.19kg/m^2).

Table 2 shows the results of the comparison of the characteristics describing the movement of the pelvis during walking among non-overweight and overweight children. A significantly higher general coefficient of the symmetry of the movement of the pelvis has been noted for non-overweight children. Greater range of movement of the right side of the pelvis in the sagittal

Table 1. Gender, the status of the body mass, and setting of the knees of the participants

Sex	Body mass	Correct knee alignment	Valgus knee alignment	The sum in a row
Girls	Normal weight	80 91.95%	7 8.05%	87
	Excess weight and obesity	13 61.90%	8 38.10%	21
	Total	93 86.11%	15 13.89%	108
Boys	Normal weight	48 92.31%	4 7.69%	52
	Excess weight and obesity	13 40.63%	19 59.38%	32
	Total	61 72.62%	23 27.38%	84
	The sum in a column	154	38	192

Table 2. Symmetry and range of movement of the pelvis during walking in the participants with normal and excess body weight

Symmetry of the movement of the pelvis in gait	Normal body weight (n=139)		Excess body weight (n=53)		p
	Mean	SD	Mean	SD	
A general coefficient of symmetry [%]	97.56	3.77	96.40	2.96	0,044*
Coefficient of the symmetry of movement in the sagittal plane [%]	67.95	25.39	75.50	22.17	0,058
The range of pelvic movement in the sagittal plane – left side [°]	3.20	7.98	3.65	1.33	0,680
The range of pelvic movement in the sagittal plane – right side [°]	2.52	1.23	3.69	1.33	<0,001*
Coefficient of the range of pelvic movement in the frontal plane [%]	96.57	11.61	96.90	3.95	0,842
The range of pelvic movement in the frontal plane – left side [°]	5.13	2.18	4.46	1.83	0,048*
The range of pelvic movement in the frontal plane – right side [°]	5.21	2.21	4.51	1.87	0,042*
Coefficient of the symmetry of movement in the horizontal plane [%]	97.56	3.77	96.17	7.84	0,217
The range of pelvic rotation in the horizontal plane – left side [°]	11.91	5.32	14.24	5.35	0,007*
The range of pelvic rotation in the horizontal plane – right side [°]	12.16	5.37	14.49	5.70	0,009*

*statistically significant differences

plane, lower range of movement of the right and the left side of the pelvis in the frontal plane, and greater range of rotation of the right and the left side of the pelvis among overweight children have been observed.

Children with correct knee alignment had a significantly higher overall pelvic movement symmetry coefficient compared to children with valgus knees (Table 3). On the other hand, the pelvic movement symmetry coefficient in the sagittal plane was greater in children with valgus knees. Girls and boys with valgus knees also had a greater range of motion of the right side of the pelvis in the sagittal plane and a greater range of rotation of the right and left side of the pelvis.

The research on the correlation between variables has shown a significant but weak relationship between BMI and the overall movement symmetry coefficient of the pelvis during motion, the range of motion of the right and left side of the pelvis in the sagittal and frontal plane, and the pelvic movement symmetry coefficient in the frontal plane (Table 4).

Since BMI significantly differentiated children with correct and valgus knee alignment, the correlation between the distance between medial and alternating ankles, the latter of which describe the pelvic movement during motion, was researched separately for children with correct and valgus knees. It was done to evade any research bias. Among children with correct knee

Table 3. The symmetry and range of pelvic movement during motion, in participants with correct and valgus alignment of knees

