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Comparative analysis of head-tilt and forward head position during laptop use between females with postural induced headache and healthy controls

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ABSTRACT

Objectives. To compare 1) maximum manually induced head-protraction, head-tilt and forward head position and 2) the evolution of head-tilt and forward head position during a laptop-task between a headache- and control-group.

Methods. Angles for maximum head-protraction, head-tilt and forward head position of 12 female students with postural induced headache and 12 female healthy controls were calculated at baseline and while performing a laptop-task.

Results. The headache-group demonstrated an increased passive head-protraction of 22.30% compared to the control-group. The ratio of forward head position during habitual sitting to the maximum head-protraction differed significantly ($p = 0.046$) between headache-group (1.4 ± 0.4) and the control-group (1.1 ± 0.2). The headache-group showed a biphasic forward head position and head-tilt profile. These profiles differed significantly ($p < 0.05$) between groups and were negatively correlated (rE = - 0.927).

Conclusion. The headache-group showed a larger passive head-protraction with a habitual forward head-position further located from the end-range. During the laptop-task forward head position and head-tilt behaved biphasically with a more static forward head position and a more dynamic head-tilt.

Keywords. Postural induced headache, forward head position, head-tilt, laptop

1. INTRODUCTION

University students show an increasing laptop-use compared to the use of a desktop computer. In 2005, 52.8% of the students used a laptop compared to 75.8% in 2007 (Jacobs et al 2009). The risk of developing musculoskeletal complaints is correlated to the duration of the computer- or laptop-use and gender. Bernard et al 1994 identified a dose-response relationship between the duration of computer-work and the associated musculoskeletal complaints. Daily computer- or laptop-use greater than three hours was associated with a higher prevalence of musculoskeletal complaints (Kanchanomai et al 2012). Female college students report a higher frequency of discomfort using a laptop or desktop computer (Noack-Cooper et al 2009). Malińska et al 2010 reported in a cross-sectional study that in workers who regularly used portable computers in their everyday occupational duties headache was the most important complaint in 55% of the females.

Increased use of the laptop can thus elicit posture-related complaints such as headache and neck pain. Sitting behavior during laptop use is characterized by an augmented neck flexion and head-tilt (Straker et al 1997, Berkhout et al 2004), less head movement, a shorter viewing distance and a larger forward head position (Saito et al 1997). A more pronounced forward head position is a typical feature in patients with migraine, cluster headache, cervicogenic headache, tension-type headache, neck pain and temporo-mandibular dysfunction (Fernández-de-Las-Peñas et al 2010, Abboud et al 2013). These postural features cause an increased load on the musculoskeletal system (McLean 2005, Hamilton et al 2005) and might explain the higher incidence of headache and neck pain in video display users (Lewis et al 2001).

Headaches emanating from structures in the cervical spine, provoked or aggravated by sustained neck postures or movements include tension-type headache, cervicogenic headache or a mixture (Jull 1986, Fernández-de-Las-Peñas et al 2010). Processes known to contribute to such ‘postural induced headaches (PHA)’ are divided into peripheral and central. Prolonged nociceptive input from peri-cranial structures innervated by the upper cervical nerves can cause sensitization of the trigeminal nucleus caudalis in the trigemino-cervical complex. This complex contains major relay neurones for nociceptive afferent input from cervical structures and trigeminal afferents. It is well accepted there is convergence between these neurons in the trigeminal nucleus caudalis leading to referral into the parietal, frontal and orbital regions. Prolonged nociceptive input from the cervical region may sensitize the central nervous system and thereby increasing pain sensitivity (Bogduk & Govind 2009, Goadsby & Bartsch 2010, Watson & Drummond 2012).

