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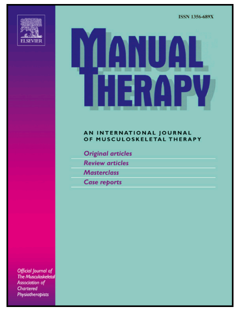
Accepted Manuscript



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PII: S1356-689X(15)00068-5

DOI: 10.1016/j.math.2015.03.015

Reference: YMATH 1705

To appear in: *Manual Therapy*

Received Date: 19 December 2013

Revised Date: 2 March 2015

Accepted Date: 23 March 2015

The relationship between sitting posture and seated-related upper quadrant musculoskeletal pain in computing South African adolescents: a prospective study

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ABSTRACT

Background: There is evidence that consistent sitting for prolonged periods is associated with upper quadrant musculoskeletal pain (UQMP). It is unclear whether postural alignment is a significant risk factor. **Objective and design:** The aim of the prospective study (2010 – 2011) was to ascertain if three-dimensional sitting postural angles, measured in a real-life school computer classroom setting, predict seated-related UQMP. **Method:** Asymptomatic Grade 10 high-school students, aged 15 - 17 years, undertaking Computer Application Technology, were eligible to participate. Using the 3D Posture Analysis Tool, sitting posture was measured while students used desk-top computers. Posture was reported as five upper quadrant angles (Head flexion, Neck flexion; Craniocervical angle, Trunk flexion and Head lateral bending). The Computer Usage Questionnaire measured seated-related UQMP and hours of computer use. The Beck Depression Inventory and the Multidimensional Anxiety Scale for Children assessed psychosocial factors. Sitting posture, computer use and psychosocial factors were measured at baseline. UQMP was measured at six months and one-year follow-up. **Results:** 211, 190 and 153 students participated at baseline, six months and one-year follow-up respectively. 34.2% students complained of seated-related UQMP during the follow-up period. Increased head flexion (HF) predicted seated-related UQMP developing over time for a small group of students with pain scores greater than the 90^{th} pain percentile, adjusted for age, gender, BMI, computer use and psychosocial factors (p=0.003). The pain score increased 0.22 points per 1° increase in HF.

Conclusions: Classroom ergonomics and postural hygiene should therefore focus on reducing large HF angles among computing adolescents.

Keywords: posture, three-dimensional, adolescent, pain

INTRODUCTION

Adolescent upper quadrant musculoskeletal pain (UQMP) is a significant health concern with a worldwide prevalence of 30% (Ayanniyi et al., 2011; Rees et al., 2011; Wiklund et al., 2012). Adolescent musculoskeletal pain is associated with reduced social interactions, mental health, school attendance, scholastic competence and participation in physical activities (Guite et al., 2007; Sunblad et al., 2009; Rees et al., 2011). The aetiology of adolescent UQMP may include complex physical and psychosocial factors (Prins et al., 2008; Aslund et al., 2010; Rees et al., 2011).

Research into sitting posture and UQMP has been compromised by two factors. Firstly, most studies report sitting posture measured in an artificial environment (laboratory set-up), which may not reflect habitual sitting postures (Straker et al., 2008a). Secondly, the evidence-base mainly comprises cross-sectional studies which do not detect UQMP predictors (Murphy et al., 2004; Grimmer et al., 2006). Although there is consistent international evidence that prolonged periods of sitting are associated with adolescent UQMP (Prins et al., 2008; Ayanniyi et al., 2011; Hakala et al., 2012), there is scant evidence on the association between sitting posture (postural angles while sitting), and UQMP (Prins et al., 2008). A recent systematic review however reported that postural angles of the thorax and lumbar-pelvic regions are associated with neck and shoulder pain in children and adolescents (Brink et al., 2013a). To date, there have been no investigations of postural angles measured in 3D, which predict adolescent UQMP.

Adolescents are increasingly exposed to screen-based activities at home and school (Torsheim et al., 2010). A South African study of high school students reported a significant association between neck pain and weekly computer use of nine or more hours (Smith et al., 2009). Although Straker et al. (2009a) reported on 3D sitting postural angles of children when using computers, they did not measure the relationship between posture and pain. The connection between sitting postures, computing tasks and pain thus needs to be further tested. This paper reports on a prospective one-year cohort study which investigated whether 3D sitting postural angles, measured in a real-life context (computer classroom), are associated with seated-related UQMP.

METHODOLOGY

Ethical approval

Institutional ethical approval was obtained. The Western Cape Education Department (WCED) provided permission. Written informed consent was obtained from students and parents.

Study aim, design and population

The study aimed to identify specific spinal segmental postures associated with development of UQMP over a 12 month period. The confounding influences of gender, computer use, anxiety and depression were considered. We sought high-school students, aged between 15 and 17 years, living in the Western Cape metropole, asymptomatic and naïve to computing classes; hence our focus was on Grade 10 high-school students without UQMP, who attended

Computer Application Technology (CAT) studies for the first time at the beginning of the 2010 academic year.

