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PHYSICAL ACTIVITY AND COMPENSATION OF BODY POSTURE DISORDERS IN CHILDREN AGED SEVEN

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Abstract
Introduction. Physical activity is an indelible part of human life, but the impact of industrial changes on society has led to a hypokinetic lifestyle not only in adults but also in children and youth. This paper aims to present the results of a study of the body posture of 7-year-olds, which is an essential part of their physical development evaluation. The aim of our study was to expand our knowledge of the occurrence of body posture disorders in 7-year-olds, as well as to develop an appropriate movement programme which would help improve the current situation. ***Material and methods.*** The research sample consisted of 393 first-graders from 4 grammar schools in Kosice. We used muscle testing according to Janda and Tichy to obtain data on individual muscle weaknesses and postural deviations. ***Results.*** Our research confirmed the findings of several other researchers who had pointed out that muscle weaknesses and postural deviations can be observed already in preschoolers. Due to a lack of physical activity and movement, muscle weakness in preschool children results in more serious health issues at school age and later in adulthood. ***Conclusions.*** We managed to stabilise and even to correct the weaknesses we observed by implementing a movement programme focusing on the diagnosed muscle weakness.

Key words: preschool age, lack of physical activity, movement programme, muscle imbalance, body posture assessment

Introduction

Movement or physical activity is part of the lives of all living organisms, and it is one of the basic human needs and expressions. One related key need is our need to take care of our health. This is where regular and adequate physical activity, which may have different forms, plays an integral part. As Vystrcilova-Kacmar [1] observed, even though physical activity was one of the human organism's development and vitality factors during phylogeny [2], the most common position of the body found in adults nowadays is sitting. Several other studies [3, 4, 5, 6] confirm the predominance of passive activities in children's lives, compared to active leisure activities. The fact that the volume of physical activity in the lives of children and youth has recently fallen under the level characterised as the biological need is also linked to that [7, 8]. The constant increase in the standard of living allows for different ways of using one's free time, in which physical activity should be adequately represented. The hypokinetic lifestyle is one of the causes of the ever growing number of orthopedic disorders (incorrect body posture, flat feet) as well as obesity in preschoolers [9, 10, 11, 12, 13, 14, etc.]. These disorders can be prevented with good nutrition, a sufficient amount of time spent outdoors, and appropriate physical activities. Our research has focused on 7-year-olds who had just started school.

In emphasising the importance of adequate physical activity, it is advisable to make use of the natural need of a child to move, which should be deliberately and constantly stimulated [8]. Considering children's age, physical education (PE) classes aimed at positively influencing their physical and mental health, functional and movement development, as well as shaping their psychological, intellectual, and moral qualities play a key role in this process [15]. Making sure that these basic functions of PE are fulfilled is a prerequisite for the adequate development of a child's organism; what they learn may become part of their healthy lifestyle and aid their proper integration into society [16]. The movement programme we had chosen became part of the PE curriculum at four schools.

The aim of the study was to expand our knowledge about the current situation regarding children's body posture. We also explored the possibilities of correcting the disorders existing in 7-year-olds through the movement programme we chose and implemented.

Material and methods

We collected and processed data concerning 393 participants over the course of four years. The participants were 7 years old and they were first-graders from 4 grammar schools in Kosice. The schools were selected randomly based on the interest in the research expressed by the heads of the schools we approached. The research was focused on finding shortened and weakened muscles – muscle imbalances that are associated with incorrect body posture and body posture disorders, which are occurring in young school children more and more frequently. At the beginning of our research, we approached several grammar schools, four out of which agreed to participate in the study. However, the majority of them were not willing to dedicate more than a few PE classes to the research. Therefore, the number of schools participating in the research gradually decreased.

During school year 2011/2012 (data set S1), 161 pupils from 4 grammar schools in Kosice were tested. Since in this part of

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the research the pupils were tested only before the movement programme was designed, we consider this part of the study pilot research. We focused here on the occurrence of shortened and weakened muscles and postural disorders, and we made several positive findings. In this year of research, the movement programme was implemented for 1 month, and the pupils participated in it twice a week during their PE classes. The research was of a fact-finding nature: it allowed us to determine the level of muscle imbalance in children in the first years of elementary school, and it made it possible for the parents and teachers to form an accurate picture of their children's health in terms of their posture.

