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Effect of holiday on postural tone and selected parameters of body posture in young people with Down syndrome

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Abstract

Background: Regular physical therapy of people with Down syndrome improves the efficiency of such treatment. However, it remains unclear whether a discontinuation of the therapy over the period of summer holiday influences the effects of the therapeutic process. The aim of this study was to evaluate the effect of summer holiday on postural tone and quantitative parameters of body posture (angle of trunk rotation in the transverse plane and the spinal curvatures such as kyphosis or lordosis in the sagittal plane) in young people with Down syndrome.

Material/Methods: Twenty one people aged 14 to 24 years were examined, with IQ scores from 54 to 35 on the Wechsler Intelligence scale. The experimental group was young people with Down syndrome whereas the control group were people with moderate intellectual disability without additional neurological, orthopaedic and other genetic disorders. The postural tone coefficient (PTC) and values of the spinal curvature (lordosis and kyphosis) and angle of trunk rotation (ATR) were evaluated twice. The first measurement was performed after 10 months of regular neurorehabilitation according to the neurodevelopment concept while the second - after 2 months of summer holiday.

Results: During the holiday, the PTC value reduced significantly in the controls, from 0.40 to 0.37 (p=0.02), whereas in young people with Down syndrome, postural tone did not change significantly (p=0.33). In terms of the parameters of body posture, one significant change was observed in the group of patients with Down syndrome (kyphosis, p=0.00).

Conclusions: No significant correlations were found between postural tone and values of kyphosis, lordosis and angle of trunk rotation, except for the relationship between PTC and angle of trunk rotation obtained in the main thoracic measurement (Th5- Th12, p=0.03).

Keywords: intellectual disability; postural tone; angle of trunk rotation; kyphosis; lordosis

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INTRODUCTION

A genetic disorder caused by chromosome 21, termed Down syndrome, determines a specific psychomotor development in people affected by this congenital malformation. Defects of the cardiovascular, digestive, genitourinary, respiratory and immune systems cause that the development of children with Down syndrome is far from the standards for healthy children (Sadowska et al., 1997) and represents the basis for permanent and regular medical check-up and treatment of coexisting disorders. Numerous studies have found many structural cerebral modifications that determine deficit of cognitive, motor and sensory functions (Wiśniewski et al., 1986; Sadowska et al., 2005; Gruna-Ożarowska et al., 2006). Down syndrome is characterized by genetic postural hypotonia (Korenberg et al., 1994), motor disorders (Levy 1976; Rast et al., 1985; Shumway-Cook et al., 1985; Mon-Williams et al., 2001) and body posture disorders (Shumway-Cook et al., 1985). Various forms of treatment, including physical therapies, are used in order to improve the quality of life and support psychomotor development of people with Down syndrome with those deficits. Many therapeutic methods have been demonstrated to be effective (Limbrock et al., 1991; Bogdanowicz et al., 1992; Sadowska et al., 2000, 2001; Matthews-Brzozowska et al., 2009). However, no studies have examined the effect of summer holiday on the effects of rehabilitation processes.

In light of the above facts, patients with Down syndrome should participate in regular and lifelong therapies. However, this is impossible in practice. Therefore, the question arises of which consequences can be expected after discontinuation of the therapeutic process. Such situations naturally occur during holiday periods.

The aim of this study was to evaluate the effect of summer holiday on the level of postural tone and selected parameter of body posture in young people with Down syndrome who participated in a process of neurodevelopmental therapy.

MATERIAL AND METHODS

Participants

A criterion for selection of the place for examination was facilities and organization of the process of physical therapy for young people with Down syndrome. A special care school where young people with Down syndrome are involved in regular (all school year long) neurodevelopmental therapies was selected for the study. The inclusion criterion was moderate intellectual disability (IQ score ranging from 54 to 35 on the Wechsler scale) and age (from 14 to 24 years) (SD=1.703). Young people with additional neurological, orthopaedic and other (than Down syndrome) genetic disorders were excluded. The group of students who met the inclusion criteria was further subdivided into two subgroups (the experimental group and control group). The experimental group was 10 people with Down syndrome and the control group was 11 people with moderate intellectual disability. All the participants and/or their legal guardians gave a written consent to participate in the study. The study also received a positive opinion from the local bioethics committee.

