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Short-term effects of carrying a school bag on the distribution of force and plantar pressure during walking of children of different levels of physical activity

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ABSTRACT

Introduction: Carrying a school bag is a dominant activity that a child performs during daily productive activities. The aim of the research is to examine how carrying a school bag of different weights affects the distribution of force and plantar pressure during normal walking on the flat terrain of children of varying levels of physical activity.

Methods: The pilot study included 124 students aged 11-12 from Banja Luka. According to the protocol, each group of respondents was treated with an intervention-customized school bag and a comparator-school bag that the child only opted for. For the research, the Physical Activity Questionnaire for Older Children, measurement of anthropometric parameters, school bag weight, and Zebris tape (Zebris Medical GmbH, Germany) were used for gait analysis.

Results: Inactive children achieved the lowest and active children's highest walking speed during normal walking without a bag, with their customized school bag. When carrying a custom school bag: The highest maximum force is projected on the left heel 330.72 N in inactive children, and the lowest 265.93 N in moderately active children, the highest maximum pressure on the left heel is registered in inactive children, 27.60 N/cm^2, and the lowest 21.85 N/cm^2 in moderately active children. The maximum force-time of % of standing time on the left foot in the middle part lasted the longest in inactive children, and the shortest active children carried their school bag 40.31% and a custom school bag 39.76%.

Conclusion: High physical activity and individual adjustment to distribute the burden well allow the child to adequately respond to the loads carried by the weight of the school bag.

Keywords: Primary school children; school bag; physical activity; gait analysis

INTRODUCTION

Carrying a school bag is a dominant activity that begins at the age of 4-18, and the child performs it in performing daily productive activities. The contents of the school bag change significantly during the educational process. The most significant change occurs with the transition from a class to subject teaching in the pre-period of accelerated growth and development. In recent years, nonspecific back pain, neck pain, shoulder pain, and poor posture among school children have increased importance in the literature. These conditions have been associated mainly with congestion caused by heavy school bags (1-3). Diseases due to lack of movement and physical inactivity can be considered a significant pathogenic condition factor (4). Inactive lifestyle leads to the uneven development of muscle groups and some other environmental factors (improper sitting) that can lead to improper posture. The U.S. Department of Health, in its second edition of the Physical Activity Guidelines for Americans (PAG), recommended that children and adolescents ages 6-17 should work 60 minutes or more daily in moderate to vigorous physical activity (5). For some authors, the distance and time a child spends walking with a school bag to and from school also poses a risk to the child's spine (6,7). One group of authors states that using a school bag can contribute to postural changes, such as correcting lumbar lordosis and thoracic kyphosis, and thus cause immediate changes in spinal curvature (8,9), impaired static balance (10), stairs and movement (walking, brisk walking, running, jumping, etc.), and (11). The American Association for Occupational Therapy, the American Academy of Orthopedic Surgeons, and the International Association of Pediatric Chiropractors

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suggest that the load should not exceed 10%, the American Association for Physical Therapy 15%, and the American Association of Chiropractors 5-10% (12). Changes are noticeable when carrying a school bag weighing 20% of body weight. These changes are reflected in a decrease in speed and stride length, and an increase in the duration of the double phase of support, increased stride frequency, and reduced swing time (9,13). In children and adolescents, there is a strong inverse correlation between plantar pressure and physical activity levels (14,15). Assessment of plantar pressure may signal different postural changes in feet related to foot-level forces while standing and walking in both healthy subjects and various pathologies like obesity. Plantar pressure provides information on changes due to pain reported at the lower extremity level and stability disorders (16). The World Health Organization has defined obesity as a global epidemic. There is still a lack of preventive programs that would prevent, or at least alleviate, the progressive growth of physical inactivity and overweight, the occurrence of musculoskeletal pain among children and adolescents. Although the American Association of Occupational Therapists (AOTA, 2014) has issued guidelines for the proper use of a school bag, we lack such prevention programs (17).

The aim of the study was to examine how carrying a school bag of different weights affects the distribution of force and plantar pressure during normal walking on the flat terrain of children of different levels of physical activity. The main hypothesis for this research was that active children during an everyday walk with an adapted school bag have a significantly reduced force distribution, but not a generalization of peak pressure values.

