Participation in Activities and Relationship to Musculoskeletal Pain in Elementary School Children

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Abstract

Introduction: The purpose of the present study was to examine whether 4th to 6th grade students report discomfort or pain in the musculoskeletal system, following participation in various activities at school and at home. In addition, our aim was to examine whether or not ergonomic principles are relevant for children, especially in various learning environments. **Methods:** Participants included 168 elementary school students from one school. The school is unique in that laptop computers are incorporated as an integral part of the teaching and learning processes for 5th – 6th graders. Students completed the Children and Youth activities Questionnaire used to characterize the type of activities and frequency of participation at school and at home. The students also reported whether they experienced any pain or discomfort during or after these activities. **Results:** Data analysis showed that students of different

grades preferred to engage in different patterns of activities. All the students used a computer at home and at school. The extent and frequency of computer usage increased with age. In addition, the students reported a high frequency of participation in strenuous physical activity. In general, the students in this sample reported low levels of discomfort or pain. However, it appears that the older the children get and school demands intensify, there is an increased frequency of reported discomfort in the head, neck and back. This was attributed to the increased use of a laptop computer at school and home. **Conclusion:** The findings of this study support the importance of developing an ergonomic instruction program for children, parents and teachers. In addition, it appears that a longitudinal study may provide additional important information on the influence of the various activities on the children's health.

Introduction

In recent years, there has been a growing awareness of the implications of ergonomic principles for the evaluation of children's and youth's learning environment, although it is still under investigation. Studies have reported an increase in the number of children who complain of musculoskeletal pain (Murphy, Buckle, & Stubbs, 2007; Trevelyan & Legg, 2006). The 'work' that children do occurs during play and in their role as students. They are engaged in various environments including school, home, and outdoor activities, in activities such as sports, music and computer games (Jacobs et al., 2002; Levanon-Erez & Weintraub, 1998). Although concerns have been raised regarding the influence of various activities on children's health, very little research has been conducted to explore the range of their activities, the frequency in which they engage in them and whether or not they have adverse effects on young children's health. The present study attempts to address these issues. The following review presents the current knowledge concerning various activities and their relation to musculoskeletal discomfort.

Sports

Participation in physical activity is an important component in the health of children. Physical activity that is appropriate for the child contributes to his/her physical, psycho-motor and intellectual development. It helps reduce risk factors such as obesity, diabetes, high blood pressure and osteoporosis. In addition to its health benefits, participation in physical activity enables social interaction, pleasure, relaxation and improved self-image (Collard, Verhagen, Chin-A Paw, & Mechelen, 2008; Shanmugam & Maffulli, 2008).

Several studies report that in recent years there has been a decline in the participation of children in strenuous physical activity. Kulling (2003) presents a summary of several surveys conducted in the United States to examine the extent to which school-aged children and youth participate in sports activities. He found that close to 60% of children do not participate in strenuous sports activities. Other researchers reported a link between children's computer use and the decrease in the frequency of participation in strenuous sports activities (Straker, Briggs, & Greig, 2002; Straker, Pollock, Zubrick, & Kurinczuk, 2005). There are studies that support the theory that children who participate in physical activity have a lower risk of developing musculoskeletal system disorders due to factors such as carrying school bags or using computers (American Chiropractic Association, 2002).

On the other hand, participation in vigorous sports can be harmful and cause injuries. In a literature review Shanmugam and Maffulli (2008) concluded that most of the sports activities of children and youth are safe, because their sports injuries are usually mild. However, they point out that training programs should take into account the children's lack of motor and psychological maturity in order to allow them to adapt to the changes occurring in their bodies. Jacobs et al. (2002) adds that adolescents who participate in vigorous physical activity are exposed to additional biomechanical risk factors due to inappropriate techniques, unsuitable equipment and carrying heavy bags.

Writing

Writing is one of the first skills that children learn in school and continues to refine over the course of their lives (Parush, Levanon-Erez, & Weintraub, 1998). Writing includes sensory-motor body components and ergonomic components in the child's environment (Feder, Majnemer, & Synnes, 2000; Gregg & Mather, 2002). A relationship was found between ergonomic biomechanics risk factors (such as body position, location of the paper and pencil, pencil grip consistency and stabilization of the paper) and the quality of both handwriting and keyboarding (Rosenblum et al., 2006; Parush, Pindak, Han-Markowitz, & Mazor – Karsenty, 1998). It appears that research regarding the effect of writing on the musculoskeletal system is limited and research mostly focuses on perceptual and cognitive writing factors.