Postural tone

Twenty one characteristics were examined in order to evaluate postural tone according to the description of the postural tone coefficient provided by M. Matyja (2012):

- head position: the subject stood in a relaxed position while the researcher evaluated head position and assigned a specific number of points (0 - proper position: nose is not protruding from the vertical line that passes through the upper part of the sternum; 1 - nose protruding, face is not protruding from the vertical line that passes through the sternum, 2 - substantial frontal protrusion) - *„head”*,
- shoulder position: the subject stood in a relaxed position while the researcher evaluated shoulder position (0 - proper position: shoulders positioned symmetrically in the frontal plane, whereas the top of the shoulders in the sagittal plane is in the rear part of the neck; 1 - shoulder asymmetric or with slight anterior protrusion, 2- substantial asymmetric anterior protrusion, top of the shoulders in front of the neck outline) – *„shoulders”,*
- shoulder blade position: the subject stood in a relaxed position while the researcher evaluated shoulder blade position (0 - shoulder blades form a uniform back plane; 1 - shoulder blades protrude from the back plane to more than one finger, 2 - shoulder blades protrude from the back plane to more than two fingers) - *„shoulder blades”,*
- position and shape of the chest: pectus excavatum, the subject stood in a relaxed position while the researcher evaluated chest position (0 - proper chest, the front wall of the chest is the most protruding part, 1 - flattened chest, 2 - flat chest with symptoms of rickets, 3 - pectus excavatum) – *„pectus excavatum”*,
- thoracic kyphosis: the subject stood in a relaxed position while the researcher evaluated thoracic kyphosis through assignment of a specific number of points (0 - smooth shape of thoracic kyphosis, 1 - larger thoracic kyphosis, 2 - substantially larger thoracic kyphosis, 3 - established hyperkyphosis) – *„hyperkyphosis”*
- lumbar lordosis: the subject stood in a relaxed position while the researcher evaluated lumbar lordosis (0 - smooth shape of lumbar lordosis, 1 - insignificantly deeper lumbar lordosis, 2 - substantially deeper lumbar lordosis, 3 - established hyperlordosis) – *„hyperlordosis”,*

- costal margin: the subject stood in a relaxed position while the researcher examined (through palpation) the outline of costal margins and assigned a specific number of points (0 - proper outline of costal margin, 1 - light protrusion of costal margins, 2 - substantial protrusion of costal margins or gibbus costalis anterior) – *„protruding costal margins”,*
- position of knees in the sagittal plane: the subject stood in a relaxed position while the researcher evaluated knee position (0 - proper position, 1 - light flexion contracture/hyperextension, 2 - substantial flexion contracture/hyperextension), - *„hyperextended knees”,*
- control of pelvis in the sitting position: at the request, the subject sat up from the lying position and remained in this position by around 5 to 6 seconds. The researcher evaluated the quality of pelvis control in the sitting position and assigned a specific number of points (0 - proper pelvis control: pelvis in a vertical position, 1 - slightly disturbed pelvis control: slight posterior pelvic tilt, 2- substantially disturbed pelvis control: substantial posterior pelvic tilt) – *„pelvis control in the sitting position”,*
- cervicothoracic junction: the subject stood in a relaxed position with feet together and eyesight fixed at one point at the height of eyes. The researcher performed the measurement of the cervicothoracic junction by placing the support of the Rippstein gravitational goniometer to the segments C7-Th1 – „cervicothoracic junction”,
- functional length of the ischiocrural muscle group in the lower limbs was evaluated through measurement of the complementary angle using the Rippstein goniometer, with two scores: one for the right lower limb and the second for the left lower limb – „*functional length of the ischiocrural muscles (right)”, functional length of the ischiocrural muscles (left)”,*
- functional length of the iliopsoas muscle of the lower limb: the Thomas test was used, with two scores for the right and the left limbs – *„Thomas test (right)”, „Thomas test (left)”,*
- functional length of the adductor muscles of the lower limb: the Patrick test was used, with two scores for the right and the left limbs – *„Patrick test (right)”, „Patrick test (left)”,*
- functional length of the rectus femoris muscle of the lower limb: the subject was lying prone. One lower limb was extended in the hip joint and knee joint and it was lying on the couch while the other was bend in the hip joint and the knee joint and supported with the whole feet on the ground. The researcher bent the knee joint until the moment when the subject felt the discomfort and measured the distance from the heel to the buttock. Two results were obtained: one for the right limb and the other for the left – „*length of the rectus femoris muscle (left)”,* „*length of the rectus femoris muscle (right)”,*
- functional length of pectoral muscles of the upper limbs: the subject remained in the sitting position leaning against the wall and, at the request of the researcher, raised their hands up. Using the goniometer touching the shoulder, two measurements were performed: one for the right limb and the other for the left – „wall test (left)”, „wall test (right)”