Habitual postures and sustained static load may contribute to the development of neck pain with associated headache (Szeto et al 2005ab). In particular small changes in the head position can result in a significant increase in load on supporting structures (Harms-Ringdahl et al 1986, Straker et al 1997, Jull et al 2008). Proper motor control of the head posture and movement is crucial to avoid such overload. Yet, in subjects with postural neck pain or tension-type headache awareness of the neutral head position is disturbed (Giacomini et al 2004, Kristjansson 2005, Edmondston et al 2007).

While maladaptive head posture during sitting is recognized as a possible intrinsic etiological factor for headache (Yoo & An 2009), only few studies compared cervical postures of individuals with PHA to asymptomatic controls (Edmondston et al 2007). Nor have such postures during sitting been referenced to individual maximal end-range. Since habitual head and cervical postures vary considerably between individuals (heterogeneity) it might be relevant to express the individual head posture in relation to the maximal end-range. These positions are more likely to be provocative. Previous cross-sectional studies, comparing postural differences between subjects with pain and healthy controls resulted in no statistical differences in habitual head and cervical posture (Edmondston et al 2007). Therefore this study aims to reference the forward head position to maximal end-range postures in subject with PHA versus healthy controls (HC). Most findings of previous studies were derived from evaluating static postural control (Edmondston et al 2007, Edmondston et al 2011). To provide useful information on the dynamic postural behaviour this study aims to evaluate head-tilt and forward head position during a 30 minutes laptop computer task.

2. MATERIALS AND METHODS

2.1 Study design

Baseline head posture in sitting, estimated by head-tilt, forward head position and manually induced maximum head protraction, was compared between a PHA-group and HC. Next, head-tilt and forward head position were compared within and between groups during a 30 minutes laptop task.

2.2 Subjects

Using an informative questionnaire 24 female students were selected from an University College in Hasselt, Belgium. The 12 students with PHA met the criteria as described below. The 12 students for the HC-group were matched for gender and age.

Inclusion criteria for the PHA-group were: females between 19 and 30 years, headache induced by sustained sitting postures, neck stiffness, diagnostic criteria for tension-type or cervicogenic headache as defined by Sjaastad et al 1998 and the ICHD-III beta 2013. Exclusion criteria for the PHA-group were: pregnancy, physiotherapy or manual therapy treatment in the past 12 months for headache, history of neck or head trauma or surgery and pain radiation in the upper extremities. Inclusion criteria for the HC-group were: females between 19 and 30 years, no current headache, no history of neck or head trauma or surgery and no pregnancy.

The Ethical Committee of the Hasselt University granted approval for the study (ref. CME 2008/268) and all participants signed the written informed consent.

