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Physical activity as the main factor affecting body composition of the visually impaired

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Abstract

Introduction. The aim of the study was to determine how physical activity affected the physical fitness and body composition of the blind and visually impaired.

Methods. The study included 28 male students from the Lower Silesia Special Educational Centre No. 13 for the Blind and Visually Impaired in Wroclaw, aged 18–22 years, with disability degree certificates. The subjects were divided into two groups: physically active men (TR, n = 15) and physically inactive men (NTR, n = 13). The researchers assessed the physical activity levels in both groups with the Physical Fitness Testing of the Disabled (project Unique) battery, and the general and segmental body composition using a body composition analyser (BC-418MA).

Results. Men engaging in additional forms of physical activity presented significant ($p < 0.005$) changes in most trials evaluating physical fitness, and there were also significant ($p < 0.005$) differences in body composition between active male respondents and those not involved in extracurricular exercise.

Conclusions. Additional physical activity undertaken by the visually impaired has a positive effect on their physical fitness, namely and primarily on their flexibility, functional strength, speed, arm movement speed, jumping ability, and the strength of the abdominal muscles. Moreover, additional physical activity significantly affects the overall and segmental body composition in the lower limbs and the right upper limb.

Key words: physical activity, body composition, physical fitness, the blind

Introduction

Physical activity constitutes one of the key determinants of a healthy lifestyle; it is not only beneficial to physical health but also has an impact in the sphere of social and mental health [1–3]. Gradually, its lack also leads to some limitations in the sphere of social and economic activity [4–7]. Despite the main advantages of active lifestyle, most western European adults do not perform regular life-related activities. It is especially alarming with regard to young people and adults with disabilities [8–10].

Visual dysfunctions are considered to be the most common cause of lack of physical activity [11–13]. Studies have shown that people with visual impairment have a greater need for health. Their daily activity requires a lot of energy compared with healthy peers. Exercises are a preventative measure for them and give them the opportunity to improve weakened functions [14–19]. Low physical activity among disabled people is not a new phenomenon; despite this, there are very few scientists interested in the subject.

Research in this area is scarce. Since the article by DePauw [20], only a few studies have been performed ($n = 11$) in the over 30-year period. One of the reasons for the lack of intervention research in this area can be difficulty with obtaining an appropriate number of participants with visual impairments [9]. Even fewer researchers have examined the relationship between motor skills and body composition in people with vision problems. Good et al. [21] showed a connection between the decrease in physical activity and functional efficiency. Low functional status has a direct impact on the quality of life, especially among people with visual impairment. The relationship between physical fitness and somatic constitution of the visually impaired has also been proved [8, 21–23]. In the literature of the subject, one can find few scientific publications discussing the occurrence of diseases of affluence in people with visual impairments, mostly describing male volunteers. Little interest of visually impaired females in participating in research studies has also been reflected by Rutkowska and Kosmol [24]. They claim that older school-age boys are much more willing to engage in physical activity than girls. As compared with the able-bodied peers, the visually impaired present health deterioration [25] and an increased risk of the occurrence of diseases of affluence [26–28]. According to Crews et al. [29], a considerable part of the group of visually impaired individuals report the occurrence of one of the coexistent ailments, such as breathing problems, hypertension, hearing impairment, depression, diabetes, heart problems, and low back pain.

Among the main illnesses people struggle with in the 21st century are overweight and obesity. Ray et al. [13] have shown a significant correlation between the level of vision loss and body mass index (BMI). The occurrence of overweight and obesity increased together with the level of vision impairment. Jones et al. [28] have conducted research according to which within a group of people with vision impairments, overweight concerned 28.2%, while obesity was

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observed in 21.8%. Therefore, half of the respondents presented excessive body weight, which is especially alarming. Simultaneously, 75.9% of the respondents admitted not to engage in any physical activity. This has also been confirmed in a study carried out by Holbrook et al. [12]. According to other observations, too, visually impaired people avoid physical activity, leading sedentary lives [3, 23].