METHODS

The research was a pilot study according to the Patient/Population, Intervention, Comparison, Outcome (PICO) methodology PICO. Using the cluster sampling method, the study included 737 students of both sexes aged 11-12, seven city primary schools from Banja Luka. After meeting the criteria for inclusion and testing of students with the Physical Activity Questionnaire The Physical Activity Questionnaire for Older Children (PAQ-C) (18,19), respondents entered the study successively. They were divided into three groups: Active, moderately active, and inactive children. The study included 124 students of both sexes and 613 students of both sexes not included.

Study included children older than primary school age 11-12, both sexes, children who have signed written consent of a parent or legal representative, children who have given permission and signed written consent to participate, and children who have the ability to self-ambulance.

From study are excluded children with intellectual disabilities, epilepsy, cerebral palsy, hemiparesis, diabetes mellitus, heart and circulatory diseases, respiratory system, children with a history of fractures or injuries of the lower extremities in the past year, children without signed parental consent or legal representatives, and children who have not given their consent to participate and children who use a mobility aid, fatigue, pain, inability to adapt to the work of the zebra strip were excluded from the study.

The research was approved by the Ministry of Education and Culture of Republika Srpska, heads of primary schools in local self-government in Banja Luka, head of the Institute for Physical Medicine and Rehabilitation "Dr Miroslav Zotovic" Banja Luka, and the Ethics Committee of the Medical Faculty of the University of Banja Luka. All respondents and parents gave their voluntary consent, which, in addition to the oral explanation, was also contained in the informed consent and written information for parents and students. The research was conducted during the 2019/2020 school year. Subjective and objective tests were used for the research.

As a subjective test, we used a PAQ-C physical activity questionnaire consisting of 9 questions specially evaluated on a 5-point scale. The total result of physical activity is predicted at the arithmetic mean of the given answers, especially assessed on a scale from 1 to 5. According to the given criteria, the questionnaire enables the classification of respondents (result 1-2 - inactive, 3 - moderately active, and 4-5 - active children) (18,19).

As an objective test, we used body mass index (BMI) as the ratio of body mass (BM) to the square of body height (BH). BM is expressed in kilograms and BH in meters (WHO, 2018). Nutritional status was assessed by applying a standard BMI according to the criteria (WHO, 2000) and by classifying values according to percentile curves for boys and girls aged 5-19 years (WHO, 2007) according to standard limit values. The obtained result classifies the child into five categories: obese, increased body weight, normal body weight, malnourished and undernourished (20).

The weight of the school bag is determined by the differences between the two weights and will represent the weight of the school bag. The percentage ratio of body weight to school bag weight is obtained by multiplying the school bag weight by 100 and dividing by the body weight (21,22).

Walking performance was assessed on a multifunctional Zebris tape (Zebris Medical GmbH, Germany) for gait training and analysis. The Zebris system consists of a conveyor belt with a diameter of 158 cm × 60.1 cm, containing a sensor surface with a diameter of 149 cm × 54.2 cm with 11,264 sensors, technical, and computer elements. Recording on the Zebris belt requires the preparation of respondents. Adjustment begins at a speed of 0.5 kilometers per hour (km/h) and then increases by 0.3 km/h every 15 seconds (sec) by one step until the subject informs that the speed that best characterizes their normal, normal gait has been reached. After a 10-min adaptation phase, the system is ready to record for 30 sec. Due to the high density of the sensor, the foot is mapped at a high resolution, allowing the registration of subtle changes in the distribution of force and pressure (23).

Predictor variables in our study represent the value of the total score of physical activity (inactive, moderately active, and active children), and dependent variables represent contact time, maximum force, maximum force time, maximum pressure and which are determined separately for the back, middle, and front of the foot on both sides. Load transfer time for which the load is transferred from the back to the front of the foot on both sides.

Testing of children with the PAQ-C Physical Activity

Questionnaire was performed at school and objective measurements in the Cabinet for gait analysis in the Institute for Physical Medicine and Rehabilitation "Dr Miroslav Zotović" Banja Luka Department II (Figure 1).

Each respondent was required to bring their school bag for testing. According to their assessment, they were supposed to get the contents of the school bag (textbooks, notebooks, school supplies, physical education equipment, and additional contents he brings to school every day) from 1 working day, which he considered the heaviest school bag of the week.