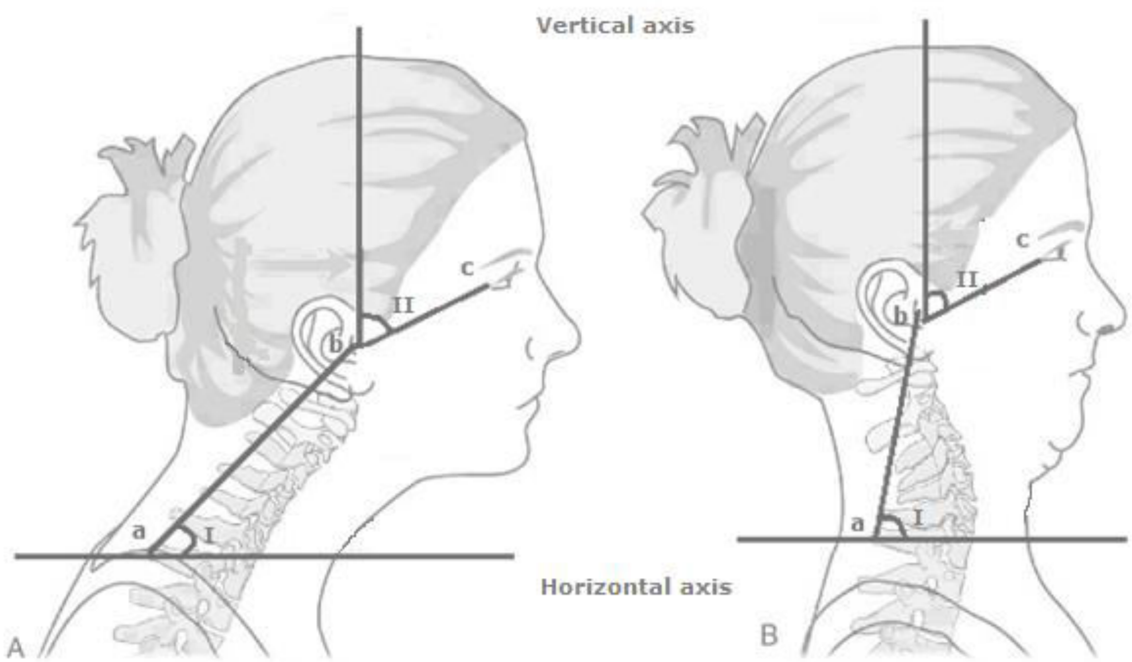
2.3 Measurements and instruments

The selected subjects with PHA kept a diary for two weeks prior to the study. Duration (hours/day) and intensity of their headache were questioned daily. Scores of headache intensity were given using the Visual Analogue Scale (VAS) (Lundqvist et al 2009). Scores ranged between 0 (no pain) and 10 (the most pain possible). After two weeks average scores were calculated. Next, all subjects received information about the procedure before starting the measurements.

To measure the postural variables (manually induced maximum head protraction, forward head position, head-tilt) markers were fixed at three anatomical reference points on the right side of the body. The reference points used to calculate the angles (°) were: the lateral orbital margin, the tragus of the ear and the C7 spinous processus (Figure 1) (O'Sullivan et al 2002). Angles for the following postural variables were calculated:

- Manually induced maximum head protraction (MHP) during neutral sitting: the angle (I) between the C7 spinous processus (a), the tragus of the ear (b) and the horizontal axis through C7 after a manually induced maximal head protraction. A smaller angle indicates a larger maximal cervical flexion.

- Forward head position (FHP) during habitual sitting: the angle (I) between the C7 spinous processus (a), the tragus of the ear (b) and the horizontal axis through C7. A smaller angle indicates a larger cervical flexion.
- Head-tilt (HT) during habitual sitting: the angle (II) between the tragus of the ear (b), the lateral margin of the orbit (c) and the vertical axis trough the tragus. A smaller angle indicates a larger upper-cervical flexion.



[insert caption to illustration 'Figure 1' here]

To standardize the test procedure the postural variables were first measured in neutral (as described below) and next in habitual sitting. The subjects were not given any instructions or information about their sitting postures and a pause of 10 minutes was provided between both measurements.

1. Maximal cervical flexion (MHP) was evaluated at baseline with the subject in neutral sitting posture, i.e. sitting with both feet flat on the floor and 90° flexion in the hips and knees. The spine was neutrally positioned from lumbar to cervical. Shoulders were placed in a relaxed position with the arms resting on the table. Next, the same tester positioned each subject's head in a MHP.

2. Cervical flexion (FHP) and upper-cervical (HT) range of motion (ROM) were evaluated in habitual sitting while performing a 30 minutes laptop typing task.

From all sitting postures lateral view digital pictures were taken. The camera (Canon Powershot A70) was perpendicular placed on a tripod at a height of 1 m at 2.20 m from the subject and connected to a programmed laptop (software Cam4You, Informer Technologies, Inc.). From this set of pictures the angles of MHP, HT and FHP were automatically calculated by using specific software (COACH 5 version 2.1, Copyright © 2001 CMA).

2.5 Statistical analysis

Statistical analysis was performed using SAS software (version 9.1) and SPSS (version 15.0 for windows). All tests were set at 5% significant level ($p < 0.05$).