Changes in the perception of people with disabilities, especially those with visual impairment, encourage the search for solutions that would promote their better development and functioning in everyday life. Attention was paid to quality of life, social and occupational activation. Lower levels of activity, as well as insufficient opportunities for participation make it difficult for the visually impaired who are more likely to take part in physical activity [5]. Currently, therapeutic and educational centres for this group of people are beginning to focus on both daily life and physical and occupational classes [23]. Residential schools for the blind and visually impaired can provide safe and accessible opportunities to engage in physical activity and participate in programs tailored to their needs [30]. Even when on-site after school programming has been made available, however, students tend not to engage in moderate to vigorous physical activities [31]. Rose et al. [32] maintain that in general, adolescents with disabilities do not have the necessary skills or opportunities to seek and participate in physical activity during their free time. Thus, the need for implementing physical activity interventions to promote leisure time physical activity in the moderate to vigorous range is warranted for adolescents with visual impairments who will soon transition from school to community life. According to Rosołek and Gawlik [23], people with visual impairment are more prone to civilizational diseases related to physical activity. In addition, the authors emphasized two important issues. Firstly, there is a need for greater interest among researchers in the health and physical activity of people with visual impairment. Secondly, physical activities should be adapted to the needs and abilities of people with visual impairment to improve their physical, mental, and social health.

The aim of the study was to determine how physical activity affected the physical fitness and body composition of the visually impaired. Are there differences in the body composition of the visually impaired with regard to their engagement in physical activity? Are there differences in segmental body composition of the visually impaired depending on their engagement in physical activity? What are the differences in physical fitness between the visually impaired engaged in different forms of physical activity and those who do not participate in any additional physical activity?

Subjects and methods

The study included 28 male students from the Lower Silesia Special Educational Centre No. 13 for the Blind and Visually Impaired in Wroclaw, aged 18–22 years, with a disability degree certificate. The quantity of females participating in additional physical activity was insufficient to involve them in the study. The condition for being included in the research was the residence in the boarding school of the Special Educational Centre No. 13. This guaranteed a homogeneous character of the group (place of residence, climatic conditions, diet, forms of physical activity available in the centre). The research was conducted before noon (8:00–12:00) in a gymnasium. The respondents were divided into two subgroups: those engaged in physical activity (TR, $n = 15$) and ignoring physical activity (NTR, $n = 13$). The forms of physical activity offered by the centre were, among others, goalball, showdown, soccer, and strength activity training. The inclusive criteria for the TR group were participation in regular 2-hour extracurricular activity for at least 6 months, twice a week, and taking part in physical education classes. The criterion for being included in the NTR group was participation in 45-minute physical education classes only (3 times a week). There were no health-related contraindications to engage in physical activity except for the responders' limitations stemming from visual impairment. All the subjects provided their written consent and were informed of the possibility to resign at any stage of the research.

Items from the Physical Fitness Testing of the Disabled (project Unique) battery were used to assess physical fitness. It is the first battery of tests dedicated to evaluate physical fitness of both able-bodied and disabled people that takes the type of impairment into consideration [33]. The following parameters were assessed: balance, arm movement speed, suppleness, explosive strength, jumping ability, static strength, abdominal muscle strength, functional strength. Body height was determined by means of a Harpender anthropometer (Holten Polska, Poland); body weight and composition were verified by the electrical bioimpedance method with a BC-418MA body composition analyser with GMON 3.1.5. software (Tanita, Japan). The following parameters were analysed in the research: body fat percentage (%) (FatP), fat mass (kg) (FatM), fat-free mass (kg) (FFM), predicted muscle mass (kg) (PMM), total body water (%) (TBW). The segmental body composition analysis was carried out for FFM, FatP, and FatM in the following distribution: right leg (RL), left leg (LL), right arm (RA), left arm (LA), and torso (T). On the basis of the obtained measurements (body height and weight), BMI was calculated; waist-hip ratio (WHR) was determined with the use of peripheral measurements.

