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Exploring School Ergonomics: Backpack use, Writing Posture and Musculoskeletal Health in Children with Spinal Deformity

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Methods: This is a cross-sectional study which includes 108children who had at least one spinal deformity. School backpack weight, backpack positioning, handwriting posture, and their correlations with postural deformities were analyzed. Body weight, backpack weight and backpack position were recorded. Writing position was assessed by Rapid Upper Limb Assessment (RULA). Posture analysis was conducted with observation to record other deformities except spinal deformities and total number of these deformities was recorded.

Keywords: *primary school, backpack, handwriting, posture.*

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Exploring School Ergonomics: Backpack use, Writing Posture and Musculoskeletal Health in Children with Spinal Deformity

Backpack and Handwriting among Children

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Results: It was found that most children with spinal deformity had inadequate backpack weight and incorrect writing posture. No relationship was shown among writing position (r=0.140), backpack position (r=0.045), and backpack weight/body weight (r=0.046) with other postural deformities. Although we cannot state that inappropriate writing or backpack use cause other deformities, we have seen that most children used inappropriate backpack weight and wrote in weak ergonomics.

Conclusion: Most children with spinal deformity used heavy backpacks with a low positioning on the back and their writing postures were not adequate so there is a need of change in these factors which are important determinants of schools ergonomics. Furthermore, children with spinal deformity tend to carry heavy backpacks and write inappropriately so future prospective papers may help to understand the "egg or chicken" relationship more clearly.

Keywords: primary school, backpack, handwriting, posture.

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I. Introduction

Children commonly start to face musculoskeletal problems at school ages, probably related to school based activities because children spend 30% of their time in school. One of the most common factors affecting the incidence of musculoskeletal discomfort is heavy school bags.[1] Children usually transport their books and school supplies by using backpacks as an external force to their bodies. These backpacks should be at safe load limit according to their body mass. In literature, range from 10% to 15% of children's body mass is acceptable for backpacks.[2,3] Carrying a heavy backpack may result in postural misalignment with musculoskeletal deformities including scoliosis, excessive kyphosis, lordosis and head tilt.[4,5] These issues are global concern and children are more affected than adults astheir bodies still grow while being exposed with these external forces [(5)]. Additionally, the upper side of backpack should be at shoulder level so upper positioning on back with bilateral straps is recommended for a less risky backpack carriage instead of low positioning and using of backpack with unilateral strap.[6]

Moreover, handwriting is an important basic skill that children need to practice this skill for several hours to take notes or do homework. Sitting posture may worsen while handwriting because children try to do beautiful handwriting or they may feel tired in time and not protect correct posture. Sitting with inappropriate positions for long duration affects spine, shoulders, and pelvis.[7] In literature, there is limited research about the effects of inadequate uses of backpacks and incorrect handwriting posture on musculoskeletal health or vice versa. Various musculoskeletal diseases such as disc hernias can develop or be triggered from early ages due to these ergonomic conditions of schools. Thus, if there is a relationship among them, it will be important to search further whether postural deformities cause inadequate ergonomic conditions or inadequate ergonomics results in more postural deformities.

The aim of this study was to determine the school backpack weight, positioning of backpack on spine, handwriting postures, and

postural deformities of schoolchildren who have at least one spinal deformity and then correlate these parameters.

II. Materials and Methods

This study was a cross sectional study. All data was collected in the last month of the Fall semester of 2019-2020 academic year in order to standardize academic loading on children.

a) Participants

The children who continued to 4thgrade in primary school and were 9 years old were included in the study because of their academic curriculums and their classroom locations. They have similar books etc. in their backpack and similar responsibilities at school. Moreover, in general, children had no problems about backpacks in the first years and they still try to find their best posture for handwriting in the first years of primary school, so the class was fixed rather than age. The schools in capital city of Nicosia were included in the study to exclude possible regional differences. The inclusion criteria were to be participated in a 4th grade, to have at least one spinal deformity which was determined with postural analysis (from anterior, posterior, and lateral),to have a backpack with straps, and to have a class in second floor since climbing up one floor with backpacks was fixed for the participants. All parents of these children were invited to the study.

The study was conducted in accordance with the recommendations of the Declaration of Helsinki. Before data collection, the children and their parents were informed about the purpose of the study and they signed informed consent forms. This ethical procedure was approved by the ministry of education in Northern Cyprus (İÖD.0.00-35/1B-988).

b) Procedure

Firstly, the parents or guardians were questioned whether they permit their children to be included in the study. Children of volunteer parents were included in the study. The assessments of every child took almost 30 minutes. All assessments were conducted by the first and second authors who were specialist physiotherapists. They shared the measurements so every measurement was conducted by the same researcher. The data was recorded by the third author to minimize bias.

c) Instruments

Socio-demographic information

Gender was recorded. After shoe removal, height and body weight were measured. Socioeconomic status of families was determined from the Socioeconomic Status Table which includes the occupation of parents.[8]

