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Original research article

MOTOR ABILITIES OF CHILDREN WITH DIFFERENT LEVELS OF VISUAL ACUITY

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Abstract. *The aim of this study was to determine the differences in the motor abilities between students with different levels of visual acuity. The research included 51 participants of both genders, aged 7 to 12, divided in to a group of typically developed children, with normal visual acuity (n=24) and a group of students with visual impairment (n=27). The group of students with visual impairment (VI) was divided into two groups: students with moderate visual impairment (MVI) and students with severe visual impairment (SVI). To evaluate their motor abilities we used eight tests from the Eurofit battery of tests. Typically developed children scored statistically significant higher results on the Flamingo Balance test, Plate Tapping, Sit-and-Reach, Sit-Ups in 30s the 10 x 5m, Shuttle Run and the 20m endurance shuttle run. Between two groups of participants with VI, statistically significant differences were determined only for the Flamingo Balance test for the evaluation of static balance, in favor of students with SVI. The assumption is that students with SVI rely on information obtained by peripheral sections of the retina more so than students with MVI. It is necessary to carry our further studies that would include a greater number of participants and a greater number of tests for the evaluation of balance, maintaining posture and walking so that the obtained hypotheses could further be confirmed.*

Key words: *visual acuity, visual impairment, balance, peripheral vision, differences*

INTRODUCTION

Visual perception accounts for approximately 80-90% of the information that the people receive from the environment (Barati, Barati, Gaeeni, & Ghanbarzadeh, 2013). Our sight enables us to perceive space, offers us information on the objects and beings around us enables us to recognize and predict dangerous situations, gives a spatial dimension to kinesthetic sensations, supervises the quality of the performed movement, adapts and

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automates sequences of movements (Brambring, 2006). Visual information plays a very important role in acquiring motor skills and abilities, since it offers motivation for movement and the manipulation of objects, and encourages the child to imitate the behavior of the other people in its surroundings (Stančić, 1991).

The International Classification of Diseases ICD -10 (2006) posits that there are 4 categories of visual function; however, for legal or educational purposes, the classification consists of five categories Stančić, 1991; Sugden, Hart, & Wade, 2013; Vučinić, 2014):

1. Category 1: moderate visual impairment (MVI), (visus from 0.3 to 0.1 or 20/70 - 20/200),
2. Category 2: severe visual impairment (SVI), (visus from 0.1 to 0.05 or 20/200 - 20/400),
3. Category 3: blindness - visus from 0.05 to 0.02 or less than 20/400, or visual field of 5°-10^0, regardless of visual acuity,
4. Category 4: severe blindness - visus from 1/60 (finger counting at 1m), and light perception or visual field of less than 5°,
5. Category 5: amaurosis - no visual ability (individual does not have light perception)

A person, whose visual acuity of his/her better eye is lower than 30% with correction, is considered a low vision person. This term points out that their vision is lower than usual, but they still possess visual abilities, and that differentiates them from blind persons (Dickinson, 1998).

In both the legal and sport classification systems, visual acuity and field of vision are measured to establish classification guidelines. According to Skaggs & Hopper (1996), The International Blind Sports Association (IBSA) defines three groups of visually impaired athletes:

1. Class B-1, athletes with total blindness to those athletes who still retain light perception but cannot seeing the contours of an object at any distance;
2. Class B-2, athletes with visual acuity up to 20/600, and/ or visual field of no more than 0-5°. They can see hand movements;
3. Class B-3 athletes with visual acuity from 20/599 to 20/200, and/ or visual field constricted to a diameter of 5°-20°.

The effects of visual abilities on developing and maintaining motor performances

The effects of visual impairment (VI) on an individual's life include the reduction in functional activities and a reduced quality of life (Freeman et al., 2007). Due to a lack of visual stimuli, blind and low vision children lack any motivation to explore their environment. A reduced interest in movement in space leads to minimal motor activity, which further results in a delay in motor development and the acquisition of motor skills (Bouchard, & Tetreault, 2000; Brambring, 2006; Sugden et al., 2013). Under such circumstances, the remaining sensory systems are required to make up for the lack of information from external sources that provide control and feedback for movement (Sugden et al., 2013).

