



Research Article

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Correlations of Physical Fitness with Changes of Body Posture Features After Carrying a Schoolbag on the Back or Chest and Back-Chest Among 7-Year-Old Students of Both Sexes

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Summary

Introduction: The role of physical education in the treatment system for postural defects should not be overestimated.

Material and Method: The research of body posture was carried out in a group of 65 students aged 7 years, by projection moiré method in 4 positions. Measurement of physical fitness was done by Sekita test.

Results: Relationships of physical fitness traits with changes in the value of postural traits under the load and restitution time in carrying the schoolbag on the back or chest and back-chest were analysed.

Applications: (1) The effect of physical fitness traits on studied differences of features value in carrying a 4-kilogram schoolbag on the spine or chest was low. (2) The corrective effect of physical fitness on the value of extra-normal abnormalities of postural traits in carrying on the back among boys reached 17% and it was mainly force, endurance, strength and agility, and among girls up to 3%. In carrying on the chest among boys reached up to 20% and it was mainly endurance, strength, force and agility, and among girls up to 3%. In carrying on the back-chest among boy sit was up to 20% and it was mainly endurance, strength and force, and among girls up to 3%. (3) The corrective effect of physical fitness on the restitution of the value of body posture features among boys reached up to 20% and it was mainly speed and endurance, and among girls up to 6% and it was the endurance. In carrying on the chest among boys the major effect reached 17% and it was endurance, and among girls up to 3%. In carrying on the back-chest among boys reached to 17% and it was endurance and see pd (after 17%), and among girls up to 3%.

Keywords: Children's Health, Moire Topography, Physical Fitness, Postural Asymmetry Factor

Introduction

The appropriate body posture due to age and gender is one of many factors of a child's health condition not only in preschool age. Education in healthy lifestyles and the use of special physical efforts to correct abnormal habits can be an effective preventive measure in this regard. Nowadays, the percentage of significant postural abnormalities in children depending on age and gender is 60-80% [1,2]. Some publications report a number of posture disorders in

students in kindergarten and first grades of elementary school [3]. The consequence of the observations should be to support all activities aimed at appropriate development of students' motor skills [4-6] according to age and gender [7]. Corrective treatment should point out clearly a pattern, which corrective exercise will strive to. According to various publications, the correct posture of children of preschool and early school age is: the head slightly inclined forward,



shoulders in one plane, the lower angles of the shoulder blades adjusting to the surface of the back, the abdomen slightly convex, noticeably delineated physiological sagittal curves of the spine with a symmetrical course of the line of spinous processes of the vertebrae of the spine [8,9]. According to various works, postural disorders are regarded as unstable and non-normative spatial deviations of the axial organ [10-12]. The authors call frontal plane abnormalities "asymmetrical posture", caused by a disorder in the central nervous system and appearing by an asymmetrical course of the spinal spinous process lines [8, 13]. In such a situation, it is necessary to diagnose their stability or instability [14]. According to other authors, these disorders may be caused by muscular dystonia of the left and right deep back muscles and a reduction in overall body strength [14] or a reduction in postural muscle strength, resulting in muscle imbalance [15-17]. *Razumeiko* [18] and *Nowotny* [19] believe that posture correction with physical exercise can only have a good effect if the current postural habit is simultaneously changed to the correct one. To do this, the authors believe that it is necessary to remodel the muscular-articular sensitivity that allows the habit to be corrected. Thus, according to physiological laws, a child's posture is a dynamic stereotype influenced by a set of developed and mutual conditioned reflexes in a specific external environment. Therefore, the child's posture can change, despite the relative stability of anatomical factors. It can be corrected in the process of special physical activity, but posture can also deteriorate in a new lifestyle when the school starts [6]. Musculoskeletal problems associated with using a backpack are becoming a growing problem for school children [20]. *Haisman, et al* [21] *Knapik, et al* [22] Musculoskeletal problems associated with using a backpack are becoming a growing problem for school children. *Haisman, et al* [21] and *Knapik et al* [22] see the reasons in the excessive weight, shape and dimensions of the load being carried, its physical characteristics, the method and time of carrying, the distribution of weight in the container being carried, the physical characteristics and condition of the unit. *Haisman's* research [21] suggests that maximum loads for adults should be in the range of 25% to 40% of body weight. The author suggested that due to physiological factors and biomechanical differences, the load on women should be less than on men. Teenagers experience accelerated skeletal and soft tissue development [23]. At the same time, the growth of spinal structures takes longer than other bone elements, so inconsistencies in the rate of development can cause a threat to postural quality [24]. In addition, there may be external factors (carried loads) as well as internal factors that modulate the growth, development and maintenance of spatial symmetry of the body [25]. As a result, the posture of adolescents is highly susceptible to injuries. Measurements by *Chansirinukor, et al* [26] showed an increased craniovertebral angle while carrying a backpack on both shoulders weighing 15% of a student's body. This is supported by a study by *Pascoe, et al* [27], who reported that carrying a backpack in the same manner and weighing 17% of a student's body weight causes similar changes. This means that the weight of the backpack affects changes in the cervical region and shoulder alignment. The authors recommend that the backpack weight of 13-16-year-old students should be less than 15% for proper posture.

The research program entitled "Backpack as an epigenetic factor initiating postural defects" was one of the first attempts to empirically define the relationship between physical fitness traits and postural static disorders resulting from different ways of carrying a schoolbag by 7-year-old students. A further goal of the implemented program was to define the fitness characteristics that most immunizing the posture against the disorders resulting from such carrying. The author tested the significance of differences between the values of the "0" measurement (habitual posture) and the values of the last 5-seconds of a 10-minute load of a 4-kilogram mass in carrying obliquely on the right or left shoulder and at the heteronymous hip, in the container drag mode with the right or left hand, on the back, on the chest, on the back and on the chest. The restitution of the values of the posture-describing traits at 1 and 2 minutes after the load removal was also studied. Analysis of the obtained measurements showed significant changes in all thirty-six values of posture-describing traits of male and female students, as well as incomplete restitution in each plane and mode of carrying. The analysis also included associations of the studied fitness (endurance, speed, strength, force, agility and general fitness) with changes in the value of postural traits. A large variation in non-significant associations was found for each mode of carrying and gender [28-45]. The aim of the study was to determine which physical fitness traits show the greatest and which show the least relationship with changes in the value of postural traits in carrying a schoolbag on the back, chest, back-chest.