Computer use

Children's school environment is in the process of changing. There is an increased use of computers and other electronic devices (tablet, smartphone) both at school and at home. In the United States and Sweden, standard textbooks are gradually being replaced by computerized online books (Straker et al., 2002). In Israel, pilot programs and initiatives in the educational system (private and national) began to incorporate personal laptop use (about 10 years ago) and more recently, tablets.

In the United States a telephone survey of 56,000 households found that 80% of kindergarten children (aged 5) use computers, and from grade six (age 11) and above most students use computers at home and at school. No gender differences were found, but race and socioeconomic status influenced the scope and frequency of computer use (the lower socioeconomic population reported a lower volume of use) (National Center for Education Statistics, 2005). In another study, Jacobs, Hudak, and McGiffert (2009) conducted a longitudinal study of 376 students in grades 6-7. About 90% of children reported that they use the computer between 0-6 hours a day and 10% reported using computers 4-6 hours daily.

Studies examining the impact of computer use on the health of adults point to a link between frequencies of computer use and the development of musculoskeletal disorders (Bernard, 1997; National Research Council and Institute of Medicine, 2001). Such a connection has not been thoroughly established through studies on children, but the importance of continued research on the subject is recognized (Barrero & Hedge, 2000; Jacobs & Baker, 2002; Straker et al., 2002; Williams & Jacobs, 2002). Studies that examined the impact of computer use on the health of children show mixed results. Some point to the possibility of negative effects and report that children working at a computer use postures which may constitute a health risk factor for their musculoskeletal system (Laeser, Maxwell, & Hedge, 1998; Oates, Evans, & Hedge 1998; Williams & Jacobs, 2002). Jacobs et al. (2009) reported that 41% of 352 middle school students complained of discomfort or pain in their musculoskeletal system after using the computer. Another survey, conducted in the United States among 476 students ages 12-18, reported significant differences in discomfort in neck and arms between children who use a computer on a daily basis, and those who seldom use a computer or not at all (Gillespie, 2006). In contrast, Straker and colleagues (cited in Bar-Haim Erez, Shenkar, Jacobs, & Gillespie, 2007) examined 884 adolescents and found no differences in reported neck and shoulder pain among adolescents who do not use computers and those who use a computer frequently.

Playing musical instruments

There are no recent studies that examined children's report of discomfort / pain in the musculoskeletal system from playing a musical instrument. Fry and Rowley (cited in Goodman & McGrath, 1991) examined the extensiveness of complaints of pain as a result of playing an instrument in 1,249 students attending the School of Music in Australia. He found that 9.3% of the students reported musculoskeletal difficulties related to overuse of the instrument. A correlation was found between reports of discomfort, increased length of playing time, and level of complexity of playing. In another study, Goodman and McGrath (1991) examined

169 children (aged 7-19) attending a music school. Seventy one percent of the children reported pain in various body parts.

Pain in the musculoskeletal system in children

The scope of children's complaints of musculoskeletal pain is still being investigated. In a retrospective study conducted in Madrid, the medical records of children aged 3-15 years who sought medical treatment in a public clinic were examined. It was found that 6% of all visits were due to muscular, joint and soft tissue pain. In addition, they found that the percentage of patients' complaints due to musculoskeletal pain increased with age. When the sample was examined according to age groups the researcher found that growing pains was the most common etiology underlying pain in kindergarten children (ages 3-5) (67%), pains in primary school children (ages 6-9) commonly stemmed from trauma (35%), and among adolescents (ages 10-14) pains commonly stemmed from overuse (66%) (De Inocencio, 2004).

Another interesting study was conducted by El-Metwally et al. (2004). They followed up on children (5th graders) who had participated 6 years earlier in a research that investigated musculoskeletal pain. Of the 564 children who reported pain in the first study, 53.8% continued to report pain. These studies do not emphasize the need to examine the factors that lead to a relatively high percentage of complaints of pain in the musculoskeletal system in children and adolescents.

A recent literature review of musculoskeletal discomfort among children using laptops or tablet computers for educational purposes, revealed increasing reports of an association between increased MSD complaints in children and use of laptops and tablet computers. Although children regularly use these devices in their everyday lives and at school, the research investigating MSD complaints and the use of such technologies is limited (Binboga & Korhan, 2014).

