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The Development of School Bag Weight as a Risk Factor for Poor Posture During School Attendance

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Abstract

The submitted study addresses the weight of school bags as one of the risk factors of poor posture in pupils during mandatory school attendance. The research group included 680 children aged 6 to 14. The weight of the school bag was measured during one workweek from Monday to Friday. The results showed that many early school age pupils are overburdened with an inappropriate school bag weight. The weight of the empty school bag that exceeds the permitted weight according to the Czech national standard has a significant effect on the total weight of the school bag. Teachers should participate in the remedy of the situation. They should not only look for possible solutions, but also educate the parents of the pupils in this matter.

Keywords: *empty school bag, full school bag, back pain, contents of the school bag*

Introduction

A healthy development of the child's locomotor system is the foundation for the future life quality of each individual. Locomotor defects are becoming more and more common due to the current lifestyle and the related hypokinetic trends related to the prevailing static load in the sitting position. Such defects are manifested by poor posture and back pain as early as in school age children (Kratěnová, Zeliglicová, Malý, & Filipová, 2007; Ståhl, El-Metwally, & Rimpelä, 2014; Taimela, Kujala, Salminen, & Viljanen, 1997; Troussier et al., 1999). The fact that the child

spends about 1/3 of daily wakefulness at school (Sigmund, Sigmundová, Hamrik, & Madarásová Gecková, 2014) makes the school environment an important factor that may affect the condition of the child's bearing and locomotor system. This implies the importance of the teacher's role as the teacher is one of the fundamental factors in the education process who is responsible for its preparation, organization, management and results (Průcha, Walterová, & Mareš, 2003) but who also disposes of most of the child's worktime. Therefore, the teacher has a great capacity to influence and shape pupils' positive habits that will lead to a healthy lifestyle and therefore to the prevention of civilizational diseases that currently include back pain. The significance of leading pupils to a healthy lifestyle is also confirmed by the formation of the People and Health section within the Framework Education Program (Válková, 2008; Vlček & Janík, 2010). This area also includes the subjects of physical education and education to health. However, that does not mean that only teachers of those subjects should participate in the development of a healthy lifestyle and elimination of negative effects. In particular, teachers of lower grades spend a large part of the school day with their pupils in their class. Teachers can influence pupils, namely, in the prevention of negative effects of the school environment on children's bearing and locomotor system. Such negative effects associated with long static work in inappropriate positions during educational activities and also the school furniture, the construction of which does not have to meet the pupils' physical proportions (Syazwan et al., 2011). Who else can influence the method of work and position during education than the teacher of the specific subject? Therefore, the commonly stated professional competences of the teacher should also include the competence related to the area of a healthy lifestyle in addition to competences related to their field of study and subjects: didactic and psycho-didactic; generally educational; diagnostic and interventional; social, psycho-social and interventional; managerial and normative (Průcha, 2002; Spilková, 2004; Vašutová, 2001). One of the other negative factors is children's inappropriate load in the form of learning aids and other things that children carry in their school bags to school every day (Abrahams, Ellapen Van Heerden, & Vanker, 2011; Forjuoh, Schumannet, & Lane, 2004). The problem is that there is no binding legal standard for the weight of the school bag. In the Czech Republic, there is only a national standard for the weight of an empty school bag (CSN 796506). The permitted weight of an empty school bag is 1.2 kg for pupils at the elementary level (6–11 years old) up to 1.4 kg for pupils at the secondary level (12–15 years). The question is what the weight of the school bag really is and how it affects the pupil's total body weight. Obtaining such information, particularly when the overburden of pupils is confirmed, is the condition for the teacher's

appropriate activity, whether it concerns a measure of the school that will reduce the weight of the school bags, or education aimed at parents.

The objective of the study is to analyze the weight of the school bag in relation to pupils' changing body weight during mandatory school attendance.

Methods

Participants

The study group included 680 children, boys and girls, aged 6–14. The monitored pupils participated in mandatory school attendance. They were categorized in the corresponding age group according to the WHO. An individual is assigned to an age category when the chronological age within the annual range is exceeded (e.g., 11 years old = 11.00–11.99 years old). The rates of frequency in the individual age categories and the basic anthropometric parameters are presented in Table 1. The research only included participants whose legal representatives signed an informed consent with the measurement.

