Locomotor skills of visually impaired students compared to non-disabled students: cross-sectional study

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Abstract

Background: Most available publications assessing locomotor skills (LS) and comparing results between visually impaired (VI) and non-disabled peers focus on quantitative evaluation, often neglecting qualitative aspects. Qualitative assessment of motor skills in children with visual impairments can provide valuable insights into their development. Further research is needed to better understand the quality of motor development in this group and to tailor appropriate therapeutic strategies.

Aims: The aim of this study was to compare the LS of students with VI to those of non-disabled peers and to evaluate the impact of selected factors on LS levels in the compared groups.

Material and methods: The study was conducted in March 2022 at the Róża Czacka School and Education Center for Blind Children in Laski as part of the research project "Assessment of Locomotor Skills in Children and Youth with Visual Impairments." The study included 47 primary school students: 26 blind and 21 partially sighted, aged 7-17, along with 85 non-disabled students from three primary schools in Warsaw. The Test of Gross Motor Development-3 (TGMD-3) battery was used, specifically the "Locomotion" subtest comprising six movement tasks.

Key words

motor development, visually impaired, blind, visual dysfunction, locomotor skills, TGMD-3.

Results: No correlation was found between parameters such as height, body weight, age, and gender with the total points scored in the test. Significant differences were observed in the results of the TGMD-3 "Locomotion" subtest when comparing VI and non-disabled individuals.

Conclusions: The level of LS mastery in children and adolescents with VI appears to be independent of gender, age, and basic body parameters. Lack of or significant limitation in visual experiences affects the process of mastering basic LS, making regular assessments essential for the development of rehabilitation programs to address existing deficits. The TGMD-3 battery provides crucial information about the current level of basic locomotor skills necessary for independent daily functioning in VI individuals. The analysis of these results can help develop strategies to support motor development in this group of children and adolescents with disabilities.

Introduction

Most available publications assessing locomotor skills (LS) and comparing results between visually impaired (VI) individuals and their non-disabled peers focus on quantitative evaluation, often neglecting qualitative aspects. The comparison of these studies shows a large variation in assessing the mastery of selected LS in children with VI (**Table 1**). The researchers concentrated on various basic motor skills such as walking, running, jumping, and object manipulation. The goal was to evaluate how these skills develop in children with visual impairments and how they differ from their non-disabled peers.

Research focused on observing and qualitatively analyzing individual elements of movement, such as coordination, balance, strength, and precision. Many studies have highlighted certain deficits or delays in mastering LS compared to non-disabled peers. Qualitative assessment of motor skills in children with visual impairments can provide valuable insights into their development. However, due to the limited number of scientific studies in this area, further research is needed to better understand the quality of motor development in this group of children and to tailor appropriate therapeutic strategies.

Aims

The aim of this study was to compare the LS of students with VI to those of non-disabled peers and to evaluate the impact of selected factors on LS levels in the compared groups.

Material and methods

Ethical considerations

The project was approved by the Senate Ethics Committee of the Józef Piłsudski University of Physical Education in Warsaw, Poland.

Study participants

The study was conducted in March 2022 at the Róża Czacka School and Education Center for Blind Children in Laski as part of the research project "Assessment of Locomotor Skills in Children and Youth with Visual Impairments." The study included 47 primary school students from the center in Laski, consisting of 26 blind and 21 partially sighted students, as well as 85 non-disabled students from three primary schools in Warsaw. The assessment of non-disabled students was performed as part of a previous project on the evaluation of LS in non-disabled children, with results used with permission from the project author (mgr Kalina-Kaźmierska-Kowalewska).

Table 1. Literature review.