In the second year of our research, school year 2012/2013 (data set S2), we tested 114 pupils from 3 grammar schools. The initial assessment for S2 was carried out in October. Subsequently, the movement programme was implemented for 16 weeks, once a week in the third PE class, under the supervision of an instructor. After implementing the movement programme, the final assessment was carried out in April 2013.

Only two of the schools we approached continued cooperating with us and were in favour of the project and its continuation throughout the school year. The movement programme was implemented during the school year, beginning with the initial assessment in October, up to the final assessment in June. School year 2013/2014 (data set S3, n = 65) was the third year of our research, which lasted from 1st October 2013 to 29th June 2014. In the fourth year of our research, school year 2014/2015 (data set S4), 53 children were tested, and the movement programme was implemented from 29th September 2014 to 26th June 2015. Both groups of children took part in 25 hours of the movement programme, which was carried out once a week in the third PE class, under the supervision of an instructor.

The research activity always consisted of three parts:

1) initial assessment of muscle imbalances and body posture;
2) movement programme implementation;
3) final assessment of muscle imbalances and body posture.

The movement programme was designed based on the findings of the initial assessment carried out in S1 in 2011, as well as the assumptions made based on practice and the outcomes of other authors' work [6, 17, 18, 19, 20, 21, 22]. Considering the age of the movement programme participants, we tried to simplify the process of remembering the exercises and to make the PE classes more interesting. For this purpose, we chose pictures of animals that the children then imitated. The programme lasted for about 25-30 minutes given that the participants knew the routine. It comprised 11 exercises organised according to the following structure: 4 compensatory relaxation exercises, 4 compensatory stretching exercises, and 3 compensatory toning exercises. The exercises were arranged in accordance with principles mentioned by other authors [23, 24, 25, 26] in the following way: the relaxation exercises were preceded by stretching exercises followed by toning exercises. In the case of relaxation exercises, we focused on the lower, middle, and upper parts of the lumbar spine – the L1-L3 and Th-l segments, which are critical; this is where low thoracic spine mobility is combined with high lumbar spine mobility [27]. The exercises comprised 4 basic types of movement (flexion, extension, lateral flexion, and rotation) that are carried out in high squat on outstretched hands. The relaxation exercises according to Kaltenborn [28] were carried out in 4 different positions depending on the part of the spine where the blockage occurred. The exercises were performed slowly, fluently, and in the correct body position. Fast movements are not recommended as they can have the opposite effect: they can cause a reflexive contraction of the muscles. We used a cat and a dog as models in our programme. Most stretching exercise programmes recommend stretching the shortened muscle for 6-30 seconds. Due to ongoing debates about appropriate methods, we used the model by Alter [29], who recommends repeating each exercise 2-3 times for 10 seconds or one stretch for 20-30 seconds. We used the one 30-second stretch variant focusing on stretching the identified shortened muscles: m. triceps surae (Ts) – monkey, m. biceps femoris (Bf) – monkey, m. adductores (Add) – monkey, m. pectoralis major (Pm) – butterfly, and m. rectus femoris (Rf) – stork. The toning exercises were aimed at these weakened muscles: mm. rhomboidei (Rh) – tortoise, and m. rectus abdominis (Abd) – bear. We applied methods which develop strength endurance. We used body weight and a maximum number of repetitions (until refusal) [30].

In order to examine muscle imbalances, we used muscle tests according to Janda [31] focused on establishing the strength of individual muscle groups. In the individual tests, we did not focus only on the main muscle, but we also examined and analysed the execution of the whole movement. Even though the tests are subject to evaluation errors, they are reliable to such an extent that it is possible to draw valid conclusions [31] based on them. Arm drift (R), pelvic tilt (P), hyper thoracic kyphosis (Th-k), and lumbar lordosis (L-l) were assessed by means of observation and palpation according to Tichy [32].

