Journal of Physical Education and Sport ® (JPES), Vol. 21 (4), Art 228, pp. 1806 - 1813, June 2021
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Biomechanical control of motor function of junior schoolchildren with hearing impairment

IRENE KHMELNITSKA[1], GENNADII LISENCHUK [2], VITALII LELEKA[3], NATALIA BORETSKA[4], SVITLANA KRUPENYA[5], GRIGORIY DANKO[6]
[1]Biomechanics and Sports Metrology Department, National University of Ukraine on Physical Education and Sport , UKRAINE
[2,3,4]Theory and Methodology of Physical Culture Department, V.O. Sukhomlynskyi National University of Mykolayiv, UKRAINE
[5]Horting and Rehabilitation Department, National University of the State Fiscal Service, UKRAINE
[6]Combat Sports and Strength Events Department, National University of Ukraine on Physical Education and Sport, UKRAINE

Published online: June 30, 2021
(Accepted for publication June 15, 2021)
DOI:10.7752/jpes.2021.04228

Abstract:
The most important methodological approach in the adaptive physical education of schoolchildren is to take into account the individual characteristics of their motor skills development. *The purpose of the research* is to develop the technology of computer monitoring of the motor skills of junior schoolchildren with hearing impairment and to justify experimentally its use in the programming of physical education. *Methods:* The data generalization of scientific and methodological literature and practice experience, biomechanical video-computer analysis, pedagogical testing & experiment, mathematical statistics. *Participants:* 59 students aged 7-10 years with hearing deprivation and 111 students with normal hearing. *Results:* A biomechanical analysis of the coordination abilities of junior schoolchildren with hearing deprivation revealed disorders of the rhythm and spatial orientation sense ($p < 0.05$). The error in reproducing the tempo-rhythm structure of the individual phases of the equally rhythmic exercise in the frontal plane by schoolchildren of 7–10 years old with hearing deprivation reaches 67, 60, 56, and 48% respectively. It was found that in junior schoolchildren with hearing deprivation, the most typical disorders in reproducing the spatial characteristics of movement are observed in the angle between the vertical and the "shoulder" bio-link and the angle between the shoulder and the forearm. As a criterion, the performance of the same exercise by schoolchildren with normal hearing was selected As a result of the cluster analysis; the subjects were divided into 2 groups of schoolchildren with different reproduction of the tempo-rhythmic structure: "low level of tempo-rhythmic feeling" and "middle level of tempo-rhythmic feeling". *Conclusions:* As a result of the pedagogical experiment, the effectiveness of computer monitoring of the motor skills of junior schoolchildren with hearing deprivation based on differentiated and individual approaches was confirmed. The introduction of the corrective program for junior schoolchildren with hearing deprivation improved statistically significant ($p<0.05$) parameters of their motor actions.
Key Words: adaptive physical education, child's coordination, hearing deprivation, biomechanical analysis.

Introduction

To date, school physical education programs for children with hearing deprivation, are essentially a "simplified version" of general education programs, while the problem of physical development under conditions of hearing impairment is the multitude of possible motor disorders caused by primary and secondary hearing impairment factors (Baykina, 2003; Savlyuk & Khmelnytska, 2017; Boretska, 2019). The most important methodological approach in the adaptive physical education (APE) of schoolchildren is to take into account the individual characteristics of their motor skills development (Auxter, Pyfer, Heuttig, 1993; Fallen & Umansky, 1998; Kashuba et al., 2020). To solve this problem it is necessary to choose firstly the methods and tools that allow diagnosing the features and degree of movement disorders (Krutsevych et al., 2019;Trachuk et al., 2019). However, effective diagnostic computer technologies for organizing the adaptive physical education (APE) process with hearing impaired children are currently insufficient (Kurková, 2015; Kashuba & Savliuk, 2017). This fact served as the basis for the search for new tools for measuring and evaluating the characteristics of motor skills of students with hearing deprivation.

Corresponding Author: IRENE KHMELNITSKA, E-mail: khmeln.irene@gmail.com

The purpose of the research is to develop the technology of computer monitoring of the motor skills of junior schoolchildren with hearing impairment and to justify experimentally its use in the programming of physical education.

