Musculoskeletal impact of computer and electronic game use on children and adolescents

R.M. Gillespie[a], M. Nordin[b], M. Halpern[b], K. Koenig[c], N. Warren[d], M. Kim[e]

[a] *454 Fort Washington Ave, #66 New York, NY 10033 USA*
[b] *Graduate Program of Ergonomics and Biomechanics, New York University, New York, NY 10014, USA*
[c] *Department of Environmental Medicine, New York University School of Medicine, New York NY 10016 USA*
[d] *Occupational and Environmental Health Center, University of Connecticut, Farmington, CT 06030 USA*
[e] *Department of Epidemiology & Population Health, Albert Einstein College of Medicine, Bronx, NY 10461 USA*

Abstract

Children and adolescents engage in activities similar to demands known to cause musculoskeletal disorders in working adults. In this study, computer and electronic game use were proposed as contributors to neck or upper extremity (NUE) symptoms of pain or discomfort in adolescents. A cross-sectional survey was distributed in a northeastern US city. Subjects reported use of computers at school and home, TV-based games, and hand-held games, exercise, musculoskeletal symptoms occurring in the past month, demographics and personal characteristics.

Frequent home computer users (daily or almost daily) were at increased odds of reporting NUE symptoms compared to less frequent users (OR=1.7, 95% CI=1.2-2.4). School computer use and electronic game use were not associated with increased NUE symptoms. Age, race or gender did not confound the relationship.

Girls were more likely to report NUE symptoms than boys (OR=1.6, 95% CI=1.1-2.4). Being overweight and wearing vision correction were associated with symptoms.

As computer use patterns and weight are modifiable characteristics, they suggest targets for reducing the negative effect of computer use in this population. Additional research and interventions involving the roles of physical activity, equipment design, psychosocial demands and physical development are recommended.

Keywords: musculoskeletal symptoms/disorder, epidemiology, school, technology

1. Background

Using a computer at work is thought to be associated with neck and upper extremity (NUE) symptoms and clinical disorders [1, 2]. Posture, duration, frequency and force are the physical exposure parameters of concern.

Most children and adolescents in the United States use computers and electronic games regularly as reported in surveys and government statistics [3, 4] Although use levels are not the same as for adult computer users who are at risk of work-related upper extremity problems, children's overall burden of computer and electronic device use is notable. Combined media use estimates approach a working day, with combined keyboard and game use accounting for up to three hours [5]. Newer technologies such as text-messaging phones may add to the load.

Musculoskeletal pain and discomfort are common in children and adolescents, although as yet tendonitis, neuropathies and other clinical syndromes typically related to computer use are reported rarely [6]. Thus it

may be difficult to identify an increase in symptoms related to computer or electronic game use unless the difference in symptoms rates between frequent users and less frequent users is quite large.

It is clearly possible that computer and electronic game use poses musculoskeletal risks for young users [7]. Clinical syndromes can be caused by game use: Cleary [8] and Macgregor [9] have described cases of game-related tendonitis and neuropathy. With the expansion of the Internet access, home computer use and electronic games, any problems can be expected to accelerate in the next few years, as they have in the workplace following the introduction of computers. Trends in physical activity and weight may also have an impact on musculoskeletal symptoms in young people who use computers.

The current study was designed to identify the impact of computer and other electronic device use on the prevalence of musculoskeletal symptoms, the size of any impact, and what activities, use patterns or personal characteristics might modify the effect. Increased risk was expected to be related to frequent and extended use because of repeated microtrauma and limited recovery times, and to equipment position because of related constrained and awkward postures.

2. Methods

2.1. Study design

A six page cross-sectional written questionnaire was designed and tested by the first author. Question content was drawn from survey research in occupational ergonomics, physical activity and pain reporting in children. In field tests the survey questions showed moderate to good retest reliability in 40 adolescent subjects, but external validity was not measured [10]. Subjects reported frequency, average duration and maximum duration without a break for computer use at home and school, electronic game use and exercise. Questions about equipment position (monitor, keyboard, other input device and foot support) and type (desktop, notebook, hand-held game and TV-based game) were used as approximate measures of biomechanical demand. Symptoms occurring in the past month were marked freely on a body map, and rated for intensity and frequency on five-point scales for defined body areas. Demographic and personal characteristics included race, gender, age, height, weight and vision correction. Risk of overweight was defined as having an age and gender normed body mass index greater than 85th percentile, as calculated using the NutStat program in EpiInfo 2000 (CDC, Atlanta, Georgia, USA).