All the variables obtained during the study that characterizes the value of postural tone were evaluated according to the algorithm of the postural tone coefficient (PTC) (Matyja 2012),

$$WWN = \frac{\text{The sum of the standardized value of } \text{21 traits identified in the test reliability}}{21}$$

where twenty one characteristics are: head + shoulders + shoulder blade + hyperkyphosis + pelvis control in the sitting position + cervicothoracic junction + functional length of the ischiocrural muscles (right) + functional length of the ischiocrural muscles (left) + Thomas test (right) + Thomas test (left) + Patrick test (right) + Patrick test (left) + length of the rectus femoris muscle (left) + length of the rectus femoris muscle (right) + wall test (left) + wall test (right) + pectus excavatum + hyperlordosis + protruding costal margins + hyperextended knees + cervicothoracic junction.

Next, the spastoid tone coefficient (PTC-Spasto) was evaluated for 16 characteristics: head + shoulders + shoulder blade + hyperkyphosis + pelvis control in the sitting position + cervicothoracic junction + functional length of the ischiocrural muscles (right) + functional length of the ischiocrural muscles (left) + Thomas test (right) + Thomas test (left) + Patrick test (right) + Patrick test (left) + length of the rectus femoris muscle (left) + length of the rectus femoris muscle (right) + wall test (left) + wall test (right) according to the equation:

$$WWN - Spasto = \frac{\text{The sum of the standardized value of } \text{16 traits identified in the test reliability}}{16}$$

The athetoid tone (PTC-Ateto) was determined for 5 characteristics:
pectus excavatum + hyperlordosis + protruding costal margins + hyperextended knees + cervicothoracic junction, according to the following algorithm:

$$WWN - Ateto = \frac{\text{The sum of the standardized value of } \text{5 traits identified in the test reliability}}{5}$$

Parameters of body posture

Evaluation of the angle of trunk rotation (ATR)

Evaluation of the angle of trunk rotation (ATR) was made using the classic Adams test (1882) i.e. during body bend. The researcher applied Bunnell scoliometer to the surface of the back and perpendicularly to the long axis of the spinal column, and the value was read at 3 levels:

- in the upper thoracic spine region, with the first 5 vertebrae (Scoliometer angle of trunk rotation - ATR measure upper compensatory curve),
- in the region of the main thoracic curve (Scoliometer ATR measure main curve),
- in the lumbar spine region (Scoliometer ATR measure lower compensatory curve).

Three ATR values were obtained: one in the main curve and two on the compensatory curves (upper and lower) (Bunnell 1984; Kotwicki et al. 2009).

Evaluation of anterior and posterior curvatures of the spine - lordosis and kyphosis

Rippstein gravitational goniometer was applied to the pelvis in the plane of the sacrum and the device was zeroed and, in the next step, the device was applied to the thoracolumbar junction (Th 12 region), where lumbar lordosis was evaluated. Next, without detaching the device from the child's back, the device was zeroed and applied to the thoracic kyphosis curvature in the region between Th 1 and Th 3, where the thoracic kyphosis value was read. The last measurement was performed in the region Th4 - interscapular reading (Dobosiewicz et al., 2005).

Procedures

The examination was repeated. The first measurement was performed in June at the end of the school year, after the period of 10 months of regular neurorehabilitation consistent with the neurodevelopmental concept. In this period, the subjects from both groups were included in the regular neurodevelopmental therapy, one hour a week. The second measurement was performed in September, after the summer holiday, when the subjects from both groups were not involved in the therapy.

Statistical Analysis

Statistica 10.0 software was employed for statistical analysis of the material collected. Non-parametric tests were used. Consistency with normal distribution was verified using the Shapiro-Wilk W-test, whereas homogeneity of variance was evaluated by means of the Levene's test. The Wilcoxon signed-rank test was used as an alternative for the t-test for dependent variables, which allowed for examination of the intraclass variability for pre-test and post-test results.