Procedures

On the first day, the body height (BH), body mass (BM) and the weight of the empty school bag (WSB_E) of each pupil were measured. The pupils were described the areas of their backs (neck, chest, lumbar) so that they could specify a potential occurrence of pain. The weight of the full school bags (WSB_F) was measured on all days, recording the contents of the school bags and back pain occurrence. The back pain occurrence table only included those pupils who suffered from back pain every day.

The body height was measured by Anthropometer A-226 (Trystom, Czech Republic), the body mass (BM) was measured in underwear using the Salter 9106 digital scale (Salter, HoMedics Group, UK). WSB_E and WSB_F were measured in the following way: the pupil was first weighed without the school bag and then he/she put on the school bag and was weighed again. The weight with the school bag was deducted from the weight without the school bag.

Statistical Analysis

The results were statistically processed by PASW Statistics ver. 19.0 software (IBM Company, USA). The normality of distribution was verified using the Shapiro-Wilk test. The normality of data distribution was not disturbed. Therefore, we used one-way ANOVA to assess the statistical significance of the differences in

the means of the monitored parameters. To determine between which age groups there were statistically significant differences, we used the post hoc test (Games-Howel test). The statistical significance level was set at $\alpha = 0.05$ for all the used tests. The values that showed statistical significance were also assessed for practical significance. To assess practical significance, we used the effect of size (ES) by Cohen. The recommendations for ES assessed by Cohen's *d*: 0.2 = small effect, 0.5 = medium effect, 0.8 = large effect (Cohen, 1988). The practical significance level was set at $d \geq 0.5$.

The study protocol was approved by the Ethics and Research Committee of the University of Ostrava. All the participants signed an informed consent form.

Results

Table 1 presents the basic anthropometric characteristics of the monitored pupils and parameters related to the weight of the school bag. The mean value of WSB_F as well as the mean value of the percentage share of the weight of the school bag in the pupil's body mass (% BM) was calculated as a mean of the values measured on the individual days of the school week (Monday – Friday).

Table 1. Basic Characteristics of the Monitored Pupils and Weight of the School Bag

Age (years)	n	BH (cm) M±SD	BM (kg) M±SD	WSBE (kg) M±SD	WSBF (kg) M±SD	% BM M±SD
6	71	120.6±4.7	22.6±3.3	1.7±0.7	3.9±0.7	17.6±3.7
7	73	130.5±4.9	29.5±4.7	1.6±0.3	4.7±0.9	16.0±3.3
8	76	135.3±5.6	31.0±5.4	1.5±0.7	4.4±0.9	14.2±4.4
9	79	139.6±6.8	34.0±7.5	1.0±0.4	4.6±0.9	13.7±4.2
10	72	150.5±7.5	38.3±7.8	1.0±0.4	5.1±0.6	13.5±3.5
11	76	154.0±6.2	46.6±7.7	0.9±0.3	5.2±1.1	11.5±3.3
12	80	162.9±8.7	51.3±11.0	0.8±0.3	4.4±0.7	9.1±2.4
13	76	165.7±7.1	54.0±8.6	0.8±0.3	4.7±1.0	8.9±2.6
14	77	169.1±7.3	61.6±11.6	0.7±0.3	4.5±0.5	7.7±2.4

n – frequency, BH – body height, BM – body mass, WSB_E – weight of the empty school bag, WSB_F – weight of the full school bag, % BM – percentage of the total body mass of the participants, M – mean, SD – standard deviation

The ANOVA results confirmed statistically significant differences with regard to the age in all the monitored parameters (WSB_E, WSB_F, % BM), $p<0.001$. Table 2 shows the groups between which the differences were statistically significant.

