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Original Article

Full factorial experiment and discriminant analysis in determining peculiarities of motor skills development in boys aged 9

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Abstract
The objective is to determine the peculiarities of motor skills development in boys aged 9.
Materials and methods. The participants in the study were boys aged 9 (n = 48). The study relied on theoretical and empirical methods: analysis and collation of scientific and methodological literature; modeling, pedagogical observations and experiment, methods of mathematical experiment planning (2^k type FFE), discriminant analysis.
Results. The discriminant analysis has made it possible to determine the modes of performing physical exercises in the process of developing motor skills; to answer the question as to how the modes of training differ by the effectiveness of motor skills development; which of these variables most substantially influence the differentiation of classes; what class the object belongs to based on the values of discriminant variables.
Conclusions. A full factorial experiment method makes it possible to mathematically describe the process in some local area of the factorial space and to verify the regression model. Regression equations provide an opportunity to select the modes of performing for each exercise being studied. To select the most rational mode of performing exercises in the process of developing motor skills in boys aged 9, the first discriminant function can be used, focusing on the most informative variables.
Key words: classification; modeling; learning process; boys aged 9

Introduction

The issue of optimizing the learning process of schoolchildren is relevant for both Ukraine (Krucevich, & Bezverkhnia, 2010; Ivashchenko, Khudolii, Yermakova, Pilewska Wiesława, Muszkieta Radosław, & Stankiewicz Błazej, 2015; Ivashchenko, Yermakova, Cieślicka, & Śukowska, 2015; Khudolii, Iermakov, & Prusik, 2015) and Europe (Ekberg, 2016; Lang, Feldmeth, Brand, Holsboer-Trachsler, Pühse, & Gerber, 2017).

The areas of optimizing physical education in schools are the following:

- developing a methodology of pedagogical control of the learning process and motor abilities development using multidimensional statistics (Ivashchenko, 2016, 2017; Ivashchenko, & Cieślicka, 2017);
- developing methodological approaches to the rationalization of learning programs (Ivashchenko, 2001; Miroshnychenko, 2007; Khudolii, 2008a, 2008b);
- studying the regularities of motor functions development in children and adolescents (Nosko, 2001; Nosko, Kryvenko, & Manievych, 2001; Nosko, & Sumak, 2000);
- studying the regularities of the body reaction to different modes of alternating physical exercises with rest intervals (Khudolii, & Iermakov, 2011; Khudolii, Ivashchenko, Iermakov, & Rumba, 2016).

The objective of physical education for schoolchildren is to teach them physical actions and to develop their motor abilities (Vaskov, 2016; Arziutov, Iermakov, Bartik, Nosko, & Cynarski, 2016; Khudolii, Ivashchenko, & Chernenko, 2015).

The learning process is approached from the following perspectives:

- organization: it is suggested to plan the process of physical education in schools by periods each having its goal: adjusting period (September), preparatory period (October), main period (November-December), transitional period (January 1-10), preparatory period (after January 10 to January 30), main period (February-May), transitional period (June-August) (Krucevich, Trachuk, Napadij, 2016; Ekberg, 2016); educational process planning based on learning models and motor abilities development (Ivashchenko, 2016);
- motivation for motor activity: the higher the level of proficiency in exercises performance, the wider the range of motor activity (Darnis, & Lafont, 2015; Xu, & Ke, 2014);
- study of the connections between learning outcomes and motor activity: learning success leads to an increase in motor activity (Al-Ravashdeh Abdel Baset, Kozina, Bazilyuk, & Ilnickaya, 2015; Lang,

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Feldmeth, Brand, Holsboer-Trachsler, Pühse, & Gerber, 2017);

- cognitive and motor learning (Chatzipanteli, Digelidis, Karatzoglidis, & Dean, 2016; Altunsoz, & Goodway, 2016; Koh, Ong, & Camiré, 2016);
- influence of motor preparedness on the effectiveness of learning (Ivashchenko, 2017; Khudolii et al., 2016),
- influence of physical activity on the effectiveness of learning (Ivashchenko, Kapkan, 2015; Kapkan, 2015).

