American Journal of Biomedical Science & Research

www.biomedgrid.com

ISSN: 2642-1747

Research Article

Restitution of the Values of Body Posture Features in the Frontal Plane After Carrying a Schoolbag on the Chest and its Correlations with Physical Fitness Among 7-Year-Old Children

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To Cite This Article: *Mirosław Mrozkowiak*. Restitution of the Values of Body Posture Features in the Frontal Plane After Carrying a Schoolbag on the Chest and its Correlations with Physical Fitness Among 7-Year-Old Children. Am J Biomed Sci & Res. 2023 19(5) AJBSR.MS.ID.002629,*

DOI: 10.34297/AJBSR.2023.19.002629

Received: July 27, 2023; **Published:** August 04, 2023

Summary

Introduction: Restitution of the values of body posture features may reflect to low level of physical fitness in a 7-year-old student. It may also be a signal of a necessary need to change the way of carrying a schoolbag and decreasing its weight.

Material and Method: The body posture tests were carried out in a group of 65 students aged 7 years, using the moiré projection method in 4 positions: 1st-habitual posture, 2nd-posture after a-10-minute of axial symmetrical loading, 3rd-one minute after the load removal, 4th-two minutes after the load removal. Physical fitness was measured with the Sekita test, completed by an endurance test.

Results: The significance of differences between 1st and 3rd, 1st and 4th, 2nd and 3rd as well as 3rd and 4th measurement were analysed to determine the restitution of the features values after loading and their correlation with physical fitness.

Conclusions:

a) After the load removal of carrying school supplies from the chest, there was an incomplete and sex-independent restitution of all values of the diagnosed posture features in the frontal plane after the first and second minute.

b) The relationships between the examined determinants of physical fitness and the restitution of the values of posture features are much more frequent among boys than girls. The most frequent correlation was between agility, overall fitness and endurance among boys, whereby agility and overall fitness appeared among girls.

c) There should be actions taken to promote a healthy lifestyle for children, including physical education.

Keywords: Children's health, Moiré topography, Physical fitness, Postural asymmetry factor

Introduction

The Chief Sanitary Inspectorate, in a letter of October 13th, 2009, ref. GIS-HŚ-HK-078-125/KŁ/09 in consultation with the Ombudsman for Children, on October 15th, 2009, recommended weighing backpacks in schools all over Poland. This was related to the numerous and disturbing signals from parents to the Ombudsman for Children and the Chief Sanitary Inspectorate. In the Warmian-Masurian voivodship, the research covered 221 grades, including: 55 first grades, 57 second grades, 53 third and 56 sixth grades. A total of 3,873 backpacks were weighed, 1,973 of which belonged to boys and 1,900 belonged to girls. Preliminary analysis of the research results showed that the first-grade students had an average body weight of 27kg and were wearing backpacks with an average weight of 2.42kg, whereas schoolgirls: 25.5kg and 2.1kg, respectively. Second grade male students: 30kg and 2.8kg, and female students: 30.2kg and 3.1kg. The male third grader had an average body weight of 34.5kg, and his schoolbag was about 3.3kg, the female third grader had 34kg and 3kg, respectively. Boys attending the sixth grades had an average body weight of about 47kg and wore backpacks weighing 4.7kg, while sixth graders girls were 47kg and 4.65kg, respectively. Considering the preliminary assumptions about the permissible 10% ratio of the weight of the backpack to the weight of the student, the statistical average shows that only girls attending the second grades in the Warmian-Masurian Voivodeship have overloaded backpacks. However, a detailed analysis of all 221 questionnaires carried out by the Department of Child and Youth Hygiene of the Provincial Sanitary and Epidemiological Station in Olsztyn showed that the averaged data did not reflect the actual load of schoolbags on students. 2201 weighed backpacks, out of 3,873 had a weight greater than 10% of the students' body weight. In the Warmian-Masurian voivodship it constitutes 56.8% of all weighed backpacks [1]. Studies by *Śmigiel, et al.,* [2] in a group of 76 children showed that the average weight of a backpack was 5kg, which indicates that the lockers did not fulfill the basic function they were intended for. The authors believe that this is one of the reasons for the identified misalignment of the shoulders in the sagittal plane in 41%, and in the frontal plane in 54% of the examined children. The research by *Deng* [3] and *Zhang* [4] showed a significant relationship between pain in the neck and back and the occurrence of posture defects due to the excessive weight of the backpack. Neck and back pain occurred at a frequency of 41.1% and 32.8%, respectively. A study conducted by the County Sanitary Inspectorate in Nakło at the river Noteć in a group of 471 children showed that 159 students have a locker at school, and more than half of them (61%) declared that their schoolbag is heavy. The research also shows that the backpacks overloading in the urban population was observed in 75%, in rural-in 24% of students, with the average weight of a schoolbag ranging between 2.5-4.5kg [5]. A study by *Aggarwal, et al.,* [6] in a group of 87 children aged 9 to 13 showed a significant relationship between the head protrusion and the cervical pain syndrome with the weight of a worn backpack. *Bejia, et al.* [7] proved that all sagittal and frontal asymmetries of body posture are a consequence of wearing a backpack and the desks not well adapted to the height of children and not enough physical activity aimed at shaping the correct body posture. The authors believe that too low chairs may lead to the keeping the head forward the shoulders put forward, and to sitting a position in the frontal plane . The results of the research by *Mrozkowiak and Żukrowska* [8] proved that in the correction process of disturbances in body statics, Good Chair plays an important and complementary role in relation to the physical efforts during body posture correction classes. This is a type of orthosis fulfilling the tasks of supporting orthopedic equipment in the prophylaxis of children aged 7 to 10. The author's interest in the issues stems from the persistently high percentage of disorders of the body posture of students from the oldest preschool group and 1st-3rd grades of primary school [3], the constantly proclaimed opinion about the negative impact of the way of carrying school supplies on body postures, and the lack of clear recommendations about the optimal weight and contraindications against the negative way of carrying these utensils. The general objective of the implemented research programme is an attempt to determine the impact of weight of carried school supplies in the following way: obliquely on the right shoulder or left shoulder and at the heteronymous hip, on the left or right shoulder, on the back, on the chest, on the back and chest, pulled with the left or right hand.

The aim of the study was to demonstrate the restitution of the values of selected posture features in the frontal plane after removing the weight of school supplies carried on the chest and its relationship with physical fitness.

Research Material

The study involved children from randomly selected kindergartens in the West Pomeranian and Greater Poland voivodeships. Body posture defects and disturbances were not criterions that excluded participation in the research programme. The division of the respondents into those from rural and urban environments was abandoned since this feature would never determine the homogeneity of the group and the cultural and economic blurring boundary of both environments. The respondent was qualified to the programme according to the following scheme: if the respondent was 6 years, 6 months and 1 day old and under 7 years, he was included in the 7-year-old age group. This allowed to use the previously developed normative ranges appropriate for this age and sex category, diagnosing the quality of the body posture from the test day [9].