Sampling method

The sample size was based on a logistic regression model using pain as a binary response variable on a continuous predictor (posture angles). A sample size of 240 students gave 93% power at $\alpha=0.05$ to detect a change from 0.11 at the mean of the predictor to 0.2 when the predictor is increased to one standard deviation above the mean. This indicated that at least 821 students should be screened at baseline, to provide a minimum completing sample of 240 students. The commencing sample was based on similar male:female ratios in class, and factored in symptomatic students who would be excluded, a 10% drop-out rate (including non-consent) and 10% loss-to-follow-up over the 12 months. Schools were the unit of recruitment, with a sample estimate of 20 schools required to recruit at least 821 students (Brink et al., 2009).

Eligibility for school inclusion depended on 1) having fully functional computer rooms; 2) offering CAT as school subject; 3) having similar computer laboratory set-up (chair/desk height, etc.); and 4) participating in the Khanya project (a national project aiming to increase computer literacy among educators and school students). Schools in the Western Cape metropole were screened for eligibility (identifying 111 potentially-eligible schools). Twenty schools were selected from this group using computer-generated randomization.

The students were initially screened for UQMP by completing the pain section of the Computer Usage Questionnaire (CUQ) which was developed and validated in South African high school settings by Smith (2007). The CUQ has six subsections of which the pain section describes musculoskeletal pain experience by South African adolescents. Students were excluded if they: 1) were not aged between 15 and 17 years; 2) were repeating CAT; 3) had movement disorders and/or severe fixed skeletal abnormalities (as indicated on the CUQ and screened during the baseline data collection phase) 4) did not provide written informed consent; or 5) complained of UQMP during the previous month.

Sitting posture measurement

The 3D Posture Analysis Tool (3D-PAT) measures students' sitting posture at desk-top computers. The 3D-PAT is a validated, portable 3D posture measurement instrument for use in real-life computer classrooms (Brink et al., 2013b). This study reports on five postural angles which represent key spinal segments in sitting (see Table 1).

<<Table 1>>

Psychosocial factors and computer use measurements

Psychosocial factors were assessed using the Beck Depression Inventory (BDI) and the Multidimensional Anxiety Scale for Children (MASC) (Beck and Steer 1987, March et al., 1997). Both the BDI and the MASC have been used for South African adolescents (Seedat et al., 2004; Fincham et al., 2007; Brink et al., 2009). The CUQ captured hours of computer use at school and elsewhere. Exposure to computer use was described for analysis purposes as duration per session, frequency of weekly usage, and total number of hours per week.

UQMP measurement

All participants were asymptomatic in the upper quadrant at baseline (enrolment into the study). Emergent UQMP was measured at six-month and one-year follow-up (Feldman et al., 2002). All students completed the pain section of the CUQ at both follow-up periods, which required recall of any musculoskeletal pain during the preceding month. The area of pain (10 body areas) was indicated on a body chart, with its intensity measured on a 2-point scale indicating either “slight discomfort/pain” or “severe discomfort/pain” using faces (Auvinen et al., 2007; Smith, 2007).

Procedure

Baseline

Height (steel tape measure mounted against wall); weight (calibrated digital scale; computer use (CUQ) and psychosocial factors (BDI and MASC) were measured. Postural evaluation was performed in the school computer classroom, using the 3D-PAT. Reflective markers were placed on nine anatomical landmarks (both canthi; both trachi, C_7 spinal process (SP); T_5 SP; both greater trochanters; and the superior border of the sternum) of the students by one researcher, for consistency (Brink et al., 2013b).

Students used the same computer monitor settings and chair as during a normal class. The 3D-PAT set-up was fixed at one computer workstation per school. Students were given a short paragraph to type, starting with five minutes before 3D-PAT data capturing commenced, and they typed the passage repeatedly until data capturing was completed. This approach was sufficient to allow data capturing of students' habitual postures (Szeto et al., 2002; Briggs et al., 2004).

Six months follow-up

From the responses to the CUQ, students were determined as ongoing asymptomatic, or symptomatic, if they experienced UQMP during the preceding month.

One-year follow-up

All baseline measures were repeated at one-year follow-up. On the basis of the CUQ responses, students were determined as a) remaining asymptomatic, b) resumed asymptomatic status after reporting UQMP at six months (demonstrating no further problems), c) remaining symptomatic with UQMP at both 6 and 12 months, or d) becoming symptomatic if they complained of UQMP during the preceding month (asymptomatic up until then). Figure 1 summarises the time frames for data collection.

<<Figure 1>>

Data processing

Baseline data of posture and potential confounders (psychosocial and computer use) were used because exposure must be measured prior to the outcome (pain) in a cohort study to understand temporality.

