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Research Article

THE EFFECT OF A SCHOOL BACKPACK MASS CARRIED OBLIQUELY ON THE RIGHT OR LEFT SHOULDER AND AT THE HETERONYMOUS HIP ON THE VALUES OF BODY POSTURE FEATURES IN THE FRONTAL PLANE OF 7-YEAR-OLD STUDENTS OF BOTH SEXES

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Abstract

Introduction: The student's environment is a set of stressors in the field of human ecology, containing the genetic and epigenetic factors within its limits.
Material and Method: The body posture tests were carried out in a group of 65 students aged 7 years, using the projection moiré method in 4 positions: 1st – the habitual posture, 2nd- the posture after a-10-minutes-loadwith school items container 3rd–the posture after one minute of the load removal, 4th – the posture after two minutes of the load removal. Physical fitness was measured with the modified Sekita test.
Results: The values of the body posture features were analyzed to determine the significance differences between consecutive measurements and their relationship with the values of physical fitness features.
Conclusion. (1) The way of carrying school items obliquely on the left or right shoulder and at the heteronymous hip can cause significant adaptive changes in the skeletal and muscular system. It should be assumed that the bigger these changes are, the longer the carrying time is, the greater the mass of the container and the intensity of physical effort are. The changes are not contingent on gender. (2) The level of general physical fitness shows a gender-specific relationship with the magnitude of changes in the body posture. The relationship is greater among boys. (3) School items should not be obliquely carried on the left or right shoulder and at the heteronymous hip by7-year-old children.

Keywords: Student's, Heteronymous.

INTRODUCTION

The student's environment looms large in the development of biomechanical disorders in the body posture. The most frequently mentioned disorders arean incorrect place of study in the school classroom and at home, an incorrect carrying of the mass of school items, the resting position and a sedentary lifestyle [1]. The Health Behavior in School aged Children report on children's health in Europe shows that the number of factors contributing to the development of a bad posture increased significantly in the last decade. The authors of the report claim that only one in four of 11-year-olds and one in six of 15-year-olds reach the recommended volume, intensity and frequency of the proactive physical activity. There was also a regress in the percentage of children who spend time passively in front of the TV in favor of dexterity computer games. As they further forecast, this time whereby will prolong due to the more frequently introduced e-textbooks [2]. The results of research by McMaster et al. showed a significant relationship between various disorders of the axial organ and the lack of physical activity [3]. This is confirmed by the results of studies by Latalski *et al.,* which show that bad postures are more common among girls than boys, and that may be related to the fact that boys prefer team games and girls prefer less intense activities [4]. According to the report of Wawrzyniak *et al.,* bad postures are a significant health problem in a child population, suggesting that this problem will increase relevantly due to the observed tendency to limit physical activity in favor of sedentary activity. It is necessary to implement primary and secondary prophylaxis in order to reduce possible adverse health effects [5]. Conclusions from the contemplations of Kratenova et al. correspond to the Polish recommendations that school age is the most optimal period for carrying out the proactive steps to prevent the bad posture progress [6]. Primary prophylaxis will be effective and comprehensive completed with secondary one. According to the Chief Sanitary Inspectorate's recommendations regarding the proper choice and manner of carrying school items, a schoolbag cannot weigh more than 10-15% of the body weight and should be carried on both shoulders. There should be a stiffened support touching the back and with equal wide straps, and the heavier items should be placed on the bottomof the backpack whereas the lighter ones higher. The influence of the student's environment on their posture was investigated by, among others, Wandycz [7, 8, 9, 10, 11], Romanowska [12], Annetts et al. [13], Mrozkowiak [14, 15, 16, 17], Mrozkowiak, Żukowska [18]. Researchers have usually focused on the role of a school chair and a table in a student body posture development, ignoring the impact of carrying school items. Mrozkowiak's early research delineated slightly this problem. The investigations included the influence of the school backpack's weight on the changes of the selected values of thebody posture features and the subsequent restitution of the peroneal and frontal spine parameters and pelvis after the load removal [14]. The author's interest comes from the persistently high percentage of the statics disorders in the body posture of students from the reception class and 1st to 3rdgrade of primary school. The author also pays attention to a constantly proclaimed opinion about the negative impact of the way of carrying school items on the statics of the body posture, and the lack of clear recommendations on the optimal contraindication. The aim of the research programme was to show changes in the selected values of the body posture features in the frontal plane influenced by the load of the school items container obliquely carried on the left shoulder and at the right hip or the right shoulder and the left hip.

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Materials

Children who participated in the study were from randomly selected kindergartens of the West Pomeranian and Greater Poland voivodships. Bad body postures and disorders were not a criterion excluding the participation in the research programme. The division of the respondents into rural and urban environments was abandoned due to the fact that this feature will never determine the homogeneity of the group and the blurring of the cultural and economic boundary of both environments. The programme was qualified according to the scheme: if the subject was 6 years, 6 months and 1 day old and was under 7 years, he was included in the 7-year-old age group. This allowed to use the previously developed normative scopes appropriate for this age and sex category, diagnosing the quality of the body posture found at the day of the examination [19]. In total, 65 students participated in the programme, of whom 53.84% (35 people) were girls and 46.15% (30 people) were boys. The average body weight among girls was 24.46 kg, the body height was 123.87 cm, and among boys: 24.56 kg and 123 cm, adequately. All children had a slender body type according to Rohrer's weight-growth index [19].

Methods

The research was carried out in accordance with the principles of the Declaration of Helsinki, and the consent for their implementation was obtained from the student and his legal guardian, the tutor and the kindergarten management and the bioethical committee (KEBN 2/2018, UKW Bydgoszcz). The research was carried out from the 27th of May 2019, and always from 9.00 a.m. to 2.00 p.m. in the properly prepared same room. On the day one, all children were introduced with the purpose and course of the research. The children were also encouraged to keep the anthropometric points marked with a marker pen on the skin. A preschool teacher's assistant of the study group was always present during the measurements, in order to ensure the emotional stability of the children. During the research, the adopted rules of the research procedure were followed.