2.2. Subjects

All school principals in the small northeastern US city were asked to randomly select general education classrooms heterogeneous for academic standing and interests from the three middle and two high schools in the district. The study group consisted of 636 12-18-year-olds, about 14% of the district population in this age range.

Surveys were distributed during school time by the investigator and assistants. Losses included 14 parents and 33 subjects who refused consent, 97 subejects absent or missing from the survey session, and 16 surveys with pervasive spurious responses. Thus 476 usable surveys were obtained, representing 75% of the study group and 10% of the students in the district. The average age was 14; 47% were girls and 45% boys, with 8% not reporting gender. Subjects were predominantly White (79%), 4.3% were Black, 9.5% Hispanic, 1% Asian, and 4.5% of multiple ethnicity. Socio-economic status was not determined.

2.3. Statistics

Differences in proportions were assessed using Pearson's X^2 test. Ordinal exposure associations are reported as Spearman's rank order correlation coefficients. Univariate and multivariate unconditional logistic regression analyses were performed to evaluate predictors of binary symptoms variables and estimate odds ratios, unadjusted and adjusted for age, race and gender. Significance was defined as $p<.05$, and 95% confidence intervals for odds ratios are reported. SPSS 10.0.05 was used (SPSS Inc., Chicago, IL).

3. Results

3.1. Exposure and symptoms patterns

Daily or almost daily computer use was reported by about half of the respondents, as illustrated in table 1. Only daily TV watching was more common, at 62%. Frequent hand-held game use was rare, as was regular computer use at school. Girls were less likely than boys to report using electronic games ($p=.001$) or exercising

frequently (p= .03). Game use and exercise also decreased with age (p=.01). Hand-held game use

Table 1
Activity reporting (%) , descending frequency

Activity (N)	Daily	2-3/ week	1/ week	<1/ week
TV (475)	62.2	24.6	7.4	5.6
Home computer (476)	54.2	22.9	8.8	14.0
Exercise (475)	39.7	35.5	12.6	12.0
TV-based game (476)	31.7	23.7	12.4	32.2
Hand-held game (474)	9.0	11.3	9.7	69.5
School computer (476)	8.8	10.7	12.8	67.6

Table 2
Activity times (descending mean hours/day) (N=476)

	Weekday	Weekend	Without a break
TV	2.3	3.0	--
Computer at home	1.6	2.2	1.3
Exercise	1.5	2.0	--
TV-based game	1.0	1.8	1.0
Computer at school	0.5	--	0.6
Hand-held game	0.4	0.7	0.5

and TV-based game use frequency were correlated (Spearman's rho=0.37, p<.001) but no other activities were associated when adjusted for age and gender.

Television occupied the most time followed by home computer use, as shown in table 2. Along with TV-based game use, these were extended as well as frequent. School computer use and hand-held game use were brief and infrequent.

Symptoms were common, as shown in table 3, with 71% indicating some pain or discomfort in the past month. Girls reported more neck and upper back symptoms than boys (p=.01). Low back symptoms increased significantly with age (p=.03). No other symptoms differed significantly across demographics categories.

Severity scores were calculated by multiplying the intensity as reported on a 5-point scale by the symptoms frequency in days per month. The mean score was highest for low back symptoms, followed by the neck and upper back (data not reported).

3.2. Associations

3.2.1. Electronic activities

Associations between electronic activity frequencies and NUE symptoms are shown in table 4.

Table 3
Subjects marking symptoms on the body map

Area	N	%
Any	337	70.8
Any NUE	219	46.0
Hips, legs or feet	145	30.5
Neck	137	28.8
Lower back	132	27.7
Wrists or hands	95	20.0
Midback	94	19.7
Upper back	77	16.2
Shoulder	62	13.0
Arms or elbows	52	10.9

Subjects who used a computer daily or almost daily at home were significantly more likely to report NUE symptoms, compared to those using it less (OR=1.7, 95% CI=1.2-2.4). Moderate users (2-3 days a week) were not more likely to report symptoms than were infrequent users.

Adjusting for gender, age and race did not affect the estimates of the odds ratios: These characteristics did not confound the relationship between home computer use frequency and symptoms reporting.