Backpack measurements

Full backpack weight was firstly measured. Secondly, position of backpack was recorded by measuring the distance between the upper border of the backpack and the C7 spinousprocess.[9] Children were also asked to wear their backpacks as usual and the use of shoulder strap was recorded as bilateral/unilateral

Writing position

The children were asked to sit down on their school chairs and desks with their shoes on. They were then asked to write a specific sentence “I always go to school” on a blank A4 paper placed in front of them and their posture was observed according to the Rapid Upper Limb Assessment (RULA). The RULA which is a reliable test for assessing the children in 8-12 years has scores for every region of body.[10] For example, how much neck/trunk flexion is done or whether the legs are supported. This was developed by Mc Atamney in 2005 to evaluate the ergonomics of people at their workplaces. The risk is calculated into a score of 1 (low) to 7 (high). RULA Scores 1 or 2 mean acceptable posture, 3 or 4 mean further investigation and change may be needed, scores 5 or 6 mean change soon is needed, and lastly score 7 means that implement change is needed.[10]

Musculoskeletal system problems

Posture analysis was conducted with observation from anterior, posterior, and lateral in barefoot condition. Total number of postural deformities including all postural deformities except spinal deformity such as pes planovalgus, genu valgum/varum, and anterior head tilt was recorded.

d) Data Analysis

The data were analyzed using the IBM Statistical Package for the Social Sciences (SPSS) 20.0. The qualitative findings were analyzed as frequencies and percentages (%). The quantitative findings were analyzed as means and standard deviations. Shapiro-Wilk test was used to analyze the distribution of the variables and the data was not normally distributed. The chi-square test was used to analyze the association between categorical variables. Difference on the $p<0.05$ level was statistically significant.

Since the data was not normally distributed, Spearmann correlation test was used to analyze the relationships. The correlation coefficient was classified as r =.00-.30: negliable, r=0.30–0.50: low, r=0.50–0.70: moderate, r=0.70–0.90: high and r=0.90–1.00: very high correlation.

III. Results

There were 968 children in the 4th year of the schools in Nicosia. 332 children had the criteria for inclusion in the study. 108 children (64 females, 44

males) were recruited with the consent of their caregivers. According to the socioeconomic level, 35.2%families were low, 41.7% families were middle, and 23.1% families were upper level.

When we analyze the results for the backpack, it shows that the mean backpack weight of the children was 5.83 ± 2.13 kg. In accordance with the body weight, we found that, the mean percentage was 16.17±6.68 (Table 1). When 15% was taken as a maximum limit, 62 children (57.4%) had heavy backpack. On the other hand, 10% was taken as a maximum limit, 88 children (81.5%) had heavy backpack.

Table 1: Descriptive results of the outcomes

	Mean ± SD
Body mass index (kg/m^2)	18.85 ± 3.92
Backpack weight (kg)	5.83 ± 2.13
Backpack weight/body weight (%)	16.17 ± 6.68
Backpack position (cm)	13.2 ± 6.62
Writing position (RULA)	5.02 ± 0.96

SD: Standart Deviation, RULA: Rapid Upper Limb Assessment

The mean distance between backpack to the neck region was 13.2 ± 6.62 cm. Additionally, it was observed that 92.6% of children used the bag straps bilaterally. According to the RULA, most of the children needed immediately change position (Table 2).

Table 2: The results of RULA

RULA	n(%)	
Score 1-2	6(5.6)	Risk negligible risk, no action required low risk.
Score 3-4	30(27.8)	Low risk, position change may be needed.
Score 5-6	72(66.6)	Medium risk, change may be needed, further investigation needed.
Score 6+	0	Very high risk, implement change now.

There was no relationship between the variables shown in the Table 3, except a low relationship between RULA and back extensor muscle strength.

Table 3: Correlations of backpack use and writing position with musculoskeletal factors

		Writing position (RULA)	Backpack position (cm)	Backpack weight/body weight (%)	Postural deformity	Extansor muscle strength
Writing position (RULA)	Speaman correlation	1	.045	-.046	.140	-.234*
	Sig. (2-tailed)		.646	.637	.150	**.015**
Backpack position (cm)	Speaman correlation	.045	1	-.093	-.066	.029
	Sig. (2-tailed)	.646		.337	.499	.763
Backpack weight/body weight (%)	Speaman correlation	-.046	-.093	1	.013	.037
	Sig. (2-tailed)	.637	.337		.890	.702
Postural deformity	Speaman correlation	.140	-.066	.013	1	-.161
	Sig. (2-tailed)	.150	.499	.890		.096
Extansor muscle strength	Speaman correlation	-.234*	.029	.037	-.161	1
	Sig. (2-tailed)	**.015**	.763	.702	.096	

IV. Discussion

In this study, we analyzed the school ergonomics of children with spinal deformity according to backpack use and handwriting positions and we found that most children used heavy backpacks and had inadequate postures while writing. These ergonomic parameters were not found to be correlated with other postural deformities.