Visually impaired children tend to lag in motor milestones, particularly in mobility and locomotion. This delay is a consequence of the primary lack of visual stimuli as well as limited motor activities. Lack of vision decreases stimulation to move and makes movement more difficult (Sermeev, 1980; Winnick, 1985). A lack of participation in movement and inability to develop motor skills lead to poor performances in physical activities. Lack of physical activity leads to insufficient levels of physical fitness, a common occurrence among the VI children (Ponchillia, Armbruster, & Wiebold, 2005). “There is strong evidence that blind children are at risk of poor physical fitness, but it appears that this is not a direct consequence of their VI and is instead due to a lack of participation” (Sugden et al., 2013, 333).

The main characteristic of students with VI and no additional developmental issues is their overall low level of physical fitness. Students with VI score significantly lower results on most components of physical fitness tests compared to their peers without VI or compared to the norms (Short et al., 1986; Skaggs et al., 1996; Lieberman & McHugh, 2001), irrespective of gender and age (Short et al., 1986). Skaggs et al. (1996) determined that individuals with VI had significantly lower levels of cardiovascular endurance, muscular endurance, flexibility, and balance than their typically developed peers. Two extensive studies (Buell, 1982; Short & Winnick, 1986) of motor abilities of VI students point out that these students can pass the regular norms and testing procedures for some tests (like pull and push ups, arm hang, standing long jump, sit-ups), but adjusted norms and testing procedures are needed to measure performances of these students, especially in running tests. VI (low vision or blindness) has an especially negative effect on motor skills that require significant control (coordination, endurance, speed, rhythm of movement), where deviation from the norm ranges from 15% to 30%. On the other hand, in the case of exercises that do not require visual control (force and strength of individual muscle groups), students with VI achieve good results (Sermeev, 1980; Short et al., 1986). Winnick (1985) highlights that the performance of VI students on different physical fitness items varies according to the nature of particular motor test.

The data from previous research of the differences in motor skills of students with different levels of VI (blind and low vision), is inconsistent. Winnick & Short (1982) stated that the physical fitness of VI students decreases as the severity of VI increases. But, Lieberman et al. (2001) determined that blind and low vision students are similar, and resemble each other more so than they do their typically developed peers. But, when comparing low vision (LV) to the blind students, LV ones have better motor skills (Lieberman et al., 2001). In most of the studies carried out so far in the field of motor abilities and skills of students with VI, typical developed students were usually compared to the VI primarily blind ones (Skaggs et al., 1996; Houwen, Visscher, Lemmink, & Hartman, 2009). Based on meta analysis of the Houwen et al., (2009) which included 26 research papers, only six of them compared the motor skills of typical developed students and students with different levels of VI. This indicates a lack of studies which would focus on the motor skills of students with different levels of visual abilities.

Thus, the aim of this study was to determine the differences in the motor skills of students with different levels of VI manifested as low vision, as well as any existing differences compared to their peers without VI.

METHODS

Sample of participants

The study included 51 participants of both genders, 7 to 12 years old, divided into a group of 24 typically developed children with normal visual acuity and 27 students with VI. The students without VI attended Elementary school “Kralj Aleksandar I” from Novi Beograd, while the students with VI attended the Elementary School for protection of vision “Dragan

Kovačević” in Belgrade and the School for visually impaired pupils “Veljko Ramadanović” in Zemun.

The average age, height and weight of the participants is shown in table 1.

Table 1 Participant characteristics.

Participants	Students without VI			VI students		
	N	Mean	SD	N	Mean	SD
Age	24	9.22	1.57	27	8.96	1.65
Height	24	140.63	10.64	27	140.06	11.69
Weight	24	35.83	8.06	27	35.79	9.44

All participants (students with and without VI) were matched in terms of height and weight. The group of students without VI was somewhat older 9.2 ± 1.7 (Mean ± SD) than the group of students with VI 8.96 ± 1.65. In addition to the participants being matched in terms of height, weight and age, they were also matched in terms of the frequency with which they participated in organized forms of physical activity. Accordingly, none of the participants actively participated in any sports, and when it came to organized forms of physical activity, they all had two physical education classes a week.

In order to form a sample of students with VI, the following criteria were adhered to: level of VI according to WHO criteria and no neurological, psychological, intellectual and health issues, so that these factors would not have any undue influence on the results of the motor tests. This means that the sample of participants with VI did not include children with multiple disabilities.

Characteristics of participants related to the vision abilities

The sample of students with VI was divided into two groups, based on the level of their VI, which is shown in table 2.

Table 2 Characteristics of VI participants in relation to the level of visual acuity and visual field.