Their school bag was customized according to the guidelines of the American Association of Occupational Therapists and whose weight is 10% of their body weight (17). Before arrival, subjects were advised to eat 2 h before testing, ingest sufficient fluids, and perform physiological needs. Each respondent has individually explained the procedure on the Zebris bar according to the recommendations for using the Zebris Software Manual zebris FDM (24). After a 10-min adaptation period on the Zebris strip, each measurement with a different school bag weight lasted 30 sec. Measurement of anthropometric parameters, school bag weight took 30 min, and Zebris tape testing 15 min.

The research was conducted by a research team consisting of the principal researcher, occupational therapist-physiotherapist, occupational therapist, physical education teacher, and doctor. One examiner measured the Zebris strip and measured anthropometric parameters and characteristics of the school bag by two surveyors. Before the start, training was conducted by the principal investigator, and a work diary was kept following the study protocol.

Complete statistical analysis of data was done with the statistical software package, SPSS Statistics 18. Most of the variables were presented in a text and table as frequency (%) of specific categories. In continuous data, variables were presented as mean value ± standard deviation, minimum and maximal values. Kolmogorov–Smirnov test was used to evaluate the distribution of continual data. Statistical significance between groups was tested by ANOVA tests for independent or repeated measures. In case of finding a significant difference between groups, the *post hoc* Tukey test was applied.

All the analyzes were estimated at a $p < 0.05$ level of statistical significance.

RESULTS

The description of the sample, values of anthropometric parameters, BMI, and school bag weight are presented in Tables 1-3 concerning gender and total population, and graphically (Graph 1) the level of physical activity. Table 4 shows the results of the analysis of variance on the short-term effects of carrying a school bag on the distribution of force and plantar pressure during normal walking on flat terrain only where a statistically significant difference between three predictors and 29 dependent variables was found. The values of the t-test results are expressed in Newton's (N), newtons per square centimetre (N/cm^2), percentages (%), kilogram (kg.), grams (g), centimeter (cm), kilometers per hour (km/h) and seconds (sec).

The study involved 124 students, boys 50% (n = 62) and girls 50% (n = 62), aged boys 11.94 ± 0.39 (10.91-12.91) and girls 11.85 ± 0, 45 (11: 16-12.75). The average value of the tight mass of the observed population was 49.92 kg. Girls (49.23 kg) were average lighter than boys (50.51 kg), but their average BH values were the same, 1.57 cm.

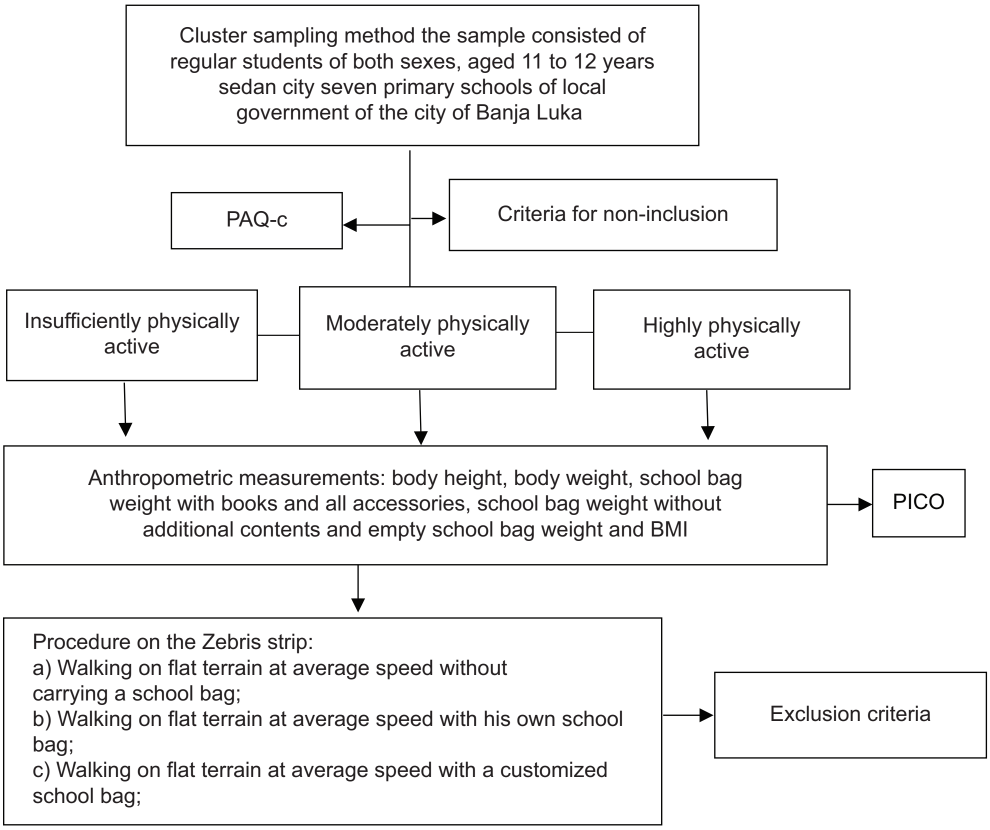


FIGURE 1. Population, sampling, and study protocol.