Table 2. Post Hoc Test Results

Age (years)	WSBE (kg)	WSBF (kg)	% BM
6.	7, 8, 9*, 10*, 11*, 12*, 13*, 14* years	7*, 8*, 9*, 10*, 11*, 12*, 13*, 14* years	8*, 9*, 10*, 11*, 12*, 13*, 14* years
7.	6, 8, 9*, 10*, 11*, 12*, 13*, 14* years	6*, 8, 10, 11 years	8, 9*, 10*, 11*, 12*, 13*, 14* years.
8.	6, 7, 9*, 10*, 11*, 12*, 13*, 14* years	6*, 7, 9, 14 years	6*, 7, 12*, 13*, 14* years
9.	6*, 7*, 8* years	6*, 7, 11 years	6*, 7*, 11, 12*, 13*, 14* years
10.	6*, 7*, 8* years	6*, 7, 12*, 14* years	6*, 7*, 11, 12*, 13*, 14* years
11.	6*, 7*, 8* years	6*, 7, 9, 12*, 14* years	6*, 7*, 8*, 9, 10, 12*, 13*, 14* years
12.	6*, 7*, 8* years	6*, 10*, 11* years	6*, 7*, 8*, 9*, 10*, 11*years
13.	6*, 7*, 8* years	6* years	6*, 7*, 8*, 9*, 10*, 11*years
14.	6*, 7*, 8* years	6*, 10*, 11* years	6*, 7*, 8*, 9*, 10*, 11*years

WSB_E – weight of the empty school bag, WSB_F – weight of the full school bag, % BM – percentage of the total body mass of the participants, * practical significance $d \geq 0.5$

As for the weight of the empty school bag (WSB_E), it was determined that the 6-year-old pupils' empty school bags are the heaviest. However, no practical significance between the weight of their bags and the weight of the 7-year-old and 8-year-old pupils' empty bags was found. Practical significance was confirmed between the weights of the 6 to 8-year-old pupils' empty school bags and the 9 to 14-year-old pupils' empty school bags (Table 2). The value of Cohen's *d* was always higher than 0.8 (large effect). Therefore, the difference found can be labelled as large.

When compared with other pupils, the 6-year-old pupils had the lightest full school bags (WSB_F). The differences found were both statistically and practically significant (Table 2). Practical significance ranged from medium to large ($d = 0.6–1.8$). Table 2 provides a detailed analysis of the differences in WSB_F between the individual age groups.

The largest share of the weight of the school bag (WSB_F) in the total body mass was found in the 6-year-old pupils. The mean difference in the percentage share of the weight of the school bag in total mass between the 6-year-old pupils and older pupils was statistically and practically significant. The size of the difference was large in all cases, the value of Cohen's *d* always exceeded the value of 0.8 ($d = 0.83–3.23$). The 7-year-old pupils were the only exception as no statistical significance was confirmed in this group (Table 2). Table 2 provides a detailed analysis of the differences in between other age groups.

Discussion

There are several professional studies that deal with the weight of the school bag and its effect on body posture, defects of the locomotor system and back pain (Al-Hazzaa, 2006; Dianat, Javadivala, & Allahverdipour, 2011; Macedo et al., 2015; Rodríguez-Oviedo et al., 2012; Skaggs et al., 2006; Skoffer, 2007). However, those studies focus on the total weight of the school bag and completely omit the weight of the empty bag determined by its design. We can influence the contents of the school bag but not its design weight. The only option is to select a suitable school bag. The results of our study showed that the share of the mean weight of the empty school bag in its total weight in the 6-year-old pupils was 43.6 %. The mean values of empty school bags in 6- to 8-year-old pupils were higher than those permitted by the national standard (CSN 796506). Therefore, there are school bags on the market that are too heavy and unsuitable for pupils. The weight of the bag decreases in older pupils (aged 9 and over) as a result of their mean weight that is in compliance with the national standard, as well as a substantial reduction in its share in the total weight of the school bag. This share is only 15.6% in 14-year-old pupils.

