Issue Rehabil. Orthop. Neurophysiol. Sport Promot. 2024; 49: 7–13. ISSN 2300-0767
DOI: 10.19271/IRONS-000217-2024-49

ORIGINAL ARTICLE

THE INFLUENCE OF SENSORY INTEGRATION ON THE LEVEL OF MAINTAINING BALANCE IN CHILDREN WITH MILD INTELLECTUAL DISABILITY

WPŁYW INTEGRACJI SENSORYCZNEJ NA POZIOM UTRZYMANIA RÓWNOWAGI U DZIECI Z UPOŚLEDZENIEM UMYSŁOWYM W STOPNIU LEKKIM

Agata Aduła[1], Lewandowski Jacek[2,3]
[1]Department of Physiotherapy, Collegium Medicum, University in Zielona Góra, Poland
[2]Department of Physiotherapy, Calisia University, Poland
[3]Department of Physiotherapy, University School of Physical Education, Poland

ABSTRACT

Introduction

The ability to maintain balance is one of the important factors in measuring a person's physical fitness.

Aim

Analysis of the influence of Sensory Integration therapy on maintaining balance in children. Comparison of the study group with the control group of children who performed the author's general development exercises.

Material and methods

The study involved 36 children. The study group consisted of 7 girls and 11 boys who attended Sensory Integration classes. The control group consisted of eight girls and ten boys who performed the author's general development exercises. The age was determined, and the children's weight and height were measured. As part of the study, tests were conducted to assess static balance: the Romberg test with eyes open and closed and the one-legged stance test. Dynamic balance was assessed with a straight-line walking test. All children attended classes once a week for 4 months, and the tests were repeated afterward.

Results

In the study group, after 4 months of therapy, the average results of the tests assessing the vertical body posture in statics and dynamics indicated a significant improvement in maintaining balance ($p < 0.05$). In the control group, after 4 months, the results of the one-legged standing test and the straight-line walking test indicated a significant improvement ($p < 0.0002$, $p < 0.0003$).

Conclusion

The use of Sensory Integration therapy improved the children's balance. Children with normal muscle tone have the best level of balance.

Keywords: balance, sensory integration, general development exercises

Author responsible for correspondence:
Agata Aduła
Department of Physiotherapy, Collegium Medicum
University in Zielona Góra, Poland
Email: adula.agata@gmail.com
https://orcid.org/0000-0002-3417-2084 (Lewandowski Jacek)

Authors reported no source of funding
Authors declared no conflict of interest

Date received: 16th December 2024
Date accepted: 27th January 2025

STRESZCZENIE

Wstęp

Zdolność do utrzymania równowagi jest jednym z ważnych czynników pomiaru sprawności fizycznej człowieka (Wang *et al.* 2022).

Cel

Analiza wpływu terapii Integracji Sensorycznej na poziom utrzymania równowagi u dzieci. Porównanie grupy badanej z grupą kontrolną dzieci, które wykonywały autorski zestaw ćwiczeń ogólnorozwojowych.

Materiał i metody

W badaniach udział wzięło 36 dzieci. Grupa badana składała się z 7 dziewczynek 11 chłopców, które uczęszczały na zajęcia Integracji Sensorycznej. Grupa kontrolna liczyła 8 dziewczynek 10 chłopców, które wykonywały autorski zestaw ćwiczeń ogólnorozwojowych. Przed przystąpieniem do terapii, określono wiek, dokonano pomiaru masy oraz wysokości ciała. Przeprowadzono testy oceniające równowagę statyczną: próbę Romberga, test postawy jednonożnej. Równowagę dynamiczną oceniono testem chodzenia po linii prostej. Wszystkie dzieci uczęszczały na zajęcia raz w tygodniu przez okres 4 miesięcy, po tym czasie ponownie przeprowadzono testy.

Wyniki

W grupie badanej po upływie 4 miesięcznej terapii, średnie wyniki testów oceniających pionową postawę ciała w statyce i dynamice wskazywały istotną poprawę utrzymania równowagi ($p < 0,05$). W grupie kontrolnej po upływie 4 miesięcy, wyniki testów stania na jednej nodze oraz testu chodzenia w linii prostej wskazywały znaczącą poprawę ($p < 0,0002$, $p < 0,0003$). Próba Romberga przy oczach otwartych dała w obu grupach jednakowe wyniki w badaniu początkowym oraz brak zmiany po upływie 4 miesięcy.