Descriptive statistics was applied in order to describe the group (mean, *SD*). We used the Kolmogorov-Smirnov test for the comparisons between the groups. The interdependency of the values was defined by the Spearman's rank correlation. Statistical significance was accepted at the level of $p \leq 0.05$.

Results

The research results proved statistically significant differences in the body height of the visually impaired in favour of the physically active men.

The men in this group reached higher values of body weight, which differed significantly from those of men ignoring

Table 1. The characteristics of the analysed group (mean ± *SD*)

	TR (n = 15)	NTR (n = 13)
Age	20 ± 1.2	18 ± 1.9
Body height (cm)	174.53 ± 9.89**	160.23 ± 10.45**
Body mass (kg)	71.30 ± 13.42*	60.75 ± 11.03*
BMI (kg/cm^2)	23.59 ± 5.35	23.60 ± 3.62
Waist circumference (cm)	85.53 ± 11.62	83.85 ± 9.59
Hip circumference (cm)	96.20 ± 6.96	94.69 ± 7.26
WHR	0.88 ± 0.07	0.88 ± 0.05

* $p < 0.05$, ** $p < 0.001$
TR – engaged in additional physical activity, NTR – not engaged in additional physical activity, BMI – body mass index, WHR – waist-hip ratio

Table 2. Comparison of particular body composition elements among physically active blind men and those who were not engaged in any form of physical activity (mean ± *SD*)

	TR (*n* = 15)	NTR (*n* = 13)
FatP (%)	18.73 ± 11.20*	27.39 ± 10.28*
FatM (kg)	13.87 ± 9.81	17.12 ± 7.90
FFM (kg)	57.45 ± 10.27**	43.65 ± 8.40**
TBW (%)	42.07 ± 7.50**	31.95 ± 6.18**
PMM (kg)	54.77 ± 9.80**	41.54 ± 8.10**

* $p < 0.05$, ** $p < 0.001$
TR – engaged in additional physical activity, NTR – not engaged in additional physical acivity, FatP – body fat percentage, FatM – fat mass, FFM – fat-free mass, TBW – total body water, PMM – predicted muscle mass

Table 3. Comparison of the physical fitness test results in the blind men who were physically active and those not engaging in any form of physical activity (mean ± *SD*)

	TR (*n* = 15)	NTR (*n* = 13)
Balance	49.20 ± 20.59	32.23 ± 30.09
Arm movement speed	52.47 ± 12.77**	24.08 ± 18.50**
Suppleness	40.87 ± 12.01*	19.54 ± 19.78*
Explosive strength	49.67 ± 15.80*	30.77 ± 28.80*
Static strength	36.47 ± 7.72*	21.00 ± 16.69*
Abdominal muscle strength	47.73 ± 11.85**	24.23 ± 17.92**
Functional strength	50.85 ± 21.46*	23.91 ± 23.49*
Running speed	43.53 ± 12.67*	23.08 ± 18.96*

* $p < 0.05$, ** $p < 0.001$
TR – engaged in additional physical activity,
NTR – not engaged in additional physical activity

Table 4. Comparison of body composition elements in segmental body composition of the blind men physically active and those who were not engaged in any form of physical activity (mean ± *SD*)