VI students	Visual filed of participants		
	Less then 30°	From 50° to 70°	90° and more
	N	N	N
MVI (N12)	6	4	2
SVI (N14)	2	8	3
Total	8	12	5

The first group of participants, MVI consisted of 13 students with visus from 0.3 to 0.1. which is mean moderate VI, according to WHO. The second group, SVI consisted of 14 participants with visus from 0.1 to 0.05, respectively severe VI.

In the sample of students with VI, eight of them have concentric visual field defect, on both eyes, and their field of vision spans up to 30°. These participants are characterized by a complete lack of the peripheral vision. Twelve of them have reduced visual field in temporal direction, with vision spans on both eyes from 50° to 70°. Five of the participants had a preserved field of vision, with a span of 90° in temporal direction, on both eyes. There were no monoculi in the sample, and for two of the participants no findings were obtained in terms of vision field.

Measuring instruments

To evaluate the motor status of students with and without VI, the Eurofit battery of tests was used (Council of Europe, 1993). The Eurofit Physical Fitness Test Battery consists of nine physical fitness tests that are used to evaluate flexibility, speed, endurance, strength and balance. In this study, the following tests were used: the Flamingo Balance test (FBT), Plate Tapping (PLT), Sit-and-Reach (SAR), Standing Broad Jump (SBJ), Sit-Ups in 30s (SUP), Bent Arm Hang (BAH), the 10 x 5m, Shuttle Run (SHR) and the 20m endurance shuttle run (ESHR). Some of the tests from the Eurofit battery of tests, with certain modifications that we also included, had previously been used for students with VI (Marinescu, Cazan, Linca, Ianculescu & Mujea, 2016). The reliability of most of the tests when used on a sample of students with VI was confirmed in a previous study (Houwen, Visscher, Hartman, & Lemmink, 2006).

Statistical analyses

The results obtained during the tests are shown in the tables in the form of arithmetic means – mean and standard deviation – SD. To evaluate the normality of the distribution of the results we used the Kolmogorov Smirnov test. To determine the differences in the results of the motor tests between students with and without VI as well as to determine the differences between participants belonging to a different category of VI, the t-test for independent samples was used. The SPSS statistical packaged was used for the statistical analyses (v 13.0, SPSS Inc., Chicago, IL, USA).

RESULTS

By studying the significance of the differences in the motor abilities of students with different levels of visual acuity, statistically significant differences between the groups of children with and without VI were determined for six of the eight motor tests, as shown in table 3. Students without VI scored statistically higher results ($p < .05$) on the following tests: FBT, PLT, SAR, SUP, SHR and ESHR. For the remaining two tests, SBJ and BAH, no statistically significant differences were determined between the two studied groups.

Table 3 Differences in the achieved results on the motor tests between students with and without VI.

Variable	students without VI				VI students				T-test
	N	Mean	SD	KS(p)	N	Mean	SD	KS(p)	p
FBT (n)	23	15.91	6.81	.47	21	21.81	8.45	.82	**.01**
PLT (s)	24	14.43	2.39	.80	27	20.66	4.44	.18	**.00**
SAR (cm)	24	15.42	6.59	.66	27	10.74	7.13	.95	**.02**
SBJ (cm)	24	124.71	18.12	.43	26	118.00	26.80	.97	.31
SUP (n)	24	20.04	4.83	.59	27	11.25	5.66	.59	**.00**
BAH (s)	24	12.99	11.02	.89	27	13.64	17.11	.08	.87
SHR (s)	24	25.37	2.98	.99	27	29.60	3.41	.96	**.00**
ESHR (s)	24	161.46	57.31	.88	27	110.4	44.69	.55	**.00**

Legend: FBT - Flamingo Balance test PLT - Plate Tapping, SAR - Sit-and-Reach, SBJ - Standing Broad Jump, SUP - Sit-Ups in 30s, BAH - Bent Arm Hang, SHR - the 10 x 5m Shuttle Run, ESHR - the 20m endurance shuttle run. s - second, cm - centimeters, n - number, KS (p) - level of significance of the Kolmogorov Smirnov test, p - level of significance of the T - test

By studying the significance of the differences in the motor abilities of MVI and SVI students a statistically significant difference ($p < .05$) was determined only for the test used to evaluate balance (FBT) while for the other motor tests no statistically significant differences were determined, as shown in table 4. Students with SVI have better performance on balance task in compare to MVI students.

Table 4. Differences in the results on the motor tests achieved by students with different levels of VI.