In total, 65 students participated in the programme, of which 53.84% (35 people) were girls and 46.15% boys (30 people).

Research Method

Before the measurements started, the children were instructed in order to avoid the stress associated with the research procedure and the people responsible for it. A preschool teacher's assistant of the study group was always present during the research, which was to ensure the emotional stability of the children. Measurements were carried out in accordance with the developed procedure, always with the same tools, under the same conditions and by the same people. The children were also encouraged to keep the anthropometric points marked with a marker on the skin, which was to effectively eliminate deviations in their repeated indication. The research was carried out by a physiotherapist with a 20-year-old experience in the diagnosis of body posture using the moiré projection method.

Overall Physical Fitness

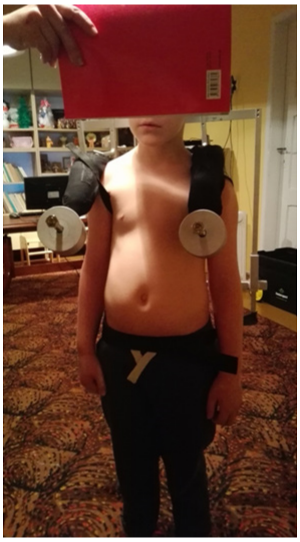
The Wroclaw Physical Fitness Test for 3-7-year-old children was used to diagnose physical fitness [10]. According to the author, the test is of a high degree of reliability and is adequate in terms of discriminatory ability and degree of difficulty [11]. The proposed test, which significantly increased the motivation to exercise in the presence of parents, consists of four tests implemented as a part of the Sports Day: agility (pendulous run over 4x5m with carrying blocks), power (standing long jump), speed (running at 25m), and force (a 1kg ball both-hands-throw from the head). The author modified the test by a fifth attempt-endurance. Starting position-high starting stance. Movement-run over 300m. The running time from the start to finish was assessed and converted into points depending on the result and gender. If the child did not finish the race, they got a score of "0". The run took place on a recreational path with a hardened surface, remaining all safety rules [12]. Visualization [13].

Body Posture

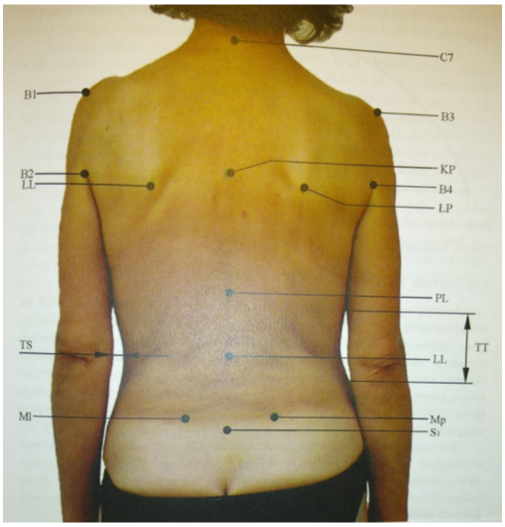
The applied method using the projection moiré phenomenon determines the value of several dozen features describing the body posture. It makes it possible to determine the influence of various methods of carrying a bag with school supplies on body posture, restitution of the value of features after removing the load, and the importance of physical fitness in disorders and restitution of the value of the diagnosed features [14,15].

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 adopted 10-minute load time was the average time to walk from the place of residence given in the questionnaire completed by the parents [16]. However, the load was determined by averaging the weight of school supplies to 4kg carried by first-class children from a randomly selected primary school. Selected features of body posture were measured in 4 positions. The first position-habitual position, Picture 1. Second position-posture after 10minutes of asymmetric loading on the back (in the last 5 seconds), Picture 2. Third position-posture one minute after the load removal, Picture 1. Fourth position-posture two minutes after the load removal, Picture 1. The load was supposed to imitate the way of carrying school supplies. The subject could move freely. This was in line with the previous results of Mrozkowiak's research, which showed that after this time, the values of posture features could be at the starting point [17]. It could be assumed that it was an appropriate and relatively constant for each student when diagnosing the habitual posture on the first day of the research programme. 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 stage of the measurements may affect the final test result. Therefore, before pulling the load up destined 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 the children as well as the weight of the carried school supplies were measured with a medical balance before the first day of the tests (Pictures 1,2).

Picture 1: Position 1st, 3rd and 4th: Habitual posture.



Picture 2: Position 2nd: posture with asymmetrical axial loading on the chest.



Picture 3: Location and markings of the torso points in the frontal plane.

The measurement site for the value of selected features of the body posture 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 of the subject and the camera were oriented spatially in accordance with the levels on the camera and in relation to the line of the child's toes. It is possible to obtain a spatial image thanks to the projection of lines on the child's back with strictly defined parameters, which falling on the body are distorted depending on the configuration of its surface. Thanks to the use of the lens, the image of the examined person is 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 multi-layered interpretation of the body posture. It is possible to determine the size of the angular and linear features describing the pelvis and physiological curvatures in the sagittal and transversal planes apart from the assessment of the torso asymmetry in the sagittal and transversal plane [18].

The following test procedure was developed in order to minimize the risk of making mistakes in the measurements of selected posture features [9]:

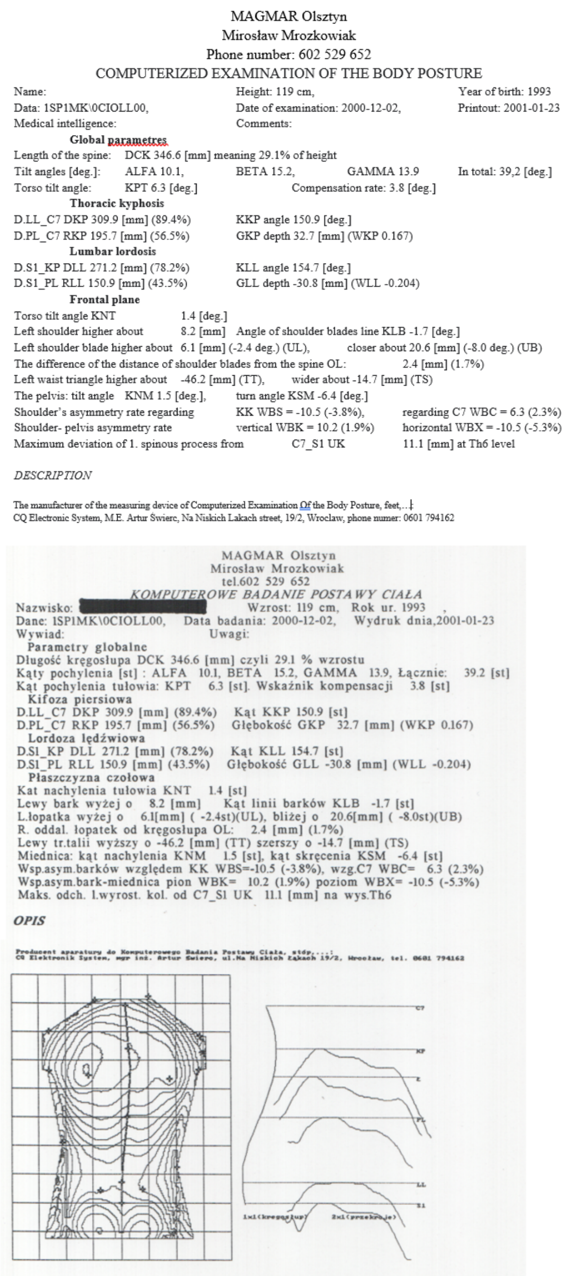
a) Habitual posture of the subject against the background of a white, lightly illuminated sheet: free, unforced posture, with feet slightly apart, knee and hip joints in extension, arms hanging along the body and eyes looking straight ahead, with the back to the camera at 2.5meters, toes at a perpendicular line to the camera axis.