Furthermore, the Spearman's rank correlation coefficient was calculated using the PTC variables and body posture parameters.

RESULTS

Participants

No significant variability was found in the group in terms of distribution of genders and mean variables: mass and age. Variability was found between the groups in terms of body height. Subjects' biometric data for individual groups are contained in the Table 1.

PTC before and after holiday

Statistical analysis based on the Wilcoxon test did not reveal statistically significant differences in the level of postural tone in the teenagers with Down syndrome between the measurements before ($\overline{X}$=0.36) and after holiday ($\overline{X}$=0.35) at the level of Z=2.30 (p>0.05).

Statistical analysis based on the Wilcoxon test found a statistically significant difference in the level of postural tone in the intellectually disabled children between the measurements before ($\overline{X}$=0.40) and after ($\overline{X}$=0.37) holiday at the level of Z=2.37 (p>0.05*)

Table 1. Biometric data in individual groups

Variable	Mann-Whitney U-test (with continuity correction) with respect to the variable Zmn1. The results are significant at z p <.05000				
	Rank sum Experimental group Down syndrome	Rank sum Control group Intellectual disability	p	N signif. Experimental group Down syndrome	N signif. Control group Intellectual disability
Mass	131.5000	99.5000	0.481322	11	10
Height	81.0000	150.0000	**0.005411**	11	10
Age	137.5000	93.5000	0.259876	11	10

Chi^2 for gender p=0.69

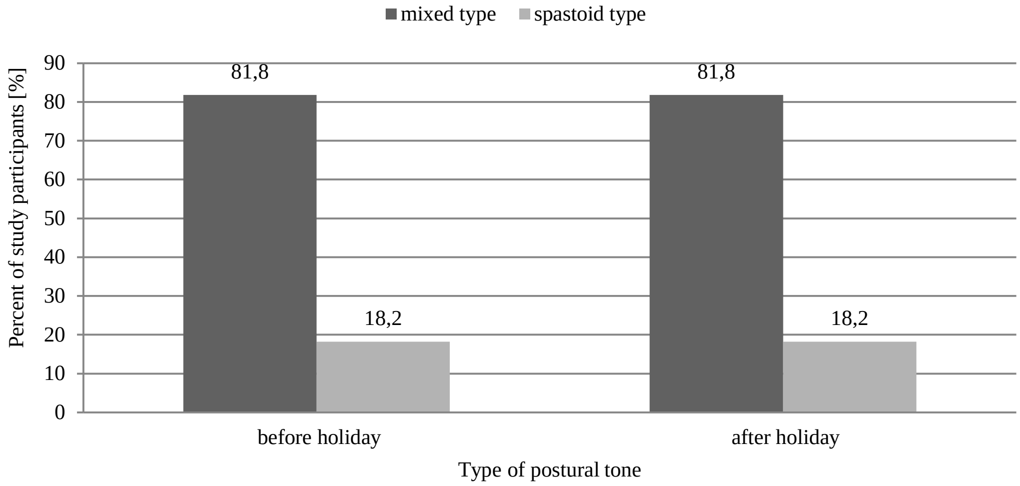

Figure 1. Distribution of postural tone before and after holiday among young people with Down syndrome

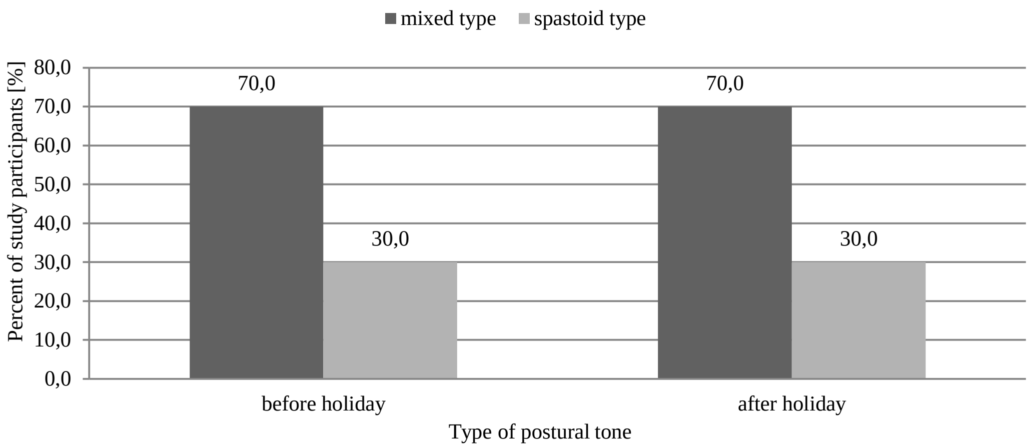

Figure 2. Distribution of postural tone before and after holiday in intellectually disabled children