Variable	MVI students				SVI students				T-test
	N	Mean	SD	KS(p)	N	Mean	SD	KS(p)	p
FBT (n)	9	26.11	4.08	.99	12	18.58	9.55	.60	**.04**
PLT (s)	13	21.72	5.00	.39	14	19.68	3.75	.76	.24
SAR (cm)	13	11.46	8.54	.89	14	10.07	5.77	1.0	.62
SBJ (cm)	13	116.38	25.33	.49	13	119.61	29.13	.99	.77
SUP (n)	13	12.23	5.89	.68	14	10.35	5.49	.40	.40
BAH (s)	13	18.48	22.51	.11	14	9.15	8.51	.87	.16
SHR (s)	13	28.45	3.17	.99	14	30.67	3.39	.98	.09
ESHR (s)	13	104.54	40.41	.24	14	115.92	49.18	.99	.52

Legend: MVI - moderate visual impairment, SVI - severe visual impairment, FBT - Flamingo Balance test PLT - Plate Tapping, SAR-Sit-and-Reach, SBJ - Standing Broad Jump, SUP - Sit-Ups in 30s, BAH - Bent Arm Hang, SHR - the 10 x 5m Shuttle Run, ESHR - the 20m endurance shuttle run, s - second, cm - centimeters, n - number, KS (p) - the level of significance of the Kolmogorov Smirnov test, p - the level of significance of the T - test.

DISCUSSION

A comparison of motor abilities of students with and without VI

The results obtained in this study mostly match the results obtained in studies carried out to date when it comes to the differences in the motor abilities of typical developed students and VI students. This study has confirmed that children with VI at a level of low vision have weaker static balance when compared to their typically developed peers (Gipsman, 1981; Pereira, 1990; Bouchard et al., 2000; Houwen, Visscher, Lemmink, & Hartman, 2008; Uzunović et al., 2015). In addition to the statistical significance ($p < .05$) of the lower results, six VI participants (22.2%) were unable to perform the assigned test of balance, unlike only one child without VI. The visual, vestibular and proprioceptive sensory systems take part in maintaining body balance. Disturbance of the leading sensory system (visual) significantly limits the performance of tasks which include balance, which is the reason why differences between students with VI and their typically developed peers were determined in the performance of tasks which include balance.

On the applied tests of strength (static strength and explosive power) no statistically significant differences were determined between students with and without VI. These findings were expected considering that in the applied tests (the Standing broad Jump and Bent Arm Hang) visual control is not dominant. These results confirm the findings of other authors (Sermeev, 1980; Buell, 1982; Short et al., 1986) who indicate that students with VI on motor tests which do not require visual control can achieve equally good results as their typically developed peers. In terms of muscle endurance and cardio-respiratory endurance (measured on the tests SUP and ESHR), students with VI had significantly lower results compared to students without VI ($p < .05$), which confirms the findings of other researchers (Sermeev, 1980; Short et al., 1986; Lieberman et al., 2001). Sermeev (1980) especially points out the weakness of the cardio-vascular system and breathing among students with VI, aged 8 to 12, which deviates by 25%, in comparison to the predicted norms for typically developed children.

Students with VI scored the lowest results compared to their peers without VI on unimanual speed (Houwen et al. 2008), which was confirmed in this study. Students with VI had statistically lower results ($p < .05$) on the Plate tapping test, which was used to evaluate speed of upper limb movement. Speed and agility were evaluated using the SHR test among students without VI, and the results are significantly higher ($p < .05$) in comparison to students with VI. This confirms the research results (Sermeev, 1980) indicating that visual control is a necessary precondition for the successful performance of speed. In terms of flexibility, students without VI scored statistically better results. Considering the obtained results, physical exercise programs can be used to increase the level of motor abilities of children with VI, which has been confirmed in research (Paravlic et al., 2015).

A comparison of motor abilities of students with different levels of VI

In this study, no statistically significant differences were determined on the applied motor tests between students with different levels of VI. These results confirm the findings of Lieberman, Byrne, Mattern, Watt, & Fernandez-Vivo (2010), who stated that there are no significant differences between achievements on motor tests among the children with different levels of VI. But Lieberman, et al. (2010) compared motor abilities between blind and SVI, while this study compares motor abilities of students with SVI and MVI, both on the level of low vision.

In this study, the only statistically significant difference between students with different level of VI was determined static balance (FBT test), in favor of the participants with SVI. The visual potentials of children with VI do not enable them to receive information which would enable them to maintain a stable quiet stance (Bouchard et al., 2000). Studies indicate that the visual system does contribute to the control of posture. One of the assumptions is that it is peripheral vision rather than central vision that is essential for the control of posture and motion (Berencsi, Ishihara, & Imanaka, 2005). However, even though several studies have been carried out on the subject, the functional role of central or peripheral vision in postural control and maintaining balance is still unclear (Berencsi et al., 2005; Agostini, Sbrollini, Cavallini, Busso, Pignata, & Knaflitz, 2016).