From the above literature review, it appears that there is a need to expand the knowledge about ergonomic risk factors that children are exposed to while participating in a wide range of activities. It is necessary to first identify those activities that caused the children's reported discomfort / pain. The purpose of this study was to examine whether students in 4th through 6th grades reported musculoskeletal discomfort or pain following participation in a variety of activities at school and at home. The study attempted to characterize both the extent of the phenomenon and the possible risk factors, such as type of activity and frequency.

Method

Participants

Included 168 students in 4th, 5th and 6th grade (see Table 1). All students were from one school in Israel, which incorporated the use of laptops in the regular 5th and 6th grade curricula.

Table 1

Participants: Grade and gender

4th Grade				5th Grade				6th Grade			
N=68				N=46				N=54			
Boys		Girls		Boys		Girls		Boys		Girls	
n	%	n	%	n	%	n	%	n	%	n	%
38	(56)	30	(44)	27	(59)	19	(41)	20	(37)	30	(63)

Measures

A translated version of the Young People's Activity Questionnaire was used (with permission from its developer Prof. Leon Straker, Curtis University). This questionnaire was developed for completion online by middle school students. The questionnaire was adapted for Hebrew speaking students and to be completed via a 'paper and pencil' format. The questionnaire underwent a validation process following the guidelines of Benson and Clark (1982) and Van de Vijver and Hambleton (1996). The validation process for content validity included: (a) a review of the translated questionnaire by 10 occupational therapists with expertise in ergonomics and in child development for the purpose of adapting it for use by elementary school children; (b) administration of the questionnaire to 30 children (4th through 6th grade) by occupational therapists for the purpose of examining whether the items were understood by children and the time it took for it to be completed; (c) a review by five elementary school teachers. The changes that were made were culturally and linguistically related; such as types of sports activities were changed to those commonly played in Israel, medical terms were omitted, and terms related to the reporting of frequencies were simplified.

The final translated version of the Young People's Activity Questionnaire includes 158 items and is divided into three main sections: (a) demographics,

medical and developmental history; (b) reports of pain or discomfort related to the musculoskeletal system, and (c) reported types of activities students participated in over the previous month. The children had to rate the frequency of participation in activities at school and outside of school and whether they experience pain due to these activities. The activities listed included: sports, watching TV, writing, reading, playing a musical instrument, leisure activities that require much hand use, playing electronic games, using the computer (PC and laptop use were listed separately). Frequency was related to both the number of times activities were engaged in per month or per week and the average length of engaging in that activity. The report of pain related to that experienced during the previous month and was rated via a numerical VAS scale (0=no pain and 10=extreme pain) for each area of the body (from head and eyes to lower extremities).

Procedure

Approval for the research was obtained from the scientific authority for research in the Education Ministry for the participating school. Letters were sent to all the parents explaining the research objectives and procedure. Parents who did not want their children to participate were requested to send the attached form back to the teachers, and those who agreed were asked to complete the questionnaire and return it to the teachers. Less than 10 parents declined consent for their children to participate in this research. Data was collected during a one-day period. Two occupational therapists were present in each classroom to explain the purpose of the study and how to complete the questionnaire. They remained in the classroom to assist the students and answer questions.

Data analysis

Analysis of the type of activities and frequencies of participation was carried out using descriptive statistics (percentages). The differences between grades in participation in the various activities were analyzed using non-parametric statistical methods, i.e., Mann-Whitney and Kruskal-Wallis tests. Reports of pain were analyzed in various ways:

1) Average pain was calculated for each student, regardless of body parts, and was used to analyze gender and grade differences. The differences between grades on average pain reported were analyzed using analysis of variance (ANOVA) and post hoc Scheffé. Gender differences were analyzed using independent t-tests.

2) Analyses of the frequencies of pain reported in each different body part were conducted and each activity was individually analyzed. Chi-square analysis was applied to assess the correlations between reported pain and the frequency of participation for each activity.

Results

Participation in Activities

Students in all grades reported that they frequently participated in sports, computer use at home and school, watching TV, writing, reading and playing electronic games (See Table 2). Significant differences were found between grades in reported frequencies of writing (Chi^2=16.31, p=0.00) and duration of writing (Chi^2=12.27, p<0.00). The Mann-Whitney test revealed that the 4th grade students reported higher frequencies and longer periods of writing compared to 5th and 6th graders (U=1092, p < 0.01).