Material & methods

Participants: The research involved 59 students aged 7-10 year of special secondary boarding school No. 9 in Kyiv for children with hearing loss. For a comparative analysis of the motor skills of children with hearing deprivation with healthy peers, a study was conducted of 111 students with normal hearing in secondary school No. 229 in Kyiv. All parents of every child gave written permission to participate in this research according to the recommendations of the Ethics Committee, in accordance with the ethical standards of the Helsinki Declaration.

Procedure/Measure: For the pedagogical experiment, 20 students of 9-years-old with hearing deprivation were divided into control (10 children) and experimental (10 children) groups. The method of physical education in the control group was built traditionally, in the experimental group – according to our individual programs of correction of motor abilities, taking into account the biomechanical characteristics of the motor skills of the hearing impaired schoolchildren. The duration of the experiment was 9 months.
A test exercise with an equally rhythmic structure in the frontal plane performed by 59 children with hearing impairment and 111 healthy children was recorded using a standard (PAL / SECAM) digital camcorder at 25 frames per second. This shooting speed is quite sufficient to detect those features of hearing impaired child's motor skills that can be used to build physical education programs.

In the research, we used an automated processing system based on the video-computer complex – personal computer (PC) with the "BioVideo" software developed by Irene Khmelnitska in order to perform the biomechanical analysis on the basis of registration (video recording) of child's motion action by a digital camera (Khmelnitska, 2003). The use of this measurement system has made it possible to investigate the motor function of hearing impaired children at a whole new level. As a model of the child's musculoskeletal system, a 14-segment branched bio-kinematic chain was used. The coordinates of its links, by geometrical characteristics, correspond to the coordinates of the position in the space of the human body's bio-links, and the reference points – to the coordinates of the centers of the major joints (by Bernstein, 1991). The obtained qualitative and quantitative information about the motor function of hearing impaired children was the basis for the development of physical education programs for coordination abilities correction of children in primary school age with hearing impairments.

Data collection and analysis: We used the data generalization of scientific and methodological literature and practice experience, biomechanical video-computer analysis, pedagogical testing, pedagogical experiment, methods of mathematical statistics. The following methods of mathematical statistics were used: descriptive and non-parametric statistics, and the cluster analysis. The following parameters were determined: arithmetic mean – $\bar{x}$, standard deviation – SD, variance – D, range –R (the difference between maximum and minimum sample variant). As the size of schoolchildren samples was small – from n=10 to n=20 – nonparametric statistics was used. The estimation of the statistical probability of the difference between the independent samples in the pedagogical experiment was determined using the Mann-Whitney U test, Wilcoxon test was used for the dependent samples. Non-parametric Kruskal-Wallis ANOVA was used to compare several groups of indicators of hearing impaired children to normal-hearing children. The method of k-means clustering was used to form exactly 2 clusters of schoolchildren with different reproduction of the tempo-rhythmic structure. The calculations were performed using the Statistica 10.0 (StatSoft, Inc).

Results

Biomechanical phase analysis of kinematic characteristics of schoolchild's motor actions in test exercise with an equally rhythmic structure allowed to measure quantitatively such independent relatively types of coordination abilities, as a sense of rhythm.

The duration of each phase was measured; the ability to estimate spatial-time motion parameters – the velocities of separate phase movements of the wrist's center, the hand's end, the centers of mass (CM) of the shoulder, forearm and hand were measured, as well as the angular characteristics – the amplitude of the shoulder and elbow joints. It should be noted that, none of the 59 students of 7–10 years with hearing deprivation performed the test exercise without a single error.

The results of the biomechanical phase analysis of the time characteristics of test motor performance by schoolchildren of 7-10 years with hearing deprivation and their healthy peers are presented in Table 1.