Overall Physical Fitness

The Wroclaw Physical Fitness Test for 3-7-year-old children was used to diagnose the children's physical fitness [20]. According to the author, the test has a high degree of reliability and is adequate in terms of discriminatory strength and difficulty level [21]. The proposed test consists of four trials carried out as part of the Sports Day, which significantly increased the motivation to exercise in the presence of parents: agility (pendulous run with carrying blocks at4x5 m distance), strength (long jump), speed (running at 25 m distance), force (both hands overhead throw with a 1 kg ball). The author modified the test by adding a fifth attempt - endurance. Starting position - high starting stance. Movement - run at a distance of 300 m. The running race time from start to finish line was converted into points depending on the gained score and gender. If a child did not finish the race, the score was nil. The run took place on a fitness trail with a hardened surface in compliance with all safety standards [22].

Body posture

The used photogrammetric method is one of the most objective methods for diagnosing the body posture. It enables to determine the impact of various methods of carrying a container with school items on a body posture, restitution of the values of the features after the load removal and the importance of physical fitness in disorders and restitution of the diagnosed values of the features [23, 24]. Any loading of the body posture was provided by the constructed diagnostic frame (utility design protection right no. W.125734) (photos 1, 2). The presence of the assistant during the examination was dictated by the need to minimize the time from the load removal to second registration of the values of the posture features. Every effort has been made to ensure that the weighted frame is individually adapted to the type of a child's build. The adopted 10-minute load time was the average time to go from the place of residence given in the questionnaire completed by the parents [25]. On the other hand, the load was determined by averaging the weight of school items carried by 1st grade children from a randomly selected primary school with the burden of 4 kg. Selected features of the body posture were measured in 8 positions, 4 for each way of carrying. The first position - habitual position, pic. 3. Second position - posture after 10 minutes of asymmetric oblique loading (in the last 5 seconds), pic. 1, 2. Third position - posture one minute after the load removal, pic. 3. Fourth position - posture two minutes after the load removal, pic. 3.

Photo 1. Position 3: Demonstration of the body posture with an oblique load from the left shoulder to the right hip.

Photo 2. Position 2: Demonstration of the body posture with an oblique load from the right shoulder to the left hip.

Photo 3. Position 1: Demonstration of the habitual posture

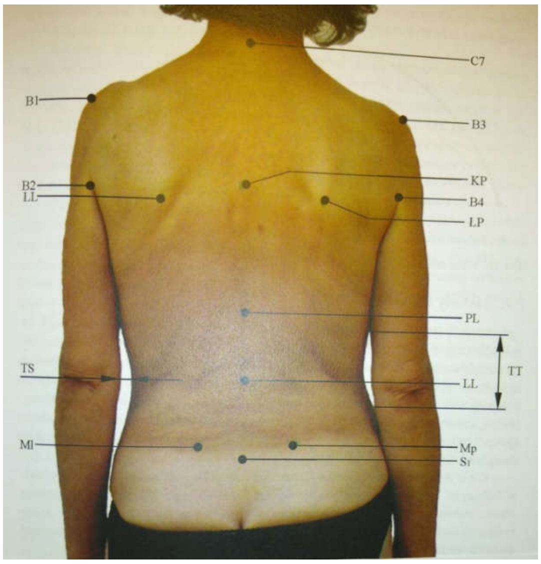

Photo 4. The arrangement and marking of the torso points in the frontal plane

On the day one, the measurements included all children in positions 1, 2, 3 and 4 with anoblique load from the right shoulder to the left hip, and on the next day from the left shoulder to the right hip. The load was supposed to imitate the way of carrying school items. The subject could move freely. In this way, efforts were made to exclude the overlapping of postural muscle fatigue from one position to another during the examination process. This is consistent with the previous results of Mrozkowiak's research, which shows that after this time the values of the posture features may be at the starting value [14]. When diagnosing the habitual posture on the first day of the research programme, it could be assumed that it was an appropriate and relatively constant for each student. However, in order to maintain the reliability of the research, it was assumed that any inconsistency with the values of the features from the first edition of the measurements may affect the final test result. Therefore, before putting the load predicted by the procedure, the features of the habitual posture were always determined as a reference for the subsequent dynamic changes of the diagnosed features. The height and weight of children as well as the weight of transported school items were measured with a medical scale before the first day of the tests.

The measuring station for the selected values of the body posture features consists of a computer and a card, a programme, a monitor and a printer, a projection-receiving device with a camera for measuring selected parameters of the pelvis-spine syndrome. The place and the camera of a subject were oriented spatially in accordance with the camera's contours and in relation to the line of the child's toes. It is possible to obtain a spatial image with the lines projection on the child's back with strictly defined parameters, which catching on the body, are distorted depending on the configuration of its surface. The lens usage enables the image of the examined person to be taken by a special optical system with a camera, and then transferred to the computer monitor. Line image distortions recorded in the computer memory are processed by a numerical algorithm into a contour map of the tested surface. The obtained image of the back surface enables a multistranded interpretation of the body posture. Apart from the assessment of the torso asymmetry in the frontal plane, it is possible to determine the values of the angular and linear features describing the pelvis and physiological curvatures in the sagittal and transversal planes [26].

In order to minimize the risk of making mistakes in the measurements of selected posture features, the following test procedure was developed [19]:

1. Habitual posture of the subject against the background of a white slightly lighted sheet: free unforced posture, with feet slightly apart, knee and hip joints in extension, arms sagging along the body and eyes directed straight ahead, backwards to the camera at a distance of 2.5 meters with toes at a perpendicular line to the camera axis.
2. Marking points on the back skin of the examined: the tip of the spinous process of the last cervical vertebra (C_7), the spinous process being the top of the thoracic kyphosis (KP), the spinous process being the top of the lumbar lordosis (LL), the transition from thoracic kyphosis to lumbar lordosis (PL), the lower angles of the shoulder (Łl and Łp), the posterior superior iliac spines (M1 and Mp), the S_1 vertebra. A white necklace was put around the subject's neck to clearly mark points B_1 and B_3, Fig. 4. Long hair was bound to reveal the C_7 point.
3. After registration of the necessary data about the examined (name and surname, year of birth, weight and body height, comments: about the condition of the knees and heels, chest, past injuries, surgical procedures, diseases of the musculoskeletal system, walk, etc.), the digital image of the back was recorded in the computer memory in each of the tested positions from the middle phase of free exhalation.
4. Processing of the recorded images takes place without the participation of the subject.
5. After saving the mathematical characteristics of the photos in the computer memory, the values of the body posture features that describe spatially the posture are printed, Fig. 1.