Backpack weight is still a huge problem, and a solution has not found yet.[11] It was determined that the average backpack weight was 5.8±2.1 kg in our study. When we calculate the backpack percentage of body weight was 16.0±6.7%. This percentage is higher than acceptable range.[2,3] There may be different causes of this percentage. Moreover, most children used heavy backpacks considering the upper limits as both 10% and 15%. One of the most probable reasons is that many schools did not have private traps to prevent carry everything between home and school in Northern Cyprus. There are various studies which show the effects of inadequate use of backpacks on posture of children while using it.[5,12] Mo et al. showed that heavier backpacks caused an increase in forward head posture, rounded shoulder, and lateral tilt of shoulders while walking.[12] Vaghela et al. found a significant increase on sagittal shoulder posture of school children in standing with school backpack as compared to without backpack in standing [(5)]. Thus, it can be recommended that backpack-friendly school environments will be a good solution for excessive school backpack weights and their harms.

Additionally, Ramprasad et al.[13] reported that backpack load of even 5% of body weight can significantly change trunk and lower limb angles and 15% of backpack load changes all the angles pertaining to head, neck, trunk, and lower limb and affects overall posture. Apostol et al.[14] stated that lower placement of backpack on back causes more postural sways in the postures of children. While all these papers searched the changes in dynamic postures of children, our paper focused to investigate a correlation among backpack weight, backpack position over back and permanent musculoskeletal changes.[14] This will be a pioneer for the readers to discuss the findings of this paper since children with a spinal deformity used inappropriate backpacks and inadequate handwriting posture so these ergonomics probably deteriorates existing deformity/deformities if no intervention is applied in this condition.

Looking at the correlation results, there was no correlation between backpack use and musculoskeletal systems of children with spinal deformity. Although many factors were standardized with the same class and location of class, there are still factors which may cause this result because the children were included from different schools. The other reason may be related to the possible different use of backpacks according to the lectures in week. The other reason may be carrying duration of the backpacks as although we put a factor as second floor, in the capital city Nicosia, cars are commonly used for transportation and no children need to carry their backpacks for long times. We can conclude this result that inappropriate backpacks may not be a negative factor for musculoskeletal disorder even if child has a class in second floor. Nevertheless, further studies including children who carry their backpacks for longer durations are required.

In the past, handwriting posture was only investigated for the effects of dominant hemisphere of brain on various parameters.[15,16] Nowadays, it is popularly stated that bad postures of handwriting negatively affect the quality of writing, but more importantly, these postures may harm children's spines.[17] Moreover, today handwriting takes important roles to detect some mental diseases in earlier times and handwriting significantly contributes to improve fine motor skills of children so it should be searched more, especially for childhood.[18] According to the observation by the RULA, the children in our study had trunk flexion, lateral flexion, and rotation in general and repetitive loading was added to every child as handwriting is long lasting activity in education. Considering the mean result and percentages of the RULA, we showed that most of the children needed a change soon.

To our knowledge, no study showed the correlation of handwriting positions with musculoskeletal problems, or no paper investigated the effects of bad handwriting position on musculoskeletal system of children. Thus, our paper has a pioneer role that investigated the correlation between handwriting posture and musculoskeletal problems. However, we did not find any significant correlation between handwriting posture and postural deformities. Thus, when we consider that most children with spinal deformity used heavy backpacks and used inappropriate handwriting posture, we can conclude that these factors probably caused this spinal deformity/deformities. Number of deformities may not be adequate to show a correlation so different methods like measuring angles of trunk can be used to investigate more details about postural misalignment. More research with prospective controlled study designs is required to investigate the effects of handwriting and observe the changes over time on children's health.

V. Limitations and Suggestions for Future Research

As a cross sectional study, sample size was not specified with a power analysis as we had limited number of children due to the population of Nicosia city so we included all adequate children of volunteer parents. The other limitation is the use of field tests as

outcome measures since the children were included in their natural environments, schools. More objective outcome measures could be used to assess postural deformities in laboratories. Lastly, schools were different so their ergonomic conditions and socioeconomic levels of the parents were also different and it can be stated that these factor may affect the results.

Although there was no correlation between ergonomic factors determined and postural deformities, school ergonomics was weak in most of the children included. Most of the primary school children with spinal deformity used heavy backpacks. Moreover, these children had bad postures while writing. Thus, ergonomic interventions are required for handwriting postures and backpack use of children. Moreover, teachers may be educated by ergonomic experts collaboration with physiotherapists and an ergonomic education lecture may be integrated into the curriculum of schoolchildren. In conclusion, more studies with larger samples and different study designs will be beneficial to guide health professionals and school managements in terms of school related loading to musculoskeletal system of children.

Key Messages

- Most of the children with spinal deformities use heavy backpacks and the positions of their backpacks are incorrect.
- The handwriting positions need change soon among children with spinal deformities.
- The number of other postural deformities rather than spinal deformities is not correlated with the factors of school ergonomics.
- Teachers, particularly primary school teachers, should be careful about the postures of children while teaching them writing and using the school staff.

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Declaration of Interest Statement
None

Availability of data

The data that support the findings of this study are available on request from the corresponding author, [……]. The data are not publicly available due to the restrictions containing the privacy of participants.

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