	TR (*n* = 15)	NTR (*n* = 13)	TR (*n* = 15)	NTR (*n* = 13)
	Right leg		Left leg	
FatP (%)	19.85 ± 12.44*	30.63 ± 10.70*	20.05 ± 11.44*	30.09 ± 10.76*
FatM (kg)	2.66 ± 1.96	3.44 ± 1.42	2.58 ± 1.69	3.31 ± 1.40
FFM (kg)	10.10 ± 1.79**	7.59 ± 1.49**	9.82 ± 1.93*	7.49 ± 1.53*
PMM (kg)	9.57 ± 1.72**	7.19 ± 1.43**	9.31 ± 1.81**	7.06 ± 1.47**
	Right arm		Left arm	
FatP (%)	21.52 ± 10.54*	30.11 ± 10.74*	22.96 ± 10.77	31.02 ± 10.74
FatM (kg)	0.82 ± 0.46	0.92 ± 0.39	0.88 ± 0.51	0.98 ± 0.41
FFM (kg)	2.95 ± 0.66*	2.13 ± 0.66*	2.97 ± 0.65*	2.15 ± 0.60*
PMM (kg)	2.79 ± 0.63*	1.99 ± 0.63*	2.79 ± 0.64*	2.00 ± 0.58*
	Torso			
FatP (%)	17.40 ± 10.95	24.76 ± 10.77		
FatM (kg)	7.02 ± 5.30	8.48 ± 4.47		
FFM (kg)	31.56 ± 5.43**	24.29 ± 4.30**		
PMM (kg)	30.31 ± 5.24**	23.30 ± 4.16**		

* $p < 0.05$, ** $p < 0.001$
TR – engaged in additional physical activity, NTR – not engaged in additional physical activity, FatP – body fat percentage, FatM – fat mass, FFM – fat-free mass, PMM – predicted muscle mass

physical activity. Other body constitution parameters did not show any significant differences between the groups (Table 1).

FatP and TBW showed statistically significant differences between physically active visually impaired men and those who were not engaged in any form of physical activity.

The FatM, FFM, and PMM parameters revealed statistically significant differences in body composition: FFM and PMM. FatM presented no significant differences (Table 2).

Statistically significant differences were observed in 7 of the 8 items of Physical Fitness Testing of the Disabled. There were no statistically significant differences in the balance test among the physically active visually impaired men and those not active (Table 3).

The segmental analysis of body composition among the visually impaired physically active and physically not engaged men pointed at statistically significant differences in all components except for FatM (Table 4).

There was no correlation between body composition and physical fitness in the study groups.

Discussion

Overweight constitutes one of the greatest problems of the 20th century [15]. In Poland, it concerns 20% of children and youth [34–37]. It is of special significance among the disabled and remains related with children and youth isolation in permanent care facilities. Children and youth can stay at home under their parent supervision only in big cities. The aforementioned isolation has its advantages and disadvantages. It enables one to make childcare uniform and have complete control over the child's physical activity. Simultaneously, a visually impaired individual is limited by the possibilities of an educational facility and the carers' approach to their future abilities. Avoiding physical activity by the visually impaired contributes to the occurrence of diseases resulting from its lack as well as decreased quality of life and self-esteem [11, 22, 23, 38].

The research by Rutkowska and Kosmol, as well as by Łuczak [24, 39] involving a group of children aged 7–18 years has shown that visually impaired boys are shorter and lighter than their able-bodied peers. Similar results were obtained in the study presented here, and this especially concerned the group of physically inactive youth; their average body height was only 160.23 cm, much below the standard for men in the comparable age group. According to Cabak [40], there are much more considerable differences in somatic constitution occurring in younger than older children. The author has also observed a lower level of somatic development of children with visual impairment as compared with their able-bodied peers. Physically active youth are taller, slightly heavier, and, simultaneously, their BMI is lower. Similar results have been provided by Lee et al. [41], who have indicated that lower height values in visually impaired youth result from considerably limited physical activity in the period of early childhood. Physical activity during childhood plays a significant part in stimulating a young person's growth [42, 43], which is related to the role of physical effort in the process of body growth – hormonal function, energy expenditure, and stimulation of skeletal system growth [44, 45].