Authors	Research Aim	Study Group	Research Methods	Results and Practical Implications
Haibach P., Wagner M., Lieberman L. [1]	Determinants of gross motor skill performance in children with visual impairments	N = 100	Quantitative analysis of motor skills in VI children	Identified age, gender, and degree of VI as factors influencing motor skills. Emphasized need for tailored interventions
Wagner M., Haibach P., Lieberman L. [2]	Gross motor skill performance in children with and without visual impairments	N = 23	Comparative analysis of motor skills in VI and non-disabled children	Found significantly lower motor skill levels in VI children compared to non-disabled peers
Houwen S., Hartman E., Jonker L., Visscher C. [3]	Reliability and validity of the TGMD-2 in primary--school-age children with visual impairments	N = 75	Psychometric evaluation of TGMD-2 in VI children	Demonstrated reliability and validity of TGMD-2 for assessing motor skills in VI children
Valentini N., Duarte M., Zanella L., Nobre G. [4]	Test of Gross Motor Development-3: Item Difficulty and Differential Functioning by Gender and Age with Rasch Analysis	N = 989	Assessment of TGMD-3 in children with various disabilities	Confirmed TGMD-3 as an effective tool for assessing motor skills across different phases of childhood
Brian A.S., Starrett A., Pennell A., Beach P.H., Miedema S.T., Stribing A., Gilbert E., Patey M., Lieberman L.J. [5]	The Brief Form of the Test of Gross Motor Development-3 for Individuals with Visual Impairments	N = 1000	Development and validation of a brief TGMD-3 form for VI individuals	Provided an efficient tool for assessing motor skills in VI individuals

Abbreviations: *TGMD-3 – Test of Gross Motor Development-3*; VI – *visually impaired.*

Qualification criteria

Inclusion criteria for VI individuals: consent to participate in the study, regular participation in physical education classes, visual acuity below 3/60 in the better eye or a visual field of 10 degrees where the full visual field is 180 degrees (according to WHO classification from 2022), visual acuity above 3/60 but below 6/18 for partially sighted individuals, age 7-17 years, no other dysfunctions besides VI, and normal intellectual capacity.

Measurements

Height and body weight were measured (**Table 2**), and Body Mass Index (BMI) was calculated. Body weight was measured with an electronic scale accurate to 0.1 kg, and height was measured with a wall-mounted tape measure accurate to 0.5 cm. Basic characteristics of the participants are presented in **Table 2**.

Table 2. Characteristics of the study group.

Group	Blind (n=26)	Partially Sighted (n=21)	Non-Disabled (n=85)
Girls	11	7	40
Boys	15	14	45
Age (years)	13 (8-17±2.25)	12 (7-16±2.45)	85 (6.5-10±1.02)
Height (cm)	153.3 (128-178±13.3)	156 (126-186±15.85)	133 (112.5-152±9.58)
Weight (kg)	48.2 (23.8-95±15.27)	53.4 (24.6-109±21.33)	31.1 (10-53±7.73)
BMI	20.5 (13.3-29.98±4.13)	22 (13.8-37.7±5.87)	17.6 (7.2-26.5±2.92)

Abbreviations: *Min – minimum values; Max – maximum values; BMI – body mass index.*

This study used the Test of Gross Motor Development-3 (TGMD-3) test battery, an adaptation of the earlier TGMD-2, which was designed to assess, among other things, the UR of individuals with DW [3, 6]. The creator of the test battery, an accurate and reliable tool for the qualitative assessment of motor skills in children and adolescents, is Dr Dale Ulrich [7]. The test consists of two parts that assess gross motor skills, including locomotor skills and the ability to control training equipment.

In the current study, the Locomotion subtest was used, which consists of six motor tasks: (1) Run, (1) Gallop, (3) Hop, (4) Horizontal Jump, (5) Skip, (6) Slide.

Each trial was recorded by telephone and analysed by three experts for people with DW and one expert for people without disabilities. Assessors also performed the tests. The scoring was done according to the rules and criteria given in the instructions for each trial [7, 4, 8]. The final score was the sum of the points obtained in each movement task, awarded by consensus of the experts (people with DW).