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

MAGMAR Olsztyn
Mirosław Mrozkowiak
Phone number: 602 529 652
COMPUTERIZED EXAMINATION OF THE BODY POSTURE

Name: Height: 119 cm, Year of birth: 1993
Data: 1SP1MK\0CIOLL00, Date of examination: 2000-12-02, Printout: 2001-01-23
Medical intelligence: Comments:

Global parametres

Length of the spine: DCK 346.6 [mm] meaning 29.1% of height
Tilt angles [deg.]: ALFA 10.1, BETA 15.2, GAMMA 13.9 In total: 39,2 [deg.]
Torso tilt angle: KPT 6.3 [deg.] Compensation rate: 3.8 [deg.]

Thoracic kyphosis

D.LL_C7 DKP 309.9 [mm] (89.4%) KKP angle 150.9 [deg.]
D.PL_C7 RKP 195.7 [mm] (56.5%) GKP depth 32.7 [mm] (WKP 0.167)

Lumbar lordosis

D.S1_KP DLL 271.2 [mm] (78.2%) KLL angle 154.7 [deg.]
D.S1_PL RLL 150.9 [mm] (43.5%) GLL depth -30.8 [mm] (WLL -0.204)

Frontal plane

Torso tilt angle KNT 1.4 [deg.]
Left shoulder higher about 8.2 [mm] Angle of shoulder blades line KLB -1.7 [deg.]
Left shoulder blade higher about 6.1 [mm] (-2.4 deg.) (UL), closer about 20.6 [mm] (-8.0 deg.) (UB)
The difference of the distance of shoulder blades from the spine OL: 2.4 [mm] (1.7%)
Left waist triangle higher about -46.2 [mm] (TT), wider about -14.7 [mm] (TS)
The pelvis: tilt angle KNM 1.5 [deg.], turn angle KSM -6.4 [deg.]
Shoulder's asymmetry rate regarding KK WBS = -10.5 (-3.8%), regarding C7 WBC = 6.3 (2.3%)
Shoulder- pelvis asymmetry rate vertical WBK = 10.2 (1.9%) horizontal WBX = -10.5 (-5.3%)
Maximum deviation of1. spinous process from C7_S1 UK 11.1 [mm] at Th6 level

DESCRIPTION

The manufacturer of the measuring device of Computerized Examination Of the Body Posture, feet,…:
CQ Electronic System, M.E. Artur Świerc, Na Niskich Lakach street, 19/2, Wroclaw, phone numer: 0601 794162

MAGMAR Olsztyn
Mirosław Mrozkowiak
tel.602 529 652
KOMPUTEROWE BADANIE POSTAWY CIAŁA

Nazwisko: [redacted] Wzrost: 119 cm, Rok ur. 1993 ,
Dane: 1SP1MK\0CIOLL00, Data badania: 2000-12-02, Wydruk dnia,2001-01-23
Wywiad: Uwagi:
Parametry globalne
Długość kręgosłupa DCK 346.6 [mm] czyli 29.1 % wzrostu
Kąty pochylenia [st] : ALFA 10.1, BETA 15.2, GAMMA 13.9, Łącznie: 39.2 [st]
Kąt pochylenia tułowia: KPT 6.3 [st]. Wskaźnik kompensacji 3.8 [st]
Kifoza piersiowa
D.LL_C7 DKP 309.9 [mm] (89.4%) Kąt KKP 150.9 [st]
D.PL_C7 RKP 195.7 [mm] (56.5%) Głębokość GKP 32.7 [mm] (WKP 0.167)
Lordoza lędźwiowa
D.S1_KP DLL 271.2 [mm] (78.2%) Kąt KLL 154.7 [st]
D.S1_PL RLL 150.9 [mm] (43.5%) Głębokość GLL -30.8 [mm] (WLL -0.204)
Płaszczyzna czołowa
Kat nachylenia tułowia KNT 1.4 [st]
Lewy bark wyżej o 8.2 [mm] Kąt linii barków KLB -1.7 [st]
L.łopatka wyżej o 6.1[mm] (-2.4st)(UL), bliżej o 20.6[mm] (-8.0st)(UB)
R. oddal. łopatek od kręgosłupa OL: 2.4 [mm] (1.7%)
Lewy tr.talii wyższy o -46.2 [mm] (TT) szerszy o -14.7 [mm] (TS)
Miednica: kąt nachylenia KNM 1.5 [st], kąt skręcenia KSM -6.4 [st]
Wsp.asym.barków względem KK WBS=-10.5 (-3.8%), wzg.C7 WBC= 6.3 (2.3%)
Wsp.asym.bark-miednica pion WBK= 10.2 (1.9%) poziom WBX= -10.5 (-5.3%)
Maks. odch. l.wyrost. kol. od C7_S1 UK 11.1 [mm] na wys.Th6

OPIS

Producent aparatury do Komputerowego Badania Postawy Ciała, stóp,...:
CQ Elektronik System, mgr inż. Artur Świerc, ul.Na Niskich Łąkach 19/2, Wrocław, tel. 0601 794162