For the baseline comparison the first goal was to investigate if there was a difference in manually induced maximal cervical flexion between the PHA-group and the HC. Secondly, the differences in the mean upper-cervical ROM and cervical flexion during habitual sitting between the groups were calculated. The outcomes of both groups showed normal distribution (based on the Shapiro-Wilk test) and equal variance. However, taking the sample size into account a non-parametric Wilcoxon Mann-Whitney test was used.

For the comparison over time the goal was to analyse the behavior of the upper-cervical and the cervical spine within and between the PHA-group and the HC during a 30 minutes laptop task.

Variance profiles and fluctuations of the upper-cervical ROM and cervical flexion were calculated from the snapshots taken automatically every two minutes during the 30 minutes laptop task. Differences in upper-cervical ROM and cervical flexion were calculated at 10 (0 to 10th minute), 20 (0 to 20th minute) and 30 (0 to 30th minute) minutes corrected for the baseline.

Variance in differences for the upper-cervical and cervical ROM during the laptop task compared to the baseline were analysed between groups using an approximate F-test. Differences in average evolution in upper-cervical and cervical ROM between groups were analysed by fitting a multivariate regression model. Fluctuations in upper-cervical and cervical ROM between groups during the task were analysed by inspection of the correlation between the time points at two minutes using the Heterogeneous Toeplitz (TOEPH) correlation coefficients. A lower correlation corresponds with more fluctuation, a higher correlation with less fluctuation. In order to investigate the relation between the upper-cervical and cervical profile within both groups the random-effects approach for joint modelling of multivariate longitudinal data was used.

3. RESULTS

3.1 Characteristics subjects

Subject's characteristics are reported in Table 1.

[insert Table 1 here.]

3.2 Baseline maximum head protraction, forward head position and head-tilt

Subjects with PHA showed an increased manually induced maximal cervical flexion in neutral sitting. The ratio of the cervical flexion to the manually induced maximal cervical flexion was significant larger in the PHA-group. Thus, the head posture during habitual sitting lays further from the end-range (Table 2).

[insert Table 2 here.]

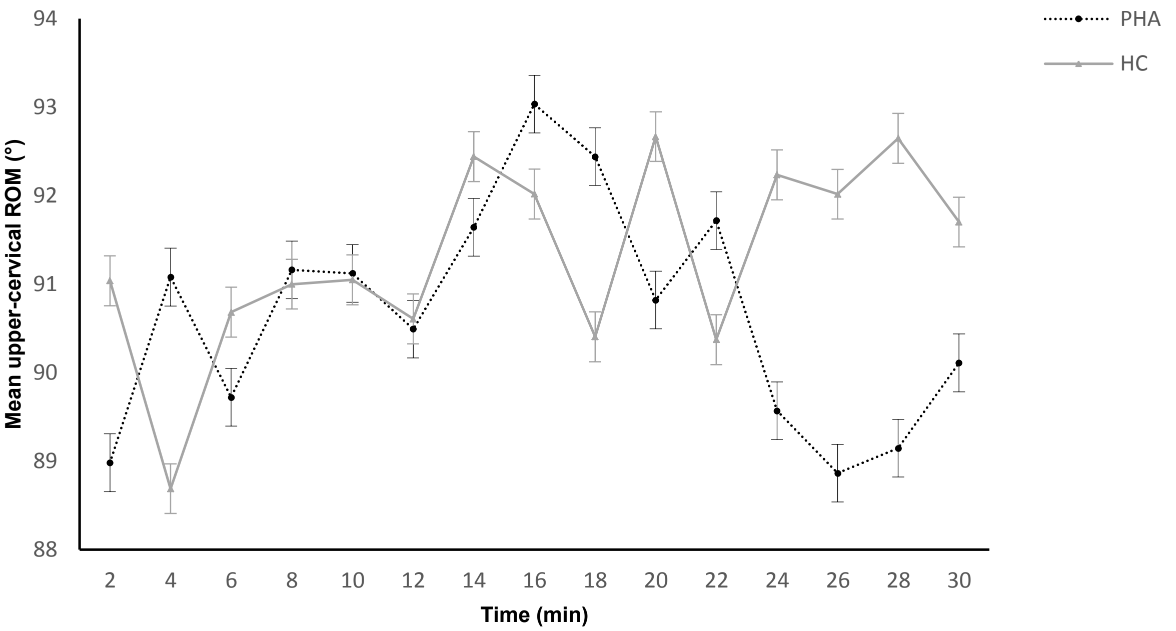
3.3 Head-tilt and forward head position during the laptop task