Table 1

Time characteristics and coordination of movements of schoolchildren with hearing deprivation (n = 59) and healthy schoolchildren (n = 111) of 7-10 years old

Age, years	Phase number	Number of hearing impaired children	Average value of errors in performance	Schoolchildren with hearing deprivation			Quantity of healthy children	Average value of errors in performance	Schoolchildren with normal hearing		
				Phase duration, s					*Phase duration, s*		
				$\bar{x}$	***SD***	***R***			$\bar{x}$	***SD***	***R***
7	1	10	2	0.68	0.34	0.48	20	1	0.82	0.29	0.28
	2		3	1.28	0.25	0.36		3	0.58	0.24	0.26
	3		2	1.32	0.14	0.20		1	1.18	0.38	0.52
	4		3	0.33	0.23	0.32		3	1.14	0.31	0.60
8	1	17	1	1.29	0.18	0.36	30	1	0.66	0.14	0.32
	2		1	1.6	0.24	0.44		1	1.39	0.12	0.58
	3		1	1.43	0.22	0.40		2	1.16	0.37	0.24
	4		2	0.76	0.12	0.20		2	0.8	0.26	0.36
9	1	20	0	0.70	0.14	0.20	30	1	0.62	0.26	0.18
	2		1	0.66	0.14	0.20		0	0.8	0.13	0.34
	3		1	0.44	0.13	0.04		0	0.74	0.27	0.12
	4		2	0.82	0.31	0.44		1	0.88	0.12	0.36
10	1	12	0	0.84	0.11	0.16	31	0	1.08	0.16	0.56
	2		0	0.52	0.10	0.14		0	0.74	0.15	0.26
	3		1	0.74	0.06	0.14		0	0.72	0.19	0.24
	4		1	0.72	0.08	0.18		1	0.68	0.20	0.20

For the purpose of visualization of the rhythm feeling in schoolboys of 7-10 year old with hearing deprivation, the chronograms of time indicators are presented in Fig. 1. Those data are based on the ratio of the duration of each of the 4 phases, which is expressed as a percentage of the total duration of the whole exercise (the ratio of the duration of each of the 4 phases should be 25% in ideal). The dynamics of time indicators of schoolboys with hearing deprivation of 7-10 year showed that the ability to reproduce the tempo-rhythmic structure of movements developed with age: if in 7-year-old boys the range R in phase duration was 14%, then in 8-year-old boys this indicator was almost the same – 15 %, in 9-year-old boys – 11%, and in 10-year-old boys the range decreased to 7%.

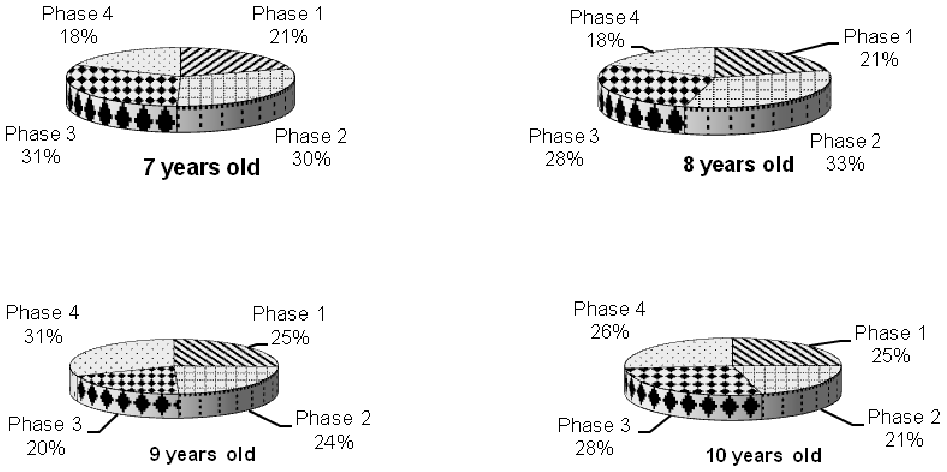

Fig. 1. Chronograms of a test exercise with equally rhythmic performance by schoolboys of 7–10 years old with hearing deprivation

The chronograms of a test exercise with equally rhythmic performance by schoolgirls of 7–10 years old with hearing deprivation are showed in Fig. 2. The dynamics of their time indicators determined that 7-, 8-, and 10-years-old girls had the worse ability to reproduce the tempo-rhythmic structure of movements than boys-

peers: the range of phase duration in 7- and 10-years-old girls was 18%, in 8-years-old girls this indicator was higher – 21%, in 9-years-old girls one is the same as in 10-years-old boys – 7%.