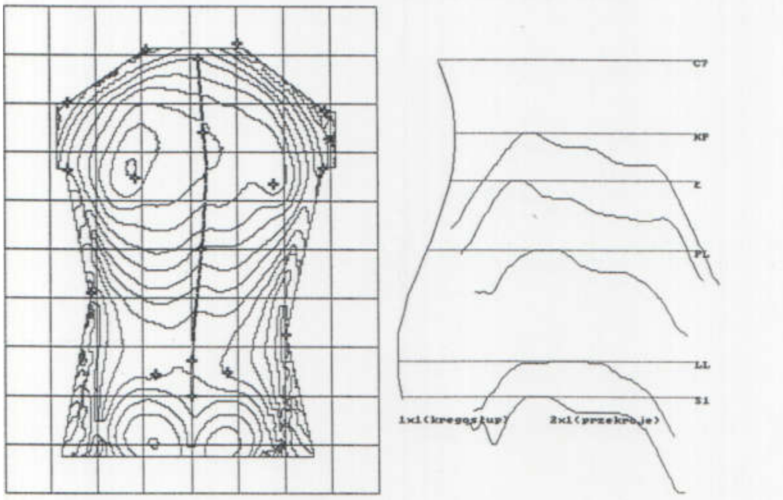

Table 1. List of registered torso and morphological features

No.	Symbol	Parameters		
		Label	Name	Description
Frontal plane				
1	KNT -	degrees	The angle of the torso bend to the side	It is determined by the deviation of the C_7-S_1 line from the vertical to the left.
2	KNT	degrees		It is determined by the deviation of the C_7-S_1 line from the vertical to the ight.
3	KLB	degrees	The angle of shoulders line, where theright one is higher	The angle between the horizontal and the straight line going through the B_2 and B_4 points.
4	KLB –	degrees	The angle of shoulders line, where the left one is higher	PLBW=LBW-PBW
5	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 andŁp points.
6	UL -	degrees	The angle of shoulder blades, where the left one is higher	
7	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 Łl and Łp points.
8	OL -	mm	The lower, more distant angle of the right shoulder blade	
9	TT	mm	The left waist triangle is higher	The difference in the distance measured vertically between the T_1 and T_2 points and between T_3 and T_4 points.
10	TT –	mm	The right waist triangle is higher	PLTT = LTT – PTT
11	TS	mm	The left waist triangle is wider	The difference in the distance measured horizontally between the straight lines going through the T_1 and T_2 points and T_3 and T_4 points.
12	TS -	mm	The right waist triangle is wider	
13	KNM	degrees	The pelvic tilt angle, the right ala of ilium is higher	The angle between the horizontal and straight line going through the M1and Mp points.
14	KNM -	degrees	The pelvic tilt angle, the left ala of ilium is higher	
15	UK	mm	The maximum deviation of the spinous process of the vertebra to the right	The greatest deviation of the spinous processfrom the vertical coming from S_1. The distance is measured on the horizontal axis.
16	UK -	mm	The maximum deviation of the spinous process of the vertebra to the left	
Morphological features				
17	Mc	kg	The body weight	The body height and body weight were measured on an electronic medical balance
18	Wc	cm	The body height	

Source: own research

Subject of research

The Wrocław fitness test made it possible to measure the strength, power, speed and agility of preschool children. The author modified Sekita's test with a test of endurance. Definitions of the examined physical and complex motor skills are generally available in the literature on the subject. The photogrammetric method applied using the projection moiré phenomenon defines several dozen features describing the body posture. Sixteen angular and linear features of the spine were selected altogether with pelvis and torso in the frontal plane, as well as the body weight and height for statistical analysis. There was a need for the most reliable and spatially complete look at the child's body posture, which allowed for full identification of the measured discriminants, Tab. 1, Pic. 4.

Research questions and hypotheses

There are following research questions based upon the aim of the research:

1. Does the accepted way of carrying the school items significantly affect the value of the body posture features in the frontal plane and do these disorders depend on gender?
2. Does physical fitness show a significant relationship with the value of posture disorders and is this relationship dependent on gender?
3. Can the applied way of carrying the school container be recommended to 7-year-old students as the least disturbing the statics of the body posture?

Our own research results and the analysis of the available literature allow us to believe that:

1. There will be significant differences between the values of the features of the habitual body posture and posture influenced by an asymmetric load. The differences will be gender independent.
2. In the accepted way of carrying the school items, the most frequent relationship with significant changes in the values of the body posture features will be visible in general fitness. The relationship will be more common among boys.
3. Carrying of school itemson the right or left shoulder and at heteronymous hip will not be recommended for 7-year-old students.

Statistical Methods

The analysis of the research results was performed using the IBM SPSS Statistics 26 programme. At the initial stage, the Shapiro-Wilk and Kołmogorow-Smirnow tests were used to check, whether the distributions of the analyzed variables were consistent with the normal distribution. In the case of majority of the variables, there were statistically significant deviations from the normal distribution at the level of $p <0.05$. Therefore, it was decided to use tests and nonparametric factors in the statistical analysis. The Wilcoxon's rank test was used to determine, whether there is a statistically significant difference (change) between two measurements (in the same group) of a ratiometric variable, which distribution is significantly different from the normal one. The following symbols are used in the tables: M - arithmetic mean, Me - median, SD - standard deviation, Z – Wilcoxon's test statistic, "p" – Wilcoxon's test significance. The level of significance was set at $p <0.05$ marked as *, and additionally the significance level $p <0.01$ marked as **. Ifthere is $p <0.05$ or $p <0.01$, then the difference between the measurements is statistically significant. The Spearman's rho correlation factor was used to determine, whether there are statistically significant correlations between the variables measured at the ratiometric level, which distribution significantly differs from the normal one. The level of statistical significance was set at $p <0.05$ marked as *, and additionally the level of significance $p <0.01$ marked as **. If there is $p <0.05$ or $p <0.01$, then the correlation between the variables is statistically significant. If the correlation is statistically significant at the level of $p <0.05$, then the correlation rho factor should be interpreted. It can take values from -1 to +1. The more distant it is from 0, and the closer it is to -1 or +1, the stronger the correlation is. Negative values mean that as the value of one variable increases, the value of the other variable decreases. On the other hand, positive values indicate that as the value of one variable increases, the value of the other variable increases, too. In the individual tables of correlation, only the variables (in the lines) were considered, for which at least one statistically significant result was recorded. Individual values of posture features are expressed in different values and ranges, so it is not possible to calculate the average difference for all these variables between these two measurements. An analysis performed in such a way would distort the results and make the variables, in which the values are higher, of greater importance and the variables, in which the values were lower, of less importance. Therefore, the correlation between the averaged difference in the values of features between 1st and 2ndmeasurements and physical fitness was made separately for girls and boys, using absolute values. There were not used exact numerical values concerning the differences in the calculations, but the ratio of the difference to the initial value. This approach causes that none of the variables are overrepresented or underrepresented in the average result. It was assumed that the standard deviation is a standard of variety. The higher it is in relation to the mean, the greater the variation of results in each group is. In the description of the results no reference was made to it, but in analytical practice its service was treated as a measure being incidental to the arithmetic mean. In the used analysis the reference to SD was abandoned. These were only given in the introductory tables (where M was also given) as a formality. SD is measure being incidental to M. It was also assumed that the value of SD in the performed studies is not interpreted in any way, especially if the analysis is based on nonparametric tests and the median (Me), but not the mean (M). That is why SD and M were finally removed from the initial analyzes in order to concentre the tables and leave there thing, which is really needed for the research. Standard deviation is a measure being incidental to the arithmetic mean, and therefore it is not valid to give its values next to the median. Correlation analysis was performed between the results of physical fitness tests and the difference between 1st and 2nd measurements, separately for the carrying on the right shoulder and the left hip, and on the left shoulder and the right hip, separating girls and boys. Only those subjects, who had both physical fitness tests and appropriate measurements were considered. To concentre the results of the analysis as much as possible, only the correlation factors (rho) were included in the tables. Correlations statistically significant at the level of $p < 0.01$ are marked **, and correlations statistically significant at the level of $p < 0.05$ are marked *. The individual tables include only those variables (in the line), for which at least one statistically significant result was recorded.