According to previously published works, the level of schoolchildren's motor preparedness depends on the correlation between learning processes and motor abilities development. It is effective to develop motor abilities provided that they form part of acquired motor skills. Research has found that the effectiveness of learning improves when using the method of algorithmic instructions (Khudolii, 2008a, 2008b; Ivashchenko, 2001) and taking into account the modes of alternating exercises performance with rest (Khudolii, & Ivashchenko, 2013; Ivashchenko, 2016, 2017). One of the methods for studying the peculiarities of motor skills development in children and adolescents is modeling.

Recent publications have proved that modeling is an effective method to obtain new information on current and final control through testing children's and adolescents' motor preparedness (Khudolii, & Ivashchenko, 2013, 2014; Lopatiev, Ivashchenko, Khudolii, Pjanylo, Chernenko, & Yermakova, 2017; Vlasov, Demichkovskyy, Ivashchenko, Lopatiev, Pitin, Pjanylo, & Khudolii, 2016). One of statistical modeling methods is discriminant analysis. Referring to the data of scientific literature (Khudolii, & Ivashchenko, 2014; Milić, Milavić, & Grgantov, 2011; Ivashchenko et al., 2015; Khudolii et al., 2015), discriminant analysis is effective for the classification of children's and adolescents' functional and motor preparedness.

Consequently, it is relevant to study the peculiarities of motor skills development in junior school age children.

The study objective is to determine the peculiarities of motor skills development in boys aged 9.

Materials and methods.

Study participants. The participants in the study were boys aged 9 (n = 48).

Organization of study. To achieve the objective set, the study relied on the following methods: analysis and collation of scientific and methodological literature, general scientific methods of theoretical level, such as analogy, analysis, synthesis, abstraction, induction, as well as general scientific methods of empirical level: observation, testing, experiment.

When setting up the study, the researchers used conceptual approaches to planning the experiment on studying the learning process effectiveness and developing learning models (Khudolii, 2011; Ivashchenko, 2016).

The study used full 2^3 type factorial experiment plans (see Table 1). The purpose of the FFE was to optimize the modes of learning and to determine the peculiarities of motor skills development in boys aged 9, using the analysis of regression equations.

Table 1. Matrix for a 2^3 type factorial experiment in studying the influence of different modes of repeating exercises on the level of proficiency in performing them

Experimental groups	Factors		
	x_1 number of sets (times)	x_2 number of repetitions per set (times)	x_3 rest interval (sec)
1	6	1	60
2	12	1	60
3	6	3	60
4	12	3	60
5	6	1	180
6	12	1	180
7	6	3	180
8	12	3	180

During the pedagogical experiment, the researchers studied the influence of the number of sets (x_1), the number of repetitions per set (x_2) and rest intervals (x_3) on the level of proficiency in gymnastic exercises performance of the boys aged 9.

When teaching gymnastic exercises, the study evaluated the level of proficiency during every class by the alternative method ("performed", "failed"), and calculated the probability of exercise performance (p = n/m, where n is the number of successful attempts, m is the total number of attempts).

When teaching the junior school age children, the study used the method of algorithmic instructions (Ivashchenko, O.V., 2016; Khudolii, O.M., 2008a, 2008b). The boys aged 9 were taught the forward roll.

Statistical analysis.

This study used the methods of analyzing the results of a full 2k type factorial experiment (Khudolii & Ivashchenko, 2014; Ivashchenko, 2016).

The study materials were processed in the IBM SPSS 20 statistical analysis program. In the process of discriminant analysis, the researchers created a prognostic model for group membership. This model develops a discriminant function (or, when there are more than two groups — a set of discriminant functions) in the form of a linear combination of predictor variables, ensuring the best division of groups. These functions are developed according to a set of observations, for which their group membership is known. These functions can continue to be used for new observations with known values of predictor variables and unknown group membership.

For each canonical discriminant function, the study calculated: eigenvalue, dispersion percentage, canonical correlation, Wilks' Lambda, Chi-square.

To determine the influence of the suggested modes of performing physical exercises by the boys aged 9, the study conducted a discriminant analysis. The researchers analyzed the influence of the number of sets, the number of repetitions per set and the rest interval on the level of proficiency in the following movements: 1. Take-off from lying support to straddle stand, straighten up quickly; 2. 2-3 step running squat mount, straddle jump dismount; 3. 2-3 step running vault, piked straddle stand on top of side horse, arched jump dismount; 4. From squat position on horse to straddle vault over horse or buck in front; 5. Standing straddle vault over side horse.