For sitting posture, the frame closest to the 50th frame (Straker et al., 2002), in which the student's eyes were focused on the computer screen, was selected per camera to form a set of five photographs. Marker selection of the reflective markers and the calibration object were performed, thus reconstructing the 3D-coordinates to calculate the five postural angles (Brink et al., 2013b).

For the BDI, the score for each item was added to represent a depression score. The T-score from the MASC total column was used to present a score for anxiety. The number of hours per week of computer use at school and elsewhere was summed as the total amount of computer use per week.

Students reporting seated-related UQMP during the preceding month, at six-month or one-year follow-ups, were assigned a pain score on a continuous scale. If the student had UQMP due to reasons unrelated to seated activities (e.g. sport), a 0 pain score was allocated. Since physical factors and intensity of adolescent musculoskeletal pain and/or multiple areas of adolescent musculoskeletal pain are associated (Auvinen et al., 2007; Paananen et al., 2010), the number of pain areas and the intensity of pain were taken into consideration to calculate the pain score. For instance, each upper quadrant area with slight pain and severe pain was assigned one and two points, respectively. The points were tallied to give a total pain score. Although pain scores were available for each student at the follow-up time points (six-month and one-year), only one score per student was used in the analysis. If the student experienced pain at both intervals, the pain score at one-year was used. If students experienced pain at six months but no pain at one-year, they were allocated a 0 score. If the student experienced pain at six months, but there were no pain data for one-year follow-up, the student was allocated the pain score received at six months.

Statistical analysis

A continuous pain scale was advantageous, since the skewed distribution of the pain data (zero-inflated pain scores) compromised the use of the pain data in binary form. Therefore, for the associations of postural angles with pain at one-year, we were interested in the extremes, i.e. the upper deciles of the pain score. This was done using quantile regression analysis (Koenker and d'Orey, 1993), which models the relationship between the predictors (posture angles) and specific conditional quantiles (80^{th} and 90^{th}) of the response variable (pain score). The regression coefficient indicates the effect on pain of a unit change in that factor, assuming other factors are fixed. Since no association between psychosocial factors, computer use and UQMP have been found within this particular adolescent population, the factors were analysed only as potential confounders of seated-related adolescent UQMP. Potential confounders included age, gender, BMI, computer use, anxiety and depression.

To investigate the impact of angle combinations (specific postures) on pain, factor analysis was performed on the five postural angles to determine their latent constructs. For ease of interpretation, a varimax rotation (rotation of original factors which makes two factors uncorrelated) was used to provide orthogonal factors. The significant factors were then entered into the quantile regression as predictors of UQMP.

RESULTS

Sample compositions

Two of the 20 selected high schools withdrew just prior to data collection and due to time constraints were not replaced. Moreover posture data of two schools and two students from another school were rejected due to technical problems with the 3D-PAT (n=17). Thus, even though 211 students participated (88% of planned sample), the data from only 194 students (81% of planned sample) are reported. 190 (98.1%) and 153 (79.6%) Of these students participated at six month and one-year follow-up respectively. The age and gender distribution of participating students did not differ from those excluded from the study. Table 2 reports on students included and excluded at baseline and measured at six months and one-year follow-ups.

<<Table 2>>

Baseline measurements

The mean age, height, weight and BMI were 16.3 (±0.5) years, 1.66 m (±0.1), 59.35 kg (±13.1) and 21.34 (±3.9), respectively.

The descriptive statistics (mean, SD, maximum and minimum) of the postural data and the exposure to computer use, at school and elsewhere, for the 194 students are reported by Brink et al., (2014). Students' anxiety (mean 39.02 ±14.43; minimum = 0; maximum = 87) and depression scores (mean 9.34 ±8.46; minimum = 0; maximum = 59) were recorded.

<u>Six months and one-year follow-up measurements</u>

Figure 2 describes all symptomatic students and indicates those students with seated-related UQMP at six month and one-year follow-up. Figure 3 reports the percentage of students complaining of each of the 10 upper quadrant areas, for both follow-up periods.

<<Figure 2>>

<<Figure 3>>

Of the 194 students at baseline, four had missing data due to absenteeism and were thus excluded. Over the 12 month follow-up period, 127/190 students were assigned a 0 pain score, leaving 34.2% students (N=63) complaining of UQMP. These students had composite pain scores ranging from 1.0 to 14.5 (mean 4.2 ± 3.9). Considering all 190 students, the mean pain score was 1.39 (± 2.98).