From the perspective of statistical data evaluation based on the observation of experimental effects, we carried out a pedagogical, multiple factor, and multiple group experiment. We used basic descriptive statistics, tables, and frequency charts to present the information collected in the measurements carried out. The statistical significance of the dependence of the monitored disorders on gender was evaluated with a chi-square test, in which $\alpha = 0.05$. The chi-square test of independence represents an extension of the chi-square goodness-of-fit test, and it is based on the comparison of empirical and theoretical frequencies for each category of the features monitored, with the null hypothesis assuming that the given qualitative features are independent of each other [33].

Results

Table 1 shows the results of the initial assessment of the disorders monitored in children in all data sets before the beginning of the movement programme.

The initial assessment showed that 389 out of the total number of 393 children suffered from at least one of the selected postural disorders or muscle imbalances. The majority of the diagnosed muscle weaknesses occurred in items Pm, Bf, and Abd.

Table 2 illustrates the difference between the initial and final assessments in data sets S2, S3, and S4. The final assessment was not carried out in data set S1 as this was a pilot group.

The outcomes reveal that out of the total number of 232 children from the three data sets, almost all had at least one positive finding in the selected items. We can conclude that 15 children from the original sample did not have a positive finding in any of the diagnosed items. Even though the condition of only 4 children improved in items Th-k and L-l, we did not observe any negative changes or deterioration in the children's condition in any of the items. Moreover, we found the highest occurrence of positive changes (more than 10%) in items with the highest number of children (Pm, P, Bf, and Abd).

Successful corrections of postural disorders and of weakened and shortened muscles according to the duration of movement programme are shown in figures 1 and 2.

Table 1. Results of the initial assessment of selected conditions (pretest) in all the data sets (%)

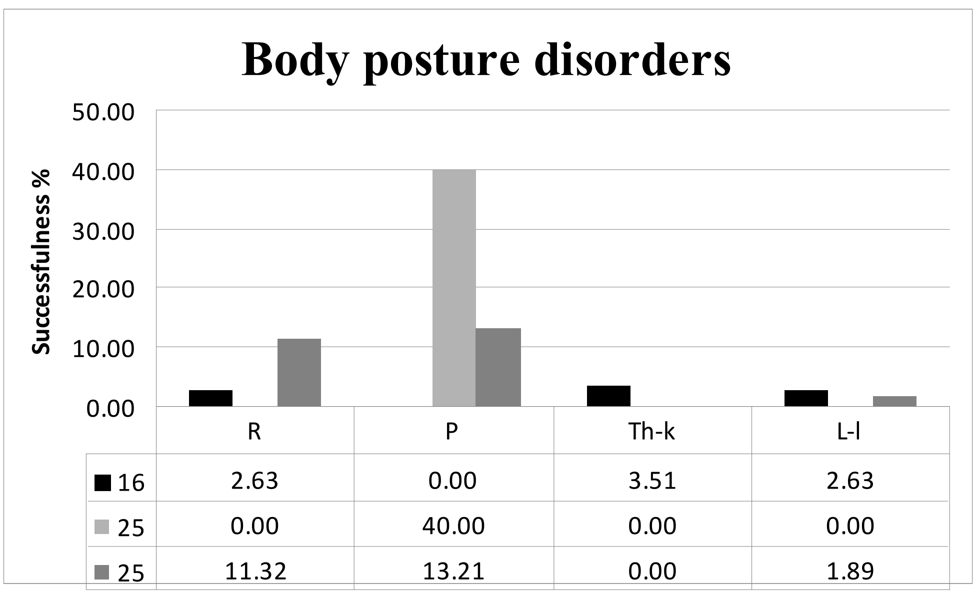
Data set	Diagnosis	R	P	Th-k	L-l	Ts	Bf	Add	Pm	Rf	Abd	Rh
S1 n = 161	100	49.7	39.1	9.9	9.3	23.0	79.5	15.5	83.2	17.4	74.5	33.5
S2 n = 114	97.4	52.6	11.4	11.4	13.2	19.3	64.9	13.2	80.7	15.8	55.3	45.6
S3 n = 65	100	18.5	52.3	13.8	7.7	13.8	75.4	10.7	84.6	16.9	70.8	26.2
S4 n = 53	98.1	52.8	20.8	15.1	11.3	17	69.8	13.2	79.2	17	56.6	30.2
Total n = 393	99	45.8	30.8	11.7	10.4	19.6	73.3	13.7	82.2	16.8	65.9	35.4

*n = number of participants; S1-S4 = data sets; R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; Ts = shortened m. triceps surae; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhomboidei.