The numerical data were transformed into the qualitative data to reflect a type of postural tone (distribution) among people with Down syndrome before and after holiday. These data are illustrated in Fig. 1.

A mixed type of muscular tone was found in 9 study participants (81.8%) whereas spastic type was observed in 2 participants (18.2%), both before and after holiday.

Similarly, the numerical data obtained in young people with intellectual disability before and after holiday were transformed into qualitative data to reflect the type of postural tone (distribution). These data are illustrated in Fig. 2.

Angle of trunk rotation before and after holiday

Parameters concerning the angle of trunk rotation did not differ statistically significantly during the measurements before and after holiday, neither in the group of young people with Down syndrome nor in the control group (see Tab. 2) ($p>0.05$).

Spinal curvatures before and after holiday

Statistical analysis based on the Wilcoxon signed-rank test demonstrated one significant change ($p<0.01$**, kyphosis) before and after holiday in the group of young people with Down syndrome. Other parameters did not differ significantly between the measurements before and after holiday.

Table 2. Angle of trunk rotation before and after holiday in the control and experimental groups

Angle of trunk rotation	Before holiday			After holiday			Significance (p)
Experimental group Down syndrome							
	$\overline{x}$	Me	s	$\overline{x}$	Me	s	
Scoliometer ATR measure, upper compensatory curve	3.73	4.00	2.00	4.00	4.00	1.41	Z=0.31 p=0.7532
Scoliometer ATR measure, main curve	3.36	3.00	1.12	3.09	3.00	2.30	Z=0.76 p=0.4469
Scoliometer ATR measure, lower compensatory curve	6.00	6.00	2.79	5.18	6.00	2.60	Z=1.27 p=0.2049
Control group intellectual disability							
Angle of trunk rotation	Before holiday			After holiday			Significance (p)
	$\overline{x}$	Me	s	$\overline{x}$	Me	s	
Scoliometer ATR measure, upper compensatory curve	4.80	4.50	2.30	4.00	4.00	1.56	Z=0.84 p=0.4017
Scoliometer ATR measure, main curve	4.80	4.50	2.97	4.30	4.00	2.45	Z=0.81 p=0.4185
Scoliometer ATR measure, lower compensatory curve	4.40	3.50	2.88	3.90	3.00	2.56	Z=1.10 p=0.2733

Table 3. Spinal curvatures before and after holiday in the experimental and control groups

Spinal curvatures	Before holiday			After holiday			Significance (p)
Experimental group Down syndrome							
	$\overline{x}$	Me	s	$\overline{x}$	Me	s	
Lordosis	28.00	29.00	11.38	26.00	27.00	11.76	Z=1.33 p=0.1834
Kyphosis	35.09	32.00	7.61	30.27	29.00	7.35	**Z=2.80 p=0.0051****
Interscapular reading	17.91	20.00	4.87	17.18	18.00	4.35	Z=1.26 p=0.2076
Control group intellectual disability							
Spinal curvatures	Before holiday			After holiday			Significance (p)
	$\overline{x}$	Me	s	$\overline{x}$	Me	s	
Lordosis	25.40	24.50	9.36	24.00	23.00	9.04	Z=1.13 p=0.2604
Kyphosis	42.40	40.50	11.93	40.90	41.50	12.45	Z=0.82 p=0.4148
Interscapular reading	24.00	21.00	10.94	26.10	23.50	8.46	Z=0.65 p=0.5147

(p<0.01**)

Correlations

We found no statistically significant correlations (p>0.05) between PTC and ATR, kyphosis and lordosis. All the relationships obtained ranged from |R|=0.1 do |R|=0.2.