In total, the research carried out in a group of 65 people of both sexes allowed for the registration of 5005 values of features describing body posture in a habitual posture and dynamic positions, body weight and height, and physical fitness. The analysis included a comparison of the 2nd with 1st measurement in the left shoulder - right hip and the right shoulder - left hipcarrying, separately for each sex, in order to show significant changes in the way of carrying school items in the analyzed posture features. Considering the changes in the values of the posture features in the oblique left shoulder - right hip carrying and considering only boys, the Wilcoxon's rank test showed a statistically significant difference of 2nd and 1st measurement in the range of almost all analyzed variables. The exception is the value of the torso asymmetry (KNT +), where no statistically significant change was noted, Tab. 2. In the right shoulder - left hipcarrying, a statistically significant difference was observed between the 2nd and the 1st measurement in the range of all analyzed variables, Tab. 3. Among girls the left shoulder - right hip and the right shoulder - left hip carrying, the Wilcoxon's rank test showed a statistically significant difference between 2nd and 1st measurement in the range of all analyzed variables, Tab. 4, 5. The analysis of the results of the Wroclaw fitness test and the endurance diagnostic test showed that the research group of 7-year-old children from the West Pomeranian and Greater Poland regions represented a sufficient level of physical fitness, taking gradation such as: insufficient, sufficient, good, very good. Nevertheless, this level is significantly lower than the values obtained in the measurements of other authors from 2006, 1996, 1972 and 1967.

Taking into account the differences in the boys' results between the 1st and the 2nd measurement in the left shoulder - right hipcarrying, it turned out that the greater the endurance is, the smaller the asymmetry of the width of the waist triangles is (TS-), but the greater the asymmetry of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the distance of the angles of the lower shoulder blades from the line of the spinous processes of the spine (OL +) is, of the height of the waist triangles (TT-) and the course of the spinous processes' line of the spine with a left-sided convex is (UK-). The grater the speed is, the smaller the asymmetry of the torso (KNT +) is, of the shoulders (KLB-) and shoulder blades (UL-) is, of the distance of the angles of the lower shoulder blades from the

Tab. 2.The significance of differences in the values of the posture features in the frontal plane between 2nd and 1stmeasurementwith an oblique load on the left shoulder and at the right hip among boys

No.	Variables	Measurement1			Measurement2			Wilcoxon's test	
		M	Me	SD	M	Me	SD	Z	p
1	KNT-	1,56	1,40	1,04	8,48	8,40	0,75	-4,111	<0,001**
2	KNT+	2,04	2,35	1,50	0,73	0,50	0,64	-1,960	0,050
3	KLB-	2,60	1,90	1,64	0,98	0,90	0,68	-2,524	0,012*
4	KLB+	1,60	1,05	1,39	8,08	8,00	0,65	-4,109	<0,001**
5	UL-	3,01	4,15	2,30	0,98	1,00	0,87	-2,533	0,011*
6	UL+	2,43	1,95	1,59	7,55	7,60	0,70	-4,107	<0,001**
7	OL-	8,89	8,10	5,71	11,87	10,15	5,49	-4,108	<0,001**
8	OL+	4,16	4,30	2,55	1,28	1,10	0,68	-2,524	0,012*
9	TT-	5,44	4,80	2,05	2,31	1,85	1,46	-2,521	0,012*
10	TT+	8,95	8,30	4,38	15,30	14,30	4,55	-4,107	<0,001**
11	TS-	5,74	5,10	1,63	14,11	13,65	1,65	-2,521	0,012*
12	TS+	8,44	8,35	4,99	3,40	2,10	3,24	-4,108	<0,001**
13	KNM-	6,29	7,50	3,48	12,20	11,30	3,00	-4,015	<0,001**
14	KNM+	3,62	3,40	2,36	1,21	1,10	1,01	-2,666	0,008**
15	UK-	2,69	1,50	2,15	0,86	0,75	0,68	-2,521	0,012*
16	UK+	8,03	6,95	5,33	12,69	10,95	4,99	-4,108	<0,001**

Source: own research

Tab. 3. The significance of differences in the values of theposture features in the frontal plane between 2nd and 1stmeasurementwith an oblique load on the right shoulder and at the left hip amongboys

No.	Variables	Measurement1			Measurement 2			Wilcoxon's test	
		M	Me	SD	M	Me	SD	Z	p
1	KNT-	1,56	1,40	1,04	0,60	0,45	0,51	-4,111	<0,001**
2	KNT+	2,04	2,35	1,50	6,19	5,85	0,83	-2,521	0,012*
3	KLB-	2,60	1,90	1,64	5,88	5,60	1,40	-2,521	0,012*
4	KLB+	1,60	1,05	1,39	0,62	0,35	0,66	-4,111	<0,001**
5	UL-	3,01	4,15	2,30	5,99	6,20	1,73	-2,521	0,012*
6	UL+	2,43	1,95	1,59	1,27	0,80	0,99	-4,111	<0,001**
7	OL-	8,89	8,10	5,71	5,59	4,70	4,88	-4,109	<0,001**
8	OL+	4,16	4,30	2,55	7,81	6,05	4,14	-2,521	0,012*
9	TT-	5,44	4,80	2,05	10,60	10,10	1,99	-2,524	0,012*
10	TT+	8,95	8,30	4,38	4,34	3,90	2,52	-4,107	<0,001**
11	TS-	5,74	5,10	1,63	10,00	9,15	1,90	-2,533	0,011*
12	TS+	8,44	8,35	4,99	4,89	3,85	4,47	-4,111	<0,001**
13	KNM-	6,29	7,50	3,48	2,46	2,10	1,47	-4,016	<0,001**
14	KNM+	3,62	3,40	2,36	9,60	9,70	2,41	-2,668	0,008**
15	UK-	2,69	1,50	2,15	8,70	7,60	2,09	-2,521	0,012*
16	UK+	8,03	6,95	5,33	3,99	2,30	3,71	-4,109	<0,001**