Research Material

Children from randomly selected kindergartens in the West Pomeranian and Greater Poland provinces participated in the study. Postural defects and disorders were not an exclusion criterion for participation in the research program. The division of the study subjects into those from rural and urban environments was abandoned, because this characteristic will never constitute the homogeneity of the group and the blurring of the cultural and economic boundary between the two environments. Eligibility for the program was done according to the scheme: if the respondent was 6 years, 6 months and 1 day old and under 7 years old, he was counted as a 7-year-old. A total of 65 students participated in the program, of which 53.84% (35 subjects) were girls and 46.15% boys (30 subjects). 2.

Subject of the Study

The Wrocław Fitness Test allows to determine the level of strength, force, speed and agility of preschool children. The author completed Sekita's test with an endurance test. Definitions of the studied fitness and complex movement abilities are generally available in the literature. Depending on the sources, strength abilities are defined as properties that enable one to overcome significant external resistance or to counter it with muscle contraction. Speed abilities are qualities that enable a person to perform certain tasks in a short period of time (they last a short time and do not cause fatigue). Endurance characterizes a person's personal ability to un-

dertake prolonged efforts of a certain intensity, and therefore indicates the level of resistance to fatigue. Coordination abilities are determined by the functions of control and regulation of movement; they characterize the ability to accurately perform motor actions that are complex in terms of spatiotemporal relations, the ability to rearrange and adapt to new and sometimes unexpected situations [46,47]. Force is defined as the product of force and speed [48].

The measuring device used determines dozens of features

that describe posture. Thirty-six angular and linear features of the spine, pelvis and trunk in the sagittal, frontal and transversal planes, as well as body weight and height, Picture 1, were selected for statistical analysis. This was guided by the need for the most reliable and spatially complete view of a child's posture, which allowed full identification of the measured distinguishing features and their verification in accordance with previously developed normative ranges [2], (Table 1, Figure 1).



Picture 1: Diagnostic station for body posture using the projection moiré method.

Table 1: List of registered trunk and morphological features.

No	Symbol	Parametrs		
		Label	Name	Description
Sagittal plane				
1	Alfa	degrees	Tilt of the lumbosacral segment	
2	Beta	degrees	Tilt of the thoracolumbar segment	
3	Gamma	degrees	Tilt of the upper thoracic segment	
4	Delta	degrees	Sum of angle values	Delta = Alfa+Beta+Gamma
5	KPT	degrees	Angle of trunk extension	It is determined by the deviation of the C7-S1 line from the vertical (backward)
6	KPT -	degrees	Angle of trunk flexion	It is determined by the deviation of the C7-S1 line from the vertical (forward)
7	DKP	mm	Length of thoracic kyphosis	Distance measured between LL and C7 points
8	KKP	degrees	Kąt kifozy piersiowej	KKP = 180 – (Beta+Gamma)
9	RKP	mm	Height of thoracic kyphosis	Distance measured between C7 and PL points
10	GKP	mm	Depth of thoracic kyphosis	Distance measured horizontally between vertical lines passing through PL and KP points
11	DLL	mm	Length of lumbar lordosis	Distance measured between S1 and KP points
12	KLL	degrees	Angle of lumbar lordosis	KLL = 180 – (Alfa + Beta)

13	RLL	mm	Height of lumbar lordosis	Distance measured between S1 and PL points
14	GLL -	mm	Depth of lumbar lordosis	Distance measured horizontally between vertical lines passing through PL and LL points
Frontal plane				
15	KNT -	degrees	The angle of the torso bend to the side	It is determined by the deviation of the C7-S1 line from the vertical to the left.
16	KNT	degrees		It is determined by the deviation of the C7-S1 line from the vertical to the right.
17	KLB	degrees	The angle of shoulders line, where the right one is higher	The angle between the horizontal and the straight line going through the B2 and B4 points. $PLBW = LBW - PBW$
18	KLB -	stopnie	The angle of shoulders line, where the left one is higher	
19	UL	degrees	The angle of shoulder blades, where the right one is higher	The angle between the horizontal and the straight line going through the Ł1 and Łp points.
20	UL -	degrees	The angle of shoulder blades, where the left one is higher	
21	OL	mm	The lower, more distant angle of the left shoulder blade	The difference in the distance of the lower angles of the shoulder blades from the line of the spinous processes of the spine, measured horizontally at the straight lines going through the Ł1 and Łp points.
22	OL -	mm	The lower, more distant angle of the right shoulder blade	
23	TT	mm	The left waist triangle is higher	The difference in the distance measured vertically between the T1 and T2 points and between T3 and T4 points. $PLTT = LTT - PTT$
24	TT -	mm	The right waist triangle is higher	
25	TS	mm	The left waist triangle is wider	The difference in the distance measured horizontally between the straight lines going through the T1 and T2 points and T3 and T4 points.