TABLE 1. Descriptive analysis of anthropometric parameters of the sample for the total population and by sex. Values are expressed as MIN, MAX, and AS±S.D

Anthropometric characteristics	Gender														
	Boys					Girls					Total				
	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Body weight (BM) in kg	62	50,61	12.16	30,10	89,10	62	49,23	12,89	27,50	83,80	124	49,92	12,49	27,50	89,10
BH in cm	62	157,00	6,54	140	170	62	157,50	7,76	140	174	124	157,250	7,15	140	174
Age	62	11,9394	0.38992	10,91	12,91	62	11,8505	0.45131	11,16	12,75	124	11,8950	0.42238	10,91	12,91

BH: Body height, SD: Standard deviation

TABLE 2. Descriptive analysis of the school bag weight of the sample for the total population and by sex. Values are expressed as MIN, MAX, and AS±S.D

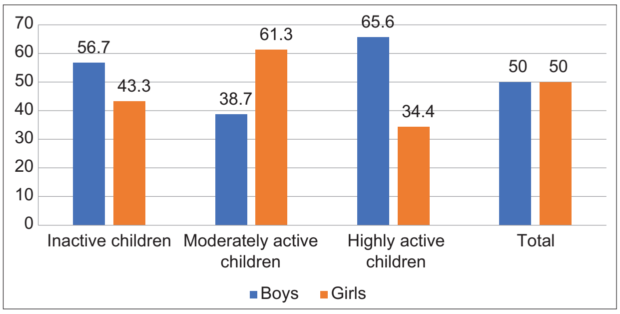
School bag features	Gender														
	Boys					Girls					Total				
	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
The weight of an empty bag, without books in gr	62	686,72	282,91	100	1500	62	563,71	289,03	100	1400	124	624,72	291,46	100	1500
The weight of your own bag with the contents in gr	62	5307,40	1191,77	3400	8300	62	5188,87	978,56	2900	7600	124	5248,14	1087,58	2900	8300
Weight of own bag% of BM of child	62	11,10	3,65	5,16	23,14	62	11,11	3,20	4,53	20,11	124	11,10	3,42	4,53	23,14
Body weight + weight of own bag kg	62	55,92	12,25	34,60	93,70	62	54,42	13,03	31,50	89,10	124	55,16	12,62	31,50	93,70
Body weight + bag weight of 10% BM kg	62	55,13	12,76	33,11	93,70	62	53,68	13,55	30,25	89,10	124	54,41	13,03	30,25	93,70

SD: Standard deviation

TABLE 3. Distribution of respondents in relation to BMI, school bag weight (by gender, and total)

Category	Parameters	Gender				Total	
		Boys		Girls			
		n	%	n	%	n	%
Body index mass (BMI)	1.	21	33.9	12	19.4	33	26.6
	2.	7	11.3	9	14.5	16	12.9
	3.	27	43.5	28	45.2	55	44.4
	4.	7	11.3	9	14.5	16	12.9
	5.	0	0.0	4	6.5	4	3.2
	Total	62	100.0	62	100.0	124	100.0
The weight of your bag (% of BM)	1.	27	43.5	26	41.9	53	42.7
	2.	28	45.2	30	48.4	58	46.8
	3.	5	8.1	5	8.1	10	8.1
	4.	2	3.2	1	1.6	3	2.4
	5.	0	0,0	0	0,0	0	0,0
	Total	62	100.0	62	100.0	124	100.0

Body mass index: category 1-Obese> 97 percentile, category 2- Increased body weight> 85 percentile, category 3- Normal body weight 15-85 percentile, category 4- Malnourished <15 percentile, category 5- Undernourished <3 percentile : Child's own weight% of TM: category 1. <10% TM, category 2.> 10% TM, category 3.> 15% TM, category 4.> 20% TM, category 5.> 25% TM. BMI: Body mass index, BM: Body mass



GRAPH 1. Level of physical activity with respect to gender and total sample. Physical activity test 1 - insufficiently physically active below the 25th percentile, 2 - moderately physically active children from the 25th to the 75th percentile, and 3 - highly active children above the 75th percentile.