b) Marking points on the back skin of the examined: the top of the spinous process of the last cervical vertebra (C7), the spinous process being the top of the thoracic kyphosis (KP), the spinous process being the top of the lumbar lordosis (LL), the transition place from thoracic kyphosis to lumbar lordosis (PL), the lower angles of the scapulae (Łl and Łp), the posterior upper iliac spines (Ml and Mp), and the S1 vertebra. A white necklace was put on the subject's neck to clearly mark the B1 and B3 points, Picture 3. Long hair up to reveal C7 point (Picture 3).

c) 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 after entering the necessary data about the examined person (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, gait, etc.).

d) Processing of the recorded images takes place without the participation of the subject.

e) The value of the features describing the body posture spatially are printed after saving the mathematical characteristics of the photos in the computer memory (Figure 1).



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 of 1. 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

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

Subject of Research

The Wrocław fitness test allowed to measure the strength, power, speed and agility of preschool children. The author modified Sekita's test for a test of endurance. Definitions of the tested physical and complex motor skills are generally available in the literature [11].

The applied method, which uses the phenomenon of the projection moiré, defines several dozen features describing the body posture. For statistical analysis, 16 angular and linear features of the spine, pelvis and torso in the frontal plane as well as body weight and height were selected. It was guided by the need of the most reliable and spatially complete look at the child's body posture, which allowed to fully identify the measured discriminants (Table 1).

Table 1: List of registered morphological and torso features.

No	Symbol	Parametres		
		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 C7-S1 line from the vertical to the left
2	KNT	degrees		It is determined by the deviation of the C7-S1 line from the vertical to the right
3	KLB	degrees	The angle of shoulders line, right one higher	The angle between a vertical line and a straight line through the B2 i B4 points
4	KLB –	degrees	The angle of shoulders line, left one higher	PLBW=LBW-PBW
5	UL	degrees	The angle of shoulder blades line, right one higher	The angle between a horizontal line and a straight line through the Ł1 a Łp points
6	UL -	degrees	The angle of shoulder blades line, left one higher	
7	OL	mm	Lower angle of the left shoulder blade more distant	The difference of the distance of the lower angles of the shoulder blades from the line of the spinous processes of the spine, measured horizontally on the straight lines passing through the points Łl and Łp
8	OL -	mm	Lower angle of the right shoulder blade more distant	
9	TT	mm	Left waist triangle higher	The difference of the distance, measured vertically between the T1 and T2 and T3 and T4 points
10	TT –	mm	Right waist traingle higher	PLTT = LTT – PTT
11	TS	mm	Left waist triangle wider	The difference of the distance, measured horizontally between the straight lines passing through the T1 and T2 and T3 and T4 points
12	TS -	mm	Right waist triangle wider	
13	KNM	degrees	The angle of pelvis tilt, right ilium higher	The angle between the horizontal line and the straight line passing through the M1 and Mp points
14	KNM -	degrees	The angle of pelvis tilt, left ilium higher	
15	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 along the horizontal axis.
16	UK -	mm	The maximum deviation of the spinous process of the vertebra to the left.	
MORPHOLOGICAL FEATURES				
17	Mc	kg	Body weight	The body height and weight was measured with electrical medical balance.
18	Wc	cm	Body height	

***Source:** Own research.

Research Questions and Hypotheses

The following research questions arise from the aim of the research:

1. Will the child unweighting in the adopted way of carrying the schoolbag significantly affecting the statics of body posture in the frontal plane, cause a sex-dependent restitution of the values of the features?

2. Will physical fitness show significant and sex-dependent relationships with the values of restitution of posture features after the first and second minute after the load removal?

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

1. The adopted way of carrying the school supplies, significantly affecting the statics of body posture in the frontal plane, will cause incomplete and gender-independent restitution of the values of the examined features.

2. Physical fitness will show significant and gender-dependent relationships with the restitution of the values of the posture features after the first and second minute after the load removal.

Statistical Methods

It was assumed that the standard deviation is a measure of differentiation. The higher it is in relation to the mean, the greater the variation of results is in each group. There was no reference to it in the description of the results, but in analytical practice its application was treated as a concomitant measure of 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 was a concomitant measure of M. It was also assumed that the value of SD in the performed studies was not interpreted in any way, especially if the analysis was based on non-parametric tests and median (Me), but not the mean (M). Therefore, SD and M were finally removed in the initial analyzes to concentrate the tables and leave there only necessary issues for the research. Standard deviation is a concomitant measure of the arithmetic mean and therefore it is not valid to put it next to the median.

The analysis of the study results was performed using the IBM SPSS Statistics 26 programme. At the initial stage, the Shapiro-Wilk and Kołmogorow-Smirnow tests were used to ensure if the distributions of the analyzed variables were consistent with the normal distribution. For most 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 non-parametric coefficients in the statistical analysis. The Wilcoxon rank test was used to determine whether there was a statistically significant difference (change) between two measurements (in the same group) of the quotient variable whose distribution was significantly different from the normal one. The following symbols were used in the tables: M-Arithmetic Mean, Me-Median, SD-Standard Deviation, Z-Wilcoxon test statistic, "p"-significance of the Wilcoxon test. The level of significance was set at $p<0.05$, marked as *, and additionally, the significance level $p<0.01$, marked as **. Thus, if $p<0.05$ or $p<0.01$, then the difference between the measurements was statistically significant. The Spearman's rho correlation coefficient was used to determine whether there were statistically significant correlations between the variables measured at the quotient level, which distribution significantly differed 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 **. Thus, if $p<0.05$ or $p<0.01$, then the correlation between the variables was statistically significant. If the correlation was statistically significant at the level of $p<0.05$, then the correlation coefficient rho should be interpreted. It could take values from -1 to +1. The more distant it was from 0, and the closer it was to -1 or +1, so the correlation was stronger. Negative values meant that as the value of one variable increased, the value of the other variable decreased. On the other hand, positive values indicated that as the value of one variable increased, the value of the other variable increased, too. In the individual tables of correlation, only the variables were considered (in the rows), which at least one statistically significant result was recorded for.