The study protocol was approved by the Ethical Committee of the University. In addition, the children and their parents or legal guardians were fully informed about all the features of the study, and a signed informed-consent document was obtained from all the parents.

Results

The first canonical function explains 73.4 % of the results variation, which indicates its high informative value (r = 0.793) (see Table 2). The materials of the canonical functions analysis prove a statistical significance of the first canonical function (λ= 0.216; p = 0.001). The first function has a high discriminant validity and value of interpretation with regard to the general totality (Table 3).

Table 2. Canonical discriminant function. Eigenvalues. Boys aged 9

Function	Eigenvalues	% despersion explained	Cumulative %	Canonical correlation
1	1.696	73.4	73.4	.793
2	.379	16.4	89.7	.524
3	.197	8.5	98.3	.406
4	.036	1.6	99.8	.187
5	.004	.2	100.0	.064

Table 3. Canonical discriminant function. Wilks' Lambda. Boys aged 9

Verification of functions	Wilks' Lambda	Chi-square	Degrees of freedom	p
from 1 to 5	.216	98.847	35	.000
from 2 to 5	.582	34.867	24	.070
from 3 to 5	.803	14.155	15	.514
from 4 to 5	.961	2.560	8	.959
5	.996	.263	3	.967

Table 4. Structural canonical discriminant function coefficients. Boys aged 9

Content	Function				
	1	2	3	4	5
Standing straddle vault over side horse	.742*	.079	.183	-.446	-.460
2-3 step running vault, piked straddle stand on top of side horse, arched jump dismount	.221	.864*	-.004	.450	-.049
From squat position on horse to straddle vault over horse or buck in front	.337	.141	-.809*	.018	.460
take-off from lying support to straddle stand, straighten up quickly	.238	-.409	.367	.741*	.304
2-3 step running squat mount, straddle jump dismount	.298	.337	.375	-.306	.750*

The structural discriminant function coefficients, which are the coefficients of correlation between the variables and the function, indicate that the functions are substantially related to the level of proficiency in the vaulting conditioning exercises. The level of proficiency in exercises depends on learning modes, and the level of proficiency in vaulting depends on the level of proficiency in the conditioning exercises (Table 4).

The graphic material given in Fig. 1 shows the density of objects in each class and the distinct boundary between the classes, which indicates the possibility of choosing the mode of performing exercises in order to successfully teach vaulting (Table 5).

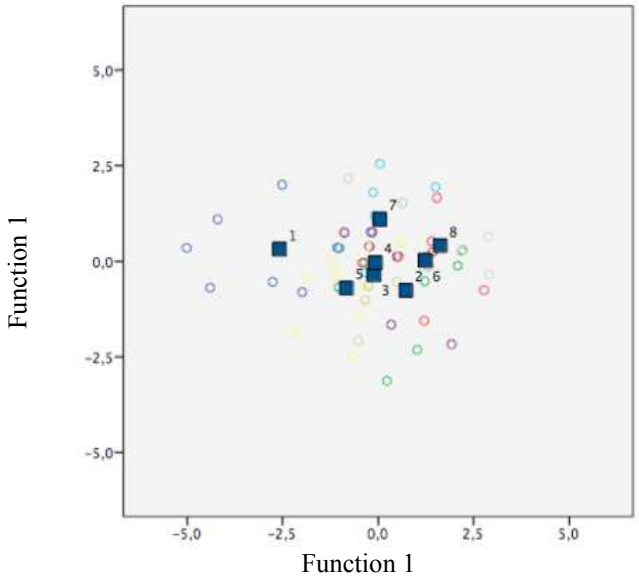

Fig. 1. Canonical discriminant functions. Graphic representation of the classification results of the level of proficiency in exercises performance of the boys aged 9: ■ —centroids for data groups after modes of performing exercises 1-8

Table 5. Functions in group centroids. Boys aged 9

Modes of training	Function				
	1	2	3	4	5
1.00	-2.580	.320	.170	.096	-.023
2.00	.725	-.766	-.064	-.266	-.035
3.00	-.118	-.354	-.489	.190	.104
4.00	-.078	-.035	-.735	-.055	-.032
5.00	-.841	-.704	.483	-.002	-.029
6.00	1.229	.023	.595	.026	.076
7.00	.040	1.100	.011	-.257	.028
8.00	1.624	.415	.028	.268	-.088

To specify the influence of different modes of performing physical exercises on the level of proficiency, let us analyze the regression models (Table 6).