The average weight of an empty school bag without books for the whole sample (n = 124) was 624.72 g. For girls, the empty bag averaged 563.71 g, and for boys, 686.72 g. The weight of their bag with teaching content averaged 5,248.14 g, for girls 5,188.87 g, and for boys 5307.40 g. Regardless of gender, the% of school bag load concerning BM was approximately the same (11.06 ± 3.65; 5.16-23.14 in boys), (11.11 ± 3.20; 4.53-20.11 in girls). When carrying one's own bag for the observed population, the average body weight values were 55.16 kg, and with an adapted school bag, 54.41 kg.

Looking at Table 3, we notice that the average BMI in 26.6% of our sample was obese (boys 33.9% and girls 19.4%), 12.9% of overweight children, malnourished 12.9%, and undernourished 3.2% of our sample. In our sample (n = 124), no participants owned a school bag that was >25% BM. The largest number of girls, 48.6% of our sample, had a school bag weight >10% BM, and only 2.4% of the sample had a school bag weight >20% BM. In 42.7% of the sample, the school bag was <10% BM.

Looking at Graph 1, we notice that the largest percentage of respondents (38.7% boys and 61.3% girls) is on average physically active, inactive children (56.7% boys and 43.3% girls) and active children (65.6% boys and 34.4% girls).

Looking at Table 4, during normal walking without a school bag, a statistically significant difference was found

TABLE 4. Significant gait parameters of groups of inactive, averagely active, and active children registered during gait without a school bag, gait with their school bag, and gait with a custom school bag

Test	Stroke parameter	Significance[1]		Groups of respondents, mean, (pairwise comparisons)		
		F	Sig.	Inactive (1)	Average active (2)	Active (3)
Gait (without school bag)	Velocity, km/hour	5.46	0.005	1.53	1.71 (1-2)*; (1-3)*	1.73
Gait (school bag)	Velocity, km/hour	8.64	0.000	1.45	1,69 (1-2)*; (1-3)*	1.71
	Max force heel left	5.24	0.007	334.85	245.37 (1-2)*	271.37
	Max pressure heel left	5.42	0.006	27.8	20.23 (1-2)*	23.08
	Max force time % of stance time: midfoot left	3.498	0.033	48.83	44.59 (1-3)*	40.31
Gait (customized school bag)	Velocity, km/hour	10.27	0.000	1.49	1.79 (1-2)*; (1-3)*	1.84
	Max force heel left	3.68	0.028	330.72	265.93 (1-2)*	280.20
	Max pressure heel left	4.38	0.015	27.60	21.85 (1-2)*	23.66
	Time change heel to forefoot sec left	5.46	0.005	0.65	0.47 (1-2)*	0.51
	Max force time % of stance time: midfoot left	3.087	.049	47.69	44.55 (1-3)*	39.76
	Contact time % of stance time:heel left	3.30	0.040	74.16	63.77	66.89
				(1-2)*		

*p<0.05. [1]ANOVA, pairwise comparisons performed by Takey test

only at walking speed. Active children walked the fastest at 1.73 km/h, and inactive children walked the slowest at 1.53 km/h. Differences in walking speed were significant between all three groups, namely, inactive and moderately active children and between inactive and active children.

During normal walking with their own school bag, active children walked the fastest, at 1.71 km/h, and inactive children walked the slowest at 1.45 km/h. Differences in walking speed were significant between all three groups, namely, passive and moderately active children and between inactive and active children. The highest maximum force on the left heel is projected in inactive children, 334.85 N, and the lowest 265.93 N in average active children. Differences in maximum force on the left heel were significant between inactive and moderately active children. The highest pressure on the left heel was found in inactive children, 27.8 N/cm^2, and the lowest average active children, 20.23 N/cm^2. Differences in maximal heel pressures were significant between inactive and moderately active children. The maximum force time of % of the standing time on the left foot in the middle part lasted 48.83% in inactive children compared to active children 40.31%. During the walk with an adapted school bag, active children walked the fastest, 1.84 km/h, and the slowest inactive children, 1.49 km/h. Differences in walking speed were significant between all three groups, namely, inactive and moderately active children and between inactive and active children. The highest maximum force was registered on the left heel, 330.72 N in inactive children, and the lowest 265.93 N in average active children. The highest maximum pressure on the left heel was registered in inactive children, 27.60 N/cm^2, and the lowest 21.85 N/cm^2 in average active children. The change in time on the left foot from the heel to the front of the foot lasted the longest in inactive children, 0.65 s, and the shortest 0.47 s, as well as the contact time of % standing on the left foot lasting 74.16% compared to the average active children 63.77%. The maximum force time of % of the standing time on the left foot in the middle part lasted 47.69% in inactive children compared to active children 39.76%.