Individual values of posture features are expressed in different sizes and ranges, so it is not possible to calculate the average difference for all these variables between the two measurements. An analysis performed in such a way would distort the results and make the variables, in which the quantities are higher of greater importance, and the variables, in which the quantities were lower of less importance. Therefore, the correlation between the averaged difference in the value of features between the measurements and physical fitness was made separately for girls and boys, using absolute values, i.e., the calculations did not use exact numerical values concerning the differences, but the ratio of the difference to the initial value. This approach makes the variables not to be overrepresented or underrepresented in the average result.

The analysis included a comparison of the value of posture features between 1st and 3rd, 1st and 4th, 2nd and 3rd and 3rd and 4th with the measurement of the school bag carried on the back. This was to show the restitution (full or incomplete) of changes in the analyzed posture features in the adopted way of carrying school supplies. To concentrate the results of the analysis as much as possible, the tables include only the medians, and the significance of the Wilcoxon test results.

The analysis of the correlation between the results of physical fitness tests and the difference between 2nd and 3rd, 3rd and 4th, 1st and 3rd and 1st and 4th measurements separately for boys and girls was also performed. Only those individuals, who had both physical fitness tests and appropriate body posture measurements were considered. To concentrate the results of the analysis as much as possible, only the correlation coefficients (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 rows), which at least one statistically significant result was recorded for.

Obtained Results

In total, the research carried out in a group of 65 people of both sexes aged 7 years allowed to register 4,615 values of features describing body posture in habitual posture and dynamic positions, body weight and height, and physical fitness.

Average body weight (MC) was as follows: among girls 24.46kg, body height (Wc) 123.87, and among boys: 24.56kg and 123cm, respectively. All children had a slender body type according to the Rohrer Weight and Growth Index [19]. Information was also obtained through a survey conducted among 65 parents of children reported to the research project [16].

The analysis of the results of the applied Wrocław fitness test and the endurance diagnostic trial showed that the tested group of children represented a sufficient level of physical fitness, assuming grading: insufficient, sufficient, good, very good. This level was significantly lower than the values obtained in the measurements of other authors from 2006, 1996, 1972 and 1967 [20-22] The phenomenon of sexual dimorphism in the studied group of 7-year-olds of both sexes was not confirmed.

When analyzing the obtained results of measurements in carrying a schoolbag on the chest by boys and girls, the Wilcoxon rank test showed a statistically significant difference between 3rd and 1st, 4th and 1st, 2nd and 3rd and 4th measurements in terms of all analyzed variables (Tables 2,3).

Table 2: Restitution of the values of body posture features in the frontal plane between 1st and 3rd, 1st and 4th, 2nd and 3rd and 3rd and 4th measurement after carrying the schoolbag on the chest among boys.

No.	Variables	Measurement				Wilcoxon's Test			
		1	2	3	4				
		Me	Me	Me	Me	1/3 p	1/4 p	2/3 p	3/4 p
1	KNT-	1,40	4,05	3,10	2,10	<0,001**	0,001**	<0,001**	<0,001**
2	KNT	2,35	4,85	3,60	3,00	0,012*	0,012*	0,012*	0,018*
3	KLB-	1,90	5,25	4,15	2,75	0,012*	0,012*	0,011*	0,012*
4	KLB	1,05	4,80	3,60	2,20	<0,001**	<0,001**	0,001**	<0,001**
5	UL-	4,15	6,30	5,10	4,70	0,012*	0,012*	0,012*	0,012*
6	UL	1,95	5,40	4,30	2,75	<0,001**	0,001**	<0,001**	<0,001**
7	OL-	8,10	10,90	9,40	8,70	<0,001**	<0,001**	<0,001**	<0,001**
8	OL	4,30	7,75	5,85	4,45	0,012*	0,012*	0,012*	0,012*
9	TT-	4,80	13,55	10,20	6,40	0,012*	0,012*	0,012*	0,012*
10	TT	8,30	14,45	11,95	9,95	<0,001**	<0,001**	<0,001**	<0,001**
11	TS-	5,10	13,55	9,55	6,65	0,012*	0,012*	0,012*	0,012*
12	TS	8,35	15,35	11,60	9,10	<0,001**	<0,001**	<0,001**	<0,001**
13	KNM-	7,50	10,50	8,60	7,90	<0,001**	<0,001**	<0,001**	<0,001**
14	KNM	3,40	9,80	6,80	4,30	0,008**	0,008**	0,008**	0,008**
15	UK-	1,50	5,50	4,65	2,90	0,012*	0,012*	0,012*	0,012*
16	UK	6,95	10,95	9,15	7,85	<0,001**	<0,001**	<0,001**	<0,001**

*Source: Own research.

Table 3: Restitution of the values of body posture features in the frontal plane between 1st and 3rd, 1st and 4th, 2nd and 3rd and 3rd and 4th measurement after carrying the schoolbag on the chest among girls.

No.	Variables	Measurement				Wilcoxon's Test			
		1	2	3	4				
		Me	Me	Me	Me	1/3 p	1/4 p	2/3 p	3/4 p
1	KNT-	0,40	4,60	3,40	2,80	0,001**	0,001**	0,001**	0,001**
2	KNT	0,80	4,70	3,40	2,50	<0,001**	<0,001**	<0,001**	<0,001**
3	KLB-	1,40	5,10	3,60	2,40	<0,001**	<0,001**	<0,001**	<0,001**

4	KLB	1,50	5,10	4,10	3,10	0,001**	0,001**	0,001**	0,001**
5	UL-	2,80	5,90	4,80	3,60	<0,001**	<0,001**	<0,001**	<0,001**
6	UL	3,20	5,40	4,50	3,60	0,001**	0,001**	0,001**	0,001**
7	OL-	7,60	12,70	10,30	8,40	0,001**	0,001**	0,001**	0,001**
8	OL	4,30	8,20	6,70	5,60	<0,001**	<0,001**	<0,001**	<0,001**
9	TT-	4,70	12,10	9,90	6,50	<0,001**	<0,001**	<0,001**	<0,001**
10	TT	4,80	13,20	11,20	7,10	0,001**	0,001**	0,001**	0,001**
11	TS-	4,90	13,80	10,20	6,90	<0,001**	<0,001**	<0,001**	<0,001**
12	TS	5,10	13,80	9,80	6,90	0,001**	0,001**	0,001**	0,001**
13	KNM-	2,70	11,30	8,70	3,80	0,001**	0,001**	0,001**	0,001**
14	KNM	2,90	9,80	6,50	4,20	<0,001**	<0,001**	<0,001**	<0,001**
15	UK-	3,60	6,90	5,30	4,10	<0,001**	<0,001**	<0,001**	<0,001**
16	UK	3,70	6,90	6,10	4,60	0,001**	0,001**	0,001**	0,001**

*Source: Own research.