Body composition is a key element determining the constitution of the human body and exerts a direct influence on physical fitness. Verifying BMI itself turns out not sufficient anymore to, for instance, assess threats concerning the overweight occurrence in the population. Body fat level analysis is of fundamental importance here [8, 12, 35, 46, 47]. The results of own research revealed differences between the body FatP in groups of visually impaired men who were physically active and those who did not engage in any additional physical activity. Rutkowska and Kosmol [24] observed that in a group of younger children with visual impairment, as many as 60% of boys had excessive FatP. The occurrence of such considerable adiposity in children with visual impairment of younger age has a direct influence on their body composition in later periods of life. Avoiding physical activity or lacking physical activity properly adjusted to the disability, as well as having no access to early intervention programmes impact on the habits acquired later in life [41, 48, 49]. According to Rutkowska and Kosmol [24], older school-age boys are much more willing to engage in physical activity than girls [24].

Apart from the increased body fat content, there were significant differences in TBW percentage observed between the physically active group and the inactive group. The men engaging in additional physical activity presented better body hydration. This may result from the fact that physical activity forces one to drink more and that, in turn, causes better body performance. Other body composition components which significantly differentiated the two groups were FFM and PMM: increased physical activity was bound with higher values of these parameters.

Negligence in physical activity, having influence on the particular components of body composition in teenage boys, may impact on their future, increasing the risk of diseases of affluence and lower physical fitness [6, 21, 28, 35]. The own research showed how regular physical activity influenced the physical fitness components in the analysed young men with visual impairment.

Monitoring the progress and abilities related to physical fitness by means of properly selected physical fitness tests is of key importance for the evaluation of children and youth with disabilities.

The organ of sight plays an insignificant part in the assessment of abdominal muscle strength, hand static strength, or suppleness. Despite the small correlation between the impairment and the measurements mentioned above, significant differences were found in abdominal muscle strength observed in the own research in favour of the people engaging in physical activity. This result is directly related to the segmental body composition of the torso. The physically inactive men presented much higher FatP values within the torso. The available literature on the subject provides the abdominal muscle strength assessment among younger children only. Rutkowska and Kosmol [24], owing to their research in a group of children of different age, have observed a systematic increase in abdominal muscle strength with age. Lieberman and McHugh [14] have shown comparable results concerning abdominal muscle strength in visually impaired people and in their able-bodied peers. It was emphasised that among the visually impaired children in whom the locomotor system was efficient, approximately 15% were unable to bend backward in a lying position in the abdominal muscle strength test [4, 17]. This proves considerable negligence in shaping physical fitness at younger school age.

Another analysed component was suppleness, constituting a key component that influences physical fitness. The own research showed significant differences in suppleness between the active and inactive people. One may presume that low suppleness in physically inactive people results from lack of stretching exercises in physical education classes: people engaging in additional activities in the training facility did some stretching exercises. The available literature on the subject provides papers indicating a comparable level of suppleness in the visually impaired [14, 50, 51], without distinguishing the physically active group.

Visual impairment has a negative influence mainly on speed and jumping ability [52]. In the own research, these parameters showed significant differences between the groups. The physically active visually impaired responders were faster and did longer standing jumps. The level of adiposity within the lower limbs was significant in the standing long jump test. On the other hand, FFM within the lower limbs in the group of physically inactive men had a significant impact on their running speed. Wyatt and Ng [53], who investigated static strength of lower limb muscles in visually impaired people, have shown weakening of hip and knee extensors. Properly selected physical activity develops muscles within the whole body, increasing, among others, strength and flexibility. This can explain the worse results obtained in the own research in both tests. The strength limitation of such great muscle groups will undoubtedly influence further development of physical fitness in young people with visual impairment [17].

The physical fitness components which have a great significance to people with visual impairment are arm movement speed and functional strength of upper limbs. Both tests revealed statistically significant differences between the analysed groups in favour of physically active subjects. The men from this group presented significant differences in segmental body composition. They showed higher values of fat-free and muscle tissue within both upper limbs. One may indicate that physical activity increases speed and strength abilities of upper limbs. To visually impaired people, the sense of touch is very important in everyday life. Physical activity focused on developing speed and strength of upper limbs is of great significance in relation to both gross and fine motor skills, whose limitations are found in people with visual perception disorders.