DISCUSSION

To explain the results of our research, we should remind that a large number of the previous studies on posture, physical activity, and carrying a school bag in school-age children are aimed at identifying risk factors associated with back curvature, pain, and pain exhaustion. Moreover, the occurrence of fatigue using statistical indicators (25,26). However, a number of authors in their research also focus on the analysis of the interaction between the legs and the ground (9,27,28), pressures continue to cause some concern about the potential long-term negative effects on the foot structure and overall functionality of children.

The study involved 124 students, boys 50% (n = 62) and girls 50% (n = 62), aged boys 11.94 ± 0.39 (10.91-12.91) and girls 11.85 ± 0, 45 (11.16-12.75). The average value of BM of the observed population was 49.92 kg and BH 1.57 cm. Girls are, on average, slightly lighter than boys. Compared to their peers from Serbia, they had a higher average BM but the same BH values. Still, compared to their peers from Montenegro, they had approximately the same average BM values and lower BH average values (29,30). The smallest number of children in our study had a normal BMI. In 26.6% of the sample, BMI was in obese children, 12.9% were overweight, malnourished 12.9%, and undernourished 3.2% of our sample indicating a significantly higher trend compared to previous studies that prevalence and the incidence of overweight and obesity in children in 2020 will amount to 14.1%, compared to that of 7.9% in 1999 (31,32).

The average weight of their bag with teaching content was 5248 g. On average, the bag was 118 g lighter for girls than for boys. The results of our study were consistent with a literature review by Ellapen et al. (2021) that included 14 studies and 1061 participants, mean age 11.5 ± 1.3 years, body weight 37.8 ± 6.6 kg, height 1.41 ± 0.05 meters (m), and backpack weight 5.2 ± 0.9 kg. The percentage of backpack weight in relation to the body weight of the respondents in our study was lower in relation to the authors' statement of 13.75%. The study concludes that there is no consensus on the precise weight of backpacks that triggers postural changes (33). The average weight of an empty school bag without books for the whole sample (n = 124) was 624.72 g, for girls, the empty bag was on average lighter by 123.41 g than for the boys. The average value of BM when carrying your school bag was 750 g higher than when they carried a custom school bag. The obtained results confirm the original assumption that school bags are 10% heavier than the prescribed norms in the world, and according to the guidelines of the International Association of Pediatricians for Chiropractic, the American Academy of Orthopedic Surgeons the American Association of Occupational Therapists (12). The weight range of the school bag was minimal in boys (3400 g) and girls (2900 g), and maximum in girls (7600 g) and boys (8300 g), which is really alarming and speak of the excessive workload of the respondents. The maximum measured weight of an empty school bag for boys is 1500 g and a girl 1400 g. The minimum weight of an empty school bag was 100 g both in boys and girls. If we look from the aspect of individual adjustment with regard to the recommendations of 10% of body weight, then it can be stated that the average minimum weight of a school bag has decreased by 290 g smaller, and the maximum weight of the school bag increased by 590 g. We can explain this statement that in children whose BMI values are classified as obese, there was no adjustment of the weight of the school bag. For these reasons, it is not appropriate for all schoolchildren to have the same weight of a school bag. Obese schoolchildren should carry a lower weight ratio of backpacks to body weight, as both authors Adeyemi et al. (2015) noted (34). The conclusion of a study by Adeyemi et al. (2017) is that obese children are recommended to carry a third lighter burden than other children (35). Minimum measured BM values while carrying a boy's school bag (34.60 kg) and a girl (31.50 kg), and maximum BM values while carrying a boy's school bag (93.7 kg) and a girl (89.10 kg) which for the age population represents one range whose values in terms of showing the optimal weight and comparison with the optimal reference frames cannot be taken into account as given in the guidelines (12). The most significant number of children, 48.6% of our sample, had a school bag weight >10% BM, and only 2.4% of the sample had a school bag weight greater than 20% BM In 42.7% of the sample, the school bag was <10% BM.