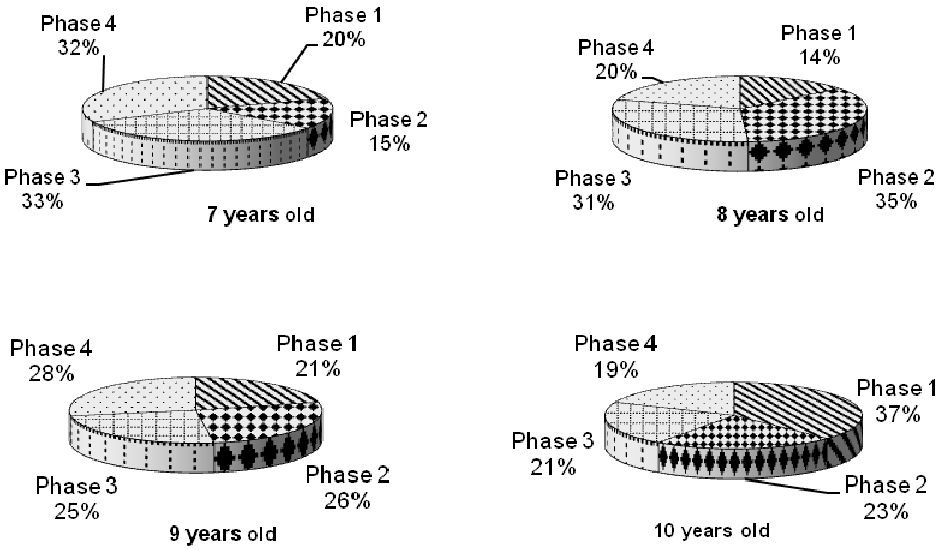

Fig. 2. Chronograms of a test exercise with equally rhythmic performance by schoolgirls of 7–10 years old with hearing deprivation

The data in table 1 show that the duration of phases 1–4 is heterogeneous, since the variation of the R values (the range that was defined as the difference between the maximum and minimum values) in some cases reached 50% or more of the arithmetic mean $\bar{x}$ (Fig. 3).