A maximum of 8 points could be obtained for each of the running, tumbling, long jump and gliding trials, 10 points for the triple jump and 6 points for the jump. The maximum raw score for the locomotion subtest was 48 points.

Statistical analysis

The results were analyzed using SPSS Statistica version 13.0, under an academic license from the AWF Warsaw. Normality of distribution was assessed using the Shapiro-Wilk test. The Kruskal-Wallis ANOVA was used to analyze differences in LS levels among blind, partially sighted, and non-disabled children, as the distribution was non-parametric. Post-hoc multiple comparisons of mean ranks were used for all trials. Spearman's rank correlation was used to assess the relationship between the total points scored in the TGMD-3 "Locomotion" subtest, characterizing LS level, and body parameters (height and weight), age, and gender. A significance level of $p \leq 0.05$ was adopted.

Results

Relationship between basic body parameters, gender, and age among vi and non-disabled individuals

No correlation was found between the total points scored in the TGMD-3 "Locomotion" subtest and body parameters (height and weight) or age in the VI group. However, a significant relationship was observed between height and age with total points in the non-disabled group. Similar correlations were found in the group of non-disabled girls (**Table 3**).

Comparison of total points scored in the tgmd-3 "locomotion" subtest by blind, partially sighted, and non-disabled individuals

Statistically significant differences were found when comparing the three groups ($H = 15.33$ for $p<0.01$). Post-hoc tests showed that higher scores (total points in the "Locomotion" subtest) were noted in the partially sighted group compared to blind and non-disabled individuals (**Table 4** and **Figure 1**).

Table 3. Comparison of relationships between basic body parameters, gender, and age among vi and non-disabled individuals.

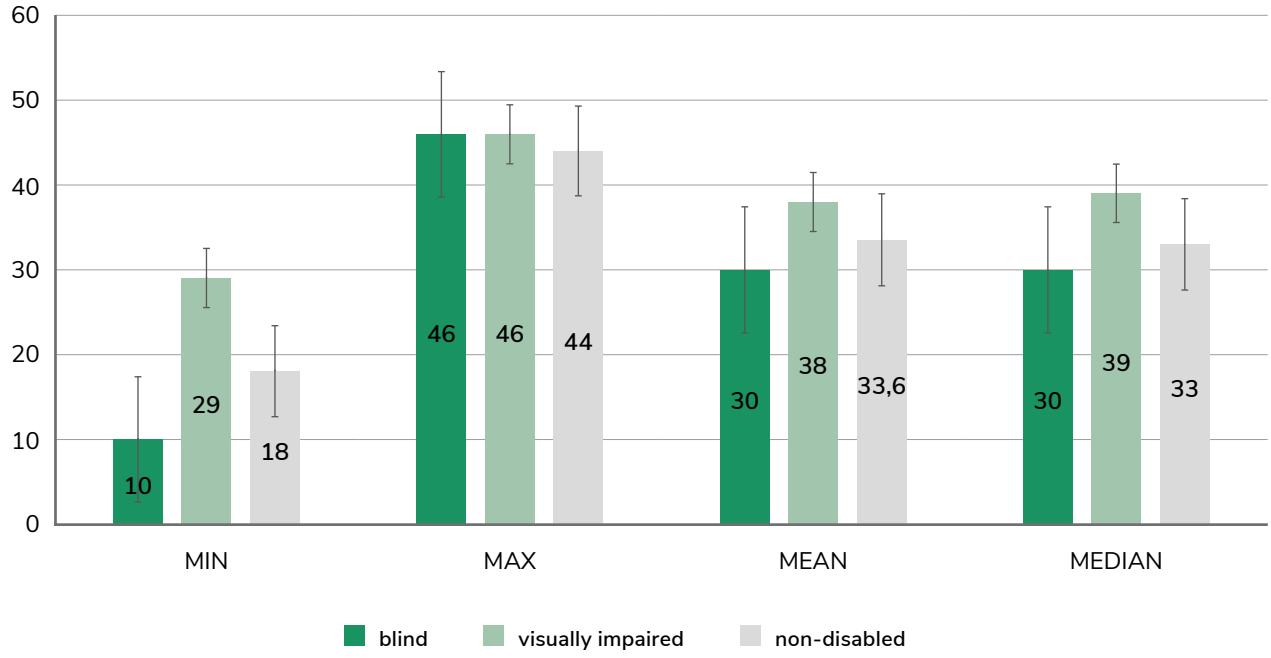
	Visually impaired			Without disabilities		
	Correlation Coefficient			Correlation Coefficient		
	Girls	Boys	Overall	Girls	Boys	Overall
Body Height (m)	0.13	0.13	0.17	**0.34***	0.09	**0.22***
Body Weight (kg)	0.11	0.11	0.11	0.08	0.06	0.08
Age (years)	0.22	0.05	0.20	**0.43***	0.27	**0.35***