Subjects using the computer for longer on a typical day did not report NUE symptoms more than briefer users. Those using for longer without a break did report more symptoms, but the increase started with any use over 0.5 hour (adjusted OR =2.1, 95% CI=1.1-4.0, for 0.5-1.5 hours compared to less.) The results for more than 2 hours compared to less than 0.5 are similar but marginally significant.

Game use and school computer use frequency or times did not predict NUE symptoms. Although years of TV-based game use did, the odds increased by only 10% a year and were close to the non-significant ORs seen for other electronic devices (data not reported).

Computer use frequency did not predict symptoms outside the NUE There were a few associations not related to the study hypotheses: Subjects who exercised daily were more likely to report symptoms in the lower extremities (adjusted OR=0.1.7, 95% CI=1.1-2.6). Daily readers reported more shoulder symptoms (adjusted OR=2.0, 95% CI=1.1-3.7. Daily TV-based gamers and daily TV watchers reported more midback symptoms (adjusted OR=1.8, 95% CI=1.0-3.2 and OR=1.7, 95% CI=1.0-3.0, respectively).

Table 4
Associations between electronic device use and neck or upper extremity symptoms

	NUE symptoms N (%)		OR (95% CI)	
	Daily users	Less frequent	Unadjusted	Adjusted*
Home computer	134 (51.9)	85 (39.0)	1.7 (1.2-2.4)	1.7 (1.1-2.5)
School computer	20 (47.6)	199 (45.9)	1.1 (0.57-2.0)	1.0 (0.53-2.0)
TV-based game	65 (43)	154 (47.4)	0.84 (0.57-1.3)	0.91 (0.58-1.5)
Hand-held game	16 (37.2)	201 (46.6)	0.68 (0.36-1.3)	0.68 (0.32-1.4)

*for age, gender and race

Table 5
Associations between personal characerisitcs and neck or upper extremity symptoms

	NUE symptoms	OR (95% CI)	
	N (%)	Unadjusted	Adjusted*
Female gender	115 (51.3)	1.6 (1.1-2.4)	1.6 (1.1-2.4)
At risk of overweight or overweight	41 (54.7)	1.4 (0.86-2.4)	1.8 (1.0-3.1)
Vision correction	84 (53.8)	1.6 (1.1-2.4)	1.4 (0.96-2.2)

*for age, gender and race

3.2.2. Equipment use position

No association was seen between equipment use position or type and NUE symptoms when analyzed over all subjects. Among predominantly game users, those using a control device on the lap, compared to a tray or table, were less likely to report NUE problems (adjusted OR=0.29, 95% CI=0.11-0.7).

Whether subjects used computers or game devices most did not affect NUE symptoms. Computer users did not report significantly more symptoms than game users, although computer use might be thought to pose a bigger risk, based on the data reported above.

3.2.3. Other factors

In univariate logistic regression, being a girl, being at risk of overweight and using vision correction were the only personal factors associated with NUE symptoms at the $p<0.2$ level. Daily exercise was protective at this level (OR=0.78, 95% CI=0.54-1.1). When these variables were entered with the electronic activities, race and age into a backwards stepwise regression procedure, the variables in the final model were daily home computer use (OR=1.9, 95% CI=1.2-2.9), being a girl (OR=1.8, 95% CI=1.1-2.8), wearing glasses or contact lenses (OR=1.7, 95% CI=1.1-2.8), and being at risk of overweight (OR=1.7, 95% CI=0.97-3.0), very close to those for the univariate analyses in table 5. Interaction effects were not significant.

4. Discussion

In this population, home computer use frequency was the only significant electronic predictor of NUE symptoms. The effect size of daily home computer use - almost a doubling of odds compared to less frequent users - was high enough to be of concern. The mechanisms by which home computer use (not to mention overweight, gender and vision correction) act were not determined.

Duration of daily use did not predict outcomes. Uninterrupted duration of home computer use was a significant predictor, but not a sensitive one. This may be related to limitations of self-reported time of device use, including variability in time of use.

Notably, electronic game use was not associated with NUE symptoms. Observations of children's contorted postures using hand-held devices and TV-based games inspired this project, so this came as a surprise, especially in view of the strong and consistent associations seen between NUE symptoms and computer use. The model and measures used in this study were perhaps better suited to the more consistent demands of computer use than the varied schedules and postures of games use.

Equipment position was expected to influence symptoms related to electronic device use, by constraining posture and increasing biomechanical demand, but no effect was established by this study.