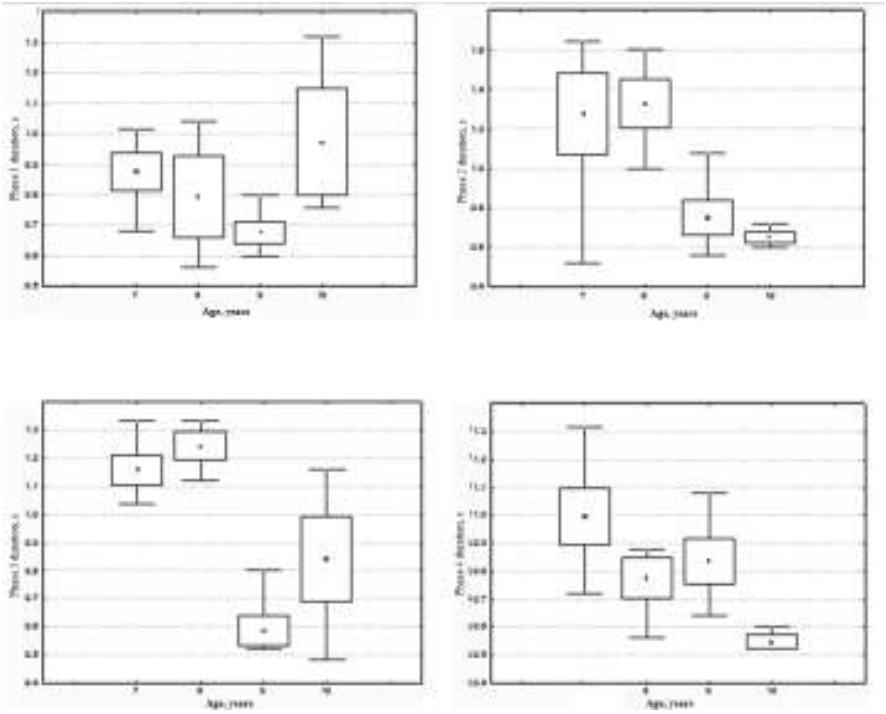

Fig. 3. Histograms of the duration of phases 1-4 in a test exercise with equally rhythm performance in the frontal plane by schoolchildren 7-10 years old with hearing deprivation
Designation: • arithmetic mean $\bar{x}$; ▭ ± SD; ⊥ Min-Max

Thus, in order to develop differentiated programs for physical education of junior schoolchildren with hearing impairment, we need to eliminate the heterogeneity of the data obtained. It is necessary to identify the

clustering in data and (if available) to take appropriate measures, for example, dividing the entire set of subjects into two or more homogeneous parts, each of which corresponds to a separate cluster. There are indeed groups in the duration values of phases 1-4, which confirms the presence of clustering (division into groups). The expediency of cluster analysis in terms of correction of child's coordination abilities consists in possibility of more effective differentiated approach to programming of physical training of children with hearing impairments in junior school age.

As a result of the cluster analysis, the subjects were divided into 2 groups of schoolchildren with different reproduction of the tempo-rhythmic structure when performing separate movements (phases 3 and 4). We have called conventionally these 2 different reproductions of the tempo-rhythmic structure of movements as follows: "low level of tempo-rhythmic feeling" (duration of the 3rd and 4th phases is greater than arithmetic mean $\overline{x}$) and "middle level of tempo-rhythmic feeling" (duration of 3rd and 4th phases is smaller than arithmetic mean $\overline{x}$). 27 subjects got in the 1st cluster "low level of tempo-rhythmic feeling" and 32 – in the 2nd cluster accordingly (Fig. 4).

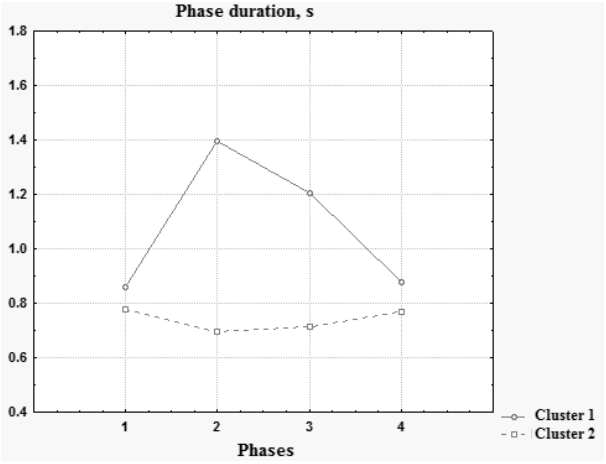

Fig. 4. Clustering of subjects with different reproduction of tempo-rhythmic structure at performance of separate movements in phases of test exercise

Table 2 summarizes the results of clustering of time characteristics of the test exercise for junior schoolchildren with hearing impairments.

Table 2

Results of time characteristics clustering of test exercise performance by children of junior school age with hearing impairment, n = 59

Phase number	Phase duration, s					
	Cluster 1			Cluster 2		
	$\overline{x}$	**S**	**D**	$\overline{x}$	**S**	**D**
1	0.86	0.10	0.01	0.78	0.12	0.01
2	1.40	0.22	0.05	0.70	0.10	0.01
3	1.21	0.12	0.01	0.71	0.12	0.01
4	0.88	0.12	0.01	0.77	0.10	0.01