Wnioski

Pod wpływem zastosowania terapii Integracji Sensorycznej nastąpiła poprawa utrzymania równowagi u dzieci. Dzieci o prawidłowym napięciu mięśniowym charakteryzowały najlepszym poziomem równowagi. Chłopcy wykazywali się lepszym poziomem utrzymania równowagi w porównaniu do dziewczynek.

Słowa kluczowe: integracja sensoryczna, równowaga, ćwiczenia ogólnorozwojowe

Introduction

The upright position of the human body is defined as the vertical positioning of the body about the support plane (Błaszczyk, 2004). This is possible thanks to the equalization of forces and their moments acting on the body; it is a given state of the postural system (Błaszczyk, 2004). Maintaining a vertical posture is possible thanks to the nervous system, which provides tension to the antigravity and postural muscles (Jacobson *et al.,* 2016). As a result of the verticalization of the human body, a complex sensory-reflex process called balance is formed, which develops in the sixteenth week of fetal life (Mucha *et al.,* 2016). The balance system controls sensory impressions between the brain and the human body (Mraz *et al.,* 2010). The main task in maintaining a vertical posture is maintaining the body's center of gravity both in the resting position and in movement (Mucha

et al., 2016). The most important element of the balance system is the vestibular organ, vision, and deep sensation receptors located in muscles, skin, and tendons. Any disorders within these systems cause dysfunctions in maintaining a vertical body posture (Pyda-Dulewicz *et al.* 2016; Gos *et al.* 2019).

The study's main objective was to analyze the effect of Sensory Integration (SI) therapy on the balance of children aged 6–8. Additionally, the effect of SI therapy on children's balance was compared to the control group, which, for various reasons, did not attend classes and, at that time, performed an original set of general development exercises.

Methodology

A total of 36 children (21M, 15F) permanently residing in the Care and Treatment Facility in Jaszkotle participated in the study. SI was used in the study group (11M, 7F), while original general development exercises were implemented in the control group. Children from the control group were excluded from SI mainly due to medical contraindications. In both groups, classes were held once a week for 4 months. The conditions for inclusion in the study were age (6–8 years), balance disorders observed by a physiotherapist, the ability to walk, and mild mental retardation. The conditions for exclusion from the group were: balance disorders caused by diseases or permanent neurological damage, general poor health, lack of cooperation with the child, and mental retardation other than mild. Exercises and tests were performed in an exercise room and a special room for SI therapy in the Children's Care and Treatment Facility in Jaszkotle. Before starting the study, written consent was obtained from the children's legal guardian. Based on medical documentation, the degree of muscle tone was determined among the examined infants. Body weight and height were measured. The static balance was assessed in the studies using:

Romberg tests (eyes open, eyes closed – T1a, T1b, respectively) (Goddard *et al.,* 2015). The following scoring (points) was used: 0 – no changes in posture, the child maintains balance; 1– slight deviation in any direction; 2 – strong swaying and deviation of the upper limbs; 3 – clear loss of balance, raising the arms; 4 – positive test, loss of balance with open and closed eyes, but also when the child maintains balance with open eyes but loses it with closed eyes.

One-legged stance test (T2). According to Goddard Blythe, the scoring (points) was adopted depending on seconds (sec.) below the age norm: 0 points – no abnormalities, 1 point – up to 2 sec., 2 points – up to 4 sec., 3 points – up to 6 sec., 4 points – up to 8 sec. (Goddard Blythe *et al.* 2015).

The Straight Line Walking Test (T3) (Goddard Blythe, 2015) assessed dynamic balance. The following scoring system was used: 0 – no abnormalities, 1 – slight difficulties in maintaining balance, hand and arm movements, change in facial expression, looking down, two symptoms as above (intensity), 3 – body sway, the child is very close to losing balance, 4 – complete loss of balance.