During the normal walk, the fastest active children walked 1.73 km/h, and the slowest inactive children 1.53 km/h. Differences in walking speed were significant between all three groups, namely inactive and moderately active children and between inactive and active children. The results of our study were in contrast to other studies that looked at detailed information on significant differences in the dynamic characteristics of the feet in subjects with normal weight, overweight, and obese children. The speed was 0.95 ± 0.25 m/s, with no differences between normal weight, overweight, and obese children (36). In one study that aimed to examine the impact of physical activity on legs and plantar pressure in overweight and obese children. Included 73 overweight subjects and obese children (age 8.3 ± 1.1 years; 47 girls and 26 boys; z-score BMI = 2.7 ± 0.7. Peak pressures were generated below the front of the foot during walking, and vice versa were correlated with time spent performing activities of different intensity levels. The conclusions of the study were consistent with the results of our study that children with higher pressure below the front and middle of the foot during normal walking had a lower level of physical activity (37). Structural changes associated with foot discomfort and increased plantar pressure may limit obese children to engage in physical activity (38). Author Paul et al. (2016), in their study, found that the distribution of pressure increased significantly in children with normal weight, but not in the overweight/obese group (15).

When the heel comes into contact with the ground, the muscles are in a negative phase, they lengthen because their force is less than the force of the load. With each contact, the feet with the ground form a greater reaction force than body weight. A statistically significant difference was observed in the force projected in the phase of contact of the heel with the ground on the left foot when carrying one's own and customized bag. The highest maximum force on the left heel was projected in inactive children, 334.85 N, and the lowest 265.93 N in average active children when carrying their own but not an adapted school bag. The difference was also observed in the maximum pressure on the left heel when carrying their customized school bag. The highest pressure on the left heel was observed in inactive children, 27.8 N/cm^2, and on average active children 20.23 N/cm^2. Although the authors Paul et al. (2016) found that pressure values continue to raise some concerns regarding potential long-term negative effects on foot structure, particularly the functionality of overweight/obese children (15). Differences are also visible in the change of time from the heel to the front of the foot and the contact time of % standing on the left foot during the full support phase and which lasted the longest in inactive children and the shortest in average active children while carrying an adapted school bag. A statistically significant difference was observed in the maximum force time of % of standing time on the left foot in the middle, which lasted the longest in inactive children and the shortest active children when they carried their own 40.31% and a custom school bag 39.76%. The results of our study were consistent with a study that reported that ergonomic intervention was effective in improving muscle strength and reducing pain intensity (39), but in contrast to other studies that reported that the gait of young adults could not be affected regardless of wearing a backpack or not, especially when walking short distances. The authors also concluded that no significant differences in gait parameters were observed between a regular backpack and a backpack with elastic straps. A backpack made of elastic straps cannot affect the gait, and that the design of the backpack must be more rigorous (40).

Based on the synthesis of the presented results, it is possible to conclude that the hypothesis was confirmed. The key findings are that active children during carrying an adapted school bag significantly reduced the time of force projected from the substrate, but not the generalization of the peak pressures.

No studies have been published in the Republika Srpska and the Federation of Bosnia and Herzegovina on the impact of carrying a school bag on the distribution of force and plantar pressure during normal walking of children of different levels of physical activity. Although it is a pilot study, the sample included a small number of children with a high level of physical activity. Therefore, initial research continues to better generalize the observed problems in the population under study.

CONCLUSION

The walking activity itself is performed in the aerobic range, but this activity must be viewed differently when the child performs it with loads such as carrying a school bag. Physical inactivity and unpreparedness of the organism to adequately respond to efforts affect all human organism systems, especially the locomotor system and the functionality of the feet. In moderately active children, the least pressure and force on the feet were projected because muscle contractions adequately responded to body weight. Active children walked the fastest while walking without a bag, with their own and customized school bag. The projection of force on the front of the foot of the left and right foot in active children was corrected when they carried an adapted bag in relation to their school bag. Moderate physical activity is crucial to respond to loads adequately and thus reduce the pressure and force exerted by the foot during walking activity. Still, a high level of physical activity while carrying an ergonomically adjusted school bag has significantly reduced the time of force projected from the ground.

RECOGNITION

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CONFLICT OF INTERESTS

Authors declare no conflict of interest.

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