Observing the relationship between physical fitness features and the differences in the values of body posture features between the 2nd and 3rd measurement among boys, it turned out that the greater the endurance, the smaller the asymmetries of shoulder height, where the left one is higher (KLB-) and the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the right (OL-) or left (OL+) angle is more distant, the width of the waist triangles where the right one is wider (TS-), and greater asymmetries in the verticality of the torso bend to the right (KNT+) and the asymmetrical course of line of the spinous processes leaning to the left (UK-). The greater the speed, the smaller the asymmetries in the verticality of the torso bend to the right (KNT+) and the course of the line of the spinous process leaning to the left (UK-), and greater the asymmetry of the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the spinous process line where the left angle is more distant (OL+) and the width of the waist triangles where the right one is wider (TS-). The greater the stength, the smaller the asymmetries in the height of the shoulder blades where the left one is higher (UL-), the shoulders where the left one is higher (KLB-), the distance between the shoulder blades and the spinous process line, where the left angle is more distant (OL+), the width of the waist triangles , where the right one is wider (TS-) and the pelvis tilt to the right (KNM-), but greater asymmetries in the verticality of the torso bend to the right (KNT+), the pelvis tilt to the left (KNM+) and the course of the spinous process line leaning to the left (UK-). The greater the force, the smaller the asymmetries in the height of the shoulders where the left one is higher (KLB-), the height of the shoulder blades where the left one is higher (UL-), the distance between the shoulder blades and the spinous process line where the left angle is more distant (OL+) and the width of the waist triangles, where the right one is wider (TS-), but greater asymmetries of the verticality of the torso bend to the right (KNT+) and the course of the spinous process leaning to the left (UK-). The greater the agility, the smaller the asymmetries in shoulders height where the left one is higher (KLB-), in the height of the shoulder blades where the left one is higher (UL-), the distance between the shoulder blades and the spinous process line where the left angle is more distant (OL+) and the width of the waist triangles, where the right (TS-) or left one is wider (TS+), but greater asymmetries in the verticality of the torso bend to the right (KNT+), and pelvis tilt to the left (KNM+), and the spinous process line leaning to the left (UK-). The greater the overall fitness, the smaller the asymmetries in shoulders height, where the left one is higher (KLB-), the height of the shoulder blades, where the left one is higher (UL-), the distance between the angles of the lower shoulder blades and the spinous process line, where the left angle is more distant (OL+) and the width of the waist triangles, where the left one is wider (TS+), but greater changes in the total length of the spine (DCK), greater asymmetries in the verticality of the torso bend to the right (KNT+), the pelvis tilt to the left (KNM+) and the course of the spinous processes line leaning to the left (UK-) (Table 4).

Table 4: Correlations between physical fitness and restitution between 2nd and 3rd as well as 3rd and 4th measurement of the values of body posture features in the frontal plane after loading the chest among boys.

No.	Variables	Difference between 2nd and 3rd Measurement						Difference between 3rd and 4th Measurement					
		WY	SZ	SI	MO	ZW	OG	WY	SZ	SI	MO	ZW	OG
1	KNT	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
2	KLB-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
3	KLB	0,10	0,03	-0,24	0,07	-0,49	-0,25	-0,06	0,15	0,61*	-0,03	0,49	0,45
4	UL-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
5	OL-	-0,54	-0,30	-0,32	-0,22	0,06	-0,30	0,55	0,19	0,15	0,11	-0,11	0,19
6	OL	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
7	TT-	-1,00**	1,00**	1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
8	TS-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
9	TS	-0,20	-0,20	-0,45	0,08	-0,66*	-0,57*	-0,18	-0,03	0,51	0,05	0,41	0,39
10	KNM-	-0,09	-0,31	-0,58*	-0,45	-0,20	-0,54	0,46	0,52	0,65*	0,21	0,38	0,62*
11	KNM	0,50	0,00	1,00**	0,00	1,00**	1,00**	-0,50	0,87	0,50	-0,87	0,50	0,50
12	UK-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**

***Source:** Own research.

By analyzing the differences between the 3rd and 4th measurements, it turned out that the greater the endurance, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height, where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but greater asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance between the shoulder blades and the line of the spinous processes, where the left angle is more distant (OL+) and height of the waist triangles where the right one is higher (TT-). The greater the speed, the smaller the differences in the total length of the spine (DCK), the asymmetries in the height of the shoulder blades where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes where the left angle is more distant (OL+) and the height of the waist triangles, where the right one is higher (TT-), but the greater asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height, where the left one is higher (KLB-), the width of the waist triangles, where the right one is wider (TS-) and the course of the course of the spinous processes line leaning to the left (UK-). The greater the strength, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but the greater asymmetries in the height of the shoulder blades where the left one is higher (UL-), the distance between the shoulder blades and the spinous process line where the left angle is more distant (OL+) and the height of the waist triangles where the right one is higher (TT-) and pelvic tilt to the right (KNM-). The greater the force, the smaller the vertical asymmetries of the torso bend to the right (KNT\+), shoulders height where the left one is higher (KLB-), the height of the shoulder blades where the left one is higher (UL-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but greater asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+) and the height of the waist triangles, where the right one is higher (TT-).

The greater the agility, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but greater asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), and the height of the waist triangles where the right one is higher (TT-). The greater the overall fitness, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning in left (UK-), but greater asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+) and the height of the waist triangles where the right one is higher (TT-), Table 4. Considering the differences between the 1st and 3rd measurement, it turned out that the greater the endurance, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-)

and the course of the spinous process line leaning to the left (UK-), but the greater heights of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+) and the height of the waist triangles, where the right one is higher (TT-). The greater the speed, the smaller the asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+) and the height of the waist triangles where the right one is higher (TT-), and greater verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous processes leaning to the left (UK-). The greater the strength, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but greater heights of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles where the right one is higher (TT-) and the width, where the left one is wider (TS+) and the pelvis tilt to the left (KNM-).

The greater the force, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but greater asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), and the height of the waist triangles where the right one is higher (TT-). The greater the agility, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height where the left one is higher (KLB-), the width of the waist triangles where the right one is wider (TS-) and the course of the spinous process line leaning to the left (UK-), but greater heights of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is most distant (OL+), the height of the waist triangles where the right one is higher (TT-) and the width, where the left one is wider (TS+). The greater the overall fitness, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulders height, where the left one is higher (KLB-), the width of the waist triangles, where the right one is wider (TS-) and the course of the spinous processes line leaning to the left (UK-), but greater heights of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles, where the right one is higher (TT-) and the width, where the left one is wider (TS+) (Table 5).

Table 5: Correlations between physical fitness and restitution between 1st and 3rd as well as 1st and 4th measurement of the values of body posture features in carrying on the chest among boys.