Abbreviations: *Significant differences ($p \leq 0.05$).*

Table 4. Significance of differences between total points scored in the tgmd-3 "locomotion" subtest in compared groups.

Multiple comparison test of mean ranks for all samples Probability for post-hoc tests			
Visual impaired	Blind	Partially sighted	Without disability
Total scores	30.04	38.24	33.60
Blind		0.0002	0.1216
Partially sighted	0.0002		0.0094
Without disability	0.1216	0.0094	

Figure 1. Comparison of total points scored in the tgmd-3 "locomotion" subtest in three groups.



Comparison of results in individual movement tasks among three study groups

In comparing the results in individual tasks of the "Locomotion" subtest, Kruskal-Willis ANOVA revealed statistically significant differences between the blind, partially sighted, and non-disabled groups in specific movement tasks. Partially sighted and non-disabled individuals achieved better results than blind individuals in running, hopping, and skipping tasks (**Table 5**). Post-hoc tests indicated that partially sighted individuals scored significantly better than blind individuals in running, hopping, and skipping tasks. Non-disabled individuals scored significantly higher than blind individuals in the running task and significantly higher than partially sighted in the skipping task. However, non-disabled individuals scored significantly lower in the horizontal jump and slide tasks compared to the VI group. No differences were noted in the gallop task.

Discussion

The aim of this study was to compare the locomotor skills (LS) of students with visual impairments (VI) to those of non-disabled peers and to evaluate the impact of selected factors on LS levels in the compared groups.

The Test of Gross Motor Development-3 (TGMD-3), specifically the "Locomotion" subtest, was used in the study. This test is a reliable and valid tool for assessing the qualitative level of LS and has been adapted and tailored for VI individuals. The study was part of a larger project and served as a pilot study. It should be noted that this research is the first of its kind in Poland, and the obtained results can be compared to a few studies by American and Dutch authors. In the analysis of the results of the current study, besides data on individuals with visual impairments, results from a previous project evaluating LS in non-disabled

Table 5. Effect of visual impairment on results of the "locomotion" subtest.

Task	Blind (Group 0) Median	Partially Sighted (Group 1) Median	Non-Disabled (Group 2) Median	ANOVA (p<0.05)
Run	4±2.64	6±1.59*	7±1.23*	p<0.001
Gallop	6±2.23	6±1.53	6±2.28	p=0.032
Hop	4±2.75	6±1.28*	5±1.74	p=0.032
Skip	3.5±2.00	4±2.06*	4±1.22#	p=0.003
Horizontal Jump	7.5±2.14	8±1.28	6±2.33#*	p=0.004
Slide (Side Step)	8±1.84	8±0.68	6±1.24#*	p=0.001

Notes: *Significantly different from Group 0; #Significantly different from Group 1.*

children were used (with permission from the project's author). The expert evaluation for individuals with VI was conducted by a three-person team, previously trained and experienced in this area. The final score was the result of the experts' consensus. For non-disabled individuals, the assessment was conducted by a single expert. Comparative analysis of the results of individuals with VI and non-disabled individuals indicates the need for verification in principal studies, i.e., conducting assessments across all study groups by the same team of experts. The absence of this approach in the current analysis is a limitation of our pilot study.