Table 2

Participation in activities during the previous month: According to grade (%)

Activity	4th grade	5th grade	6th grade
Sports	65	80	76
Frequency > 3 times weekly	***58***	*38*	*36*
Watch TV	100	100	100
Frequency > 3 times weekly	*68*	*76*	*78*
Computer use – home	100	100	100
Frequency > 3 times weekly	*60*	*70*	***83***
Laptop use-school		100	100
Frequency > 3 times weekly		*30*	***92***
Electronic games	57	61	60
Frequency > 3 times weekly	*59*	*61*	*44*
Leisure activity	74	57	50
Frequency > 3 times weekly	***56***	*44*	*34*
Musical instrument	48	36	24
Frequency 1-3 times weekly	*56*	*44*	*27*
Writing	100	100	100
Frequency > 3 times weekly	***100***	*86*	*69*
Reading	100	100	100
Frequency > 3 times weekly	***53***	*28*	*35*

Data indicated that the 6th grade students tended to use computers more frequently and write less than 5th and 4th grade students. Sixth grade students used lap-top computers more frequently than 5th grade students (U=752, P<0.01). No differences were found in computer use (PC, laptops) at home.

Reported pain and activities

Analysis indicated that 54% of students reported discomfort in at least one area of the body. The students reported discomfort more frequently in the head, neck and eyes. The intensity of discomfort was low, mostly ranging from 1-4 on the VAS scale. Students reported discomfort mainly while watching TV, playing electronic games, using the computer and writing. Students who played musical instruments reported relatively high discomfort in the hand and neck (see Table 3). Chi-square tests indicated significant relationships between discomfort and frequency of participation in most activities, except for writing at school. Higher frequency of participation resulted in higher reports of discomfort.

Table 3

Musculoskeletal discomfort according to activity

Activity	Mean (SD)	*Reported discomfort	**VAS range (%)			
			1-2	3-4	5-6	>7
Sports	0.51 (0.4)	53%	46	7		
Watch TV	0.30 (1.0)	34%	29	3	1	1
Computer use – home	0.11 (0.3)	19%	18	1		
Laptop use-home	0.28 (0.4)	52%	50	2		
Laptop use-school	0.23 (0.6)	41%	37		4	
Electronic games	0.11 (0.4)	22%	21	1		
Leisure activity	0.27 (0.7)	27%	24	2	1	
Musical instrument	0.34 (0.9)	30%	24	4	2	
Writing	0.41 (0.7)	97%	93	3	1	
Reading	0.28 (0.7)	37%	33	3	1	

* percentage of participants who reported any discomfort (on the VAS) in any body part as a result of the specified activity.

** Values represent the percentage of participants who reported pain on the VAS

T-test analyses were carried out to assess gender differences. Results showed that girls reported higher levels of discomfort than boys while using lap-top computers at home ($t=2.31$, $p<0.05$) and at school ($t=2.09$, $p<0.05$). Multiple analysis of variance (MANOVA) analysis did not find an interaction effect between age and gender.

ANOVA tests were carried to assess age differences. Significant differences were found only between 5th and 6th grade students for the use of lap-top computers at home ($F=4.05$, $p<0.05$) and at school ($F=8.88$, $p<0.01$).

Discussion

The purpose of this study was to expand the knowledge concerning the scope of participation of elementary school students in different activities, and to examine the relationship between the frequency of participation to the reports of musculoskeletal discomfort and pain.

Participation in activities

Elementary school students in this study reported high percentages of participation in sports activities, computer use, watching TV, reading and writing. More than 80% of students of all ages reported participation in vigorous physical activity more frequently than once a week, and for a continuous period of between 1-2 hours. These findings differed from those of Kulling (2003) who presented a summary of several surveys conducted in the United States. In his examination of the extent of participation of school-age children in sports activities, close to 60% of children did not participate in strenuous sports activities.

Straker et al. (2002; 2005) found an association between increasing frequencies of computer use to decreased frequency of participation in strenuous sports activities among children. The current sample showed a similar trend. Students in 4th grade reported a higher frequency and duration of participation in sports activities and a lower frequency of computer use as opposed to students in 6th grade who reported the opposite trend; lower frequency of participation in sports and higher frequency of computer use.