This may reflect a failure of the equipment position questions to approximate postural demands. It is also likely due to the variability of posture in this age group, between users and over time in each user. Postures may be especially varied in game users, who are not as constrained by chair and table dimensions as computer users. It is possible that vision correction is related to NUE symptoms because of postural constraints.

The age distribution might have affected these results, however the direction of such an effect is not readily predictable. This sample was younger than the district as a whole, because of unintentional oversampling in the middle schools. It was less varied ethnically than the US population, but similar to the school district. The sample size was not adequate to determine associations in subgroups.

A binary outcome measure of musculoskeletal symptoms reporting in the past month was used in the current analysis. Additional data concerning vision will be analysed in the future. The symptoms severity score led to associations similar to those for the binary outcome, but the values of the severity scale and resulting odds ratios were not readily interpretable.

Effectively recording the duration and severity of symptoms, including those approaching clinical syndromes, demands a longer-term assessment of musculoskeletal health, in a larger population than was possible in the current study to achieve adequate power and to take other health problems and subgroup differences into account.

Computer use might be thought to affect health by displacing active behaviour. Frequent computer users in this study did not exercise less frequently. This is similar to other recent research by Robinson and by Feldman [11, 12]. Among other sedentary activities measured, none was associated with NUE symptoms. Thus it is not simply the sedentary nature of computer use that leads to the observed associations.

Early analyses of the current dataset had suggested that exercise attenuated the relationship between computer use and NUE symptoms. Exercise did not have a direct effect, and the attenuating effect on computer-related symptoms was not significant. Exercise may indeed not be protective. However, the exercise question was not specific as to level and type of sports involvement. As competitive sports have been implicated in NUE symptoms in this age group [13], follow-up studies will record type and intensity as well as frequency and duration of activities.

Finally, not all relevant variables were measured. Work, text messaging, health status and psychosocial factors are all potentially important contributors and must be analysed in the next stage of research field.

5. Conclusion and recommendations

This study establishes baseline measures of musculoskeletal symptoms and electronic device use in an adolescent population and identifies associations between use frequency, symptoms and other contributing variables. The direction of the associations was not established. Whether the symptoms of pain and discomfort experienced at this early age are related to the development of clinical syndromes or long-term health problems is not clear.

Research tools currently available for measuring postures over time, summing activities and quantifying outcome measures in this age group have not been well validated. Similar problems are seen in research on adults, as described by Gerr [14] and by Innes and Straker [15, 16]. Flexible field-based approaches such as the portable ergonomic observation method developed by Murphy, Buckle and Stubbs [17] need to be adapted for home exposures. Measures tailored to the specific demands of computer and game use are needed. Ongoing self-report methods such as diaries might provide a more consistent measure of day-to-day use than the average daily estimates used here. More objective methods of measurement, such as a time or input device motion counter, could help. But as children use computers in varied settings and share devices, automated measures might prove unreliable.

Qualitative approaches may be better suited to clarifying the changing ergonomic environment of furniture, equipment placement, input device and interface design and software. Descriptive methods could show how postures and demands differ while playing games or notebook computers, what children do that might in fact be protective - stand up, share tasks, work in spurts, for example - and what makes them feel more comfortable. Important beginnings have been made by Jacobs and Baker [18], among others [19, 20].

Classroom and home habits interventions show promise in changing perceptions and some computer use behaviour [21, 22]. This field research investigates how ergonomics skills can be communicated to children, teachers and parents; the efficacy of posture training; and the role of physical activity in musculoskeletal health. Perhaps most intriguing, given the joint influence of computer use, exercise and

overweight on symptoms described in this study, are the efforts to change physical activity by changing the school environment [23].

Equipment design for computer and game users merits more investigation. Attempts have been made to market input devices that fit younger users, but little evidence has been provided to show improved symptoms outcomes or even an impact on comfort. The value of product design changes should be compared to the effect of changes in use habits.

Many factors, recognized and unknown, physical and psychological, contribute to musculoskeletal symptoms reporting. Some (such as gender) are immutable, and others (such as overweight) are likely to be intractable. Changing early patterns of computer use could be an important way to limit musculoskeletal symptoms in childhood and the development of longer-term problems in college and in working life. Understanding the postural demands related to young people's computer and game use should suggest improvements in technology and furniture design. Cognitive and psychosocial stressors related to school and games, as well as the impact of growth and physiological development, are also part of the story.

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