Table 6. Regression dependence of the level of proficiency in gymnastic exercises on the number of sets (x_1), number of repetitions per set (x_2) and rest intervals (x_3) in the boys aged 9

Number of exercises	Regression equations for coded variables
Take-off from lying support to straddle stand, straighten up quickly	$Y = 0.779 + 0.036\ x_1 + 0.026\ x_2x_3$
2-3 step running squat mount, straddle jump dismount	$Y = 0.686 + 0.026\ x_1 - 0.02\ x_1x_3$
2-3 step running vault, piked straddle stand on top of side horse, arched jump dismount	$Y = 0.724 + 0.039\ x_1 - 0.046\ x_2x_3$
From squat position on horse to straddle vault over horse or buck in front	$Y = 0.699 + 0.046\ x_1 + 0.036\ x_1x_2$

When teaching the straddle vault over side horse to the boys aged 9, the level of proficiency in the *first* task "Take-off from lying support to straddle stand, straighten up quickly" is positively influenced by the number of sets (x_1) and the interaction between the number of repetitions per set and the rest interval duration (x_2, x_3). The level of proficiency in the *second* task "2-3 step running squat mount, straddle jump dismount" is positively influenced by the number of sets (x_1), and negatively — by the interaction between the number of sets and the rest interval (x_1, x_3). The level of proficiency in the *third* task "2-3 step running vault, piked straddle stand on top of side horse, arched jump dismount" is positively influenced by the number of sets (x_1), and negatively influenced by the interaction between the number of repetitions per set and the rest interval (x_2, x_3). The level of proficiency in the *fourth* task "From squat position on horse to straddle vault over horse or buck in front" is positively influenced by the number of sets (x_1) and the interaction between the number of sets and the number of repetitions per set (x_1, x_2).

Thus, the effectiveness of teaching the straddle vault over side horse to the boys aged 9 is positively influenced by the increase in the number of repetitions per set to three times, the number of sets — to twelve times, the rest interval — to 60—180 seconds. The focus is on the number of sets.

Discussion

The study assumed that a full factorial experiment and discriminant analysis would make it possible to determine the peculiarities of motor skills development in the boys aged 9. The obtained results show that the matrix for a full 2^3 type factorial experiment given in Table 1 can be used when studying the effectiveness of the learning process. A full factorial experiment method makes it possible to mathematically describe the process in some local area of the factorial space around the point with the coordinates of the n-dimensional space and to verify the regression model. Regression equations provide an opportunity to select the modes of performing for each exercise being studied. The study makes an assumption on the possibility of using a discriminant function to evaluate the effectiveness of different modes of performing physical exercises when teaching a series of gymnastic exercises. The verification of the canonical functions proves their statistical significance, and the discriminant function equation provides an opportunity to select the best option for obtaining a positive effect when teaching a series of exercises.

Results obtained:

- specify the conceptual approaches to planning the experiment on studying the learning process effectiveness and developing learning models in children (Khudolii, 2011; Ivashchenko, 2016);
- regression models given in Table 5 provide an opportunity to select the best option for teaching each exercise and supplement the conclusions on the effectiveness of using a full factorial experiment (FFE) in physical education and sports research (Khudolii, & Iermakov, 2011; Khudolii, et al., 2016; Khudolii et al., 2015);
- supplement the information on the use of a discriminant function when classifying schoolchildren by motor activity (Milić et al., 2011; Gert-Jan de Bruijn, & Benjamin Gardner, 2011; Lulzim, 2013). As in the works by Geoffrey D. Broadhead And Gabie E. Church (1982), Ivashchenko, Khudolii, & Miroshnichenko, (2016), Ivashchenko, (2016), Khudolii et al. (2015), the study observed a high discriminant and predictive validity of these functions when evaluating children's and adolescents' motor preparedness.