Source: own research

Tab. 4. The significance of differences in the values of the posture features in the frontal plane between 2nd and 1st measurementwith an oblique load on the left shoulder and at the right hip amonggirls

No.	Variables	Measurement 1			Measurement 2			Wilcoxon's test	
		M	Me	SD	M	Me	SD	Z	p
1	KNT-	1,39	0,40	1,66	8,62	8,60	0,54	-3,409	0,001**
2	KNT+	1,22	0,80	0,93	0,57	0,30	0,71	-3,001	0,003**
3	KLB-	1,64	1,40	0,97	0,77	0,60	0,49	-2,941	0,003**
4	KLB+	1,89	1,50	1,41	8,19	8,30	0,61	-3,411	0,001**
5	UL-	2,33	2,80	1,59	0,64	0,70	0,41	-3,829	<0,001**
6	UL+	2,94	3,20	1,32	7,48	7,60	0,80	-3,409	0,001**
7	OL-	7,76	7,60	3,36	10,57	11,30	3,24	-3,408	0,001**
8	OL+	5,03	4,30	3,72	1,34	1,10	0,84	-3,823	<0,001**
9	TT-	5,65	4,70	2,88	2,39	1,70	1,65	-3,826	<0,001**
10	TT+	6,88	4,80	3,46	13,19	12,50	2,84	-3,408	0,001**
11	TS-	5,59	4,90	2,44	14,09	14,10	1,96	-3,824	<0,001**
12	TS+	7,86	5,10	4,57	2,61	2,10	2,38	-3,408	0,001**
13	KNM-	4,32	2,70	3,57	11,81	11,40	2,38	-3,408	0,001**
14	KNM+	3,04	2,90	2,20	0,95	1,00	0,85	-3,825	<0,001**
15	UK-	3,43	3,10	2,03	1,34	1,10	1,13	-3,824	<0,001**
16	UK+	4,97	3,70	2,98	10,79	10,20	2,31	-3,409	0,001**

Source: own research

Tab. 5. The significance of differences in the values of the posture features in the frontal plane between 2nd and 1stmeasurementwith an oblique load on the right shoulder and at the left hip among girls

No.	Variables	Measurement 1			Measurement 2			Wilcoxon's test	
		M	Me	SD	M	Me	SD	Z	p
1	KNT-	1,39	0,40	1,66	0,56	0,10	0,75	-3,434	0,001**
2	KNT+	1,22	0,80	0,93	5,42	5,40	0,49	-3,825	<0,001**
3	KLB-	1,77	1,40	1,15	4,88	4,80	1,06	-3,784	<0,001**
4	KLB+	1,89	1,50	1,41	0,72	0,30	0,82	-3,040	0,002**
5	UL-	2,33	2,80	1,59	5,43	5,60	0,93	-3,825	<0,001**
6	UL+	2,94	3,20	1,32	1,38	1,50	0,65	-3,411	0,001**
7	OL-	7,76	7,60	3,36	3,66	3,10	2,14	-3,408	0,001**
8	OL+	5,03	4,30	3,72	8,34	6,10	4,01	-3,827	<0,001**
9	TT-	5,65	4,70	2,88	11,13	10,50	2,97	-3,828	<0,001**
10	TT+	6,88	4,80	3,46	3,33	2,80	2,02	-3,409	0,001**
11	TS-	5,59	4,90	2,44	9,31	8,90	2,35	-3,827	<0,001**
12	TS+	7,86	5,10	4,57	4,56	1,50	4,07	-3,410	0,001**
13	KNM-	4,32	2,70	3,57	1,75	1,20	1,56	-3,411	0,001**
14	KNM+	3,04	2,90	2,20	8,67	8,70	2,29	-3,826	<0,001**
15	UK-	3,43	3,10	2,03	9,21	8,70	2,39	-3,832	<0,001**
16	UK+	4,97	3,70	2,98	1,81	1,40	1,30	-3,412	0,001**

Source: own research

line of the spine with a left-sided convex (UK-) is, but the greater asymmetry of the width of the waist triangles is (TS-). The greater the strength is, the smaller the asymmetry in the width of the waist triangles (TS-) is, but the greater the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the distance of the angles of the lower blades from the spinous processes of the spine (spine OL +) is, of the height of the waist triangles (TT-) is, of the pelvis (KNM +) and the course of the spinous processes' line of spine with a left-sided convex is (UK-). The greater the power, the smaller the asymmetry of the width of the waist triangles (TS-) is, but the greater the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the distance of the angles of the lower blades from the line of spinous processes of the spine (OL +) is, of the height of the waist triangles (TT-) and the course of the spinous processes' line of the spine with the left-sided convex is (UK-). The greater the agility is, the smaller the asymmetry of the width of the waist triangles (TS-) is, but the greater the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the distance of the angles of the lower shoulder blades from the line of the spinous processes of the spine (OL +) is, of the height of waist triangles (TT-) is, of the pelvic (KNM +) and the course of the spinous processes' line of the spine with a left-sided convex is (UK-). The greater the general fitness is, the smaller the asymmetry of the width of the waist triangles (TS-) is, but the greater asymmetry of the torso (KNT +) is, of the shoulder and (KLB-)the shoulder blades height (UL-) is, of the distance of the angles of the lower shoulder blades from the spine line (OL +), of the height of the waist triangles (TT-) is, of the pelvis (KNM +) and the course of the spinous processes' line of the spine with a left-sided convex is (UK-),

Tab. 6.Correlations between physical fitness and the difference in the values of the posture features in the frontal plane between 1st and 2ndmeasurement with an oblique load on the left shoulder and at the right hip among boys

Variables	The difference between 1st and 2ndmeasurement					
	WY	SZ	SI	MO	ZW	OG
KNT+	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
KLB-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
UL-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
OL+	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
TT-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
TT+	0,68*	0,48	0,09	-0,45	0,15	0,17
TS-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
KNM+	0,50	0,00	1,00**	0,00	1,00**	1,00**
UK-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**

Source: own research
The legend: WY – endurance, SZ – speed, SI – strength, MO – power, ZW – agility, OG – Generalphysical fitness