These research results can indicate the role of peripheral vision in maintaining body balance. Considering that defining the level of VI is estimated based on the quality of the image which is created in the central part of the retina, the assumption is that children with SVI rely on information obtained through the peripheral parts of the retina more so than do children with MVI. In order to verify these assumptions, we analyzed the available data on the achieved results on the test of balance and the vision field. In the group of MVI students who had significantly weaker balance one half of the participants (4 out of 8) have only central vision (visual field no more then 30°), meaning, they do not have the ability to receive visual information through peripheral vision field. Unlike them, the group of SVI students who had significantly better scores on the balance test included only one (out of 11) participant, 9.01% precisely, with only central vision. This data may indicate that in order to maintain the balance of the body, the vision span is of greater importance than the quality of the central of vision. These results confirm the findings of Schmid, Casabianca, Bottaro, & Schieppati (2008) who point out the contributions of peripheral vision in achieving a stable quiet stance when performing a balance task, especially in the case of the low values of visual acuity. Daily compensatory reliance on peripheral vision might contribute to finding balance through compensative strategies, which also leads to better results on balance tests.

Due to the small number of participants in the current study, as well as the lack of other studies which would elaborate on the mechanisms of balance among individuals with VI, additional studies need to be carried out with more participants and more tests for the evaluation of balance, maintaining posture as well as walking so that the drawn conclusions could further be verified.

CONCLUSION

The results of this study confirm that students with VI have weaker motor abilities compared to their peers with normal visual acuity. The differences are especially pronounced in the case of motor abilities that require visual control. The difference in the motor abilities of students with different level of VI, were not determined, except in the case of static balance, where the results are in favor of students with lower visual acuity. Based on these findings, one of the assumptions is that the role of peripheral vision (visual span) is of greater importance for maintaining a balanced body position than the quality of the central of vision is. Also, the assumption is that children with SVI (lower visual acuity) rely more on the information obtained from the peripheral vision during their daily activities and movement, which contribute to their reaching of better results on the assigned balance task in comparison to their peers with visual acuity on the level of MVI. However, due to differences in the applied methodology and tests, the findings of previous studies about the role of central or peripheral vision in maintaining balance tasks are not consistent. Balance results of students with VI should certainly be taken into consideration when drawing conclusions which might indicate the roles of the different parts of retina in maintaining a stable quiet stance.

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MOTORIČKE SPOSOBNOSTI DECE SA RAZLIČITIM NIVOOM VIZUELNIH MOGUĆNOSTI

Cilj ovog istraživanja je bio da se utvrde razlike u motoričkim sposobnostima između dece sa različtim nivoom oštrine vida. U istraživanju je učestvovao 51 ispitanik oba pola starosti od 7 do 12 godina, podeljenih u grupu dece tipičnog razvoja, sa normalnom oštrinom vida (njih 24) i dece sa oštećenjem vida (njih 27), čija se oštrina vida kretala u granicama slabovidosti. Deca sa oštećenjem vida su podeljena u dve grupe: decu sa umerenim, njih 13 i teškim oštećenjem vida, njih 14. Za procenu motoričkih sposobnosti korišćeno je osam testova iz Eurofit baterije testova. Deca tipičnog razvoja su imala statistički bolje rezultate u testovima Flamingo Balance test, Plate

Tapping, Sit-and-Reach, Sit-Ups in 30s, 10 x 5m, Shuttle Run i 20m endurance shuttle run. Između grupa dece sa različitim stepenom oštećenja vida statistički značajne razlike su utvrđene samo u Flamingo Balance testu za procenu statičke ravnoteže i to u korist dece sa teškim stepenom oštećenja vida. Pretpostavka je da se deca sa teškim stepenom oštećenja vida oslanjaju na informacije dobijene perifernim delovima retine više nego što to čine deca sa umerenim stepenom oštećenja vida. Potrebno je sprovesti dodatna istraživanja sa većim brojem ispitanika i sa većim brojem testova za procenu ravnoteže, održavanja posture i hoda kako bi se dobijene pretpostavke dalje proverile.

Ključne reči: *oštrina vida, oštećenje vida, ravnoteža, periferni vid, razlike*