26	TS -	mm	The right waist triangle is wider	
27	KNM	degrees	The pelvic tilt angle, the right ala of ilium is higher	Angle between Horizontal Line and Straight Line Passing through Points M1 and Mp
28	KNM -	degrees	The pelvic tilt angle, the left ala of ilium is higher	
29	UK	mm	The maximum deviation of the spinous process of the vertebra to the right	The greatest deviation of the spinous process from the vertical coming from S1. The distance is measured on the horizontal axis.
30	UK -	mm	The maximum deviation of the spinous process of the vertebra to the left	
31	Number of vertebrae	-	Number of vertebrae with maximum deviation to the right or left	Number of vertebrae with maximum deviation to the right or left in asymmetrical line course of spinous processes, counting 1 as first cervical vertebrae(C1) If the arithmetic mean has a value, e.g. from 12.0 to 12.5, it is Th5, if from 12.6 to 12.9, it is Th6.
Transversal plane				
32	UB -	degrees	The angle of convex line of lower shoulder blades, where the left is more convex	The angle difference of UB1 - UB2. The UB2 angle between a line crossing the Łl point and being simultaneously perpendicular to the camera axis and the straight-line crossing Łl and Łp points. The UB1 angle is between the line crossing the Łp point and being simultaneously perpendicular to the camera axis and the straight-line crossing Łp and Łl points. $PLLB = LLB - PLB$
33	UB	degrees	The angle of convex line of lower shoulder blades, where the right is more convex	
34	KSM	degrees	Pelvic torsion to the right	The angle between a line crossing M1point and being simultaneously perpendicular to the camera axis and a straight-line crossing M1 and MP points

35	KSM -	degrees	Pelvic torsion to the left	The angle between a line crossing Mp point and being simultaneously perpendicular to the camera axis and a straight-line crossing M1 and MP points
36	DCK	mm	Total length of the spine	The distance between C7 and S1 points measured vertically.
Morphological Features				
37	Mc	kg	Body weight	Body weight and height was measured with electronic medical balance.
38	Wc	cm	Body height	

Source*: Own research

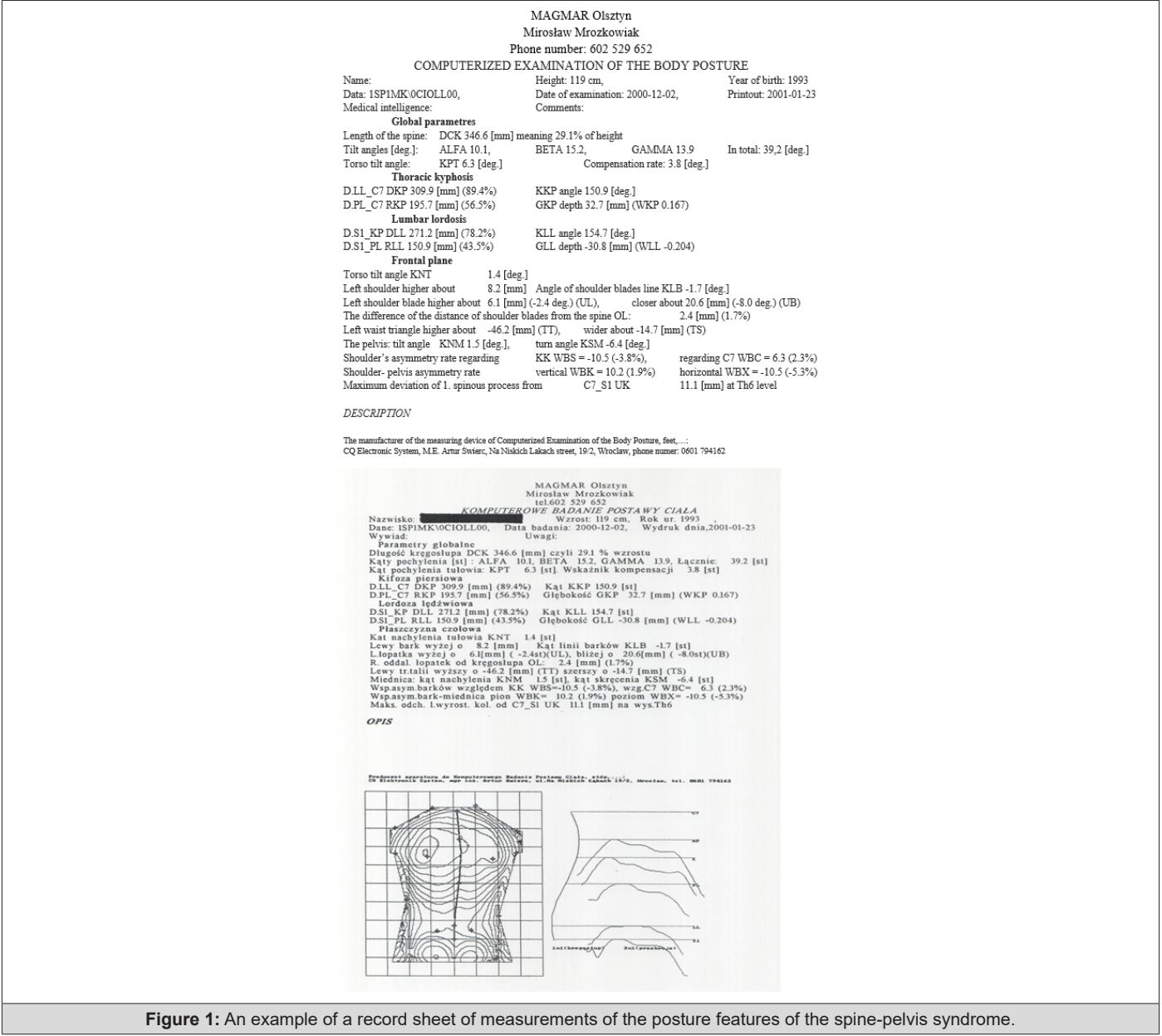
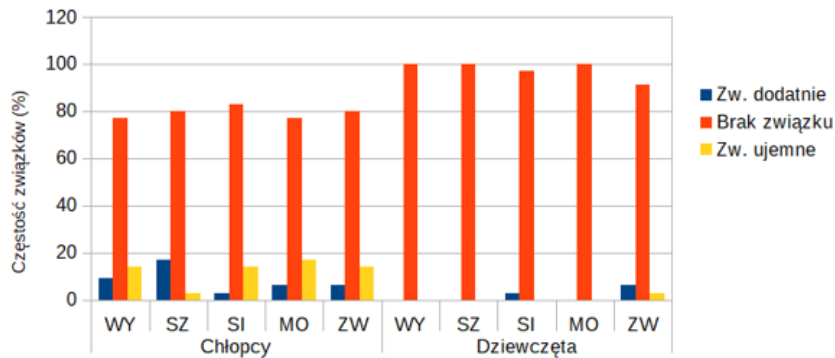


Figure 1: An example of a record sheet of measurements of the posture features of the spine-pelvis syndrome.