Tab. 6. Considering the way of the right shoulder - left hipcarrying, it turned out that the greater the strength is, the smaller the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is,of the height of the waist triangles (TT-) and the course of the spinous processes' line of the spine with a left-sided convex (UK-) is, but the greater asymmetry of the distance of the angles of the lower shoulder blades from the line of spinous processes of the spine (OL +) and the width of the waist triangles is(TS-). The greater the speed is, the smaller the asymmetry of the distance of the angles of the lower shoulder blades from the line of the spinous process of the spine (OL +) is, of the width of the waist triangles (TS-) and the course of the spinous processes' line of the spine with the right-sided convex (UK +) is, but the greater the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and the shoulder blades (UL-) is and of the height of the waist triangles (TT-) and the course of the spinous processes' line of the spine with a left-sided convex is (UK-).The greater the strength is, the smaller the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the height of the waist triangles (TT-) and the course of the spinous processes' line of the spine with a left-sided convex (UK-) is, but the greater the asymmetry of distance of the angles of the lower shoulder blades from the line of the spinous processes of the spine (OL +) is, and of the width of the waist triangles is (TS-). The greater the power is, the smaller the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the height of the waist triangles (TT-) and of the course of the spinous processes' line of the spine with a left-sided convex (UK-) is, but the greater the asymmetry of distance of the angles of the lower shoulder blades from the line of the spinous process of the spine (OL +), and of the width of the waist triangles is(TS-). The greater the agility is, the smaller asymmetry of the torso (KNT +) is,of the shoulders (KLB-) and shoulder blades height(UL-) is, of the height of the waist triangles (TT-) and the course of the spinous processes' line of thespine with a left-sided convex (UK-) is, but the greater the asymmetry of the distance of the angles of the lower shoulder blades from the line of the spinous processes of the spine (OL +), and of the width of the waist triangles is(TS-). The greater the general fitness is, the smaller the asymmetry of the torso (KNT +) is, of the height of the shoulders (KLB-) and shoulder blades (UL-) is, of the height of the waist triangles (TT-) and the course of the spinous processes' line of the spine with a left-sided convex (UK-) is, but the greater the asymmetry of the distance of the angles of the lower shoulder blades from the line of the spinous processes of the spine (OL +) is, and of the width of the waist triangles is(TS-), Tab 7.

Tab. 7.Correlations between the physical fitness and the difference in the values of the posture features in the frontal plane between 1st and 2nd measurement with an oblique load on the right shoulder and at the left hip among boys

Variables	The difference between 1st and 2ndmeasurement					
	WY	SZ	SI	MO	ZW	OG
KNT+	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
KLB-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
UL-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
OL-	0,04	-0,12	0,34	0,11	0,24	0,24
OL+	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
TT-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
TT+	-0,20	-0,57*	-0,31	-0,22	-0,03	-0,33
TS-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
TS+	-0,54	-0,69**	0,05	0,42	-0,12	-0,11
KNM+	-0,50	0,87	0,50	-0,87	0,50	0,50
UK-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
UK+	-0,34	-0,56*	-0,14	-0,05	0,06	-0,23

Source: own research
The legend: WY – endurance, SZ – speed, SI – strength, MO – power, ZW – agility, OG – general physical fitness

Considering the girls and the differences between the 1st and 2nd measurements in the left shoulder - right hipcarrying, it turned out that the greater the speed is, the greater the asymmetry in the height of the waist triangles is (TT +). The greater the strength is, the greater the asymmetry in the height of the shoulders (KLB +) and shoulder blades is (OL +). The greater the power is, the smaller the asymmetry of the width of the waist triangles (TS-) is and the greater the height of the shoulder blades is (UL-). The greater the agility is, the greater the shoulder height asymmetry is (KLB +). On the other hand, the greater the general fitness is, the greater the asymmetry of the shoulder's height (KLB +) and the height of the waist triangles is (TT +), Tab. 8. Considering the way of the right shoulder - left hipcarrying, it turned out that the greater the force is, the smaller the asymmetry of the height of the shoulders (KLB +) and shoulder blades (UL-) is and of the height of the waist triangles is (TT-). The greater the power is, the smaller the asymmetry in the height of the shoulder blades (UL-) and the waist triangles are (TT-). The greater the agility and general fitness is, the smaller the asymmetry of the shoulders (KLB +) and shoulder blades' height (UL-) is and of the waist triangle height is (TT-), Tab. 9.

Tab. 8.Correlations between physical fitness and the difference in the values of the posture features in the frontal plane between 1st and 2nd measurement with an oblique load on the left shoulder and at the right hip among girls

Variables	The difference between 1st and 2nd measurement					
	WY	SZ	SI	MO	ZW	OG
KLB-	0,00	0,60	0,32	-0,11	0,10	0,10
KLB+	0,54	0,70	0,88**	-0,57	0,84*	0,82*
UL-	0,50	-0,30	0,63	0,89*	0,70	0,70
UL+	0,63	0,52	0,30	-0,09	0,09	0,36
OL+	0,50	0,30	0,95*	0,78	0,80	0,80
TT+	0,50	0,97**	0,74	-0,17	0,63	0,79*
TS-	-0,30	0,50	-0,63	-0,89*	-0,60	-0,60
TS+	-0,63	-0,05	0,17	-0,51	0,20	-0,07
KNM+	0,30	-0,40	0,58	0,67	0,50	0,50
UK-	0,40	0,20	0,32	0,11	0,30	0,30

Source: own research
The legend: WY – endurance, SZ – speed, SI – strength, MO – power, ZW – agility, OG – General physical fitness

Tab. 9.Correlations between physical fitness and the difference in the values of the posture features in the frontal plane between 1st and 2nd measurement with an oblique load on the right shoulder and at the left hip among girls

Variables	The difference between 1st and 2nd measurement					
	WY	SZ	SI	MO	ZW	OG
KNT-	-0,34	0,40	0,35	-0,69	0,41	0,13
KNT+	0,00	0,90*	-0,05	-0,45	-0,10	-0,10
KLB-	0,30	-0,60	-0,16	0,22	0,10	0,10
KLB+	-0,45	-0,56	-0,95**	0,31	-0,98**	-0,89**
UL-	-0,70	-0,50	-0,95*	-0,78	-0,90*	-0,90*
TT-	-0,70	-0,10	-0,95*	-0,89*	-0,90*	-0,90*
TS+	-0,19	0,34	0,44	-0,89**	0,39	0,20