Studies conducted in various Western countries point to an increase in the use of computers by children. A longitudinal study of children in the United States revealed that in 1990 only one child out of 50 used a computer outside of school hours (Rocheleau, 1995). However, recent statistics indicate that 80% of American children in kindergarten use a computer after school, while use among older children is almost 100% (National Center for Education Statistics, 2005). Approximately 70% of the students in 4th - 6th grades reported that they use computers in school at a frequency of one to three times a week for a continuous period of up to an hour. In 6th grade, about 90% reported using a computer at a frequency of more than three times a week for over an hour at a time. Harris and Straker (2000) surveyed 314 students

(aged 10-17 years) who attended three Australian schools that required the use of a laptop as part of the curriculum. The duration of the average daily use of the laptop was 3.2 hours (maximum 15 hours) and average weekly use was 16.9 hours (maximum 80 hours). In another longitudinal study conducted in the United States among 376 students in grades six and seven, 90% of the students reported that they use the computer for 0-6 hours a day and a large percentage reporting using the computer 4-6 hours per day (Jacobs et al., 2009).

Musculoskeletal discomfort and participation in activities

In the present study 54.5% of the students reported general musculoskeletal discomfort in at least one area of the body. However, it appears that the level of pain was relatively low, thus we labeled it as discomfort. These findings are similar to a study that examined 152 children from 6th - 8th grades in the United States (Jacobs & Baker, 2002). Examination of the relationship between the activities and the reported pain revealed that students of different grades attributed the pain to different activities: 4th graders reported more discomfort after sports and writing; 5th graders after sports, playing a musical instrument, reading and recreational activities; and the 6th graders after playing a musical instrument, sports, using the computer at home and writing. We will now elaborate on the main activities which resulted in musculoskeletal discomfort in our study.

Writing. It is noteworthy that the highest percentage of reported discomfort in all grades was while writing. Most students reported frequently writing (more than three times a week). There is a paucity of studies that assessed children's complaints of musculoskeletal pain as a result of writing. One study examined 181 children aged 10-19 years attending regular schools. The children were asked to report pain following different activities and the majority of children who reported pain, said it was mainly due to writing (Fry & Rowley, cited in Goodman & McGrath, 1991).

Some researchers believe that children are at high risk of developing musculoskeletal pain or discomfort as a result of long hours of sitting on furniture that does not suit them (Cardon, DeClercq, De Bourdeaudhuji, & Breithecker, 2004; Storr-Paulsen & Aagaard-Hansen, 1994; Yeats, 1997). The students in our study complained of discomfort in the neck and in the palm of the hand while writing. Murphy et al. (2007) reported that out of 679 children aged 11-14 years who participated in their study, 27% reported that they suffer from neck pain. They have linked this pain to the characteristics of school furniture. Other researchers who examined the relationship between ergonomic factors and writing among students in the 3rd grade, found differences between skilled and non-skilled writers in factors such as: body posture, pencil grip,

the position of the pencil and consistency of the grip position. Skilled writers used considerably better biomechanical positions than less skilled writers. They concluded that there are significant relationships between ergonomic factors (body position, positioning the pencil grip consistently) and the quality, efficiency and process of writing (Parush et al., 1998; Rosenblum et al., 2006). Perhaps the discomfort reported by the students in the current study is due, at least in part, to long hours of sitting on inappropriate furniture.

Sports. In this study, students in all grades reported musculoskeletal discomfort after strenuous physical activity. Similarly, Royster and Yearout (cited in Bennett, 2002) found that children tend to report discomfort or pain while participating in physical activity. One explanation may be due to minor injuries such as muscle fatigue and the like, which do not result in physical limitations, but cause pain. Studies examining sports injuries in children indicate a relatively high incidence of injuries, however researchers say it is difficult to get an epidemiological pattern since various studies define injury differently (Collard et al., 2008; Shanmugam & Maffulli, 2008). Another explanation for sports injuries in children may be the use of equipment that is not tailored for their size. According to Jacobs et al. (2002), youths who participate in sports activities often use inappropriate equipment and techniques that may cause damage to the musculoskeletal system.

Computer use. In most activities involving exposure to screens (computers, television and electronic games) students reported a relatively high level of discomfort in the eyes, head and neck. There are several studies that reported similar findings in children and adults (Sommerich, Joines, Hermans, & Moon, 2000; Williams, 2002). Breen, Pyper, Rusk, and Dockrell (2007) examined 68 children in 4th grade (mean age 9.5 years) and found that 16% of the children reported pain due to using a computer. Eighty-seven percent of the pain was in the cervical spine and back and the remaining 13% was in the lower limbs. Harris and Straker (2002) surveyed 314 students (ages 10-17 years) from three Australian schools that require the use of a laptop as part of the curriculum. Most reports of discomfort in the musculoskeletal were in the neck, upper back, wrist and knees.