Research Method

The research was conducted in accordance with the principles of the Declaration of Helsinki. For their implementation, consent was obtained from: the student and his legal guardian, the kinder-

garten teacher and management, the bioethics committee (KEBN 2/2018, UKW Bydgoszcz). Prior to the measurements, the children were trained to avoid stress related to the research procedure and the implementers (Figure 2).



Note*: WY –Endurance, SZ –Speed, SI –Strength, MO –Force, ZW –Agility

Figure 2: Frequency of correlations of the values of physical fitness with the changes of the values of body posture features between 1st and 2nd measurement in back carrying among 7-year-old students of both sexes n=65.

Physical Fitness

For the diagnosis, the Wrocław Physical Fitness Test for 3-7-year-old children was used [49]. According to the author, the test has a high degree of reliability and is adequate in terms of dis-

criminatory force and difficulty [46]. The proposed test consisted of four trials conducted as part of Sports Day, which significantly increased the motivation to exercise in the presence of parents: speed, strength, power, agility. The author enriched the test with a fifth test - endurance [50]. Visualization [51] (Picture 2).



Picture 2: Instruction for the examined children.

Strength test

- Starting position (P.w.) – legs apart in front of the line, in the hands above the head a 1-kilogram medicine ball. A 2-meter-high tape is placed 1 m from the line to exclude throws to the ground.
- Movement - forward throw of the medicine ball with both hands.
- The distance in centimeters from the line to the last trace of the ball is evaluated. The more favourable measurement of both throws is important (Picture 3).



Picture 3: Strength test.

Force test

- a) P.w. – legs apart in front of the line
- b) Movement– forward jump
- c) The distance in centimetres from the line to the last trace of the jumper is evaluated. The more favorable measurement from three jumps is important (Picture 4).



Picture 4: Force test.

Speed test

- a) P.w. – starting position high in front of the starting line
- b) Movement –20 m run
- c) The time in seconds to cover the distance from the start to the finish is evaluated. The more favorable time from two attempts is important. The run was held on a tartan track in trainers and casual clothing (Picture 5).



Picture 5: Speed test.

Agility test (name taken after the author's name)

- a) P.w. – Two lines at a distance of 5 m one from the other, the starting position high in front of the starting line, there are two blocks of 5 cm x 5 cm at a distance of 20 cm one from the other on the farther line are
- b) Movement – run to pick up a block on the farther line, run back
- c) The time to cover a distance of 4 x 5m with flawless transfer of the block is evaluated. The more favorable time from two attempts is important (Picture 6).

**Picture 6:** Agility test.**Endurance Test**

P.w. – starting position high

- a) Movement – 300 m run
- b) The time of the run from start to finish is evaluated. If a child did not finish the run they received "0" points. The run took place on a recreational path with a paved surface, wearing trainers and casual clothing.
1. Determine the child's age category on the day of the test
 2. Conducting five fitness tests
 3. Reading the scores in the tables - including age and gender - assigned to a given
 4. measurement value
 5. Adding up the number of points the child obtained from performing the five test attempts (Picture 7).

The procedure for assessing a child's physical fitness included:

**Picture 7:** Endurance test.**Body Posture**

The method to assess posture using the phenomenon of projection moiré makes it possible to determine the effect of different ways of carrying a schoolbag on posture, the restitution of the value of features after the load is removed, and the importance of physical fitness in the disruption and restitution of the size of diagnosed

features [2,52]. Differentially loaded posture was provided with a custom-designed diagnostic frame was provided to ballast the body posture (utility model no. W.125734) The presence of an assistant during the examination was dictated by the need of minimizing the time from the load removal to the second registration of the value of the posture features. Every effort has been made to ensure that

the custom-designed loaded frame was individually adapted to the type of child's body structure. The 10-minute load time assumed was the average time to travel from home as reported in the questionnaire filled out by parents [53]. On the other hand, the weight of the load was determined by averaging the weight of transported school supplies by first-grade children from a randomly selected elementary school, it was 4 kg. Selected postural characteristics were measured in 4 positions. First position - habitual posture, Picture

8. Second position - after a 10-minute load (in the last 5 seconds), (Pictures 9-11). Third position - after one minute after removing the load, pic. 8. Fourth position - after two minutes after removing the load (Picture 8). The load was supposed to imitate the way of carrying school supplies. The test subject was allowed to move freely. The study was carried out by a physiotherapist with 20 years of diagnostic experience of posture by a method using projection



Picture 8: Positions 1, 3, 4: Presentation of habitual posture.



Picture 9: Position 2: Presentation of back loading.



Picture 10: Position 2: Presentation of chest loading.



Picture 11: Position 2: Presentation of back and chest loading.

Research Questions and Hypotheses

The research question: "Which characteristics of physical fitness under study are of the greatest and least importance in preventing postural static disorders in the transport of school utensils?" is the result of our own experience and analysis of the literature on the subject. Our own research results and analysis of the available literature led us to believe that the greatest importance in the prevention of postural static disorders in carrying a schoolbag is strength and agility, the least importance is endurance.

Statistical Methods

Only the results of the studies obtained according to the established procedure were qualified for statistical analysis. A meta-analysis was carried out, in which the unit of analysis was data on the correlation between the difference in measurements of body posture traits and physical fitness traits. Two categories were analyzed:

- a) Correlations between the values of change in each body posture features between the 1st and 2nd measurements and the values of physical fitness traits in each aspect separately. Thus, the following were analyzed: the number and percentage of statistically significant positive correlations (meaning that greater physical fitness in a given aspect causes greater attitude change - an undesirable situation), the number and percentage of statistically significant negative correlations (meaning that greater physical fitness in a given trait causes less attitude change - a desirable situation), the number and percentage of traits whose change does not correlate significantly statistically with a given value of the fitness trait (neutral situation).