Whether or not the total weight of the school bag is adequate may only be assessed, with regard to the missing standards, on the basis of comparison with recommendations of some authors (Forjuoh et al., 2004; Rodríguez-Oviedo et al., 2012; Skaggs, Early, D'Ambra, Tolo, & Kay, 2006), according to whom the weight of the school bag should not exceed 10% of the total mass of the pupil. As the results showed, the mean values of the percentage share of the school bag in the total mass of the pupil did not exceed 10% until the age of 12. A detailed analysis showed that the level of 10% was not exceeded in two 6-year-old pupils (2.8%), four 7-year-old pupils (5.5%), six 8-year-old pupils (7.9%), sixteen 9-year-old pupils (20.3%), sixteen 10-year-old pupils (22.2%), thirty-one 11-year-old

pupils (41.0%), fifty-one 12-year-old pupils (63.8%), fifty-seven 13-year-old pupils (75.0%) and sixty-five 14-year-old pupils (84.4%). Except for the lowest weighing school bags of the 6-year-old pupils, the weight in other age groups does not differ much. However, there is a gradual increase in the body mass of the pupils, which thus decreases the share of WSB_F in the total body mass. Figure 1 shows the gradual increase in the gap between the BM and WSB_F curve that demonstrates the decreasing % share of BM (Table 1). This implies that many pupils at the early school age are exposed to an increased load from their school bag. Similar results were obtained in a study that dealt with the weight of the school bag in pupils aged 10 to 12. The study monitored 137 pupils and the mean weight of their school bag was 4.8 ±1.5kg, which represented 12.6±4.6% of their total body mass (Vidal et al., 2013). Overburdening children with heavy school bags at the beginning of school attendance may be one of the causes of the gradual increase in the occurrence of back pain, together with long static loads that occur in unsuitable working positions, one-sided load and insufficient physical activity. The occurrence of back pain is lowest at the beginning of school attendance (6-year-old pupils). In our study group, no occurrence of pain in the chest or lumbar spine was found; 9.9% (Table 3) suffered from pain in the neck area. The older the children are, the more frequent the pain in all areas of the back is. The highest occurrence was found in the area of the neck. That confirms the trend stated by Ståhl et al. (2014). The cause is most likely long overburden of the back muscles, namely suboccipital muscles, which control the balance movement of the head.

Table 3. Percentage Occurrence of Back Pain in the Monitored Pupils

Back Pain Localization	Age (years)								
	6	7	8	9	10	11	12	13	14
Neck	9.9	11.0	11.8	13.9	15.3	18.4	22.5	25.0	28.6
Chest	0.0	4.1	5.3	6.3	8.3	11.8	13.8	14.5	16.9
Lumbar	0.0	2.7	2.6	5.1	6.9	9.2	12.5	15.8	19.5

The question is what causes the large weight of the school bag. To answer this question, we also recorded the contents of the school bag every day within the measurement (Table 4). The results did not only show what the pupil's school bag contains, but also what the possibilities of reducing its weight are. Most often, the bag contained textbooks, notebooks and other learning aids (Table 4). That opens

Table 4. Contents of School Bags

Contents of School Bag	Age (years)								
	6	7	8	9	10	11	12	13	14
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Slippers	44 (62.0)	51 (69.9)	48 (63.2)	50 (63.4)	44 (61.1)	42 (55.3)	42 (52.5)	38 (50.0)	39 (50.6)
PE gear	50 (70.4)	49 (67.1)	52 (68.4)	54 (68.4)	45 (62.5)	45 (59.2)	43 (53.8)	48 (63.2)	53 (68.8)
Text-books	71 (100)	73 (100)	70 (92.1)	79 (100)	72 (100)	69 (91.0)	69 (86.3)	76 (100)	75 (97.4)
Note-books	71 (100)	73 (100)	70 (92.1)	79 (100)	72 (100)	69 (91.0)	69 (86.3)	76 (100)	75 (97.4)
Arts	45 (63.4)	50 (68.5)	70 (92.1)	50 (63.3)	43 (59.7)	45 (59.2)	43 (53.8)	36 (47.4)	42 (54.5)
Toys	25 (35.2)	23 (31.5)	21 (27.6)	7 (8.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Snacks	71 (100)	70 (95.9)	67 (88.2)	75 (95.0)	67 (93.1)	69 (91.0)	62 (77.5)	72 (94.7)	48 (62.3)
Drinks	65 (91.5)	70 (95.9)	74 (97.4)	78 (98.7)	67 (93.1)	65 (85.5)	59 (73.7)	72 (94.7)	46 (59.7)