No.	Variables	Difference between 1st and 3rd Measurement						Difference between 1st and 4th Measurement					
		WY	SZ	SI	MO	ZW	OG	WY	SZ	SI	MO	ZW	OG
1	KNT	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
2	KLB-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**
3	UL-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
4	OL-	0,78**	0,53	0,16	-0,16	0,08	0,27	0,58*	0,45	-0,22	-0,43	0,07	-0,05
5	OL	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
6	TT-	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
7	TT	0,42	0,37	0,10	-0,51	0,20	0,18	0,71**	0,49	0,05	-0,41	0,16	0,23
8	TS-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	1,00**	1,00**	1,00**	1,00**
9	TS	-0,01	0,16	0,75**	0,06	0,72**	0,68*	0,17	0,28	0,77**	0,16	0,80**	0,80**
10	KNM-	-0,22	-0,17	0,61*	0,63*	0,25	0,49	-0,49	-0,53	-0,05	0,42	-0,30	-0,14
11	KNM	-0,50	0,87	0,50	-0,87	0,50	0,50	-0,87	1,00**	0,00	-1,00**	0,00	0,00
12	UK-	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**	-1,00**	1,00**	-1,00**	-1,00**	-1,00**	-1,00**

***Source:** Own research.

Considering the differences between the 1st and the 4th measurement, it turned out that the greater the endurance, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), the height of the shoulders, where the left one is higher (KLB-) and the course of the spinous processes line leaning to the left (UK -), but greater heights of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles, where the right (TT-) or left one is higher (TT+) and width, where the right one is wider (TS-). The greater the speed, the smaller the asymmetries in the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles, where the right one is higher (TT-) and the width, where the right one is wider (TS-), but greater asymmetries of the verticality of the torso bend to the right (KNT+), shoulder height, where the left is higher (KLB-), a pelvis tilt to the left (KNM+) and the course of the spinous process line leaning to the left (UK-). The greater the strength, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), the height of the shoulders, where the left one is higher (KLB-) and the course of the spinous process line leaning to the left (UK-), but the greater the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles where the right one is higher (TT-) and the width, where the right (TS-) or left (TS+) one is wider. The greater the force, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), shoulder height, where the left one is higher (KLB-), the pelvis tilt to the left (KNM+) and the course of the spinous process line leaning to the left (UK-), but greater heights of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles where the right one is higher (TT-) and the width where the right angle (TT-) is wider (TS-). The greater the agility, the smaller the asymmetries of the verticality of the torso bend to the right (KNT+), the height of the shoulders, where the left one is higher (KLB-) and the course of the spinous process line leaning to the left (UK-), but the greater the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles, where the right one is higher (TT-) and the width, where the right (TS-) or left (TS+) one is wider. The higher the overall fitness, the smaller the vertical asymmetries of the torso bend to the right (KNT+), the height of the shoulders, where the left one is higher (KLB-) and the course of the spinous process line leaning to the left (UK-), but the greater the height of the shoulder blades, where the left one is higher (UL-), the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+), the height of the waist triangles where the right one is higher (TT-) and the width where the right (TS-) or left one is wider (TS+) Table 5.

Observing the relationships between the physical fitness features and the differences in the values of the body posture features between the 2nd and 3rd measurements among girls, it turned out that the greater the endurance, the smaller the asymmetries of the course of the spinous process line leaning to the left (UK-), but the greater the height of the shoulder blades, where the left one is higher (UL-). The greater the speed, the greater the asymmetry of shoulders height, where the left one is higher (KLB-) and the verticality of the torso bend to the left (KPT-). The greater the agility, the smaller the asymmetry of the course of the spinous process lines leaning to the left (UK-), but the greater the height of the shoulder blades, where the left one is higher (UL-). The greater the overall fitness, the smaller the asymmetry of the course of the spinous processes line leaning to the left (UK-), but the greater the height of the shoulder blades, where the left one is higher (UL-). The analysis of the relationship between fitness features and the differences in the values of the body posture features between the 3rd and 4th measurement showed that the greater the strength, the smaller the asymmetry of the pelvic tilt to the left (KSM-). The greater the agility, the smaller the shoulders height asymmetry, where the right one is higher (KLB+), (Table 6).

Table 6: Correlations between physical fitness and restitution between 2nd and 3rd as well as 3rd and 4th measurement of the values of body posture features in the frontal plane after loading the chest among girls.

No.	Variables	Difference between 2nd and 3rd Measurement						Difference between 3rd and 4th Measurement					
		WY	SZ	SI	MO	ZW	OG	WY	SZ	SI	MO	ZW	OG
1	KLB-	0,36	0,97**	0,43	0,00	0,36	0,36	-0,20	-0,40	-0,74	-0,45	-0,50	-0,50
2	KLB	0,54	0,12	0,50	0,52	0,49	0,66	-0,44	-0,50	-0,75	0,19	-0,89**	-0,71
3	UL-	0,95*	0,26	0,81	0,82	0,95*	0,95*	0,41	0,62	0,11	-0,23	0,15	0,15
4	TT	0,59	0,16	0,43	-0,31	0,52	0,39	-0,35	0,01	-0,02	-0,12	-0,26	-0,04
5	KSM-	0,53	-0,16	0,81	0,82	0,74	0,74	-0,95*	-0,47	-0,58	-0,53	-0,79	-0,79
6	UK-	-1,00**	-0,40	-0,74	-0,67	-0,90*	-0,90*	-0,05	0,05	-0,70	-0,63	-0,46	-0,46

***Source:** Own research.

Table 7: Correlations between physical fitness and restitution between 1st and 3rd as well as 1st and 4th measurement of the values of body posture features in carrying on the chest among girls.

No.	Variables	Difference between 1st and 3rd Measurement						Difference between 1st and 4th Measurement					
		WY	SZ	SI	MO	ZW	OG	WY	SZ	SI	MO	ZW	OG
1	KNT-	-0,26	-0,17	-0,55	0,01	-0,62	-0,49	-0,14	-0,57	-0,64	0,82*	-0,60	-0,45

2	KLB	-0,27	0,11	-0,40	-0,12	-0,61	-0,41	0,39	0,84*	0,47	-0,29	0,39	0,47
3	OL	-0,90*	-0,30	-0,53	-0,45	-0,70	-0,70	-0,50	-0,70	-0,11	0,22	-0,20	-0,20
4	TT	0,29	-0,16	-0,25	0,79*	-0,43	-0,04	0,47	-0,04	-0,33	0,93**	-0,38	-0,04
5	UK-	-0,50	-0,30	-0,95*	-0,78	-0,80	-0,80	-0,67	-0,82	-0,46	-0,23	-0,56	-0,56

*Source: Own research.