The study group's classes took place in a room adapted for SI therapy. Group 18 was divided into six subgroups of 3 people. The classes took place in an obstacle course containing, among other things, hammocks, suspensions, beams, a climbing wall, and a platform. During the research, an attempt was made to follow the child and not repeat similar task patterns in a short period of time. The exercises in the control group took place in a rehabilitation room. The children performed their general development exercises, and all the classes were held in the form of play. The group of 18 children was also divided into six groups of 3 people each. Each time, the classes had the same pattern: a warm-up, the main part in which the difficulty of the exercises was graded over time, and the final part – a cool-down. In the first month, exercises were performed in sitting and quadruped positions. In the second month, exercises were performed in a standing position, while in the third month, more challenging exercises were used in a standing position;

additionally, an unstable surface was included. In the last month, the children performed balance exercises using an unstable surface, and additionally, exercises with closed eyes were included. After 4 months of therapy, the same tests were performed again to assess the level of maintaining balance in the children.

Results

Main correlations: Basic data and patient characteristics are presented in Table 1. The ages of the children studied ranged from 6 to 9 years. The age distribution in the study and control groups did not differ significantly (p for t test Student is 0.866). Similarly, in the gender structure, body mass, and height of both groups, no statistical significance was observed.

Table 1. Baseline characteristics.

Variable	Study group	Controls
Age (years): Mean ± SD	7.28 ± 0.96	7.22 ± 1.00
Sex:		
Males, n (%)	11 (61)	10 (56)
Females, n (%)	7 (39)	8 (44)
Weight (kg)		
MalesMean ± SD	18.8 ± 4.1	18.2 ± 3.4
Female Mean ± SD	21.0 ± 3.3	20.1 ± 5.5
Height (cm)		
Males Mean ± SD	110.4 ± 10.1	110.1 ± 6.7
Female Mean ± SD	118.1 ± 7.2	113.9 ± 10.5

SD – standard deviation; n – number, % – percent

Detailed results: The tests conducted in the study group before and after the implemented therapy are presented in Table 2, while for the control group, they are presented in Table 3. In the study group, for the remaining tests (T1b, T2, T3) after 4 months of SI use, the average result showed a statistically significant improvement $p < 0.05$ (the average number of points decreased). In the control group, after 4 months of general development exercises, a statistically significant improvement was found in the tests T2 and T3 ($p < 0.05$), except for the Romberg Test with closed eyes (T2) ($p > 0.0679$).

Comparison of therapies (intergroup analysis): Table 4 compares test results between groups based on the therapy implemented (SI vs. general development exercises). Children in both groups performed the Romberg test with open eyes (T1a) flawlessly before and after the implemented therapies ($p = 1.00$). The mean values of balance improvement assessed in tests T1 and T2 did not differ statistically significantly in both groups. In contrast, in test T3, a statistically significant difference was observed, i.e., a "more pronounced" improvement for the control group – general development exercises ($p < 0.05$).

Test results and muscle tone: Table 5 presents the results of balance tests based on the history of muscle tone collected from children's medical records from the neonatal period. It was omitted from the table because all children performed the T1a test without errors. The measurement results refer to all children and are not considered depending on the intention to implement a given therapy. It was found that in the group of 36 children qualified for the study, 16 (44%) showed correct muscle tone, and in 11 (31%), it was increased, and in the remaining 9 (25%) – it decreased. The T2 and T3 results were statistically significant depending on the level of muscle tone, with the best results achieved by children with a history of correct muscle tone and the poorest – with decreased muscle tone.

Discussion

Under the influence of 4 months of SI therapy, there was an improvement in the process

Table 2. The results of examinations in the study group before (Test 1) and after the therapy (Test 2).

Test	Result (pts.)	Cases (n)		Mean (pts.)		Mean difference (B2-B1)	p (Wilcoxon)
		Exam 1	Exam 2	Exam 1	Exam 2		
T1a	0	18	18	0.00	0.00	0	1.0000
T1b	0	12	17	0.33	0.06	−0.28	0.0431
	1	6	1				
T2	0	0	5	2.28	0.94	−1.33	0.0002
	1	3	9				
	2	8	4				
	3	6	0				
	4	1	0				
T3	0	0	1	2.72	1.94	−0.78	0.0010
	1	1	6				
	2	6	6				
	3	8	3				
	4	3	2				

T1a – Romberg test (eyes open), T1b – Romberg test (eyes closed), T2 – UPST, T3 – Walking straight-line test, pts – points

Table 3. The results of examinations in the control group before (Test 1) and after the therapy (Test 2).