A biomechanical analysis of the coordination abilities of junior schoolchildren with hearing deprivation revealed disorders of the rhythm and spatial orientation sense of the child's body biolinks ($p < 0.05$). Thus, the error in reproducing the tempo-rhythm structure of the individual phases of the equally rhythmic exercise in the frontal plane by schoolchildren of 7-10 years old with hearing deprivation reaches 67, 60, 56, 48%, respectively. As a result of the experiment, it was found that in junior school children with hearing deprivation, the most typical disorders in reproducing the spatial characteristics of movement are observed in the angle between the vertical and the "shoulder" biolink, which is ($\overline{x} \pm$ SD) 20.4 ± 9.9 º in boys and 20.6 ± 7.9 º in girls; the angle between the shoulder and the forearm (the value of which is regulated by the value of 180 º), which in boys is 167.8 ± 18.7 º and in girls – 165.0 ± 17.9 º.

The results of a biomechanical analysis of the motor characteristics of junior schoolchildren with hearing deprivation indicate the individual differences in motor impairment, which indicate the need for a differentiated and individual approach in organizing classes on APE. The effectiveness of corrective physical education programs on the motor function of children with hearing impairment was determined by the results of the current monitoring of their motor skills. Current control was carried out throughout the school year once every 1.5-2 months. Assessment of changes in the biomechanical characteristics of child's motorics served as the basis for making corrections to the program of physical education. Stage control of child's motorics was carried

out at the last quarter end with the aim of a general assessment of the physical education program in the school year.

In order to determine the effectiveness of the physical education program, including the technology of computer monitoring of motor skills of children with hearing deprivation, a comparative pedagogical experiment was conducted during 9 months.

In the formative experiment, schoolchildren in the experimental group improved statistically significantly ($p<0.05$) their tempo-rhythmic sensation in the test exercise by an average of 27% and in the control group – of 12%, respectively. On average, the coordination indicators of the experimental group improved significantly ($p<0.05$) by 31% and of the control group by 27%; space orientation indicators improved by 36.3% in the experimental group and 8.5% in the control group.

Discussion

Our research has allowed confirming the data of authors: N.G. Baikina, B.V. Sermeev (1991); T. Maszczak (1994); K. Kostov (2017) about fact that children with hearing deprivation have disorders of individual character in the development of motor abilities. Scientific substantiation of differentiated APE programs is possible only on the basis of quantitative indicators of child's motor skills (Roztorhui, Perederiy, Briskin et al., 2018; Tzanetakos, Papastergiou, Vernadakis et al., 2017). It is well known that the sensorimotor system is one of the most important in forming of human motorics (Korobeynikov et al., 2020). The age 7–10 years is sensitive period for coordination abilities development (Benjumea et al., 2015).

The most complete quantitative description of a human motor function can be obtained on the basis of accurate modern information technologies (Laputin & Khmelnitska, 1995; Kashuba & Khmelnitska, 2014). Analysis of the literature on the APE organization of schoolchildren with hearing impairment showed that the scientific and methodological support of the educational process is still insufficient (Thannhduser, 1997; Arndt, Lieberman, Pucci, 2004; Swanwick, Marschark, 2010). Currently, the fundamentals, basic tasks and methods of physical condition correction of schoolchildren with hearing deprivation by APE means are developed (Baykina, 2003; Evseev, 2016; Roztorhui, Perederiy, Briskin et al., 2018).

Biomechanical phase analysis of the biokinematic characteristics of rhythmic test exercise under using the "BioVideo" automated system, allowed quantitative measurement of such relatively independent types of coordination abilities, such as rhythm sensation and space orientation. As a cluster analysis of junior schoolchildren with hearing impairment by time indicators of the ability to reproduce the tempo-rhythmic structure of movements showed that pupils were divided into groups of "low level of tempo-rhythmic feeling" (duration of phases 3 and 4 was longer than the arithmetic mean $\bar{x}$), and the groups of "middle level of tempo-rhythmic feeling" (duration of phases 3 and 4 was less than the arithmetic mean $\bar{x}$), we have developed a physical education program, which is differentiated according to the development level of motorics characteristics, namely the ability to reproduce the tempo-rhythmic structure of movements and orientation in space.