Factors associated with UQMP

Individual postural angles

We investigated the relationship between the individual angles and the 80th and 90th percentile for the pain score. Only head flexion (HF) demonstrated a positive association with the pain score conditionally on the 90th percentile for pain (Estimate: 0.22; SE: 0.07; t-value: 3.05; p-value: 0.003) after adjustment for age, gender, BMI, computer use, anxiety and depression in the multiple regression model. Thus HF was a significant predictor of seated-related UQMP at the 90th percentile (4.5 in the derived pain scores) and this was not confounded by any of the covariates in the multiple regression model. This demonstrates a linear association between HF and UQMP, with a pain score increase of 0.22 points with every 1° increase in H F. Figure 4 shows the gradual increase in pain score as HF increases with the 95% confidence bands (shaded area). The line represents the fitted conditional 90th percentile of pain for a regression model in HF.

<<Figure 4>>

Table 3 presents the means, SDs and 95% Confidence intervals of the no pain and two pain subgroups above and below the 90th pain percentile. Computer use, anxiety and depression scores for each subgroup are also reported in Table 3. There was no significant difference in the mean values for the three subgroups for computer use, anxiety or depression.

<<Table 3>>

Postural angle combinations

Two factors were identified using factor analysis. The first was a linear combination with high loadings (>40) for HF (56), neck flexion (NF) (97) and thoracic flexion (TF) (60), which explained 55% of the variability in the angles. The second was a linear combination with high loadings (>40) for HF (-80) and cranio-cervical angle (CC) (91). This factor explained 43% of the variability in the angles. These two factors were included in a quantile regression analysis as pain predictors. The second factor was a significant predictor for pain at the 90th percentile of the pain score (Estimate:-1.47; SE: 0.41; t-value:-3.58; p-value: 0.0004). This implies a decrease of 1.47 points in the pain score with every one point increase in factor two at the 90th percentile. Factor two comprised mainly of HF and CC. The interpretation suggests that a one-unit increase in factor two relates to an approximate 10° increase in CC for a given HF level and will increase the pain score by 1.5 points.

DISCUSSION

To our knowledge, this is the first study describing the development of UQMP related to postural angles, accounting for computer use, anxiety and depression. Our study showed that increased HF is associated with seated-related adolescent UQMP which developed within six to 12 months, for students commencing with computing studies at school. UQMP was sought as literature has indicated an association between UQMP and computer use (Andersen et al., 2011). We described five spinal postural angles because adolescent computer users believed "bad posture" and prolonged sitting to be reasons for head, neck, shoulder and mid-back pain (Auvinen et al., 2007; Coleman et al., 2009, Briggs et al., 2009). We found increased HF a potential predictor for seated-related UQMP, for a small group of students (n=22) with severe and/or multiple areas of pain. The mean difference of 4° H F between the no pain and severe pain groups is greater than a 1° difference reported between adolescents with, and without, pain (Straker et al., 2008a; Brink et al., 2009; Straker et al., 2009b). There is an important clinical difference between the two groups for HF because the difference between the means i.e. 4° exceeds the standard error of measurement (SEM), which has been reported as 3.5° for HF (Brink et al 2013b). Furthermore when interpreting the upper 95%CI for the no pain group, less than 2.5% had HF angles equal or greater than 80° (80° HF is the cut-off point differentiating between the two subgroups as shown in Figure 4).

All 22 students complained of a combination of head, neck and upper/mid-back pain. None of the 22 students complained of elbow and wrist pain (23% in Figure 3) without indicating head and neck pain. Half of the students complaining of upper arm pain also suffered from severe spinal pain. HF represents the head-on-neck alignment (Straker et al., 2008b). Pathological changes to upper cervical structures in response to increased load on active and passive structures have been associated with headache and neck pain due to their upper cervical nerve innervation, and can account for 44% pain as shown in Figure 3 (Alix and Bates, 1999; Harrison et al., 1999; Aprill et al., 2002). The trapezius muscle functions as the anatomical link between the spinal column and the upper arm (Mathiassen et al., 1995). The trapezius muscle is innervated by the spinal accessory nerve (Cranial nerve XI) and the cervical plexus (C_1-C_4) (Kierner et al., 2001) thus increased HF could influence these nerves and potentially lead to pain experienced over the entire trapezius muscle (mid-back and shoulder pain) and account for a further 33% pain (see Figure 3). This was confirmed by Straker et al., (2009a) who reported a positive correlation between upper trapezius muscle activity and HF in children.

Angles in the sagittal plane (HF, NF and TF) is highly correlated for this population (Brink et al., 2014), therefore increased head-on-neck flexion could influence the segments below. We found a mean NF of 62° (Table 3), which is 10° greater than previously reported (Briggs et al. , 2004; Straker et al., 2009a) and in line with O'Sullivan et al., (2011) who reported 56.5° NF for adolescents experiencing musculoskeletal pain. However this study did not find either increased NF or TF to be predictive of UQMP, possibly due to lack of statistical power.