In the present study 52% of the students in the 5th and 6th grades also reported pain in their lower limbs when using a laptop at home. This may be due to use of a laptop in a variety of rooms and postures at home, such as sitting on a couch or bed with the computer on the students legs, which is not possible at school. In addition, significant differences in reported musculoskeletal discomfort were found between 5th and 6th graders with respect to the use of a laptop at school and at home. This may be due to the increased frequency of using computers reported by the 6th graders. Jacobs and Baker (2002) revealed similar findings. They examined the relationship between computer use

and musculoskeletal discomfort among 152 students in the 6th grade. They found that over 50% of the students reported some discomfort during the past year.

In their study dealing with ergonomic issues related to computer use among elementary school students, Zovkic et al. (2011) pointed out that laptop ergonomics is not ideal because they do not have height adjustment options, and the keyboard and the screen are too close to one another. Low position of a screen may lead to unconscious leaning forward and thus to neck and/or back pain.

Straker et al. (2005) examined the role of body biomechanics and the position of the torso while reading a book using a stationary and laptop computer among 33 children (ages 4-17). They found that in comparison to reading from a stationary computer, reading from a laptop computer results in the head tilting, the neck flexing and the requisite viewing angle is larger. The neck flexion was found to increase with age. In a recent literature review the authors suggested that the increased MSD complaints found among students may be due to the increased use of tablets, laptop computers and other hand held devices that support student-centered interaction-based learning together with poor adaptation of furniture in the classroom (Binboga & Korhan, 2014).

Another perspective on the findings of the present study concerning the reported discomfort while engaging in activities involving "screens" can be explained by the sedentary characteristics of these activities. Tremblay et al. (2011) conducted a systematic literature review aimed at examining the relationship between sedentary behavior and health in school-aged children and youth. Their main finding was that there is a large body of research that suggests that increased time spent in sedentary activities (such as watching TV, computer use, etc.) alongside decreased time spent participating in sports, are associated with increased health risks among children and youths aged 5-17 years.

With respect to the use of laptop computers, statistical differences between genders were also found, indicating that girls reported relatively higher levels of discomfort than boys. These findings are in line with other studies that reported higher levels of pain among girls compared to boys. De Inocencio (2004) carried out a retrospective study to examine the incidence of referrals of children aged 3-14 (N = 317) to clinics in the community due to musculoskeletal pain. He found that girls were referred to the clinics significantly more often than boys. Gillespie (2002) conducted a literature review in order to determine the effect of the use of computers and electronic games on children's health. She reported that studies show that girls generally report more symptoms than boys. In another literature review, which examined the major risk factors for the development of back pain among school-age children (11-14), the findings

were similar (Trevelyan, & Legg, 2006). Briggs, Straker, and Greig (2004) found that when reading from a stationary or mobile PC, girls bent their necks more than boys. The researchers showed statistically that the differences did not arise from differences in body dimensions.

Clinical implications

The findings of the present study revealed that more than half of the children reported low levels of discomfort / pain. The children complained of discomfort most frequently while writing and while using a computer. During both of these activities, children tend to sit for long periods of time. Studies indicate that habits of sitting and working are acquired at a young age therefore it is important to teach children safe working habits even at elementary school age (Marschall, Harrington, & Steele, 1995; Yeats, 1997). It appears that the information drawn from this study supports ergonomic intervention including the training of teachers, parents and children. This kind of intervention enhances the adjustment of the learning environment and the acquisition of proper work habits. Occupational therapists specialize in ergonomic intervention counselling and are part of the multi-disciplinary team of the education system. Health promotion is a key element of occupational therapy and the findings of this study support the need for developing ergonomic interventions for schoolchildren.

Study limitations and recommendations for continued research

The current study has a number of limitations. First, it was conducted on a convenience sample. Moreover, the school in which the research was conducted is located in a neighborhood whose residents enjoy a high socioeconomic status and does not reflect the general population in Israel. In addition, the children in grades five and six participated in a program of using laptops as an integral part of the school curriculum, which is not typical of most students in the National School System. Of note, the study is the first of its kind performed on the population of elementary school students and thus, no previous data exists for some of the findings with which to compare ours to. Finally, data collection was done using a translated questionnaire of activities for children and youths and is in the initial process of being researched and validated. The findings show that children report relatively low levels of discomfort / pain. However, there are studies that indicate an increased level of complaints of musculoskeletal pain in adolescence (De Inocencio, 2004; El-Metwally, 2004). It seems that conducting a longitudinal study to track children from elementary school to middle school may add important information on the impact of various activities on the health of children.