Source: own research
The legend: WY – endurance, SZ – speed, SI – strength, MO – power, ZW – agility, OG – General physical fitness

DISCUSSION

Romanowska [12] and Mrozkowiak [14] tried to describe the changes under the influence of the load of the student's body posture with an external load in a smaller group of young people. The authors in their investigations came to similar conclusions. They concluded that the influence of the six-kilogram symmetrical load on the shoulder girdle of 12-year-old girls showed insignificant changes in the values of selected posture features. They also showed a full restitution of the values of the diagnosed features two minutes after the load removal. The return, whereby to the output values after the first minute was more intense. Mrozkowiak also concluded that symmetrically distributed load has a little effect on the spine-pelvic syndrome in the frontal plane, including the right-hand scoliosis at the Th_3 level. According to Sowa et al., the mechanism of the degenerative changes development during everyday activities is a complex process. Cyclic load tests with an additional jointed element simulated the degenerative changes for the motor segment without articular processes [27].Research by Lewis [28], Chansirinukor [29] and Sheir-Neiss [30] has shown that excessive backpacking loads cause pain and deformations of the spine in children. McKenzie et al. [31] and Chow et al. [32] found pain associated with carrying a backpack, referred to as the "backpack syndrome". This syndrome includes the following factors: abnormal body posture causing headaches, fatigue, pain in the cervical and lumbar spine, and increased tone of the neck, shoulders, and back. The research of Neuman et al. [33] and Cook et al. [34] showed that the consequence of carrying a hand luggage asymmetrically may cause conditions in the hip joints and the spine area. Wu's research [35] showed that asymmetrically carried load causes changes in the body posture. Therefore, in order to reduce multiple negative changes system, the centre of gravity of its mass should be as close to the centre of the body as possible. The research of Hardi et al. [36] showed that changing the way of carrying the load from symmetrical to asymmetrical has the greatest impact on the quadrilateral muscles, and the least on the latissimus dorsi muscle. Obrebska et al. reached similar conclusions [37]. Grimmer [38] found a very high activity of quadrilateral muscles during the asymmetric bag carrying on the shoulder, which may result from the necessity to lift the shoulder girdle. Therefore, it may suggest that these muscles tend to lift the shoulder girdle to counteract the excessive load caused by a hand luggage. This, in turn, could have resulted in an asymmetric course of the spinous processes' line of the spine leading to an attempt to shift the centre of gravity over the fulcrum during the walking cycle.

Mrozkowiak [39], in his research on the effects of the school item load in the left or right hand drag mode of the body posture in the frontal plane of a 7-year-old student, showed that the generated load induces significant changes in the values of selected body posture features of girls and boys. He believes that the greater the weight of the container is, the greater the changes will become when the carrying time is longer and the intensity of physical exertion increases. Therefore, this way of carrying school items by the 1st grade students should not be recommended. He also showed that the level of the general physical fitness has a differential relationship with the values of changes in the body posture. This relationship is more common among boys than among girls and only with the right hand drag. Considering individual abilities among boys, speed, power, endurance and agility show associations with significant differences in the values of posture features and among girls there is strength additionally. Mrozkowiak [40] made a different analysis of the same results in order to answer the question, which of the ways of carrying disturbs the child's habitual posture less. It turned out that it was simultaneously significantly and negatively disturbed by carrying in the right and left-hand drag mode. The author believes that it may cause mistakes and consequently defects in the body posture in the longer perspective. Therefore, neither of these should be recommended. The author also has found that the general physical fitness has a greater positive significance in disorders of biomechanical statics of the body posture among boys than among girls. The relationships of their individual features are similar in both ways of carrying among boys, but the greater relationships occur in the case of right-hand drag mode among girls. The most significant motor skills among boys are endurance and strength, whereas among girls there are speed and power. The restitution value of any of the analyzed features of the body posture was incomplete after 1 and 2 minutes after ceasing the right or left hand carrying. This proves insufficient physical fitness, its laterality and slower restitution. The author's survey among parents of 7-year-old preschoolers shows that the guardians most often declare awareness of their children's health. They believe that a first grader will carry a four-kilogram schoolbag on their back, learn at school (not online) and spend about 2 hours improving their physical fitness. According to the author, the accepted lifestyle is not good for the development of the physical fitness and the prevention of static posture disorders [25].

The statistical analysis of the values of the measurements of selected posture features clearly shows that the way of carrying obliquely on the left or right shoulder and at the heteronymous hip should not be practiced by 7-year-old children because it significantly disturbs their habitual steadiness in the frontal plane. It should be assumed that the longer and more intensive the analyzed way of carrying is and the greater the mass of utensils is, the more significant the adaptive changes will become. The age of the surveyed students is also important. The student's environment will influence the ongoing body posture development in accordance with the Arndt-Schultz law. The children's physical fitness and the relationship between its individual elements and the differences in the values of the posture features have different meanings. It is greater among boys in both modes of carrying, and very small among girls. Changes influenced by the accepted load in almost all values of posture features are significant both among boys and girls, and the relationships with physical fitness are gender dependent. The most frequent changes among girls relate to strength, speed, power, agility and general fitness, especially with asymmetry of the shoulders where the right shoulder is higher (KLB +) and the left shoulder blade is higher, too (UL-). It relates to all the features of fitness among boys, mainly with the right torso bend angle (KNT +), asymmetry of the height of the shoulder blades where the left one is higher (UL-), the asymmetry of the distance of the lower shoulder blade angle from the spinous process' line, where the left angle is more distant(OL +) , the height of the waist triangles, where the left one is higher (TT +) and the width where the right one is wider (TS-) and the maximum deviation of the spinous process to the left from the optimal course of the spinous processes' line (UK-).

Conclusion

1. The carrying of school items obliquely on the left or right shoulder and at the heteronymous hip can induce significant adaptive changes in the skeletal and muscular system. It should be assumed that the longer the carrying time is, the greater container load and intensity of physical effort is, the greater the changes will arise. The changes are not dependent on gender.
2. The level of the general physical fitness shows a gender-specific relationship with the values of changes in the body posture features. The relationship is greater among boys.
3. School items should not be carried obliquely on the left or right shoulder at the heteronymous hip by 7-year-old children.

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