Pelvic movement symmetry during motion	Correct knee alignment		Valgus knee alignment		p
	Mean	SD	Mean	SD	
Overall symmetry coefficient [%]	97,50	3,66	96,17	3,16	0,040*
Movement symmetry coefficient in the sagittal plane [%]	67,52	25,98	80,22	15,28	0,004*
The range of motion of the pelvis in the sagittal plane – left side [°]	3,22	7,59	3,76	1,21	0,664
The range of motion of the pelvis in the sagittal plane – right side [°]	2,61	1,30	3,80	1,16	<0,001*
Movement symmetry coefficient in the frontal plane [%]	96,75	10,92	96,32	5,54	0,815
The range of motion of the pelvis in the frontal plane – left side [°]	5,04	2,12	4,55	2,03	0,196
The range of motion of the pelvis in the frontal plane – right side [°]	5,12	2,18	4,58	1,93	0,166
Movement symmetry coefficient in the transverse plane [%]	93,78	14,49	96,17	6,23	0,321
The range of rotation of the pelvis in the transverse plane – left side [°]	12,13	5,18	14,28	6,02	0,027*
The range of rotation of the pelvis in the transverse plane – right side [°]	12,23	3,66	15,10	5,67	0,004*

*statistically significant differences

Table 4. Correlation between BMI and variables describing the pelvic movement symmetry during motion (Spearman Rank Order Correlations)

Variables correlated with BMI	Spearman R	t(N-2)	p-value
Overall symmetry coefficient [%]	-0,283	-4,049	<0,001*
Movement symmetry coefficient in the sagittal plane [%]	0,113	1,569	0,118
The range of motion of the pelvis in the sagittal plane – left side [°]	0,338	4,924	<0,001*
The range of motion of the pelvis in the sagittal plane – right side [°]	0,337	4,913	<0,001*
Movement symmetry coefficient in the frontal plane [%]	-0,192	-2,685	0,007
The range of motion of the pelvis in the frontal plane – left side [°]	-0,161	-2,245	0,025
The range of motion of the pelvis in the frontal plane – right side [°]	-0,166	-2,321	0,021
Movement symmetry coefficient in the transverse plane [%]	0,125	1,733	0,084
The range of rotation of the pelvis in the transverse plane – left side [°]	0,119	1,645	0,101
The range of rotation of the pelvis in the transverse plane – right side [°]	0,121	1,465	0,091

*statistically significant correlations

alignment, an important albeit weak correlation between intermalleolar distance and the overall pelvic movement symmetry coefficient (R=0.21; p=0.009) was noted. In children with valgus knees, an important albeit still weak correlation between intermalleolar distance and the range of motion of the left side of pelvis in the sagittal plane (R=0.27; p=0.04) was noted.

Discussion

Excessive body weight among children is a serious problem confirmed by numerous studies [8–11]. The presented research also shows that excessive body weight is characteristic of a significant percentage of 11–13-year-old children. Social campaigns, health education, and projects encouraging teenagers to systematically exercise seem to be inefficient in this regard. Obese children are likely to grow up into obese adults who will develop the metabolic syndrome. Excessive body weight is also associated with the risk of developing faulty posture and, consequently ailments of the musculoskeletal system.

Until now, many studies to assess the defects of the lower limbs and the factors influencing their formation have been conducted. In Tarnow, a research on a group of 100 children was conducted. 11 cases of severe valgus and 5 cases of genu varum were reported among the participants. In each age group, there were 8 cases of excess weight and 6 cases of obesity in total. Significant relationships were found between the BMI value and the position of the knees. The result indicated that the increase in body weight was accompanied by an increased risk of knee defects [12]. In other studies carried out in Tarnow, the influence of excess body weight on the occurrence of the defects of the lower limbs in children aged 9–11 years was confirmed. 160 children from various primary schools in Tarnow took part in the research. When analyzing the results, height and weight, body fat content, knee position and longitudinal arch of the feet were taken into account. The results showed that 27% of students were overweight, 56% of whom were diagnosed with valgus knees [13].

The posture characteristics of 786 children from Wroclaw aged 7–15 were presented by Andrzejewska and Grabarczyk [14]. They showed that valgus knees were most common in the group of 11-year-olds (22.7% girls and 20.8% boys), while varus knees were most often diagnosed in 14-year-old boys (19.1%) and 15-year-old girls (11,9%).

Most researchers believe that knee defects spontaneously correct with age and the vast majority of patients do not require invasive treatment (and sometimes do not even require kinesiotherapy) [15]. However, studies conducted at Baqai Medical University show that in 25% of children with knee defects, a spontaneous correction does not occur, and in 4% of patients, conservative treatment does not bring improvement [16].