CLINICAL IMPLICATION

Factors such as classroom furniture (chair, desk and monitor height) and postural hygiene (knowledge and postural habits), which might contribute to increased HF posture, need to be considered, and if necessary, addressed *in situ*. Levels of depression and anxiety, and hours spent at the computer, are not significant confounders on the association between UQMP and spinal posture. Extreme HF postures, where the canthus (eye) is positioned lower than the trachus (ear), should be avoided in computing adolescents to reduce their likelihood of developing UQMP over time.

LIMITATIONS AND RECOMMENDATIONS

A longitudinal design of initially asymptomatic students who developed (or not) pain is a strength. Despite the well-powered baseline sample, an unexpectedly high number of students were excluded at baseline. This could have masked the true associations between sitting posture and seated-related UQMP. However, our follow-up retention was 17% and 6% better than reported by Feldman et al., (2002) and Grimmer et al., (2006). For this reason it could be that we found no other angle to be predictive of seated-related UQMP. Future studies, might be able to support our finding or determine whether other spinal postural angles are potentially predictive of UQMP.

Despite the longitudinal study approach, we cautiously attribute postural causation for seated-related UQMP. The key exposure (increased HF) may have been present prior to a **new onset** of seated-related UQMP, as those asymptomatic adolescents at baseline might have had a previous episode of seated-related UQMP prior to the initial one month pain recall period. If we used a longer pain recall period, recall bias due to gradual loss of recalling events over time would have introduced another bias (Milanese and Grimmer, 2010). Therefore we limit the temporality criterion required for causation to only one month retrospectively.

The two occasions of UQMP measurement may be insufficient to understand the subtleties of inconsistent adolescent UQMP reporting. Future research into UQMP should determine appropriate, reliable adolescent pain recall periods where the outcome is an inconsistently recurring event. Measuring pain intensity using two levels might have limited the students' ability to describe their pain experience and future research could employ 3-4 intensity levels (Prins et al., 2008). Interpreting the pain measurement on a continuous scale and performing quantile regression analysis after initial observation of the data, might have influenced our results and should be reconsidered in future studies.

CONCLUSION

This paper reports on the relationship between sitting posture and seated-related UQMP in computing high-school students. Increased HF was a predictor of seated-related UQMP developing over 12 months for a small group of adolescents with a high cumulative pain score.

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CAPTIONS TO ILLUSTRATIONS

Figure 1: The measurements taken at various time intervals

Figure 2: The musculoskeletal pain responses at six months and one-year follow-ups

Figure 3: Symptomatic areas of the upper quadrant, indicated by the students at six months and one-year follow-ups

Figure 4: The scatterplot graph models the relationship between the 90^{th} percentile for pain score (4.5) and head flexion with 95% Confidence Limits.

ACKNOWLEDGEMENTS

We acknowledge the WCED for allowing students to participate in this study and the Stellenbosch University Faculty of Health Sciences and the Medical Research Council of South Africa for funding the study.

Table 1: Definitions of the postural angles

Angle	**Definition**
Head flexion (HF)	The angle between lines drawn from the Cyclops[1] to the OCI[2] and the vertical axis.
Neck flexion (NF)	The angle between lines drawn from the OCI to the C_7 SP and the vertical axis.
Cranio-cervical angle (CC)	The angle between lines drawn from the Cyclops to the OCI to the C_7 SP.
Trunk flexion (TF)	The angle between lines drawn from the C_7 SP to the mid-point of the greater trochanters and the vertical axis.
Head lateral bending (HLB)	The lateral angle between lines drawn from the OCI to the trachus, with the vertical line going through the OCI (negative to the left).