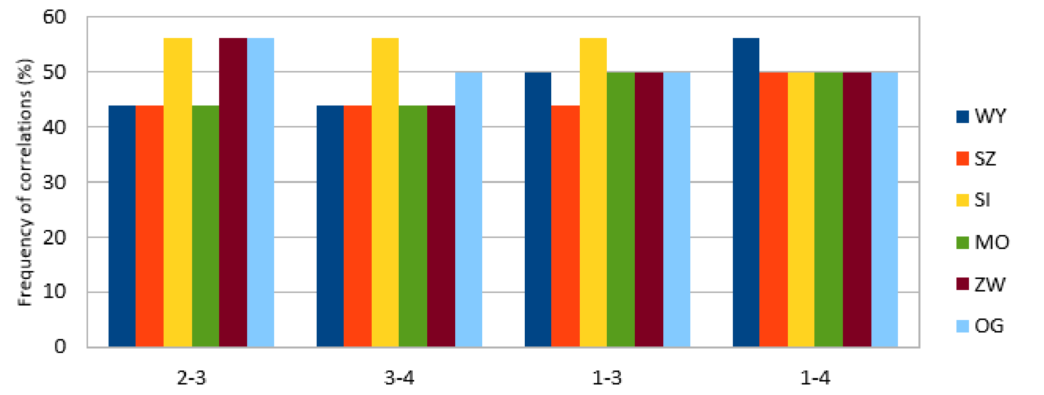
Considering the differences between the 1st and 3rd measurement, it turned out that the greater the endurance, the smaller the asymmetries of the distance of the angles of the lower shoulder blades from the line of the spinous processes, where the left angle is more distant (OL+). The greater the strength, the smaller the asymmetry of the spinous process line leaning to the left (UK-). The greater the force, the greater the asymmetry in the height of the waist triangles where the left one is higher (TT+). Observing the differences between the 1st and the 4th measurement, it turned out that the greater the speed, the greater the shoulders height asymmetry, where the right one is higher (KLB+). The greater the force, the greater the asymmetries in the verticality of the torso bend to the left (KNT-), and the height of the waist triangles, where the left one is higher (TT+), (Table 7).

Discussion

Screening tests of children in primary schools in terms of Idiopathic Scoliosis (IS) is crucial for the early detection, prevention of further deformities and the healthy development of a child. Recent reports have shown that the frequency of IS among primary and lower secondary school students varies and totals 1.02% in China, 2.3% in Turkey, 2.93% in Indonesia, and 5.2% in Germany [23-26]. Meanwhile, the occurrence of Adolescent Idiopathic Scoliosis (AIS) varies among boys and girls, depending on body composition and overweight, family scoliosis history, and ethnicity [24,27-32]. The weight of the schoolbag and the way of carrying is one of the first symptoms of IS and one of the factors influencing the increase of the torso rotation angle [33,34]. *Dockrell, et al.* [35] showed that the discomfort associated with carrying the schoolbag was reported more often in the shoulders than in the back. *Tahirbegolli, et al.,* [36] showed that there is no statistically significant correlation between the weight of the schoolbag and the torso rotation angle. *Kouwenhiven and Castelein's* [37] research showed that there is no single cause of idiopathic scoliosis development, therefore the condition is described as multifactorial. Accordingly, the weight of the schoolbag cannot be the only cause of the SI, but it can affect it. In addition, some studies have shown that backward shear loads act as an enhancer of slight preexisting vertebral rotation under critical circumstances during the growth [38,39].

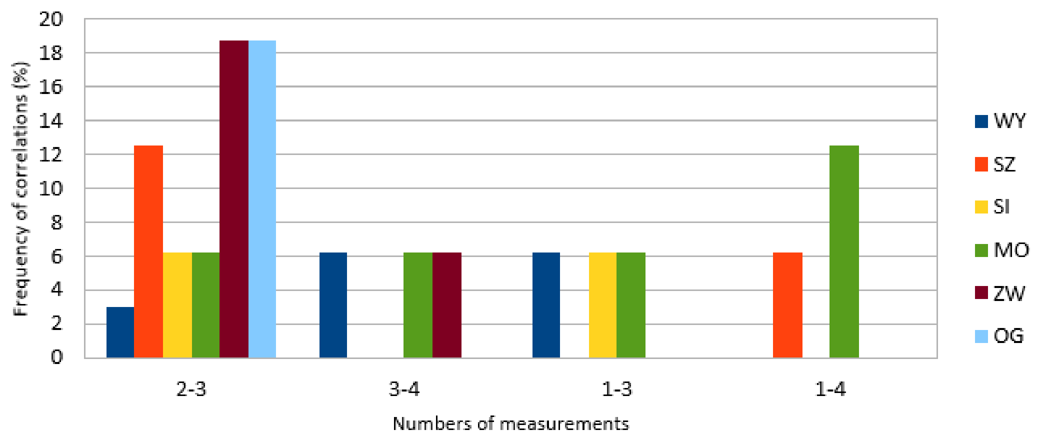
A review of the literature on the subject revealed no investigation to the restitution of significantly altered features of body posture after removing the weight of school supplies carried on the chest by 7-year-old students. The above-mentioned authors focused more on exploring the consequences of loading the school supplies carried on one of the shoulders or back, or on the effects of a different weight of the accessories themselves. It should be believed that the undertaken research is the first attempt to determine the restitution of static postural disturbances, an attempt to pay attention not only to the consequences of the load, but also the time of returning to individual stability. In *Dobosz's* research on the effects of overloading the body posture with a backpack, a habitual body posture without a load was adopted as a reference point. At the moment of carrying the backpack in the traditional way, with a load of 5% of body weight, the COP shifted backwards, which caused a strong compensatory reaction leading to its displacement forward. Although, it is not clear from statistical calculations, this trend occurs in every situation where the backpack is on the back at any load value, but the greater the load, the lower the compensation value. On the other hand, with the backpack on the front of the body, there was no postural reaction observed of the COP shifted forward in relation to its position in the no-load test, which in this case may indicate the lack or insufficient compensation, and the higher the load value, the further the COP shifted. This is only a trend that has not been confirmed statistically. It may result from the feeling of greater safety in the front bend and the awareness of the possibility of the fall amortisation with the upper limbs [36,40]. The statements quoted by *Bittman and Badtke* [41] should be also considered and provided by Schild that the changes in the movement system of 5-7-year-old children depend primarily on the genetic determinants of the maturation of the musculo-nervous system. During this period, external factors, including physical activity, do not play a major role. It seems that the influence of external factors on the development of the locomotor system begins to increase with age and maturation of the muscular and nervous systems around the age of 7-8. Based on the results of the literature review, *Janakiraman, et al.*, [42] believe that the limits of the weight of the school backpack in school-age children and the related changes in body posture are inconsistent. If backpacks cause a change in posture or a pain sensation, eliminating or minimizing the backpack weight as a contributing factor is crucial. To change posture, there must be a small base of the support and the centre of gravity must extend beyond the base of the support, as it is in the case when the backpack is loaded with more than 15% of a body weight. Based on the results of the review, the authors conclude that a backpack load of 10% of body weight would be safer for the spine of school-age children. Efforts should be made to reduce the load on the spine of schoolchildren in order to have a healthier and pain-free population in the future.