- b) Correlations between the value of change with restitution of each postural trait between the 1st and 4th measurements and the value of physical fitness traits in each aspect separately. Thus, the following were analyzed: the number and percentage of statistically significant positive correlations (meaning that greater physical fitness in a given trait causes greater postural change - an undesirable situation), the number and percentage of statistically significant negative correlations (meaning that greater physical fitness in a given trait causes less postural change - a desirable situation), the number and percentage of traits, which change does not correlate statistically significantly with a given physical fitness trait (a neutral situation)

In order to delineate individual fitness traits in terms of greater and lesser influences on changes in the value of postural traits for individual ways of carrying, cross-tabulations were performed, presenting the counts (N) and percentages (%) of statistically significant positive and negative correlations and lack of correlation between changes in the value of postural traits and the value of a given fitness trait. Analyses were performed separately for boys and girls and individual ways of carrying.

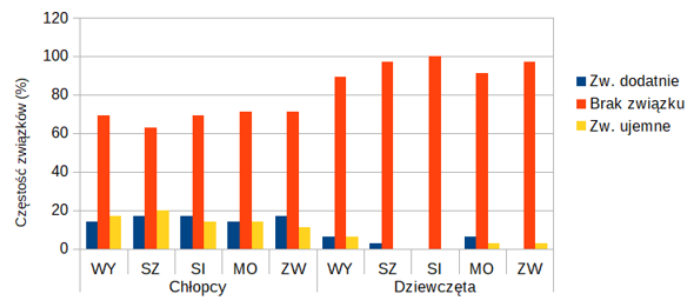
Results Obtained

A total of 65 subjects of both sexes carried out the study made it possible to record 10,010 sizes of traits describing habitual posture and in dynamic positions, body weight and height, and physical fitness. The average body weight among girls was 24.46 kg, body height was 123.87, and among boys, respectively: 24.56, kg, 123 cm. All children had a slender body type, according to the Rohrer weight and height index [54].

An analysis of the percentages of statistically significant pos-

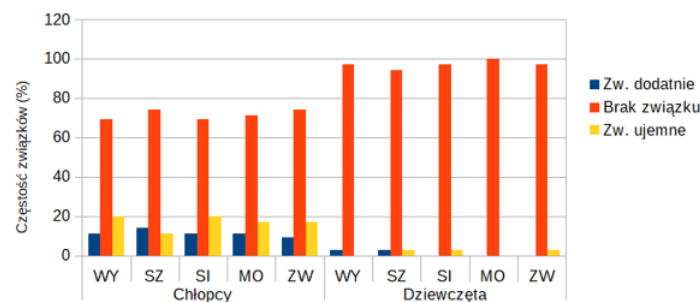
itive and negative correlations between the values of physical fitness traits and the differences in the values of body posture traits between the 1st and 2nd measurement during carrying on the back by boys showed that positively by the highest percentage (17%) the changes in differences correlate with speed, negatively by the highest percentage (17%) with force. It can be assumed that speed will be the physical fitness trait that increases differences the most, and force decreases (Table 2, Figure 2). Among girls, positively with the highest percentage (6%) with agility, negatively with the highest percentage (3%) also with agility. It can be assumed that agility will be the physical fitness trait with mostly increasing and decreasing differences. It should be thought that the importance of agility will depend on the level of development and the mutual proportions of the other traits, (Table 3, Figure 2). Considering the results of the correlation between physical fitness traits and the restitution of the value of body posture traits between the 1st and 4th measurement after carrying on the back among boys, it can be said that positively by the largest percentage (17%) of the difference changes correlate with: speed, strength and agility, negatively by the largest percentage (20%) with speed. It can be assumed that speed, strength and agility will be the physical fitness traits with most increasing differences, while speed decreases. It should be thought that the importance of speed will depend on the level of development and the mutual proportions of the other traits (Table 4, Figure 3). Among girls, positively by the largest percentage (6%), the changes in differences correlate with endurance and force, and negatively by the largest percentage (6%) with strength. It can be assumed that endurance and force will be the physical fitness traits that increase differences the most, while endurance decreases. It should be thought that the importance of endurance will depend on the level of development and the mutual proportions of the other traits (Table 5, Figure 3). An analysis of the percentages of statistically significant positive and negative correlations between the values of physical fitness traits and the differences in the values of body posture traits between the 1st and 2nd measurement during chest carrying by boys showed that positively by the largest percentage (14%) the changes in differences correlate with speed, negatively by the largest percentage (20%) with endurance and strength. It can be assumed that speed will be the physical fitness trait that increases differences the most, while endurance and strength decrease (Table 6, Figure 3). Among girls, positively by the largest percentage (3%), changes in differences correlate with endurance and speed, negatively by the largest percentage (3%) with speed, strength and agility. It can be assumed that endurance and speed will be the physical fitness traits that increase differences the most, and speed, strength and agility will decrease. It should be thought that the importance of speed will depend on the level of development and the mutual proportions of the other traits (Table 7, Figure 4). An analysis of the percentages of statistically significant positive and negative correlations between the values of physical fitness traits and the