Table 2. Results of the initial and final assessments of selected conditions (pretest and posttest) in data sets S2-S4 (%)

Data set	Diagnosis	R	P	Th-k	L-l	Ts	Bf	Add	Pm	Rf	Abd	Rh
Pretest S2-S4 n = 232 %	228 98.3	100 43.1	58 25.0	30 12.9	26 11.2	40 17.2	160 69.0	29 12.5	189 81.5	38 16.4	136 58.6	85 36.6
Posttest S2-S4 n = 232 %	213 91.8	91 39.2	25 10.8	26 11.2	22 9.5	20 8.62	113 48.7	13 5.6	158 68.0	15 6.5	67 28.9	75 32.3
Difference n = 232 %	**15 6.5**	8 3.5	**33 14.2**	4 1.7	4 1.7	20 8.6	**47 20.3**	16 6.9	**31 13.4**	23 9.9	**69 29.7**	10 4.3

*n = number of participants; S2-S4 = data sets; R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; Ts = shortened m. triceps surae; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhombidei; statistically significant results are in bold.

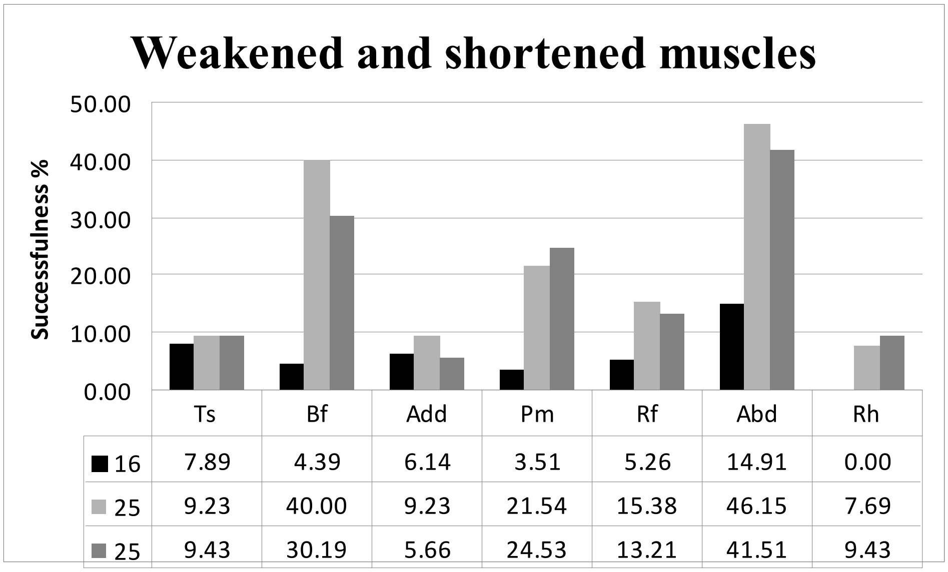


*R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; 16 = data set S2, 16 weeks of the programme; 25 = data set S3, 25 weeks of the programme; 25 = data set S4, 25 weeks of the programme.

Figure 1. Successful correction of postural disorders according to programme duration in data sets S2-S4 (%)

The graphic presentation of the results showing corrections of postural disorders in figure 1 illustrates minimum improvement in postural disorders; the 40% improvement in pelvic tilt in data set S3 is above average. In data set S4, with the same duration of the movement programme as in data set S3, improvement was achieved in all the monitored items of body posture except Th-k. In data set S2, where the movement programme was implemented for a shorter period of time than in the other two data sets, improvement occurred in all the monitored items except P.