The introduction of the corrective program for junior schoolchildren with hearing deprivation improved statistically significant ($p<0.05$) their motorics parameters (Lisenchuk et al., 2020). So, the error in reproducing the tempo-rhythm structure of an equally rhythmic exercise in the frontal plane is on average 0.18 s in the experimental group and 0.32 s in the control group. The goniometric indicators: the angle between the shoulder and forearm improved (increased) by 62.1%; the angle between the vertical and the shoulder link improved (decreased) by 10.5% ($p <0.05$); at the same time, in schoolchildren of the control group, similar angles improved by 11.0 and 5.6%, respectively ($p> 0.05$).

Conclusions

1. A biomechanical analysis of the motorics of junior schoolchildren with hearing deprivation using the "BioVideo" system revealed that the error in reproducing the tempo-rhythm structure of an equal rhythmic exercise is from 8 to 67%. A significant range of fluctuations in biomechanical parameters indicates the need for a differentiated approach to the programming of physical exercises for junior students with hearing deprivation.
2. Experimental data indicate that the period that most requires correction and development of the coordination abilities of junior schoolchildren with hearing deprivation by means of physical education is the age of 9 year, since significant changes in their motorics were observed at this age.
3. As a result of the pedagogical experiment, the effectiveness of computer monitoring of the motor skills of junior schoolchildren with hearing deprivation using the "BioVideo" system in programming of corrective physical exercises based on differentiated and individual approaches was confirmed.

Conflicts of interest - The authors have no conflicts of interest.

References:

Arndt, K. L., Lieberman, L. J. & Pucci, G. (2004). Communication during physical activity for youth who are deafblind. Teaching Exceptional Children Plus, 1 (2), Article 1.

Auxter D., Pyfer J., Heuttig C. (1993). Principles and methods of adapted physical education and recreation (7th ed.). St. Louis: Times Mirror. Mosby.

Baykina N. G. (2003). Diagnosis and correction of the motor sphere in persons with hearing impairment: Educational manual. Zaporozhye: ZGU. 232 p.[in Russian]

Baykina N. G., Sermeev B. V. (1991). Physical education at a school for the deaf and hard hearing students. Moscow: Soviet Sport, 64 p. [in Russian]

Benjumea J., Afonso J., Hurtado J., Truan J. (2015). Assessment of motor coordination in students aged 6 to 11 years. Journal of Physical Education and Sport ® (JPES), 15(4), Art 117, pp. 765 - 774, 2015 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Bernstein, N. A. (1991). On coordination and its development, Moscow. [in Russian]

Boretska N. O. (2019). Adaptive physical education: Educational and Methodical Manual. Mykolaiv, V.O. Sukhomlynskyi MNU, 2019. 216 p. [in Ukrainian] http://hdl.handle.net/123456789/259

Evseev, S. P. (2016). Theory and organization of adaptive physical education [Electronic resource]: textbook. Moscow: Sport, 617 p. ISBN 978-5-906839-42-8 .Access mode: https://rucont.ru/efd/568313 [in Russian]

Fallen N. H., Umansky W. (1998). Young children with special needs: New York: Macmilan. 200 p.

Kashuba V., Khmelnitska I. (2014). Computer systems for monitoring of hard hearing schoolchild's motorics. Theory and methodology of physical education and sports. No. 2. P. 46-49.

Kashuba V., Savliuk S., Chalii L., Zakharina I., Yavorskyy A., Panchuк A., Grygus I., Ostrowska M. (2020). Technology for correcting postural disorders in primary school-age children with hearing impairment during physical education Journal of Physical Education and Sport ® (JPES), Vol 20 (Supplement issue 2), Art 133 pp 939 – 945, 2020 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Kashuba, V.O., Savliuk, S.P.(2017). Structure and content of the technology of prevention and correction of disturbances of spatial organization of the body of children 6–10 years old with sensory systems deprivation. Journal of Education, Health and Sport. Vol. 7, N 8,1387–1407.

Khmelnitska I. V. (2003). Technology of biomechanical video analysis. The First International Scientific Congress "Sport and Health" (Russia, St. Petersburg, September 9–11, 2003), Vol. II. P.45–46.