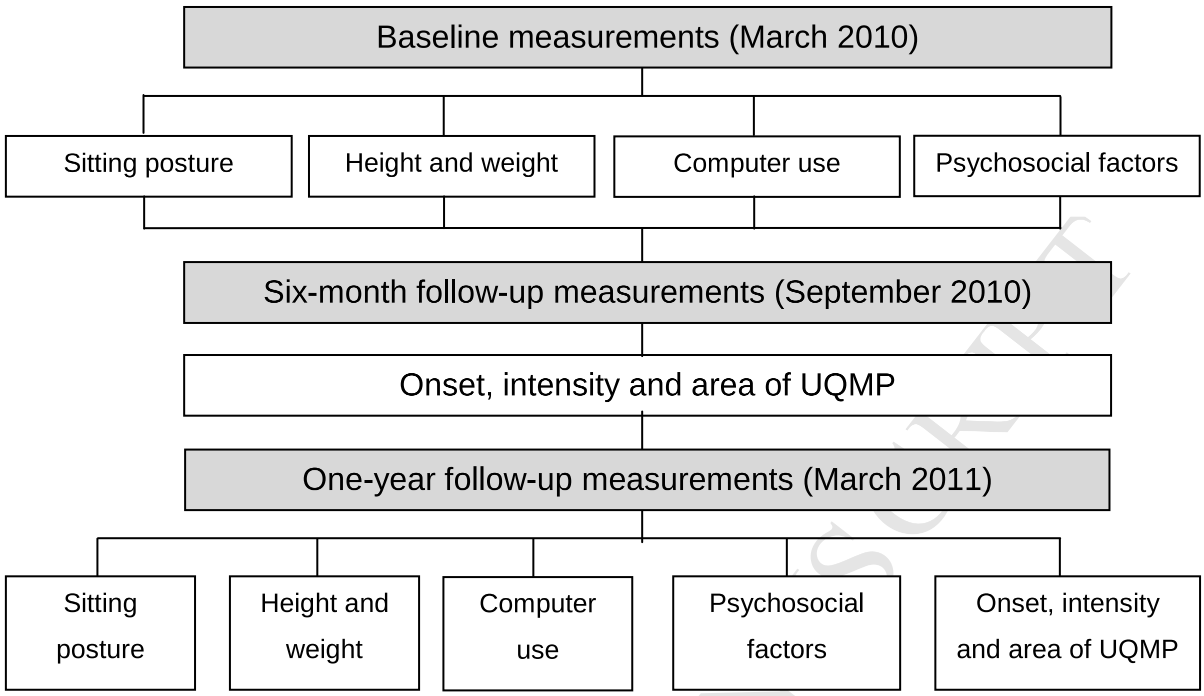
[1]Midpoint between the left and right canthus.
[2]*Midpoint between the left and right trachus.*

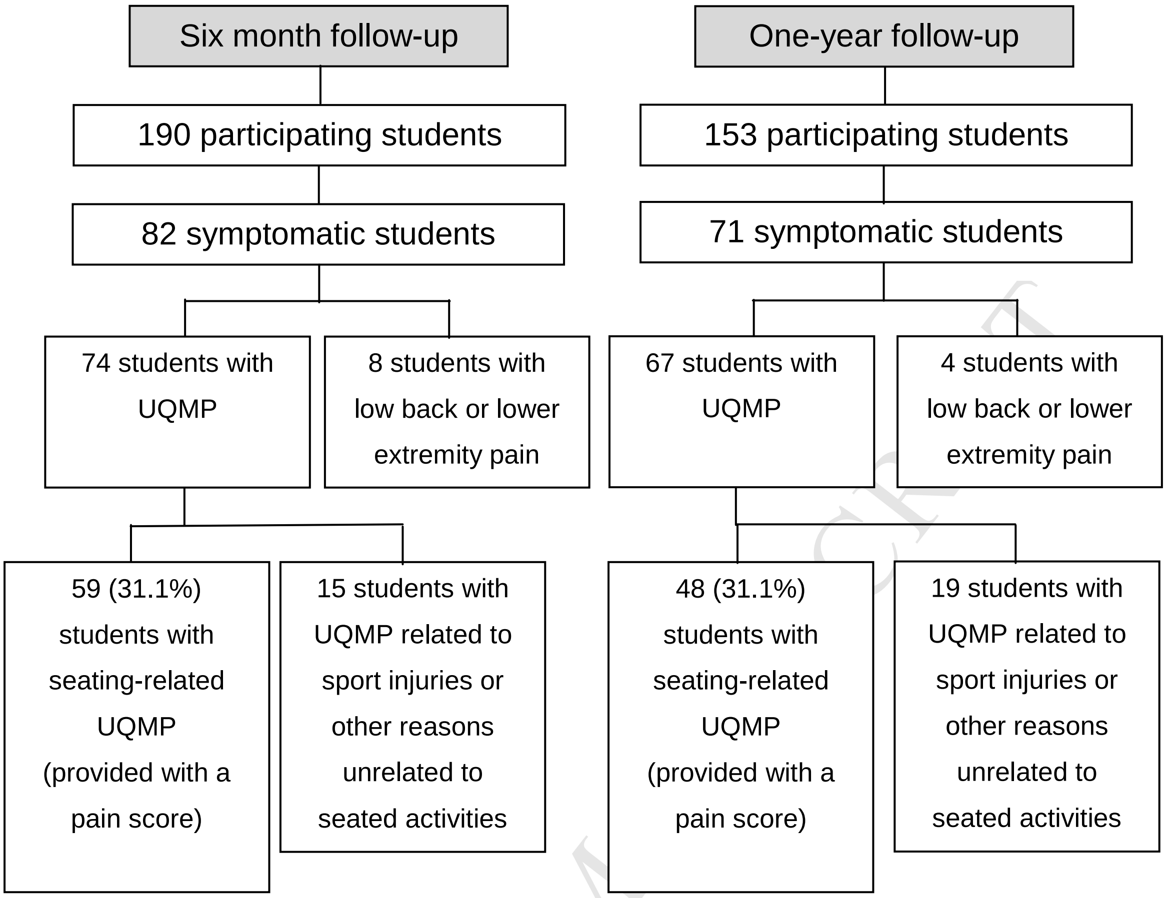
Table 2: Included and excluded students at baseline, six months and one-year follow-ups