We cannot positively state that the corrections of weakened and shortened muscles shown in figure 2 are dependent on the duration of the movement programme, but some improvement was achieved in the case of items Bf, Pm, Rf, Abd, and Rh in a significantly higher number of children in data sets S3 and S4 (more than 10%) when compared to data set S2.



*Ts = shortened m. triceps surae; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhombidei; 16 = data set S2, 16 weeks of the programme; 25 = data set S3, 25 weeks of the programme; 25 = data set S4, 25 weeks of the programme.

Figure 2. Successful correction of weakened and shortened muscles according to programme duration in data sets S2-S4 (%)

Table 3. Results of the initial and final assessments of selected conditions (pretest and posttest) in data sets S2-S4 – boys and girls (%)

Pretest	Diagnosis	R	P	Th-k	L-l	Ts	Bf	Add	Pm	Rf	Abd	Rh
Boys S2-S4 n = 136 %	135 99.2	62 45.6	42 30.9	19 14.0	21 15.4	28 20.6	98 72.1	19 14.0	115 84.6	26 19.1	91 67.0	54 39.7
Girls S2-S4 n = 96 %	93 96.9	38 39.6	16 16.7	11 11.5	5 5.2	12 12.5	62 64.6	10 10.4	74 77.1	12 12.5	45 46.9	31 32.3
Posttest	**Diagnosis**	**R**	**P**	**Th-k**	**L-l**	**Ts**	**Bf**	**Add**	**Pm**	**Rf**	**Abd**	**Rh**
Boys S2-S4 n = 136 %	128 94.1	58 42.6	21 15.4	17 12.5	17 12.5	14 10.3	78 57.4	8 5.9	103 75.7	9 6.6	44 32.4	48 35.3
Girls S2-S4 n = 96 %	85 88.5	33 34.4	4 4.2	9 9.4	5 5.2	6 6.3	35 36.5	5 5.2	45 46.9	6 6.3	23 24.0	26 27.1

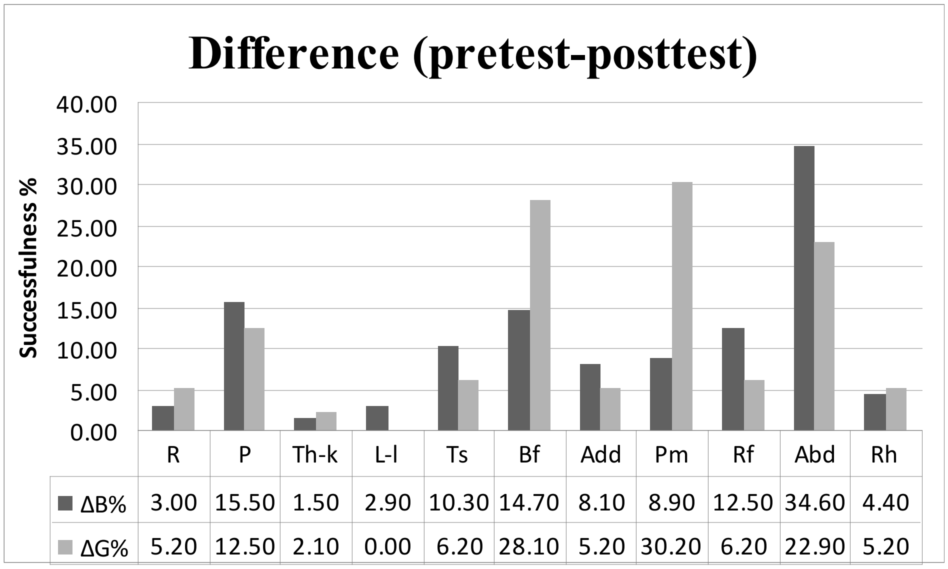
*n = number of participants; S2 S4 = data sets; % = expression in percentage; R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; Ts = shortened m. triceps surael; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhombidei.

Table 3 shows children in data sets S2-S4 again due to the fact that data set S1 comprising 161 children was a pilot group. Out of the total number of children from the three data sets, the number of girls taking part in the initial and final assessments was almost 1/3 lower than the number of boys. Only 1 boy and 3 girls did not have any of the monitored disorders. In all the monitored items, we observed a higher percentage of their occurrence in boys than in girls. The difference in successful corrections of the monitored disorders is shown in figure 3.