differences in the values of body posture traits between the 1st and 4th measurement after chest carrying by boys showed that positively by the largest percentage (20%) the changes in differences correlate with endurance and speed, negatively by the largest percentage (17%) with endurance. It can be assumed that speed will be the physical fitness trait that increases the difference the most and decreases endurance. It should be thought that the importance of endurance will depend on the level of development and the mutual proportions of the other traits (Table 8, Figure 5). Among girls, positively by the largest percentage (11%) changes in differences correlate with agility, negatively by the largest percentage (3%) with endurance, power and agility. Thus, it can be assumed that agility will be the physical fitness trait that increases differences the most, while endurance, power and agility decrease. It should be thought that the importance of agility will depend on the level of development and the mutual proportions of the other traits (Table 9, Figure 5). Considering the results of correlations between physical fitness traits and differences in the value of a body posture traits between the 1st and 2nd measurement during back-chest carrying among boys, it was shown that positively by the highest percentage (14%) changes in the value differences of body posture traits correlate with speed, negatively by the highest percentage (20%) with endurance, strength and force. It can be assumed that speed will be the physical fitness trait that increases the most, and endurance, strength and force decrease the difference in the value of postural traits (Table 10, Figure 6). Among girls, positively by the largest percentage (3%), the changes in differences correlate with endurance and speed, negatively by the largest percentage (3%) with speed, strength and agility. It can be assumed that endurance and speed will be the physical fitness traits that increase the most, and speed, strength and agility will decrease the differences in the value of body posture traits the most. It should be thought that the importance of speed will depend on the level of development and the mutual proportions of the other traits (Table 11, Figure 6). Considering the results of the correlation between physical fitness traits and the restitution of the value of postural traits between the 1st and 4th measurement after the back-chest carrying among boys, it was observed that positively by the largest percentage (23%) the changes in differences correlate with endurance and speed, negatively by the largest percentage (17%) with endurance and speed. It can be assumed that endurance and speed will be the physical fitness traits that most reduce or increase differences in the value of postural traits. It should be thought that the importance of both traits will depend on the level of development and the mutual proportions of the others (Table 12, Figure 7). Among girls, positively by the highest percentage (11%) the differences in question correlate with strength, negatively by the highest percentage (3%) with endurance, power and agility. It can be assumed that strength will be the physical fitness trait that most increases postural change, while endurance, force and agility decrease (Table 13, Figure 7).



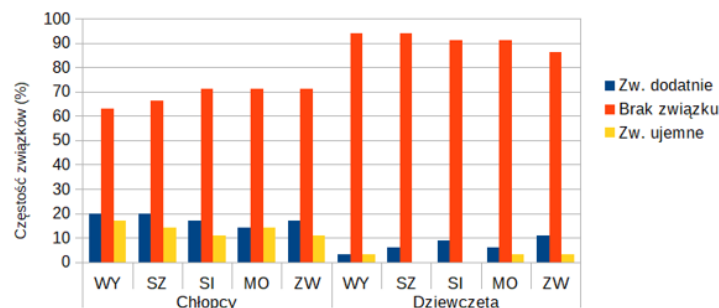
Note*: WY –Endurance, SZ –Speed, SI –Strength, MO –Force, ZW –Agility

Figure 3: Frequency of correlations of the values of physical fitness with the changes of the values of body posture features between 1st and 4th measurement in back carrying among 7-year-old students of both sexes n=65.



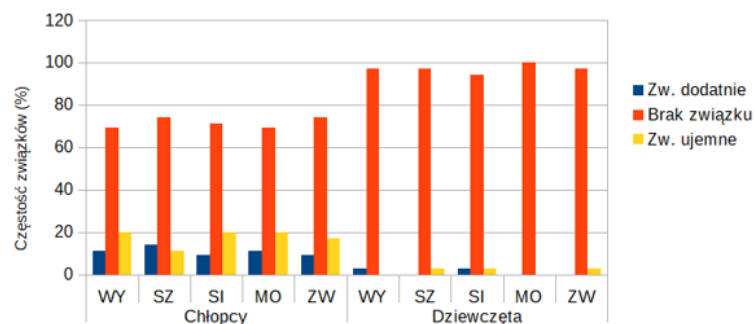
Note*: WY –Endurance, SZ –Speed, SI –Strength, MO –Force, ZW –Agility

Figure 4: Frequency of correlations of the values of physical fitness with the changes of the values of body posture features between 1st and 2nd measurement in chest carrying among 7-year-old students of both sexes n=65.



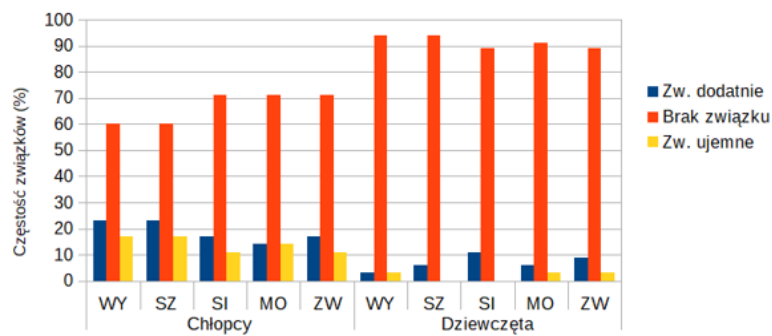
Note*: WY –Endurance, SZ –Speed, SI –Strength, MO –Force, ZW –Agility

Figure 5: Frequency of correlations of the values of physical fitness with the changes of the values of body posture features between 1st and 4th measurement in chest carrying among 7-year-old students of both sexes n=65.



Note*: WY –Endurance, SZ –Speed, SI –Strength, MO –Force, ZW –Agility

Figure 6: Frequency of correlations of the values of physical fitness with the changes of the values of body posture features between 1st and 2nd measurement in back-chest carrying among 7-year-old students of both sexes n=65.



Note*: WY –Endurance, SZ –Speed, SI –Strength, MO –Force, ZW –Agility

Figure 7: Frequency of correlations of the values of physical fitness with the changes of the values of body posture features between 1st and 4th measurement in back-chest carrying among 7-year-old students of both sexes n=65.

Table 2: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 2nd measurement of posture characteristics during back carrying in a group of boys.

Spine Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	3	9%	27	77%	5	14%	35	100%
Speed	6	17%	28	80%	1	3%	35	100%
Strength	1	3%	29	83%	5	14%	35	100%
Force	2	6%	27	77%	6	17%	35	100%
Agility	2	6%	28	80%	5	14%	35	100%

Source*: Own research

Table 3: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 2nd measurement of posture characteristics during back carrying in a group of girls.