During the analysis, the study calculated canonical discriminant function coefficients (unstandardized) acting as factors of the given values of the variables included in the discriminant functions. Based thereon, it is possible to classify the modes of performing exercises by the level of proficiency in physical exercises performance of boys aged 8, which is of practical value.

In order to select the mode of performing vaulting, let us plug the level of proficiency in each exercise that ensures a positive learning effect into the discriminant function equation:

$Y = –6.057 + 2.082X_1 + 0.270X_2 + 0.321X_3 + 2.460X_4 + 4.704X_5$,

$Y = –6.057 + 2.082×0.75 + 0.27×0.75 + 0.321×0.75 + 2.46×0.75 + +4.704×0.75 = 1.32$-, where Y is the function result, X_1 is the level of proficiency in exercise 1, X_2 — the level of proficiency in exercise 2, X_3 — the level of proficiency in exercise 3, X_4 — the level of proficiency in exercise 4, X_5 — the level of proficiency in exercise 5. Let us compare the obtained result with the values of the centroids for the first canonical function (Table 5). The comparison shows that modes of training 6 and 8 are the most favorable for teaching vaulting to the boys aged 9. Consequently, the discriminant analysis has made it possible to answer the question as to the reliability of classifying the modes of performing physical exercises; and as to how the level of proficiency in series of learning tasks influences the learning of an exercise in general.

Conclusions

A full factorial experiment method makes it possible to mathematically describe the process in some local area of the factorial space and to verify the regression model. Regression equations provide an opportunity to select the modes of performing for each exercise being studied.

The discriminant analysis has made it possible to determine the modes of performing physical exercises in the process of developing motor skills; to answer the question as to how the modes of training differ by the effectiveness of motor skills development; what motor tasks most substantially influence the differentiation of classes; what class the object belongs to based on the values of discriminant variables.

To select the most rational mode of performing exercises in the process of developing motor skills in boys aged 9, the first discriminant function can be used, focusing on the most informative variables.

The further exploration prospect is to study methodological approaches to pedagogical control in teaching physical exercises to junior school age children.

Conflict of interest

The author declares that there is no conflict of interests.

References

Al-Ravashdeh Abdel Baset, Kozina, Z.L., Bazilyuk, T.A., & Ilnickaya, A.S. (2015). Methodic of senior pupils' training to throwing movements on the bases of technology of complex impact on motor and intellectual development. *Pedagogics, psychology, medical-biological problems of physical training and sports, 19* (11), 3–10. https://doi.org/10.15561/18189172.2015.1101

Altunsoz, I.H., & Goodway, J.D. (2016). Skiping to motor competence: the influence of project successful kinesthetic instruction for preschoolers on motor competence of disadvantaged preschoolers. *Physical Education and Sport Pedagogy, 21*(4), 366–385. https://doi.org/10.1080/17408989.2015.1017453

Arziutov, G., Iermakov, S., Bartik, P., Nosko, M., Cynarski, W.J. (2016). The use of didactic laws in the teaching of the physical elements involved in judo techniques. *Ido Movement for Culture, 16*(4), 21–30. https://doi.org/10.14589/ido.16.4.4

Chatzipanteli, A., Digelidis, N., Karatzoglidis, C., & Dean, R. (2016). A tactical-game approach and enhancement of metacognitive behaviour in elementary school students. *Physical Education and Sport Pedagogy, 21*(2),169–184. https://doi.org/10.1080/17408989.2014.931366

Cieślicka, M., & Ivashchenko, O. (2017). Features of formation of the cumulative effect of power loads in boys 7 years old. *Journal of Education, Health and Sport, 7*(1), 198-208. https://doi.org/10.5281/zenodo.250599

Darnis, F., & Lafont, L. (2015) Cooperative learning and dyadic interactions: two modes of knowledge construction in socio-constructivist settings for team-sport teaching. *Physical Education and Sport Pedagogy, 20*(5), 459–473. https://doi.org/10.1080/17408989.2013.803528

Dorita DU TOIT, Anita E. PIENAAR & Leani TRUTER (2011). Relationship between physical fitness and academic performance in south african children. *SAJR SPER, 33*(3), 23-35.