Gait symmetry has been repeatedly tested in children with cerebral palsy [17–19], autism [20], Down syndrome [21], and other chronic diseases. Symmetry and gait strategy were also studied among overweight and obese people [22–24]. Parameters other than those in the presented work have often been tested. The most common analyzes were symmetry for step and stride or single and double support phase, although there is no research on the interrelationship between excess weight and obesity, knee defects and symmetry of pelvic movement in gait. Due to the lack of scientifically proven evidence, re-education is not included in the kinesiotherapy process of children with abnormal body weight and is often omitted in the correction of the knee position (therapists limit themselves to correcting the position of the lower limbs in static positions). Meanwhile, our research shows that excessive body weight and valgus position of the knees significantly affect the symmetry and range of pelvic movement while walking. There is a reduction in the overall symmetry coefficient, an increase in the range of pelvic motion in the sagittal and the horizontal planes, and a reduction in the range of pelvic motion in the frontal plane. However, it should be noted that the presented studies have some limitations: they were conducted locally and the knee positioning was assessed using a very simple clinical method. It would be interesting to extend these studies to a wider population and to investigate the relationship between the symmetry of pelvic movement in gait and the Q angle, which shows the axis course of each of the lower limbs separately. Nevertheless, the presented research seems to be a new voice in a significant discussion.

Conclusion

1. Excessive body weight occurs in a significant percentage of 11–13-year-olds, clearly more often in boys. Knee valgus is characteristic of less than 8% of 11–13-year-olds with normal body weight and 51% of their peers with excess body weight.
2. Both knee valgus and excess body weight affect the gait pattern by altering the symmetry factor and the range of pelvic motion.
3. Assessment and re-education of gait should be included in the kinesiotherapy of children with excess body weight and/or valgus knee positioning.

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Streszczenie

Wstęp: Postawa ciała, w tym ustawienie kolan, oraz nadmierna masa ciała mają wymierny wpływ na sposób poruszania się człowieka. Większość dysfunkcji somatycznych i motorycznych pojawiających się w wieku dojrzałym ma swoje podłoże w wieku dziecięcym. Pojawiające się u osób dorosłych dolegliwości narządu ruchu często są skutkiem niezauważonych lub nieleczonych wcześniejszych dysfunkcji. Liczną grupę pacjentów z zaburzeniami układu ruchu stanowią dzieci i młodzież. Celem pracy była ocena wpływu nadmiernej masy ciała i ustawienia koślawego kolan na symetrię i zakres ruchu miednicy w chodzie u dzieci.

Materiał i metody: W badaniu uczestniczyło 192 uczniów szkół podstawowych w wieku od 11 do 13 lat z okolic miasta Tarnowa. Oceniono ustawienie kończyn dolnych mierząc odstęp pomiędzy kostkami przyśrodkowymi w pozycji stojącej ze złączonymi kolanami. Symetrię ruchu miednicy w chodzie zbadano za pomocą urządzenia BTS G-Walk.

Wyniki: Nadmierną masę ciała, podobnie jak koślawość kolan, częściej diagnozowano u chłopców. Zanotowano istotny związek pomiędzy nadwagą i otyłością a koślawością kolan. Stwierdzono również istotną różnicę w symetrii i zakresie ruchu miednicy w chodzie pomiędzy dziećmi z prawidłową i nadmierną masą ciała oraz pomiędzy dziećmi z prawidłowymi i koślawymi kolanami. Badanie współczynnika korelacji pokazało, że większy wpływ na ruch miednicy w chodzie ma BMI niż ustawienie kolan.

Wnioski: Reedukacja chodu powinna być elementem kinezyterapii zarówno dzieci z koślawym ustawieniem kolan, jak i dzieci z nadmierną masą ciała.

Słowa kluczowe: wady kolan, nadmierna masa ciała, ruch miednicy w chodzie