Conclusions

1. Body composition in people with visual impairment is determined by their disability, which is visible in their lower height and higher adiposity within the torso; this is mostly noticeable in the group of people who do not engage in any additional physical activity.

2. Physically active men with visual impairment statistically significantly differ from the physically inactive ones with regard to segmental body composition of lower limbs and the right upper limb.

3. Additional physical activity in which the visually impaired engage has a positive influence on their physical fitness, especially on speed, jumping ability, and abdominal muscle strength.

Conflict of interest statement

The authors state no conflict of interest.

References

1. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc. 2000;32(5):963–975; doi: 10.1097/00005768-200005000-00014.
2. Hamer M, Stamatakis E, Mishra G. Psychological distress, television viewing, and physical activity in children aged 4 to 12 years. Pediatrics. 2009;123(5):1263–1268; doi: 10.1542/peds.2008-1523.
3. Ussher MH, Owen CG, Cook DG, Whincup PH. The relationship between physical activity, sedentary behaviour and psychological wellbeing among adolescents. Soc Psychiatry Psychiatr Epidemiol. 2007;42(10):851–856; doi: 10.1007/s00127-007-0232-x.
4. Rimmer JH, Wolf LA, Armour BS, Sinclair LB. Physical activity among adults with a disability – United States, 2005. JAMA. 2008;299(11):1255–1256; doi: 10.1001/jama.299.11.1255.
5. Longmuir PE, Bar-Or O. Factors influencing the physical activity levels of youths with physical and sensory disabilities. Adapt Phys Activ Q. 2000;17(1):40–53; doi: 10.1123/apaq.17.1.40.
6. Bolach B, Migasiewicz J, Prystupa T, Konieczna K. Assessment of physical fitness with special players in the Polish league of goalball [in Polish]. Pedagogika, psihologia ta mediko-biologicni problemi fizicnogo vihovanna i sportu. 2012;2:146–152.
7. Kawanishi CY, Greguol M. Physical activity, quality of life, and functional autonomy of adults with spinal cord injuries. Adapt Phys Activ Q. 2013;30(4):317–337; doi: 10.1123/apaq.30.4.317.
8. Augestad LB, Jiang L. Physical activity, physical fitness, and body composition among children and young adults with visual impairments: a systematic review. Br J Vis Impair. 2015;33(3):167–182; doi: 10.1177/0264619615599813.
9. Haegele JA, Porretta DL. Physical activity and school-aged individuals with visual impairments: a literature review. Adapt Phys Activ Q. 2015;32(1):68–82; doi: 10.1123/apaq.2013-0110.
10. Marmeleira J, Laranjo L, Marques O, Pereira C. Physical activity patterns in adults who are blind as assessed by accelerometry. Adapt Phys Activ Q. 2014;31(3):283–296; doi: 10.1123/apaq.2013-0039.