When we compared the differences between successful corrections of the monitored disorders in boys and girls in data sets S2-S4 presented in figure 3, we found that the corrections in items P, L-l, Ts, Add, Rf, and Abd were more successful in boys, while girls demonstrated more successful corrections in items R, Th-k, Bf, Pm, and Rh. As for item L-l, no correction or deterioration of the initial condition occurred in girls.

The dependence of the monitored disorders on gender was tested with the chi-square test of independence. Final p-values are listed in table 4 for the initial assessment and in table 5 for the final assessment.

The initial assessment results shown in table 1 do not positively prove the dependence of the monitored disorders on gender in all the conditions examined in the study. Statistically significant dependence in the sample of girls can be seen in Ts and Bf in data set S1, Th-k in data set S2, P and Abd in data set S3, and Pm in data set S4.



*n = number of participants; S2-S4 = data sets, R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; Ts = shortened m. triceps surae; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhombidei.

Figure 3. Differences between the results of the initial and final assessments of selected conditions (pretest and posttest) in boys and girls – in data sets S2-S4 (%)

Table 4. P-values of the independence test for the initial assessment (pretest) in all data sets

Pretest	S1 n = 161	S2 n = 114	S3 n = 65	S4 n = 53
R	0.921697	0.57859	0.383927	0.1321
P	0.908374	0.100439	**0.002056**	0.788351
Th-k	0.496135	0.842042	0.463218	0.477952
L-l	0.110886	**0.011171**	0.828917	0.413291
Ts	**0.012898**	0.651877	0.145392	0.300399
Bf	**0.000611**	0.801735	0.097412	0.490904
Add	0.714928	0.420673	0.921084	0.7247
Pm	0.426715	0.651877	0.709606	**0.001814**
Rf	0.722933	0.063001	0.951019	0.761303
Abd	0.699019	0.073491	**0.002445**	0.341153
Rh	0.683628	0.783336	0.368279	0.611324

* n = number of participants; SI-S4 = data sets; R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; Ts = shortened m. triceps surae; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhombidei; statistically significant results are in bold.

Table 5. P-values of the independence test for the final assessment (posttest) in all data sets

Posttest	S2 n = 114	S3 n = 65	S4 n = 53
R	0.845265	0.383927	0.119428
P	0.100439	0.051013	0.316852
Th-k	0.863898	0.463218	0.477952
L-l	**0.034977**	0.828917	0.670347
Ts	0.842042	0.111446	0.316852
Bf	0.744632	**0.00002**	0.464557
Add	0.502734	0.261504	0.968689
Pm	0.870358	**0.00114**	**0.000002**
Rf	0.840838	0.261504	0.978295
Abd	0.320941	0.936076	0.477952
Rh	0.783336	0.545817	0.344161

*n = number of participants; S2-S4 = data sets; R = arm drift; P = pelvic tilt; Th-k = thoracic hyperkyphosis; L-l = lumbar hyperlordosis; Ts = shortened m. triceps surae; Bf = shortened m. biceps femoris; Add = shortened mm. adductores femoris; Pm = shortened mm. pectorales major; Rf = shortened m. rectus femoris; Abd = weakened m. rectus abdominis; Rh = weakened mm. rhombidei; statistically significant results are in bold.

The results of the final assessment in table 5 also do not unambiguously indicate the dependence of the monitored disorders on gender. We can conclude that dependence on gender can be seen again only in the sample of girls, namely in items L-l in data set S2, Bf and Pm in data set S3, and Pm in data set S4; the dependence of the item Pm in data set S4 occurred in both the initial and final assessments.

Discussion

The 21st century lifestyle combined with the absence of physical activity has become a social issue. Considering the demands of the present time, there is an insufficient amount of physical activity in the lives of young people, including children [34, 35, 36, 37, 38, 39, 40, 41].