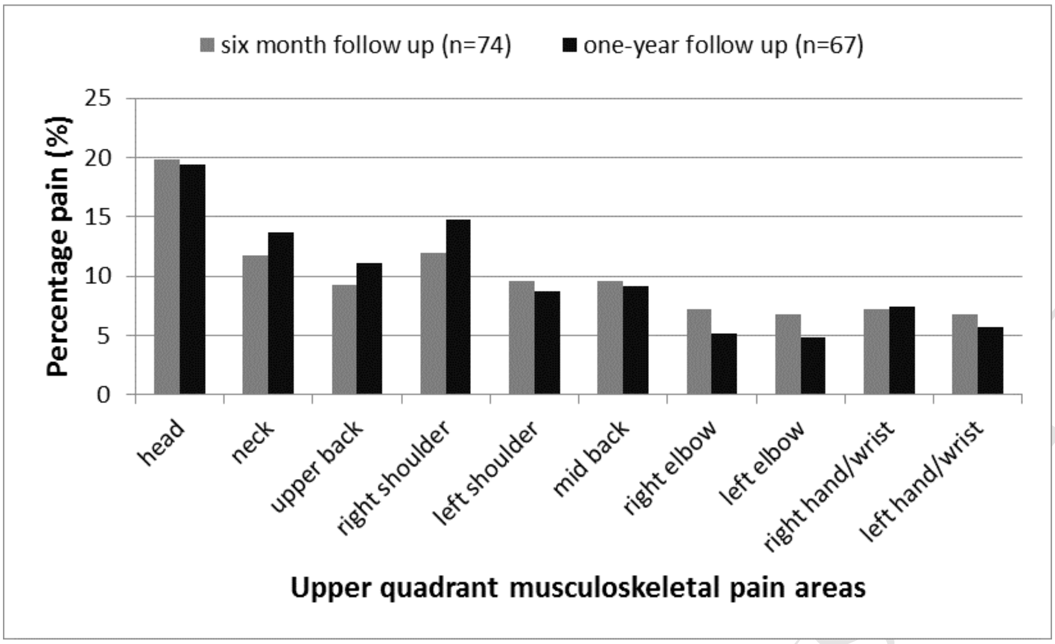
	Baseline			Six months			One-year		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
Number of schools			18						
Screened for musculoskeletal pain	502	492	994						
Excluded due to musculoskeletal pain	232	291	523						
Excluded due to age	52	47	99						
Excluded due to repeating the subject	10	8	18						
Excluded due to language barrier	0	1	1						
Received consent from parents	141	94	235						
Absent on day of measurements	13	11	24	3	1	4	12	4	16
Participating students	128	83	**211**	113	77	**190**	88	65	**153**
Students excluded, due to corrupt sitting postural data	12	5	17						
Students who discontinued their participation							4	2	6
Students who had left the participating schools							12	7	19
Analysed data	116	78	**194**	113	77	**190**	88	65	**153**