11. Łabudzki J, Tasiemski T. Physical activity and life satisfaction in blind and visually impaired individuals. Hum Mov. 2013;14(3):210–216; doi: 10.2478/humo-2013-0025.
12. Holbrook EA, Caputo JL, Perry TL, Fuller DK, Morgan DW. Physical activity, body composition, and perceived quality of life of adults with visual impairments. J Vis Impair Blind. 2009;103(1):17–29.
13. Ray CT, Horvat M, Williams M, Blasch BB. Clinical assessment of functional movement in adults with visual impairments. J Vis Impair Blind. 2007;101(2):108–113.
14. Lieberman LJ, McHugh E. Health-related fitness of children who are visually impaired. J Vis Impair Blind. 2001;95(5):272–287.
15. Haegele JA, Brian A, Goodway J. Fundamental motor skills and school-aged individuals with visual impairments: a review. Rev J Autism Dev Disord. 2015;2(3):320–327; doi: 10.1007/s40489-015-0055-8.
16. Haibach PS, Wagner MO, Lieberman LJ. Determinants of gross motor skill performance in children with visual impairments. Res Dev Disabil. 2014;35(10):2577–2584; doi: 10.1016/j.ridd.2014.05.030.
17. Wagner MO, Haibach PS, Lieberman LJ. Gross motor skill performance in children with and without visual impairments – research to practice. Res Dev Disabil. 2013;34(10):3246–3252; doi: 10.1016/j.ridd.2013.06.030.
18. Haegele JA, Sato T, Zhu X, Avery T. Physical education experiences at residential schools for students who are blind: a phenomenological inquiry. J Vis Impair Blind. 2017;111(2):135–147.
19. Haegele JA, Zhu X, Davis S. The meaning of physical education and sport among elite athletes with visual impairments. Eur Phys Educ Rev. 2016; doi: 10.1177/1356336X16650122. Available from: http://journals.sagepub.com/doi/abs/10.1177/1356336X16650122.
20. DePauw K. Physical education for the visually impaired: a review of literature. J Vis Impair Blind. 1981;75(4):162–164.
21. Good GA, LaGrow S, Alpass F. An age-cohort study of older adults with and without visual impairments: activity, independence, and life satisfaction. J Vis Impair Blind. 2008;102(9):517–527.
22. Morelli T, Folmer E, Foley JT, Lieberman L. Improving the lives of youth with visual impairments through exergames. J Vis Impair Blind. 2011;4(4):160–170.
23. Rosołek B, Gawlik K. Physical activity level of the visually impaired and the risk of lifestyle diseases – review [in Polish]. Rozprawy Naukowe AWF we Wrocławiu. 2013;42:103–108.
24. Rutkowska I, Kosmol A. Efficiency and physical activity of the blind [in Polish]. Warszawa: AWF; 2010.
25. Capella-McDonnall M. The need for health promotion for adults who are visually impaired. J Vis Impair Blind. 2007;101(3):133–145.
26. Ayvazoglu NR, Oh HK, Kozub FM. Explaining physical activity in children with visual impairments: a family systems approach. Except Child. 2006;72(2):235–248; doi: 10.1177/001440290607200207.
27. Albright C, Jerome GJ. The accuracy of talking pedom-