Ekberg, J.-E. (2016). What knowledge appears as valid in the subject of Physical Education and Health? A study of the subject on three levels in year 9 in Sweden. *Physical Education and Sport Pedagogy, 21*(3), 249–267. https://doi.org/10.1080/17408989.2014.946006

Geoffrey D. Broadhead, & Gabie E. Church. (1982). Discriminant Analysis of Gross and Fine Motor Proficiency Data. *Perceptual and Motor Skills*, *55*(2), 547–552. https://doi.org/10.2466/pms.1982.55.2.547

Gert-Jan de Bruijn and Benjamin Gardner (2011) Active Commuting and Habit Strength: An Interactive and Discriminant Analyses Approach. *American Journal of Health Promotion, 25*(3), e27-e36. https:// doi.org/10.4278/ajhp.090521-QUAN-170

Ivashchenko O., Khudolii O., Iermakov S., Lochbaum M., Cieślicka M., Zukow W., Nosko M., & Yermakova T. (2017). Methodological approaches to pedagogical control of the functional and motor fitness of the girls from 7-9 grades. *Journal of Physical Education and Sport ® (JPES), 17*(1), 254-261.

Ivashchenko O.V., Yermakova T.S., Cieślicka M., Śukowska H. Discriminant analysis in classification of motor fitness of 9-11 forms' juniors (2015). *Journal of Physical Education and Sport (JPES), 15*(2), 238-244. https://doi.org/10.7752/jpes.2015.02037

Ivashchenko, O. V. (1988). Standard indicators of training loads at initial stage of training of junior, 6-8 years old girls-gymnasts. *Cand. Diss. Moscow,* 17. (in Russian)

Ivashchenko, O. V. (2001). Methodic of gymnastic exercises training in school program. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 0*(1), 26-31. https:/doi.org/10.17309/tmfv.2001.1.7 (in Ukrainian)

Ivashchenko, O. V. (2016). Methodic of pedagogic control of 16-17 years' age girls' motor fitness. *Pedagogics, psychology, medical-biological problems of physical training and sports, 20*(5), 26-32. https://doi.org/10.15561/18189172.2016.0504

Ivashchenko, O., & Cieślicka, M. (2017). Features of evaluations of power loadsin boys 7 years old. *Journal of Education, Health and Sport, 7*(1), 175-183. https://doi.org/10.5281/zenodo.249184

Ivashchenko, O., Khudolii, O., Iermakov, S., Harkusha, S. (2017). Physical exercises' mastering level in classification of motor preparedness of 11-13 years old boys. *Journal of Physical Education and Sport ® (JPES), 17*(3), 1031-1036. https://doi.org/10.7752/jpes.2017.03158

Ivashchenko, O., Khudolii, O., Iermakov, S., Lochbaum, M.R., Cieslicka, M., Zukow, W., Nosko, M. & Yermakova, T. (2016). Intra-group factorial model as the basis of pedagogical control over motor and functional fitness dynamic of 14-16 years old girls. *Journal of Physical Education and Sport, 16*(4), 1190-1201. https://doi.org/10.7752/jpes.2016.04190

Ivashchenko, O.V. (2016). Modelling of physical education students: Monograph. Kharkiv: OVS (in Ukrainian)

Ivashchenko, O.V. (2017). Classification of 11-13 yrs girls' motor fitness, considering level of physical exercises' mastering. *Pedagogics, psychology, medical-biological problems of physical training and sports, 21*(2), 65-70. https://doi.org/10.15561/18189172.2017.0203

Ivashchenko, O.V. (2017). Special aspects of motor abilities development in 6-10 years' age girls. *Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports, 21*(3), 105-110. https://doi.org/10.15561/18189172.2017.0302

Ivashchenko, O.V. (2017). Theoretical and methodological bases of modeling of learning process and development of motor abilities in children. *Dokt. Diss. Chernigov,* 40. (in Ukrainian)