Summary

The purpose of this study was to examine whether students in 4th - 6th grades reported

musculoskeletal discomfort following participation in a variety of activities at school and at home. Similar to reports from other countries in the Western world, all the students in the sample reported that they use computers both at home and at school. It appears that the scope and frequency of computer use increases with age. Our results indicate that as the children grow, along with the increase in demands made of them, there is a rising prevalence of discomfort / pain reported. The findings are consistent with findings from previous studies and raise the need to examine the impact of using computers at home and at school on the health of students.

References

American Chiropractic Association. (2002). *Health tips*. Retrieved from http//www.acatoday.com.

Bar-Haim Erez, A., Shenkar, O., Jacobs, K., & Gillespie, R. M. (2007). Ergonomics for children and youth in the educational environment. In K. Jacobs (Ed.) *Ergonomics for therapists* (3rd ed., pp. 246-264). Elsevier: St. Louis.

Barrero, M., & Hedge, A. (2000). *School ergonomics program: Guidelines for parents*. Retrieved from http://ergo.human.cornell.edu/mbergo/intro.html

Bennett, C. L. (2002). Computers in the elementary school classroom. *Work, 18*(3), 281-285.

Benson, J., & Clark, F. (1982). A guide for instrument development and validation. *American Journal of Occupational Therapy, 36*, 789-800.

Bernard, B. (1997). *Musculoskeletal disorders in the workplace*. Washington D.C., National Institutes for Occupational Safety and Health.

Binboga, E., & Korhan, O. (2014). Posture, musculoskeletal activities, and possible musculoskeletal discomfort among children using laptops or tablet computers for educational purposes: A literature review. *Journal of Science Education and Technology, 23*(5), 605-616.

Briggs, A., Straker, L., & Greig, A. (2004). Upper quadrant postural change of school children in response to interaction with different information technologies *Ergonomics, 47*(7), 790-819.

Breen, R., Pyper, S., Rusk, Y., & Dockrell, S. (2007). An investigation of children's posture and discomfort during computer use. *Ergonomics*, *50*(10), 1582-1592.

Cardon, G., De Clercq, D., De Bourdeaudhuji, I., & Breithecker, D. (2004). Sitting habits in elementary schoolchildren: A traditional versus a Moving school. *Patient Education and Counseling*, *54*(2): 133-42.

Collard, D. C., Verhagen, E. A., Chin A Paw, M. J., & Mechelen, W. V.

(2008). Acute physical activity and sports injuries in children. *Applied Physiology*, *33*, 393-401.

De Inocencio, J. (2004). Epidemiology of musculoskeletal pain in primary care. *Archives of Disease in Childhood*, *89*(5), 431-434.

El-Metwally, A., Salminen, J. J., Auvinen, A., Kautiainen, H., & Mikkelsson, M. (2004). Prognosis of non-specific musculoskeletal pain in preadolescents: A prospective 4-year follow-up study till adolescence. *Pain, 110*, 550-559.

Feder K., Majnemer A., & Synnes, A. (2000) Handwriting: Current trends in occupational therapy practice. *Canadian Journal of Occupational Therapy*, *6*, 197-204.

Gillespie, R. M. (2002). The physical impact of computers and electronic games on children and adolescents, a review of current literature. *Work*, *18*, 249-259.

Gillespie, R. M. (2006). *CAKE* (Computers and Kids' Ergonomics): The musculoskeletal impact of computer and electronic game use on children and adolescents. (Unpublished dissertation). New York University: New York.

Goodman, J. E., & McGrath, P. J. (1991). The epidemiology of pain in children and adolescents: A review. *Pain*, *46*, 247-434.

Gregg N., & Mather, N. (2002) School is fun at recess: Informal analyses of written language for students. *Journal of Learning Disabilities*, *35*, 7-22.

Harris, C., & Straker, L. (2000). Survey of physical ergonomics issues associated with school children's use of laptop computers. *International Journal of Industrial Ergonomics*, *26*, 337-346.