Spine Girls	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	0	0%	35	100%	0	0%	35	100%
Speed	0	0%	35	100%	0	0%	35	100%
Strength	1	3%	34	97%	0	0%	35	100%
Force	0	0%	35	100%	0	0%	35	100%
Agility	2	6%	32	91%	1	3%	35	100%

Source*: Own research

Table 4: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 4th measurement of posture characteristics during back carrying in a group of boys.

Spine Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	5	14%	24	69%	6	17%	35	100%
Speed	6	17%	22	63%	7	20%	35	100%
Strength	6	17%	24	69%	5	14%	35	100%
Force	5	14%	25	71%	5	14%	35	100%
Agility	6	17%	25	71%	4	11%	35	100%

Source*: Own research

Table 5: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 4th measurement of posture characteristics during back carrying in a group of girls.

Spine Girls	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	2	6%	31	89%	2	6%	35	100%
Speed	1	3%	34	97%	0	0%	35	100%
Strength	0	0%	35	100%	0	0%	35	100%
Force	2	6%	32	91%	1	3%	35	100%
Agility	0	0%	34	97%	1	3%	35	100%

Source*: Own research

Table 6: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 2nd measurement of posture characteristics during chest carrying in a group of boys.

Chest Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	4	11%	24	69%	7	20%	35	100%
Speed	5	14%	26	74%	4	11%	35	100%
Strength	4	11%	24	69%	7	20%	35	100%
Force	4	11%	25	71%	6	17%	35	100%
Agility	3	9%	26	74%	6	17%	35	100%

Source*: Own research

Table 7: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 2nd measurement of posture characteristics during chest carrying in a group of girls.

Chest Girls	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	1	3%	34	97%	0	0%	35	100%
Speed	1	3%	33	94%	1	3%	35	100%
Strength	0	0%	34	97%	1	3%	35	100%
Force	0	0%	35	100%	0	0%	35	100%
Agility	0	0%	34	97%	1	3%	35	100%

Source*: Own research

Table 8: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 4th measurement of posture characteristics during chest carrying in a group of boys.

Chest Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	7	20%	22	63%	6	17%	35	100%
Speed	7	20%	23	66%	5	14%	35	100%
Strength	6	17%	25	71%	4	11%	35	100%
Force	5	14%	25	71%	5	14%	35	100%
Agility	6	17%	25	71%	4	11%	35	100%

Source*: Own research

Table 9: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 4th measurement of posture characteristics during chest carrying in a group of girls.

Chest Girls	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	1	3%	33	94%	1	3%	35	100%
Speed	2	6%	33	94%	0	0%	35	100%
Strength	3	9%	32	91%	0	0%	35	100%
Force	2	6%	32	91%	1	3%	35	100%
Agility	4	11%	30	86%	1	3%	35	100%

Source*: Own research

Table 10: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 2nd measurement of posture characteristics during chest-back carrying in a group of boys.

Chest-Back Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	4	11%	24	69%	7	20%	35	100%
Speed	5	14%	26	74%	4	11%	35	100%
Strength	3	9%	25	71%	7	20%	35	100%
Force	4	11%	24	69%	7	20%	35	100%
Agility	3	9%	26	74%	6	17%	35	100%

Source*: Own research

Table 11: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 2nd measurement of posture characteristics during chest carrying in a group of girls.

Chest-Back Girls	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	1	3%	34	97%	0	0%	35	100%
Speed	0	0%	34	97%	1	3%	35	100%
Strength	1	3%	33	94%	1	3%	35	100%
Force	0	0%	35	100%	0	0%	35	100%
Agility	0	0%	34	97%	1	3%	35	100%

Source*: Own research

Table 12: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 4th measurement of posture characteristics during chest carrying in a group of boys.

Chest-Back Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	8	23%	21	60%	6	17%	35	100%
Speed	8	23%	21	60%	6	17%	35	100%
Strength	6	17%	25	71%	4	11%	35	100%
Force	5	14%	25	71%	5	14%	35	100%
Agility	6	17%	25	71%	4	11%	35	100%

Source*: Own research

Table 13: Comparison of the percentages of statistically significant positive and negative correlations between the values of physical fitness characteristics and the value of change between the 1st and 4th measurement of posture characteristics during chest carrying in a group of girls.

Chest-Back Boys	Positive		None		Negative		Total	
	N	%	N	%	N	%	N	%
Endurance	1	3%	33	94%	1	3%	35	100%
Speed	2	6%	33	94%	0	0%	35	100%
Strength	4	11%	31	89%	0	0%	35	100%
Force	2	6%	32	91%	1	3%	35	100%
Agility	3	9%	31	89%	1	3%	35	100%

Source*: Own research

Discussion

A study by *Cieszkowski, et al* [55] showed that postural deviations do not significantly affect the modelling of the level of basic coordination abilities. The authors found statistically significant differences in Favor of children with postural defects in the frequency of movements, speed of reaction and in static balance of girls. Spatial orientation was dominant in the group of students without postural defects. A study by *Kasperczyk* [56] showed that a negative correlation existed between the strength of the hand flexor muscles and the total points received in the posture assessment. This proves that faulty posture was accompanied by a decrease in hand muscle strength. However, detailed analysis showed that there was no correlation between posture and strength endurance of postural muscles. *Górniak, et al* [57], in their study of 14-year-old boys in the areas of explosive, static and trunk strength, observed no clear relationship between postural quality and motor test results. *Kolodziej* [58] and *Kolodziej, et al* [59] showed that better results in the long jump from a standing position and the high jump were obtained by children with good posture compared to the results achieved by their peers with posture defects. *Jagier, et al* [60] believe that musculoskeletal disorders can take an acute or chronic form. While the acute form occurs itself suddenly, the chronic form is initially asymptomatic, being a consequence of the stereotypical movements of practiced physical and occupational activity. According to *Preisler* [61], overload is “a pathological condition of various organ localization, resulting from chronic overdose of physical exertion primarily during youth.” In addition to acute and chronic overload, the author details general disorders of the body, emerging by pain of varying severity and location such as emotional vacillation and heaviness. According to *Swiderski* [62], musculoskeletal overload is a set of phenomena in which mechanical action exceeds the physical strength or functional capacity of the muscular and skeletal systems.” *Wągrowaska-Koski* [63] modifying the definition quoted above, believes that “musculoskeletal overload is a set of phenomena in which the mechanical action exceeds the physical endurance or functional capacity of the dynamic and static elements”. It is also important to take into account Schild’s statement, cited by *Bittman and Badtke* [64], that the changes taking place in the musculoskeletal system of 5-7 year old children, depend primarily on the genetic