Ivashchenko, O.V., Kapkan, O.O. (2015). Simulation of process of 14–15 years old girls' training of light athletic and gymnastic exercises. *Pedagogics, psychology, medical-biological problems of physical training and sports,19*(8), 32–39. https://doi.org/10.15561/18189172.2015.0805

Ivashchenko, O.V., Khudolii, O.M., & Miroshnichenko, D.T. (2016). Structural model of the formation of motor function in girls of junior classes. *Visnyk Chernihivskoho natsionalnoho pedahohichnoho universytetu. Seriia: Pedahohichni nauky. Fizychne vykhovannia ta sport, 139*(1), 82-86. (in Ukrainian)

Ivashchenko, O.V., Khudolii, O.M., Yermakova, T.S., Pilewska, Wiesława, Muszkieta, Radosław, & Stankiewicz, Błazej (2015). Simulation as method of classification of 7-9th form boy pupils' motor fitness. *Journal of Physical Education and Sport (JPES), 15*(1), 142–147. DOI: https://doi.org/10.7752/jpes.2015.01023

Kapkan, O.O. (2015). Features of 14-15 years' age boys' training to physical exercises. *Pedagogics, psychology, medical-biological problems of physical training and sports, 19*(9), 26–32. https://doi.org/10.15561/18189172.2015.0904

Khudolii, O.M., Ivashchenko, O.V., & Chernenko, S.O. (2015). Simulation of junior shcoolchildren's training to acrobatic exercises and vaults. *Pedagogics, psychology, medical-biological problems of physical training and sports, 19*(7), 64-71. https://doi.org/10.15561/18189172.2015.0709

Khudolii, O.M., Iermakov, S.S., & Prusik, K. (2015). Classification of motor fitness of 7-9 years old boys. *Journal of Physical Education and Sport (JPES), 15*(2), 245-253. https://doi.org/10.7752/jpes.2015.02038

Khudolii, O. M., & Iermakov, S. S. (2011). Regularities of the learning process of young gymnasts. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 0*(5), 3-18, 35–41. https://doi.org/10.17309/tmfv.2011.5.707 (in Ukrainian)

Khudolii, O. M., & Ivashchenko, O. (2013). Information support learning and development of motor abilities of children and adolescents (for example, gymnastics). *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 0*(4), 3-18. https://doi.org/10.17309/tmfv.2013.4.1031 (in Ukrainian)

Khudolii, O. N. (2012). Regularities of development of motional skills of junior gymnasts. *Science in Olympic sports,* (1), 36-46. (in Russian)

Khudolii, O.M., Ivashchenko, O.V., Iermakov, S.S., & Rumba, O.G. (2016). Computer simulation of junior gymnasts' training process. Science of Gymnastics Journal, 8(3), 215–228.

Khudolii, O.M.,& Marchenko, S.I. (2007). Modeliuvannia rozvytku shvydkisno-sylovykh zdibnostei u shkoliariv 2-4 klasiv zasobamy rukhlyvykh ihor. *Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports,* (8), 139 – 142.

Khudolii, O.M., & Ivashchenko, O.V. (2014). Simulation of the learning process and development of motor abilities in children and adolescents: Monograph. *Kharkiv : OVS,* 320. (in Ukrainian)

Khudolii, O.M. (2008). Basics of the methodology of teaching gymnastics: A Manual. *Kharkiv : OVS.* (in Ukrainian)

Khudolii, O.M. (2008). General Fundamentals of Theory and Methodology of Physical Education: A Manual. *Kharkiv : OVS.* (in Ukrainian)

Koh, K. T., Ong, S. W., & Camiré, M. (2016). Implementation of a values training program in physical education and sport: perspectives from teachers, coaches, students, and athletes. *Physical Education and Sport Pedagogy, 21*(3), 295–312. https://doi.org/10.1080/17408989.2014.990369

Krucevich, T., Trachuk, S., Napadij, A. (2016). Planuvannia navchal'nogo procesu z fizichnoi kul'turi uchniv serednikh klasiv v zagal'noosvitnikh navchal'nikh zakladakh [Planning of physical culture training process for secondary comprehensive schools' pupils]. *Teoriia i metodika fizichnogo vikhovannia i sportu,* (1), 36–42. (in Ukrainian)