Presence of only one statistically significant correlation was found (p<0.05*) between PTC and angle of trunk rotation in the region of the main curve, with R=0.48. This result reflects an average correlation with positive orientation, that is, an increase in the value of one variable is followed by the increase in the other. Therefore, the increase in postural tone coefficient is correlated with the increase in the angle of trunk rotation R.2. This means that the angle of trunk rotation can be increased with reduction in postural tone.

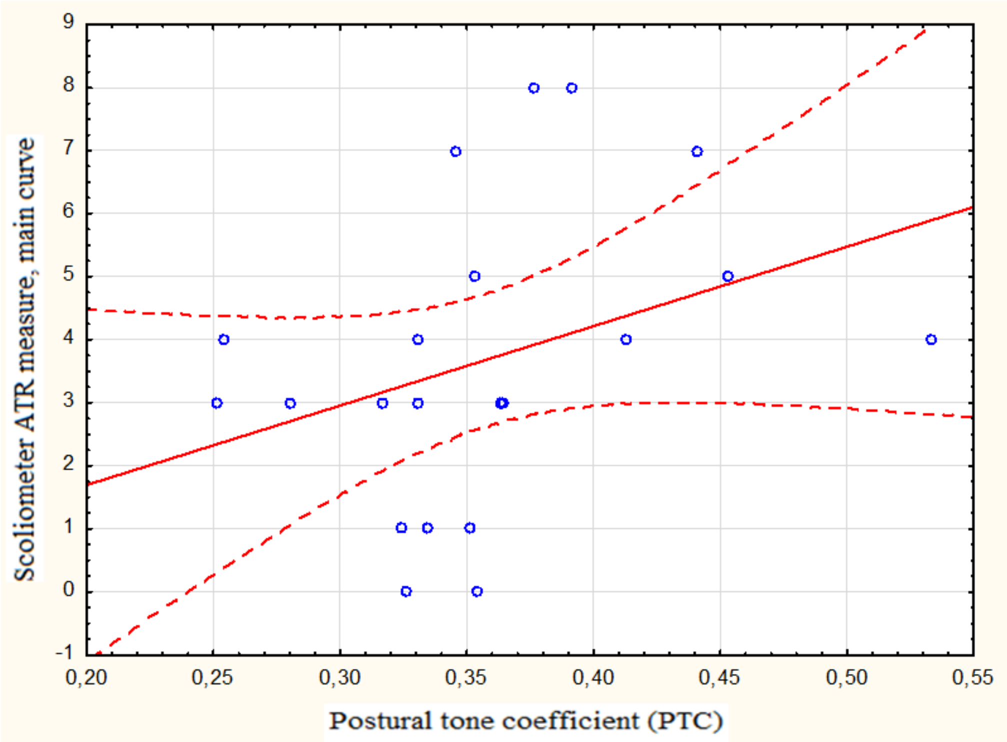

Figure 3. Correlation between PTC and ATR for the main curve

DISCUSSION

The results obtained in this study represent the first attempt to evaluate postural tone and body posture in people with Down syndrome aged 14 to 24 years after the discontinuation of the therapies during a two-month summer holiday period. The study examined students who had participated in regular physical therapies over the school year. This selection of study participants ensured verification of the parameters of postural tone during a break from school activities, including rehabilitation. The findings of the study demonstrated that postural tone did not significantly change in the group of young people with Down syndrome. However, the result obtained for postural tone coefficient at the level of 0.36 is not a standard for postural tone (Matyja 2012). According to the neurodevelopmental concept, this is likely to be caused by several compensations that cause improper body posture. The analysis of the data reveals that the most study participants with Down syndrome (81%) are characterized by a mixed type of postural tone, with disorders occurring in the area of control of individual body parts, including head, shoulder girdle, shoulder blades, thoracic kyphosis, lumbar lordosis, chest, pelvis, hyperextended knees, non-physiological anterior-posterior spinal curvatures and improper functional length of the ischiocrural muscles, iliopsoas muscles, hip adductors, rectus femoris muscle or the pectoral muscle. These compensations are attributable to a reduced postural tone (Matyja 2012). The significant correlation shows that the increase in the postural tone coefficients is accompanied by the increase in the angle of main curve rotation. This means that reduced postural tone (higher tone coefficient) causes higher angle of body rotation.