eters when used during free-living: a comparison of four devices. J Vis Impair Blind. 2011;105(5):299–304.
28. Jones GC, Crews JE, Danielson ML. Health risk profile for older adults with blindness: an application of the International Classification of Functioning, Disability, and Health framework. Ophthalmic Epidemiol. 2010;17(6):400–410; doi: 10.3109/09286586.2010.528137.
29. Crews JE, Jones GC, Kim JH. Double jeopardy: the effects of comorbid conditions among older people with vision loss. J Vis Impair Blind. 2006;100:824–848.
30. Kozub FM. Motivation and physical activity in adolescents with visual impairments. RE View Rehabil Educ Blind Vis Impair. 2006;37(4):149–160; doi: 10.3200/REVU.37.4.149-160.
31. Kozub FM, Oh HK. An exploratory study of physical activity levels in children and adolescents with visual impairments. Clin Kinesiol. 2004;58(3):1–7.
32. Rose TE, McDonnell J, Ellis G. The impact of teacher beliefs on the provision of leisure and physical activity education curriculum decisions. Teacher Educ Spec Educ. 2007;30(3):183–198;doi:10.1177/088840640703000306.
33. Winnick JP, Short FX. Physical Fitness Testing of the Disabled: project Unique. Champaign: Human Kinetics; 1985.
34. Felińczak A, Hama F. The occurrence of the phenomenon of overweight and obesity among children and adolescents in Wroclaw [in Polish]. Piel Zdr Publ. 2011; 1(1):11–18.
35. Przybylska D, Kurowska M, Przybylski P. Obesity and overweight in the adolescent population [in Polish]. Hyg Pub Health. 2012;47(1):28–35.
36. Chwałczyńska A, Jędrzejewski G, Socha M, Jonak W, Sobiech KA. Physical fitness of secondary school adolescents in relation to the body weight and the body composition: classification according to World Health Organization. Part I. J Sports Med Phys Fitness. 2017; 57(3):244–251; doi: 10.23736/S0022-4707.16.05664-4.
37. Chwałczyńska A, Jędrzejewski G, Lewandowski Z, Jonak W, Sobiech KA. Physical fitness of secondary school adolescents in relation to the body weight and the body composition: classification according to Bioelectrical Impedance Analysis. Part II. J Sports Med Phys Fitness. 2017; 57(3):252–259; doi: 10.23736/S0022-4707.17.07441-2.
38. Szczuka E. The quality of life of people with disabilities. In: Migasiewicz J, Bolach E (eds.), Physical activity of people with disabilities [in Polish]. Wrocław: TWK; 2008; vol. 3, 285–292.
39. Łuczak E. Biological and environmental factors and physical development of students with visual impairment [in Polish]. Przegląd Tyflologiczny. 1991;1–2:14–35.
40. Cabak A. Positive health measures and selected health-promoting behaviours of blind and visually impaired children [in Polish]. Warszawa: AWF; 2001.
41. Lee M, Ward G, Shepard RJ. Physical capacities of sightless adolescents. Dev Med Child Neurol. 1985;27(6): 767–774; doi: 10.1111/j.1469-8749.1985.tb03801.x.
42. Bouchard D, Tétreault S. The motor development of sighted children and children with moderate low vision aged 8–13. J Vis Impair Blind. 2000;94(9):564–573.
43. Levtzion-Korach O, Tennenbaum A, Schnitzer R, Ornoy A. Early motor development of blind children. J Paediatr Child Health. 2000;36(3):226–229; doi: 10.1046/j.1440-1754.2000.00501.x.
44. Cervantes CM, Porretta DL. Impact of after school programming on physical activity among adolescents with visual impairments. Adapt Phys Activ Q. 2013;29:127–146; doi: 10.1123/apaq.30.2.127.
45. Furtado O, Allums-Featherston K, Lieberman LJ, Gutierrez GL. Physical activity interventions for children and youth with visual impairments. Adapt Phys Activ Q. 2015;32(2):156–176; doi: 10.1123/APAQ.2014-0164.
46. Jakubowska-Pietkiewicz E, Prochowska A, Fendler W, Szadkowska A. Comparison of body fat measurement methods in children [in Polish]. Pediatr Endocrinol Diabetes Metab. 2009;15(4):246–250.
47. Giese M, Teigland C, Giessing J. Physical activity, body composition, and well-being of school children and youths with visual impairments in Germany. Br J Vis Impair. 2017;35(2):120–129;doi:10.1177/0264619617689905.
48. Sundberg S. Maximal oxygen uptake in relation to age in blind and normal boys and girls. Acta Paediatr Scand. 1982;71(4):603–608; doi: 10.1111/j.1651-2227.1982.tb09482.x.
49. Sherrill C. Adapted physical activity, recreation, and sport. Dubuque: WCB/McGraw-Hill; 1998.
50. Short FX, Winnick JP. The influence of visual impairment on physical fitness test performance. J Vis Impair Blind. 1986;80:729–731.
51. Poznecka W. Somatic level of children and adolescents from schools for the visually impaired [in Polish]. Kultura Fizyczna. 1988;9–10:38–44.
52. Poznecka W. The physical development and the physical fitness of children with visual impairments [in Polish]. Warsaw: AWF; 1990.
53. Wyatt L, Ng GY. The effect of visual impairment on the strength of children's hip and knee extensors. J Vis Impair Blind. 1997;91(1):40–46.