Krucevich, T. Yu., & Bezverkhnia, H. V. (2010). Recreation in the physical culture of different population groups: teaching. manual. *K. : Olimpiiska literatura,* 248. (in Ukrainian)

Lang, C., Feldmeth, A. K., Brand, S., Holsboer-Trachsler, E., Pühse, U., & Gerber, M. (2017). Effects of a physical education-based coping training on adolescents' coping skills, stress perceptions and quality of sleep. *Physical Education and Sport Pedagogy, 22*(3), 213–230. https://doi.org/10.1080/17408989.2016.1176130

Lang, C., Feldmeth, A. K., Brand, S., Holsboer-Trachsler, E., Pühse, U., & Gerber, M. (2017). Effects of a physical education-based coping training on adolescents' coping skills, stress perceptions and quality of sleep. *Physical Education and Sport Pedagogy, 22*(3), 213-230. https://doi.org/10.1080/17408989.2016.1176130

Lopatiev, A., Ivashchenko, O., Khudolii, O., Pjanylo, Y., Chernenko, S. & Yermakova T. (2017). Systemic approach and mathematical modeling in physical education and sports. *Journal of Physical Education and Sport (JPES), 17*(1), suplement, 146-155. https://doi.org/10.7752/jpes.2017.s1023

Lulzim, I., (2013) Discriminant analysis of morphologic and motor parameters of athlete and non athlete girl pupils of primary school on age 14 to 15 years. *RIK(2012),40*(2), 185-190.http://fsprm.mk/wp-content/uploads/2013/08/Pages-from-Spisanie-RIK-br.-2-2012-9.pdf

Milić, M., Milavić, B., & Grgantov, Z. (2011). Relations between sport involvement, selfesteem, sport motivation and types of computer usage in adolescents. In S. Simović (Ed.), *Proceedings of 3rd International Scientific Congress "Anthropological Aspects of Sport, Physical Education and Recreation".* November 2011. Banja Luka: University of Banja Luka, Faculty of Physical Education and Sport.

Miroshnychenko, D. T. (2007). Method of teaching acrobatic exercises of junior pupils. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 0*(12), 29-31. (in Ukrainian)

Nosko, M.O. (2001). Problems of training and improvement of human motor function. *Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports,* (5), 18-25. (in Ukrainian)

Nosko, M.O., Kryvenko, A.P., & Manievych, O.R. (2001). Formation of motor skills in physical education and sports. *Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports,* (8), 7-9. (in Ukrainian)

Nosko, N.A., & Sumak, E.H. (2000). Influence of different motor regimes on physical development and cardiovascular system of boys 8-10 years. *Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports,* (15), 24-26. (in Ukrainian)

Vaskov, Iu.V. (2016). Innovacijni pidkhodi do organizacii fizichnogo vikhovannia uchniv zagal'noosvitnikh navchal'nikh zakladiv [Innovative approaches to organization of comprehensive educational establishments' pupils physical education]. *Teorìâ ta Metodika Fìzičnogo Vihovannâ [Theory and Methods of the Physical Education],0*(4), 5-12. https://doi.org/10.17309/tmfv.2016.4.1174 (in Ukrainian)

Vlasenko, S.O., & Nosko, M.O. (2000). Task of action and modes of alternation of work with rest as regulating parameters of a training lesson. *Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports,* (21), 18-21. (in Ukrainian)

Vlasov, A., Demichkovskyy, A., Ivashchenko, O., Lopatiev, A., Pitin, M., Pjanylo, Y., & Khudolii, O. (2016). Sistemnij pidkhid i matematichne modeliuvannia biologichnikh ta prirodnikh ob'iektiv i procesiv [Systemic approach and mathematical modeling of biological and natural objects and processes]. *Fiziko-matematichne modeliuvannia ta informacijni tekhnologii,* (23),17-28. (in Ukrainian)

Xu, X., & Ke F. (2014). From psychomotor to 'motorpsycho': Learning through gestures with body sensory technologies. *Educational Technology Research and Development, 62*(6), 711-741. https://doi.org/10.1007/s11423-014-9351-8

WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects. (2016). Retrieved from http://www.wma.net/en/30publications/10policies/b3/index.html