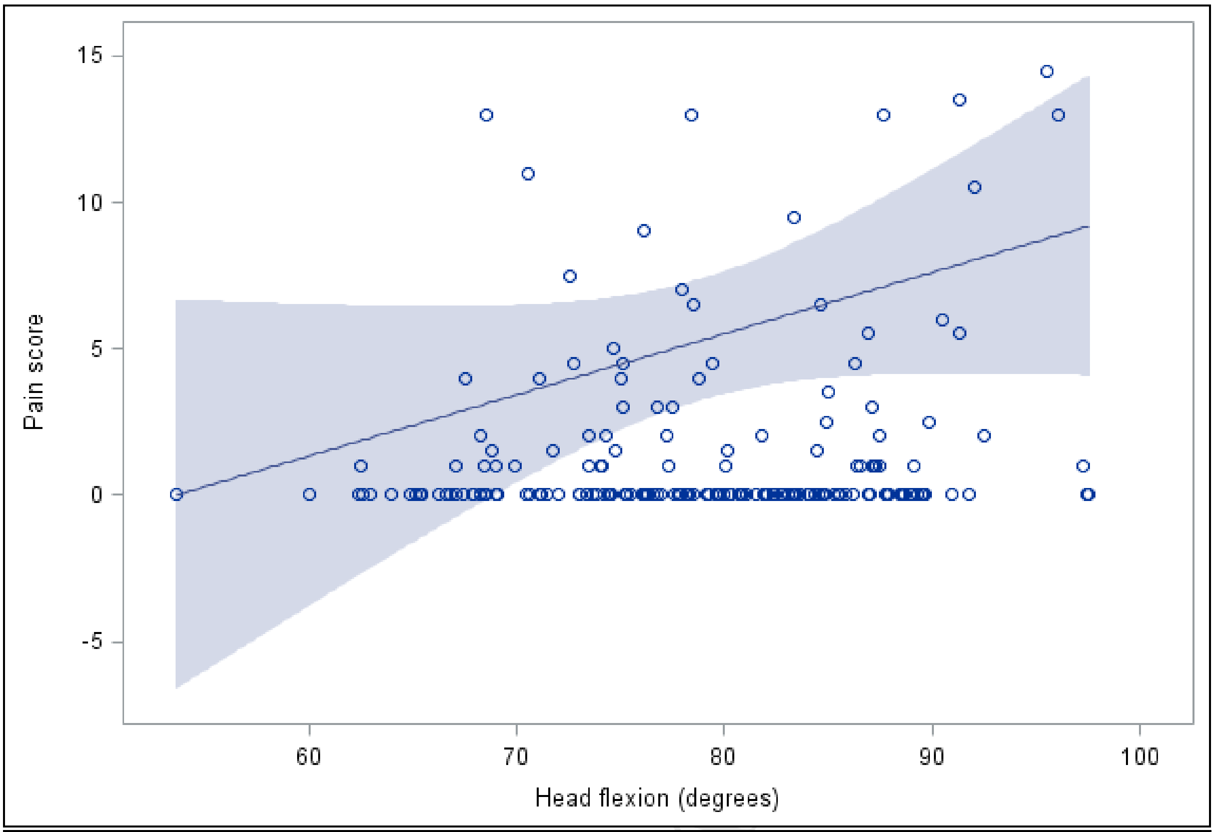
Table 3: The mean, SD and Confidence intervals for the postural angles, computer use and psychosocial factors for the no pain (n = 127), the pain < 4.5 (n = 41) and the pain ≥ 4.5 subgroups

	No pain group (n = 127)				**Pain score < 4.5 (n = 41)**				**Pain score ≥ 4.5 (n = 22)**			
	Mean	SD	UCI	LCI	Mean	SD	UCI	LCI	Mean	SD	UCI	LCI
HF(°)	78.3	8.3	79.7	76.9	78.7	8.3	81.2	76.2	82.3	8.4	85.8	78.8
NF(°)	61.2	7.9	62.6	59.8	62.4	7.2	64.6	60.2	62.8	7.8	66.1	59.5
CC(°)	161.6	7.6	162.9	160.3	161.3	7.6	163.6	159.0	161.3	8.8	165.0	157.6
TF(°)	-9.4	10.1	-7.6	-11.2	-8.6	8.5	-6.0	-11.2	-11.1	9.1	-7.3	-14.9
HLB(°)	-0.5	5.3	0.4	-1.4	-1.2	4.2	0.1	-2.5	-1.1	5.3	1.1	-3.3
Computer use (hrs per week)	8.9	5.0	9.8	8.0	9.1	5.7	10.9	7.4	8.6	4.1	10.3	6.9
Anxiety	37.91	14.18	40.38	35.44	41.49	12.93	45.45	37.53	42.41	17.97	49.90	34.92
Depression	9.20	8.93	10.75	7.65	8.85	6.84	10.94	6.76	11.05	9.26	14.91	7.19


Baseline measurements (March 2010)
Sitting posture
Height and weight
Computer use
Psychosocial factors
Six-month follow-up measurements (September 2010)
Onset, intensity and area of UQMP
One-year follow-up measurements (March 2011)
Sitting posture
Height and weight
Computer use
Psychosocial factors
Onset, intensity and area of UQMP


Six month follow-up
190 participating students
82 symptomatic students
74 students with UQMP
8 students with low back or lower extremity pain
59 (31.1%) students with seating-related UQMP (provided with a pain score)
15 students with UQMP related to sport injuries or other reasons unrelated to seated activities
One-year follow-up
153 participating students
71 symptomatic students
67 students with UQMP
4 students with low back or lower extremity pain
48 (31.1%) students with seating-related UQMP (provided with a pain score)
19 students with UQMP related to sport injuries or other reasons unrelated to seated activities


six month follow up (n=74)
one-year follow up (n=67)
Percentage pain (%)
25
20
15
10
5
0
head
neck
upper back
right shoulder
left shoulder
mid back
right elbow
left elbow
right hand/wrist
left hand/wrist
Upper quadrant musculoskeletal pain areas


15
10
5
0
-5
Pain score
60
70
80
90
100
Head flexion (degrees)

Highlights

- investigated sitting posture and musculoskeletal pain in computing adolescents
- 34.2% of previously asymptomatic students developed musculoskeletal pain
- increased head flexion was predictive of seated-related musculoskeletal pain
- pain score increased 0.22 points with every 1° increase in head flexion
- findings applicable to small group of students with pain scores greater than 4.5