The most extensive analysis carried out by the WHO has confirmed this negative trend. This analysis, carried out in 122 countries [41], found insufficient physical activity (31.1%) in the group of children and young people aged ≥ 15 years. In a study [43] focusing on repeated monitoring of muscle imbalance occurrence and body posture, a connection has been found between the time when children start school and muscle imbalance occurrence. Education regarding everyday physical activity routines should be part of health prevention in childhood. Other authors have carried out a study [44] on the effects of a postural education on a sample of 137 children aged 10.7 years. The pupils of two grammar schools were divided into experimental group (n = 63) and comparison respondents (n = 74); the experimental group took part in the postural education programme, and the comparison respondents performed exercise in accordance with the school curriculum. In the experimental group, statistically significant changes occurred in body posture while sitting during the monitored period, whereas no significant changes were observed in the comparison respondents in this respect. The results indicate there is a good reason for introducing a compensation programme for the elimination of imbalances [45] to schools. A similar education programme, "Ergonomics, Movement & Posture", is being implemented in Israel. The programme starts in childhood and is an integral part of the school curriculum [46].

The outcomes of our research confirm the absence of physical activity and deteriorating results of body posture assessments in younger school-age children. Despite the negative information obtained through our research as well as the work of other authors, there is a possibility to do prevention work or improve the existing situation with education programmes and the implementation of movement programmes in the education process.

Conclusions

The outcomes of this research confirm the results of other research pointing out the growing trend of orthopedic weakness occurrence even in preschoolers.

The initial assessment of 393 children from 4 data sets proved the occurrence of at least one weakened or shortened muscle or postural disorder in 389 children, that is 99% of them. Only 1 boy and 4 girls were not diagnosed with any of the monitored disorders. The majority of weaknesses were found in items Pm (73.3%) and Bf (82.2%).

Out of the total number of 232 children who underwent both the initial and final assessments, the number of children with at least one positive finding decreased from 228 to 213. No negative changes or deteriorations were observed even though only 4 children showed improvement in items Th-k and L-l. The highest number of positive changes was found in items with the highest number of children – Abd, 69 children = 29.7% and Bf, 47 children = 20.3%.

We are not able to positively claim that a longer duration of the movement programme had a more significant impact on positive changes in postural disorders. In data set S3, zero improvement was observed in all other items, but there was no deterioration either. On the other hand, in data set S4, with a duration of the movement programme identical to that in data set S3, improvements were observed in all the monitored body posture items except item Th-k. In data set S2, where the programme lasted shorter than in the case of the other two data sets, improvements occurred in all the monitored items except the item P. Not even the outcomes of shortened and weakened muscle corrections prove unambiguously that they were dependent on the duration of the movement programme. However, the corrections in data sets S3 and S4, where the movement programme took 25 hours, were more successful in all the tested items except Add, where improvement occurred only in 5.66% of children.

As for gender, we consider girls a less vulnerable group in terms of the prevalence of the monitored disorders, since their occurrence in girls was lower. A significant dependence in favour of girls was found in the initial assessmentfor items Ts and Bf in data set S1, Th-k in data set S2, P and Abd in data set S3, and Pm in data set S4.

On the other hand, the corrections of the monitored conditions were more successful in girls only in items R, Th-k, Bf, P, and Rh, with statistically significant differences occurring only in conditions L-l in data set S2, shortened Bf and Pm in data set S3, and Pm in data set S4. We can observe the dependence of the item Pm in data set S4 in both the initial and final assessments. There were no improvements of the item Th-K in girls, but also no deteriorations.

Considering all the above facts, we can conclude that the movement programme implemented was successful to a certain extent with regard to corrections and the prevention of the monitored conditions as no deteriorations occurred in any of these conditions. Two of the grammar schools participating in the research from its beginning to the very end are continuing to implement the movement programme. The amount of daily physical activity performed by children is insufficient, and we would, therefore, recommend PE teachers and heads of grammar schools to implement appropriate movement programmes and compensatory exercises in the third PE class as a measure for preventing poor body posture and compensating postural disorders. This also requires the initiative and interest of parents, as well as monitoring and feedback. Due to the increased occurrence of sedentary activities performed by children connected to technological development and adaptation to new lifestyle in the recent years, we also recommend increasing the level of physical activity in children of all ages.

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