Test	Result (pts.)	Cases (n)		Mean (pts.)		Mean difference (B2-B1)	p (Wilcoxon)
		Exam 1	Exam 2	Exam 1	Exam 2		
T1a	0	18	18	0.00	0.00	0	1.0000
T1b	0	12	16	0.33	0.11	−0.22	0.0679
	1	6	2				
T2	0	0	9	2.22	0.83	−1.39	0.0002
	1	4	4				
	2	7	4				
	3	6	1				
	4	1	0				
T3	0	0	5	2.61	1.11	−1.50	0.0003
	1	2	8				
	2	7	4				
	3	5	0				
	4	4	1				

T1a – Romberg test (eyes open), T1b – Romberg test (eyes closed), T2 – UPST, T3 – Walking straight-line test, pts – points

of maintaining balance in children. Rehabilitation using SI methods stimulates the vestibular system and the sense of deep sensation, positively improving children's balance (Przyrowski *et al.* 2013). SI therapy is one of the possible ways of improving children with balance disorders. During classes, there is a massive influx of sensations, especially vestibular and proprioceptive ones, which the child receives, then sorts and triggers a feedback reaction (Pierchała *et al.* 2008). In 2012, very similar studies were conducted on a group of 21 children attending SI classes once a week. Also, after 4 months, balance improved during the exercises, and coordination and accuracy were noted (Shumway-Cook *et al.* 2007). Analysis shows that children with normal muscle tone have the best level of maintaining balance. Children with reduced muscle tone demonstrated the

Table 4. Comparison of the test results between the groups dependent on the therapy.

Test	Mean [pts.]				Mean improvement [pts.]		p (Mann-Whitney)
	Study group		Controls		Study group	Controls	
	Exam 1	Exam 2	Exam 1	Exam 2			
T1a	0.00	0.00	0.00	0.00	0.00	0.00	1.0000
T1b	0.33	0.06	0.33	0.11	0.28	0.22	0.7880
T2	2.28	0.94	2.22	0.83	1.33	1.39	0.8002
T3	2.72	1.94	2.61	1.11	0.78	1.50	0.0046

T1a – Romberg test (eyes open), T1b – Romberg test(eyes closed), T2 – UPST, T3-Walking straight-line test, pts – points

weakest balance. Muscle tone disorders are characterized by difficulties in holding the body against the force of gravity (Matyja *et al.* 1997). A child with reduced muscle tone is characterized by a disorder of the sense of integration between the group of flexors and postural extensors (Matyja *et al.* 1997; Matyja *et al.* 2009). As a result, compensation occurs: the support plane is widened by tilting the pelvis forward (shifting the center of gravity), the feet and knees become valgus, and the spine curves become deeper (Matyja *et al.* 1997; Matyja *et al.* 2009). The entire change in body position causes impairment of postural stability. Thirty-six children participated in our research, of which the average age in the research group was 7.28 years.

In contrast, in the control group, it was 7.22 years, corresponding to intensive psychomotor development. The age distribution in the research and control groups did not differ significantly. The age of 7 is very intensive in terms of development. It is called the golden age of human motor skills (Mraz *et al.* 2010). At the age of 6–7, children reach their first peak of motor skills (Ostrowska *et al.* 1993). At the age of 7–8, the child's body posture is similar to that of an adult; thanks to the growth of the limbs, the abdominal muscles are strengthened, and the body's center of mass is lowered (Kasperczyk, 2000; Kasperczyk, 2004). The studies show that compared to girls, boys achieved results in the T2 and T3 tests, thus demonstrating a better level of maintaining an upright body position. Differences in external structure and gender in children aged 5–12 years, there is no significant relationship between gender and movements of individual body parts during a standing position (Lebiedowska *et al.* 1994; Przyrowski *et al.* 2013). During walking, there was also no difference between the boys and girls aged 5–18 years (Lebiedowska *et al.* 1994; McEvoy *et al.* 2005).

Study limitations

The main limitation of the work is the small number of the study group. Studies should be conducted on a more significant number of people. Additionally, children should be examined for posture defects.

Conclusions

1. The 4-month SI therapy improved the maintenance of balance in children aged 6–8.
2. After 4 months, children achieved better results in the test assessing dynamic balance because of the use of general development exercises.
3. Children with proper muscle tone have the best level of balance.
4. Boys showed a better level of maintaining balance compared to girls.

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