A significant reduction was also found for mean kyphosis in the teenagers with Down syndrome, from 35º to 30º. Interpretation of this finding can be difficult, especially due to the lack of standardized values of kyphosis and lordosis for the people with Down syndrome. The values of kyphosis in people with Down syndrome show a range similar to the values of kyphosis documented for children at the age of 9 to 16 years at a standard intellectual level in a study by Durmała et al. (2009). The findings obtained by other authors (Walicka-Cupryś et.al., 2013) have demonstrated that body posture disorders are correlated with postural stability. They found a correlation between body posture and postural stability in children at pre-school age. Based on the angle of thoracic kyphosis and lumbar lordosis, the researchers evaluated body posture in the sagittal plane. Analysis of individual parameter found less pronounced kyphosis in 5 girls (8.5%) and 9 boys (19.6%) and more substantial kyphosis in 14 girls (23.7%) and 8 boys (17.4%). Deeper lordosis was observed in 11 girls (18.6%) and 7 boys (15.2%) and more shallow lordosis - in 16 girls (27.1%) and 17 boys (37.0%). Scoliotic posture was found in 5 (4.8%) and scoliosis in 11 (10.6%) study participants, of whom 7 (6.73%) were with left-sided scoliosis. The authors suggested that the increase in the angle of thoracic kyphosis causes the increase in stabilometric parameters in the sagittal plane, both for the examinations with eyes open and eyes closed.

Another problem is a significant change in the range of postural tone after holiday period in study participants from the control group. PTC reduced from the level of 0.40 to 0.37, which represents an improvement in postural tone towards normotonia, i.e. tone without any compensation in body posture. It is remarkable that the analysis of postural tone distribution revealed proportion of the types of postural tone different form the group of young people with Down syndrome. The results show that 70% of the people from the control group are characterized by mixed postural tone, and 30% of them show the spastic type of tone. Based on the results obtained in the study and the fundamentals of the neurodevelopmental concept it can be expected that an improvement in the function of body's antigravity mechanism occurred since the results obtained were similar to the value of postural tone considered as normotonia. Due to the neurorehabilitation programs which were consistent with the neurodevelopmental concept, the effects of therapies may have been "delayed" in all the study participants. Over the school year, the child's brain is involved in education and stimulation with much information from various sensory channels. Children and young people go to school, learn and memorize information at both cognitive and sensory levels. Excess information is likely to cause overload and no learning and therapeutic effects. The time of rest (holiday) from learning stimuli and therapies usually (in practice) results in appearance of the expected effects, which is often observed in the clinical practice. The child's brain, with particular focus on the brain with damages, needs more time for analysis (integration) of information obtained during neurorehabilitation (Korenberg et al., 1994; Sadowska et. al., 2005).

Another important problem is an improvement in postural tone obtained in the control group, which was not observed in the young people with Down syndrome. This can be explained by the fact that more people in the control group were with spastic compensation compared to the group of young people with Down syndrome. The mixed type of postural tone (dominant in the study participants with Down syndrome) is characterized by a more complex combination of compensation (Matyja 2012), which may result in more difficulties with rehabilitation. Furthermore, myriads of morphological anomalies (Korenberg et al., 1994; Sadowska et al., 2005) and genetic postural hypotonia (Levy et al., 1976; Rast et al., 1985; Korenberg et al., 1994) have been observed in the brain of a child with Down syndrome. Both problems caused disorders in the function of the antigravity mechanism. On the one hand, dysfunctions of the central nervous system generate disorders in the efficiency of the integration function, leading to a reduction in postural tone, which consequently leads to improper position and response of the child's body. On the other hand, the brain integrates information from dysfunctional body with postural hypotonia improperly (Matyja et al., 2007), which is also likely to concern the people with Down syndrome.

CONCLUSION

Insignificant differences in the results were found, suggesting an improvement in postural tone and angle of trunk rotation during holiday period in young people with Down syndrome. However, these differences were not statistically significant.