A literature review indicated that children and adolescents with VI exhibited motor development deficits compared to their non-disabled peers. The magnitude and severity of these deficits depended on internal factors such as the degree of VI, brain cortex development, and sensory-motor connections. External factors were also important, such as appropriate visual stimulation, use of sensory toys, participation in sports activities, acceptance and socialization with peers with and without VI, support from close ones in daily activities, positive self-esteem, and adapting the environment and educational demands to the child's needs [9, 10, 11]. An important factor affecting motor development deficits is primarily the limited ability to use visual stimuli, which are strong motivators for movement. Lack of visual stimulation may limit the need to explore the world and the surrounding environment. Additionally, the lack of adequately adapted toys and stimuli to stimulate other senses may limit motor development in blind children compared to their non-disabled peers. VI can also delay visuomotor coordination and disrupt hand manipulation functions. Lack of early intervention and professional care can also delay development [12].

In this study, the overall LS level among blind and partially sighted children and adolescents was compared to non-disabled individuals. A literature review indicated that VI individuals aged 6-10 years presented significantly lower LS levels than non-disabled peers, prompting a comparison of VI individuals aged 7-17 years to younger non-disabled children (7-10 years). Considering

that LS assessed using the TGMD-3 "Locomotion" subtest tasks are typically mastered by non-disabled children by around age 10, it was assumed that VI individuals might need more time to reach a similar level. Therefore, the study group with VI included individuals up to 17 years old. It turned out that this assumption was not accurate, recognized as a limitation of our pilot study, and further verification is needed. In principal studies, the age of non-disabled individuals will be similar to that of VI individuals.

The current study showed that partially sighted individuals presented the highest level of LS mastery compared to blind and non-disabled students. Despite the VI group being significantly older than the non-disabled students, it was surprising that blind individuals achieved results similar to non-disabled individuals. Comparison with results from other, albeit few, studies indicated that blind individuals scored lower than non-disabled individuals, but in these studies, VI children were compared to their peers. The current study's results suggest that blind individuals achieve a similar level of LS mastery at an older age, which will be verified in future studies.

Another aspect addressed in this study was the detailed analysis of differences in mastering individual LS among the compared groups. Partially sighted individuals scored significantly better than blind and non-disabled individuals in running, hopping, and skipping tasks. Haibach's study indicated the same tasks where partially sighted individuals performed significantly better than blind individuals [1]. Blind individuals scored significantly lower than non-disabled and partially sighted individuals in the running task. Both blind children and adolescents performed the task much more cautiously and slowly than partially sighted individuals, with experts observing numerous errors in running technique. Da Silva's study emphasized that VI reduced walking and running speed, resulting in less dynamic movements [14]. The authors of the current study noted that some VI individuals preferred a typical safety posture with both arms extended in front of the body instead of alternate arm movements. Mastering running technique should be based on supporting confidence and safety in movement and spatial orientation development. It seems that in early childhood, it is also necessary to support the development of such movements as crawling, which teaches alternate limb movements essential for mastering walking and running techniques [14, 15].

Another surprising aspect of the study was the results in the horizontal jump and slide tasks, where both blind and partially sighted individuals achieved the maximum number of points, consistent with Wagner's research [2]. However, it was equally surprising that none of the non-disabled children in the comparative studies achieved the maximum number of points in any task, highlighting the importance of having all study groups assessed by the same team of experts.

One criterion for evaluating the slide task was moving sideways throughout the movement. It was expected that blind individuals would not maintain the correct movement pattern and would turn to face the direction of movement, which occurred during the instruction but was corrected in the proper trials evaluated for points.