n – frequency

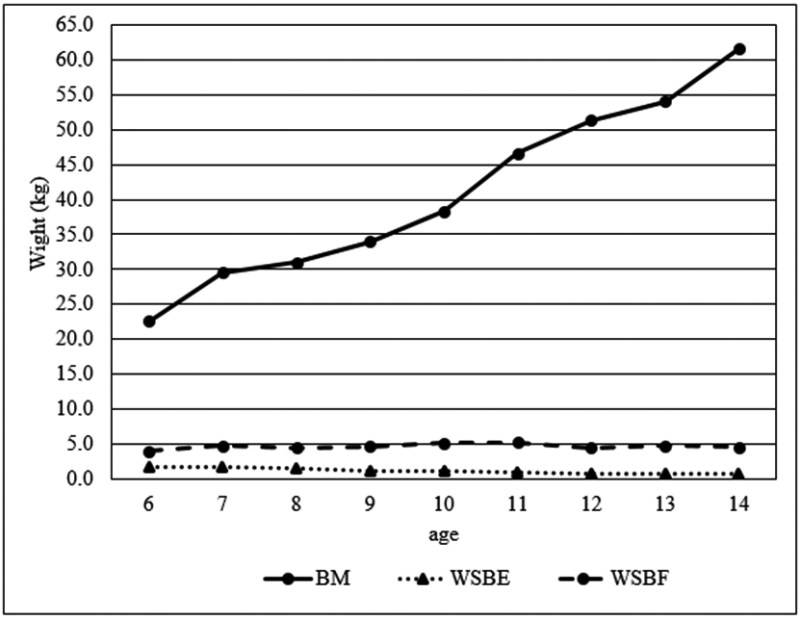

Figure 1. Development of Body Mass and School Bag Weight during School Attendance

a space for solutions on the part of the school management and teachers. Drinks that pupils bring to school with them are another significant item that affects the weight of the school bag. Some pupils had 1.5 to 2 liters of beverages. With regard to the recommendation of the total daily fluid intake for a child, such an amount is completely unnecessary. Children's total daily consumption is at the level of 40ml/kg of body mass (Malina, Bouchard, & Bar-Or, 2004; Machová et al., 2009). We cannot assess the share of the weight of toys as we did not weigh any toys.

Conclusion

The results of the research showed that the youngest pupils are mostly exposed to the risk of overburden of the bearing and locomotor system due to the carriage of a school bag of inadequate weight. The inadequate weight of the school bag affects posture and becomes a risk factor in the development of poor posture, which is subsequently projected into the increase in the occurrence of back pain. The weight of an empty school bag is a significant factor of the total weight of the school bag in the youngest pupils as it contributes to the total weight to a large extent. The results of the data on school bag contents indicated opportunities for reducing the weight of the school bag. Not only parents, but also teachers and medical workers should get involved in this process.

Teachers should inform parents of the risk of overburden to the bearing and locomotor system due to an inappropriate weight of the school bag as early as during enrolment, with emphasis on the weight of the empty school bag and a suitable design. Textbooks selected for lessons should be sets that have several parts and pupils should only bring those books that are currently used. Learning aids should remain at school. During lessons, teachers should inform pupils of proper posture during work and practice proper posture with them. For example, sitting with a rounded back leads to an increased load on the suboccipital muscles that control the position of the head, which subsequently leads to increased pain in the area of the neck. The occurrence of pain in the area of the neck was the most frequent in our research and it increased with age. Therefore, it would be very beneficial if teachers were trained in posture and proper working positions during various school activities. This area should be incorporated in further education of teachers.

Together with teachers, medical personnel should consider the implementation of a corresponding regular fluid intake of pupils, including recommendations of an optimal fluid intake during the stay at school so that pupils do not bring too many drinks to school.

Limits of the Study

We are aware that the results of the study are influenced by the monitored group (number and classification of participants). Also, the study could be restricted by the fact that the measurement only took place once (in one week) and was not repeated in another week. In spite of that we believe that the results have a predicative value with regard to the issue in question.

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