REFERENCES

1. Adams W. Lectures on the pathology and treatment of lateral and other forms of curvature of the spine. London, *Churchill*; 1882
2. Bunnell WP. An objective criterion for scoliosis screening. *J Bone Joint Surg*, 1984; 66-A:1381-1387.
3. Dobosiewicz K, Durmała J, Kotwicki T. Biodynamiczna metoda trójpłaszczyznowej korekcji skolioz idiopatycznych–opis metody. *Ortop Traumatol Rehabil*, 2005; 7(1), 49-54
4. Durmala J, Detko E, Krawczyk K. Values of thoracic kyphosis and lumbar lordosis in adolescents from Czestochowa. *Scoliosis*, 2009; 4(Suppl 1), O:53
5. Gruna-Ożarowska A, Sadowska L, Mysłek-Prucnal M. Ilościowa ocena czynności bioelektrycznej mózgu u osób zespołem Downa po stymulacji wolnozmiennymi polami magnetycznymi. Rzeszów. *Przegl Med*, 2006; (3): 199-206
6. Korenberg JR, Chen XN, Schipper R, Sun Z, Gonsky R, Gerwehr S, Carpenter N, Daumer C, Dignan P, Disteche C. Down syndrome phenotypes: cnsequwnces of chromosom imbalance. *Proc Natl Acad Sci U S A*, 1994; 24; 91(11): 4997–5001
7. Kotwicki T, Negrini S, Grivas TB, Rigo M, Maruyama T, Durmala J, Zaina F. Methodology of evaluation of morphology of the spine and the trunk in idiopathic scoliosis and other spinal deformities-6th SOSORT consensus paper. *Scoliosis*, 2009; 4(26), 1748-7161
8. Levy HB. Minimal brain dysfunction/specific learning disability: a clinical approach for the primary physician. *SMJ*, 1976; 69(5), 642-653
9. Limbrock GJ, Fischer-Brandies H, Avalle C. Castillo-Morales' Orofacial Therapy: Treatment of 67 Children with Down Syndrome. *Dev med child neurol*, 1991; 33(4), 296-303

10. Matthews-Brzozowska T, Walasz J, Matthews Z. Down's syndrome – early orthodontic therapy by Castillo-Morales stimulative appliance. *JMedSci*, 2009; 78(3-4), 253-255
11. Matyja M, Gogola A. Prognozowanie rozwoju postawy dzieci na podstawie analizy jakości napięcia posturalnego w okresie niemowlęcym. *Neurol Dziec*, 2007; 16 (32): 49−56
12. Matyja M. Neurorozwojowa analiza wad postawy ciała u dzieci i młodzieży. *AWF Katowice*, 2012
13. Mon-Williams M, Tresilian JR, Bell VE, Coppard VL, Jobling A, Carson RG. The preparationof reach to grasp movements in adults with Down syndrome. *Hum Mov Sci*, 2001; 20:587–602
14. Paszko-Patej G, Terlikowski R, Kułak W, Sienkiewicz D, Okurowska-Zawada B. Czynniki wpływające na proces kształtowania równowagi dziecka oraz możliwości jej obiektywnej oceny. *Neurol Dziec* 2011; 20 (41)121-12
15. Pokrywa J, Fugiel J, Posłuszny P. Częstość wad postawy ciała u dzieci z Zagłębia Miedziowego. *Fizjoterapia,* 2010; 18(4)27-39
16. Rast MM, Harris SR. Motor Control in Infants with Down Syndrome. *Dev med child neurol*, 1985; 27, 5: 682–685
17. Sadowska L, Gruna-Ożarowska A, Krefft A, Badowski R. Syntetyczna ocena zmian strukturalnych mózgu w badaniu magnetycznym rezonansem jądrowym (MRI) u leczonych osób z zespołem Downa. Rzeszów. *Przegl Med,* 2005 (3): 252-261
18. Sadowska L, Wójcik E. Czy w świetle współczesnych badań zespół Downa jest genetycznym przeznaczeniem? *Med Biol*, 1997; 1:10-18
19. Shumway-Cook A, Woollacott MH. Dynamics of Postural Control in the Child with Down syndrome. *Phys ther*, 1985; 65:1315-1322
20. Walicka-Cupryś K, Skalska-Izdebska R, Drzał-Grabiec J, Sołek A. Związek pomiędzy postawą ciała i stabilnościąposturalną u dzieci w wieku wczesnoszkolnym. *Post Rehabil,* 2013 (4), s. 47-54
21. Wisniewski KE, Laure-Kamionowska M, Connell F, Wen GY. Neuronal density and synaptogenesis in the postnatal stage of brain maturation in Down syndrome. *The neurobiology of Down syndrome,* 1986; 29-44