determinants of the course of maturation of the musculoskeletal system. During this period, external factors, including motor activity, do not play a major role. It seems that the influence of external factors on the development of the musculoskeletal system begins to increase with age and the maturation of the musculoskeletal and nervous systems around 7 - 8 years of age. Numerous studies have shown that students wearing backpacks reported pain, redness, swelling, fatigue and/or musculoskeletal discomfort in the upper or lower body, lower back, upper extremities, neck, upper or lower quadriceps. The majority of students experienced pain, fatigue and discomfort from carrying their school bags every day, and almost all students reported relief after removing their backpacks. At the same time, female students were more likely to report complaints [65-73]. *Puckree, et al.* [69] found that the time and method of carrying a backpack (on both or one shoulder) significantly influenced the percentage of children reporting pain. *Hong, et al.* [74] found that the type and design of the backpack did not have a significant impact on students’ possible ailments. Other authors recommend children to use backpacks adjusted to body height to reduce possible injuries and improve comfort [75] and have a hip belt, which significantly reduces the energy expended and the risk of injury [76]. Other authors [76,77] have shown that placing a heavy load causes significantly more muscle activity than a lower backpack weight. The differences are caused primarily by the force resulting from angular movement and linear acceleration during load transfer [78]. A study conducted by *Grimmer, et al.* [77] showed that to maintain proper posture, the weight of the backpack should not exceed 10% of the student’s body weight, and school bags should be worn high on the back. The authors also concluded that age and gender were not significant factors in comparing postural responses to backpack loading. *Harsha and Berenson* [79] suggest that if students stopped carrying school bags, it could impoverish their exposure to physical activity more and even reduce the benefits of daily resistance exercise by transporting the weight of the school bag. *Shultz et al.* [80] state further that this is particularly important in the situation of the growing rate of obesity in children. In schools, a reduction in the duration and frequency of physical education and sports classes was observed in favour of humanities subjects. *Dollman, et al.* [81] note that the reduction of PE teaching time is a serious public health problem. *Dockrell* [66] observed two contradictory actions

related to the act of carrying a school backpack. On the one hand, it is a form of physical exercise, but on the other, it may cause physical pain or disturbances in the student's posturogenesis.

The analysis of the research results shows that when 7-year-old students carried the mass of a 4-kilogram backpack on their backs, the positive and negative compounds reached 17%, on the chest - 14 and 20%, respectively, and on the back-chest, respectively: 14 % and 20%. Among boys after back carrying, positive correlations between physical fitness characteristics and changes in posture characteristics between the 1st and 2nd measurement were most frequently demonstrated by force (17%) and endurance, strength and agility (14% each). Among girls, agility was positive (6%), and agility was also negative (3%). Taking into account boys and chest carrying, the most frequently positive influences were speed (14%), endurance and strength (20% each), and force and agility (17% each). Among girls, endurance and speed were positive (3%), and agility, strength and endurance were negative (3% each). When analyzing boys and back-chest carrying, speed was most often positively influenced (14%), while endurance, strength and force were negatively influenced (20% each). Among girls, endurance and strength were positive (3% each), and speed, agility and strength were negative (3% each). Considering the significant relationships between the values of physical fitness characteristics and the restitution of the values of postural characteristics after the second minute of the load removal after back carrying among boys and girls, it results that the positive effect reached 17% and the negative effect - 20%.

After chest carrying, positive 20%, negative 17%. After back-chest carrying among boys: 23% and 17%. Taking into account boys and back carrying, the most frequently positive influences were speed, strength, agility (17% each), endurance and force (14% each), and negative effects on speed (20%), endurance (17%), strength and force (14% each). %, agility (11%). Among girls, endurance and force were most often positive (6%), while endurance and force were negative (6%). After chest carrying, the most common positive effects among boys were endurance and speed (20%), strength and agility (17% each), force (14%), and negative effects on endurance (17%), speed and force (14% each), strength and agility (11% each). Among girls, agility (11%), strength (9%), speed and force (6 each) were most often positive, and the negative relationships did not exceed 3%. After back-chest carrying, among boys the most common positive effects were endurance and speed (23% each), negatively endurance and speed (17% each), among girls, respectively: strength (11%), endurance, force and agility (3% each).

Conclusions

a) The influence of physical fitness characteristics on the examined differences in the value of characteristics in carrying a 4-kilogram mass of school supplies on the back or chest was small. The correcting influence of physical fitness on the level of non-normative disorders of body posture during back carry-

ing among boys reached 17% and it was mainly force, endurance, strength and agility, among girls up to 3%. On the chest among boys up to 20% and it was mainly endurance, strength, force and agility, among girls up to 3%. On the back-chest among boys up to 20% and it was mainly endurance, strength and force, among girls up to 3%.

b) The correcting effect of physical fitness on the restoration of body posture characteristics after back carrying reached 20% among boys and it was mainly speed and endurance, and among girls it was up to 6% and it was endurance. In chest carrying, among boys the greatest influence reached 17% and it was endurance, among girls it was up to 3%. In back-chest carrying among boys up to 17% and it was endurance and speed (17% each), among girls up to 3%.

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Conflict of Interest

None.

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