A detailed analysis of the results of the boys' research showed that strength, agility and overall fitness had the most frequent correlation with the restitution of the values of body posture features in the first minute, and agility and overall fitness in the second minute of restitution. Among girls, in the first minute the most frequent relationship was with agility and overall fitness, while in the second minute the relationships were of low frequency. The analysis of restitution among boys, in terms of features of habitual posture (first measurement) and the end of the first minute after removing the load (third measurement) showed that all features were most often related to overall fitness, but the least to speed, and among girls the relationships were of low frequency. The analysis of restitution among boys, in terms of features of habitual posture (first measurement) and the end of the second minute (fourth measurement) showed that the most frequently related to the restitution of the values of posture features were all the features of overall fitness, most often endurance and slightly less other features. Among girls, force was the most common, while the remaining relationships with fitness traits were of low frequency (Figures 2,3).



Note*: Legend:
1) 2-3 Restitution of the values of body posture features after first minute from the load removal (between 2nd and 3rd measurement).
2) 3-4 Restitution of the values of body posture features after second minute from the load removal(between 3rd and 4th measurement).
3) 1-3 Restitution of the values of the habitual posture features and after first minute from the load removal (between 1st and 3rd measurement).
4) 1-4 Restitution of the values of the habitual posture features and after second minute from the load removal (between 1st and 4th measurement).
WY-Endurance; SZ-Speed; SI-Strenght; MO-Force; ZW-Agility; OG-Overall Fitness.

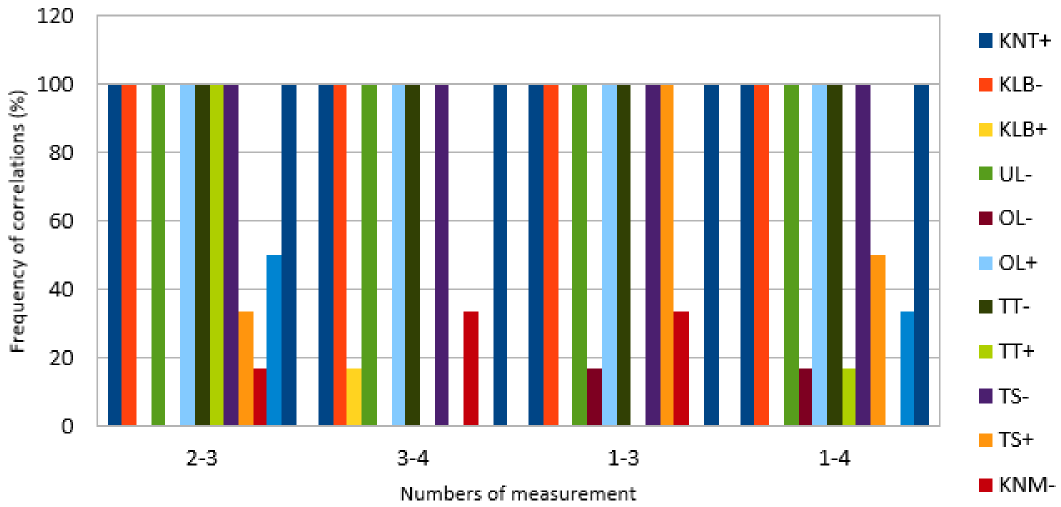
Figure 2: An example of a record sheet of measurements of the posture features of the spine-pelvis syndrome.



Note*: Legend:
1) 2-3 Restitution of the values of body posture features after first minute from the load removal (between 2nd and 3rd measurement).
2) 3-4 Restitution of the values of body posture features after second minute from the load removal(between 3rd and 4th measurement).
3) 1-3 Restitution of the values of the habitual posture features and after first minute from the load removal (between 1st and 3rd measurement).
4) 1-4 Restitution of the values of the habitual posture features and after second minute from the load removal (between 1st and 4th measurement).
WY-Endurance; SZ-Speed; SI-Strenght; MO-Force; ZW-Agility; OG-Overall Fitness.

Figure 3: Frequency of significant correlations of physical fitness features with restitution of the values of body posture features in the frontal plane among 7-year-old girls n=35.

A detailed analysis of the boys' results showed that in the restitution of the values of posture features with all fitness features in the first minute there was a relationship between the asymmetry of the verticality of the torso bend to the right (KNT+), the height of the shoulders, where the left one was higher (KLB-), the height of the shoulder blades, where the left one was higher (UL-), the distance of the lower angles from the line of the spinous processes, where the angle of the left shoulder blade was more distant (OL+), the height of the waist triangles, where the right (TT-) or left one (TT+) was higher, and the width, where the right one was wider (TS-). Among girls, the correlation was with asymmetry in the height of the shoulder blades, where the left one was higher (UL-) and the asymmetrical course of the spinous process line leaning to the left (UK-) (Figures 4,5).



Note*: Legend: Explanation of abbreviations of names of body posture features in Table 1.
WY-Endurance; SZ-Speed; SI-Strenght; MO-Force; ZW-Agility; OG-Overall Fitness.
Figure 4: Frequency of signifficant correlations of the restitution of body posture features with physical fitness features among 7-year-old boys n=30.

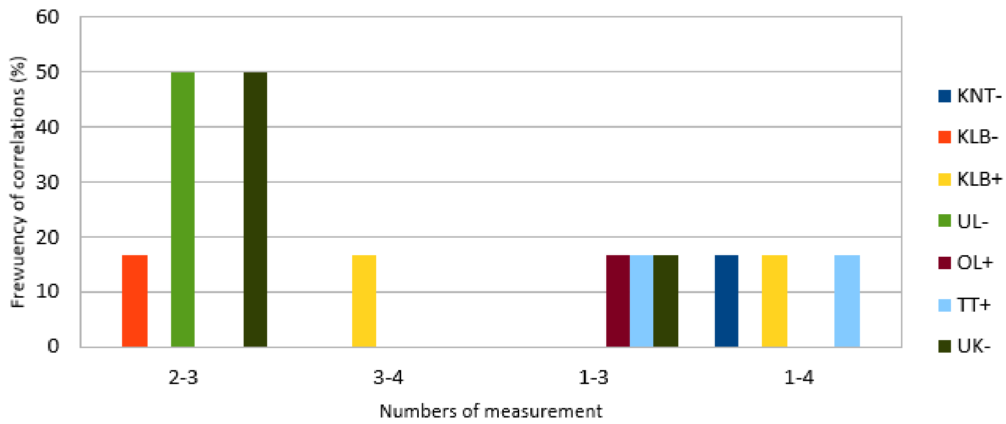


Figure 5: Frequency of signifficant correlations of the restitution of body posture features with physical fitness features among 7-year-old girls n=35.

Conclusions

a) After removing the carried weight of school supplies from the chest, there was an incomplete restitution of almost all values of the diagnosed posture features after the first and second minutes.

b) Relationships of the examined determinants of physical fitness with the restitution of the values of posture features are sex-dependent, and they are much more frequent in boys than girls. In the case of boys, the most common correlation was with agility, overall fitness, and endurance, whereas among the girls with agility and overall fitness.

c) There should be actions taken to promote a healthy lifestyle for children, including physical education.

Acknowledgement

None.

Conflict of Interest

None.

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