Korobeynikov G., Shtanagey D., Ieremenko N., Aksiutin V., Danko T., Danko G., Goletc A., Korobeynikova L., Maximovich N., Dudorova L., Kolumbet A. (2020). Evaluation of the speed of a complex visual-motor response in highly skilled female boxers. Journal of Physical Education and Sport ® (JPES), Vol.20 (4), Art 235 pp. 1734 - 1739, 2020 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Kostov K. (2017). Motor and mental development of the 7 year old students (state and correlation dependence) Journal of Physical Education and Sport ® (JPES), 17(2), Art 137, pp. 899 - 904, 2017 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051.

Krutsevych, T., Pangelova, N., Trachuk, S. (2019) Model-target characteristics of physical preparedness in the system of programming sports and recreational activities with adolescents. Journal of Physical Education and Sport, Vol 19 (Supplement issue 1), 242 – 248. DOI:10.7752/jpes.2019.s1036

Kurková P. (2015). Emotions in the physical activities of Czech students who are deaf or hard of hearing in general and special education. Journal of Physical Education and Sport ® (JPES), 15(4), Art 126 pp.823 - 828, 2015 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Laputin A. N., Khmelnitska I. V. (1995). Mastering of Biodynamic Structure of Complex Motional Acquirement by Means of Directional Correction of Human Body's Gravitation Interactions / Proceedings of the ninth Biomechanics Seminar, Centre for Biomechanics. Chalmers University of Technology and Gothenburg University. April 27–28, 1995.

Lisenchuk G, Khmelnitska I, Adyrkhaeva L, Krupenya S, Lysenchuk S. (2020). Diagnostics of human motor function in physical rehabilitation. Theory and Methods of Physical Education and Sports. 2020; 1: 42-48 DOI: 10.32652/tmfvs.2020.1.42-48.

Lisenchuk G., Khmelnitska I., Krupenya S., Litvinenko O., Boretska N. (2020). Computer control systems of motorics in physical education of schoolchildren with hearing deprivation. Bulletin of Zaporizhia National University: Collection of scientific works. Physical education and sports. Zaporozhye: Helvetica Publishing House, 2020, 2: 54-62. https://doi.org/10.26661/2663-5925-2020-2-08 [in Ukrainian]

Maszczak T. (1994). Rozwoj fizyczny i sprawnosc fizyczna dzieci gluchych. Wychowaniefizyczne i sport dzieci specjalnej troski, AWF, Warszawa. P. 35–44.

Roztorhui, Mariia; Perederiy, Alina; Briskin, Yuriy; Tovstonoh, Olexandr (2018). The training system of athletes with disabilities in strength sports. SportLogia . Jun 2018, Vol. 14. Issue 1, p. 98-106.

Savlyuk S. P., Khmelnytska I. V. (2017). Somatic characteristics of health children with hearing deprivation. Journal of Education, Health and Sport. 2017;7(1):159-174. eISSN 2391-8306.

Swanwick R. A., Marschark M. (2010). Enhancing Education for Deaf Children: Research into Practice and Back Again. Deafness & Education International,. Vol. 12(No. 4), pp. 217-235

Thannhduser J. (1997). Sprawnosc psychomotoryczna dzieci gluchych iniedosfyszqcych. Rozprawa doktorska, Wroclaw. [in Polish]

Trachuk S., Semenenko V., Biletska V., Kudria M., Kuznetsova L., Kholodova O., Mykhalchuk A. (2019). Interrelation of the indicators of the physical preparedness level and functional condition of junior schoolchildren organism. Journal of Physical Education and Sport ® (JPES), Vol.19 (4), Art 364, pp. 2405 - 2410, 2019 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Tzanetakos Nikolaos, Papastergiou Marina, Vernadakis Nikolaos, Antoniou Panagiotis (2017). Utilizing physically interactive e videogames for the balance training of adolescents with deafness within a physical education course. Journal of Physical Education and Sport ® (JPES), 17(2), Art 93, pp. 614– 623, 2017 online ISSN: 2247 - 806X; p-ISSN: 2247– 8051.