In this study, the influence of selected factors on the LS level in the compared groups was also assessed. It was found that age, gender, and basic body parameters of individuals with VI were not related to the level of LS mastery. Similar results were presented in studies by Haibach [1] and Da Silva [14]. In the current analyses, a positive correlation related to age was expected, meaning that the older the participants, the better the results, which was found only in the group of non-disabled individuals. A similar relationship among non-disabled children and adolescents was detected by the authors of the study [16]. Adolescents with VI who have more movement experiences, including locomotion, should have a higher level of LS mastery than children. One reason may be the described low level of physical

activity, decreasing among school youth with age, and a sedentary lifestyle among individuals with VI [17, 18].

Study limitations

In the case of non-disabled people, the assessment was carried out by an expert. The comparative analysis of the results of those with DW and those without DW shows the need to revise the measures in the core studies, i.e. to have the same team of experts perform the assessment in all study groups.

Furthermore, comparisons were made between groups of subjects of different ages, i.e. non-disabled children (7-10 years) versus those with DW (7-17 years), and the Discussion explains the reason for this. It turned out that this assumption was not valid, and we acknowledge this as a limitation of our pilot study, so the inference must be very cautious and needs further verification. In the main study, the age of the people in the comparison groups will be similar.

An important factor to consider in future studies is the previous motor experience of children with DW. The current group of respondents with DW appeared to be heterogeneous in terms of this variable. It is likely that the large variation in results was due to the fact that not all children had attended primary school at the Laski School and Educational Centre since Year 1. From the opinions of the teachers working with the respondents, it appeared that some of the children had previously attended mass schools where they either did not participate in physical education or their participation was illusory as the teachers were not prepared to teach people with this type of disability. This factor has also been mentioned in the literature [12, 19, 17, 18]. Therefore, it would be worthwhile to extend the study to assess both the level of AF and the experience of physical activity in early childhood.

Another important factor that could affect the UL of people with DW, which was not included in the current study, is a more accurate assessment of the level of dysfunction, e.g. in terms of differences in visual acuity (e.g. according to the IBSA classification) or a more detailed WHO classification [5]. Other vision-related factors affecting motor skill mastery could also be analysed, although this would require a very thorough ophthalmological examination.

Although we were not immune to errors in the pilot study, we gained a lot of experience and information necessary for the main part of the project.

Conclusions

The assessment of UR using the TGMD-3 test battery provides important information about, among other things, the current level of mastery of basic locomotor skills, which are crucial to achieving independence in daily functioning for people with DW. Analysis of the results of the assessment can be helpful in developing strategies to support the motor development of this group of children and young people with disabilities.

On the basis of the study, it was concluded that the level of mastery of UL by the children and adolescents with DW studied seemed to be independent of gender, age and basic parameters of the body structure, in contrast to non-disabled persons, in whom the development of these skills was observed with age between 7 and 10 years.

The absence or severe limitation of visual sensation influenced the difficulties in the process of mastering basic UL, so that regular assessment should be carried out, especially in the blind group, and on this basis, if necessary, a programme of improvement and/or correction of existing deficits should be developed.

The motor tasks that were most problematic and least mastered by the visually impaired (running, triple jumping, skipping) required an adequate level of bilateral coordination and the ability to maintain balance. The development of these aspects of motor skills can promote the reduction of existing limitations.

Declarations

Ethical Considerations: The project was approved by the Senate Ethics Committee of the Józef Piłsudski University of Physical Education in Warsaw, Poland. Informed consent was obtained from each participant after providing comprehensive information on the study's aim and protocol. The study was designed and conducted in accordance with the Declaration of Helsinki (1964) and Good Clinical Practice (GCP) guidelines.

Clinical Trials: This study was not registered as a clinical trial as it did not involve investigational products or interventions that would classify it under clinical trial regulations.

Conflict of Interest: The authors declare no conflict of interest. The study was conducted independently and without any influence from external organizations or entities.

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