Jacobs, S., Bhasin, G., Bustamante, L., Buxton, J. C., Chiang, H. A., Greene, D., . . . Wieck, A. (2002). Everything you should know about ergonomics and youths but were afraid to ask. *OT Practice*, *27*, 11-18.

Jacobs, K., & Baker, N. A. (2002). The association between children's computer use and musculoskeletal discomfort. *Work*, *18*, 221-226.

Jacobs, K., Hudak, S., & McGiffert, J. (2009). Computer- related posture and musculoskeletal discomfort in middle school students. *Work*, *32*, 275-283.

Kulling, F. K. (2003). Special considerations in the pediatric and adolescent athlete. In DeLee & Drez's (Eds.) *Orthopedics sports medicine* (2nd ed., pp. 621-625). Saunders, Elsevier:US.

Laeser, K. L., Maxwell, L. E., & Hedge, A. (1998). The effects of computer workstation design on students posture. *Journal of Research on Computing in Education*, *31*, 173-188.

Marschall, M., Harrington, A. C., & Steele, J. R. (1995). Effect of workstation design on sitting posture in young children. *Ergonomics, 9*, 1932-1940.

Murphy, S., Buckle, P., & Stubbs, D. (2007). A cross-sectional study of self-reported back and neck pain among English schoolchildren and associated physical and psychological risk factors. *Applied Ergonomics, 38*, 797-804.

National Center for Education Statistics (2005). *Rates of computer and internet use by children in nursery school and students in kindergarten through 12th grade.* Department of Education: Washington, DC, U.S.

National Research Council and Institute of Medicine (2001). *Musculoskeletal disorders and the workplace: Low back and upper extremities.* Washington, DC: National Academy Press.

Oates, S., Evans, G., & Hedge, A. (1998). A preliminary ergonomic and postural assessment of computer work setting in American elementary schools. *Computers in the Schools, 14*(3), 55-63.

Parush, S., Levanon-Erez, N., & Weintraub, N. (1998). Ergonomic factors influencing handwriting performance. *Work*, 11, 259-305.

Parush, S., Pindak, V., Han-Markowitz, J., & Mazor – Karsenty, T. (1998). Does fatigue influence children's handwriting performance? *Work, 11*, 307- 313

Rocheleau, B. (1995). Computer use by school-age children: Trends, patterns and predictors. *Journal of Educational Computing Research 12*, 1-17.

Rosenblum, S., Goldstand, S., & Parush, S. (2006). Relationship among biomechanical ergonomic factors, handwriting product quality, handwriting efficiency and computerized handwriting difficulties. *American Journal of Occupational Therapy, 60*, 28-39.

Shanmugam, C., & Maffulli, N. (2008). Sports injuries in children. *British Medical Bulletin, 86*, 33-57.

Sommerich, C. M., Joines, S. M. B., Hermans, V., & Moon, S. D. (2000). Use of surface electromyography to study neck muscle activity. *Journal of Electromyography and Kinesiology, 10*, 377-398.

Straker, L., Briggs, A., & Greig, A. (2002). The effect of individually adjusted workstations on upper quadrant posture and muscle activity in school children. *Work, 18*, 239-248.

Straker, L. M., Pollock, C. M., Zubrick, S. R., & Kurinczuk, J. J. (2005) The association between information and communication technology exposure and physical activity, musculoskeletal and visual symptoms and socio –

economic status in 5-year-olds. *Child: Care, Health & Development, 32*, 343-351.

Storr-Paulsen, A., & Aagaard-Hensen, J. (1994). The working positions of schoolchildren. *Applied Ergonomics, 25*, 63-64.

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., . . . Gorber, S. C. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 98

Trevelyan, F. C., & Legg, S. J. (2006). Back pain in school children – Where to from here. *Applied Ergonomics, 27*, 45-54.

Van de Vijver, F., & Hambleton, R. K. (1996). Translating tests: Some practical guidelines. *European Psychologist, 1*, 89-99.

Williams, C. D., & Jacobs, K. (2002). The effectiveness of a home – based ergonomics intervention on the proper use of computers by middle school children. *Work, 18*, 261-268.

Yeats, B. (1997). Factors that may influence the postural health of schoolchildren (K-12). *Work, 9*(1), 45-55.

Zovkic, M., Vrbanec, T., & Dobsa, J. (2011). Computer ergonomics of elementary school students. In Proceedings of the 22nd Central European Conference on Information and Intelligent Systems Varazdin, Croatia, (pp. 37–45).