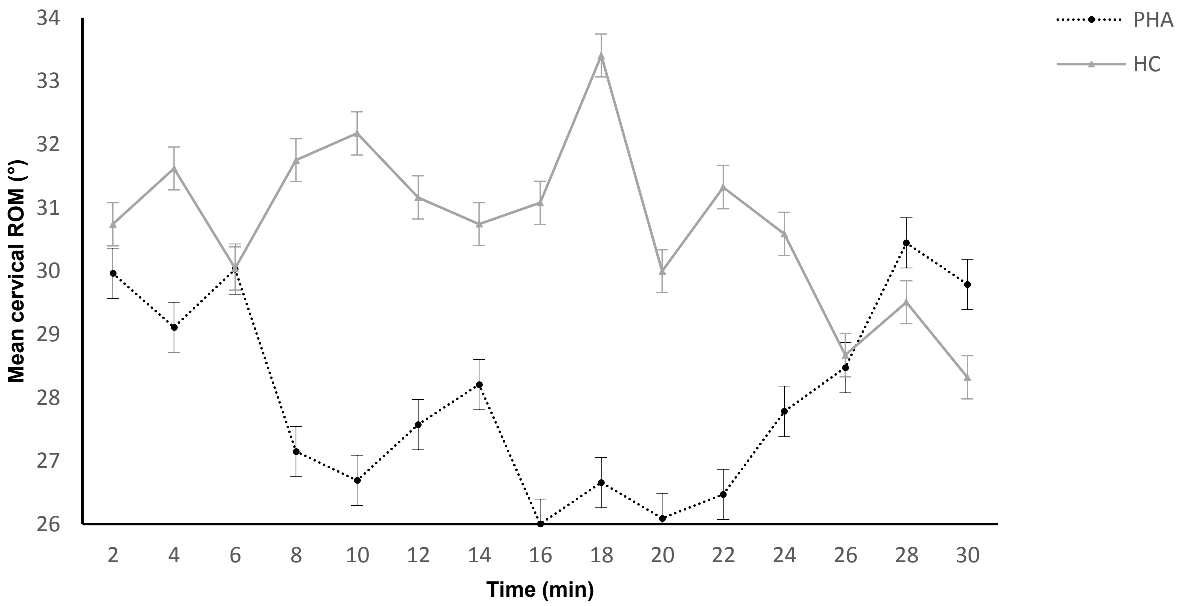
Differences in head-tilt and forward head position profiles between groups

Figure 2 illustrates differences in upper-cervical and cervical profile for both groups. The upper-cervical profile for the PHA-group shows a biphasic pattern. A gradual increase in upper-cervical extension was seen until 16 minutes, followed by a fast decrease of the angle indicating a postural change of the upper-cervical spine into upper-cervical flexion. In contrast, the HC showed an inconsistent gradual increase in upper-cervical extension throughout the task.

A biphasic pattern was also observed for the cervical flexion in the PHA-group. Initially a more pronounced cervical flexion was observed followed by a cervical extension. In the HC-group the cervical flexion gradually increased throughout the task.

The changes in upper-cervical and cervical profile, calculated at three different time points (10, 20 and 30 minutes) referenced to the baseline were statistically significant between groups for four measurements (Table 3).



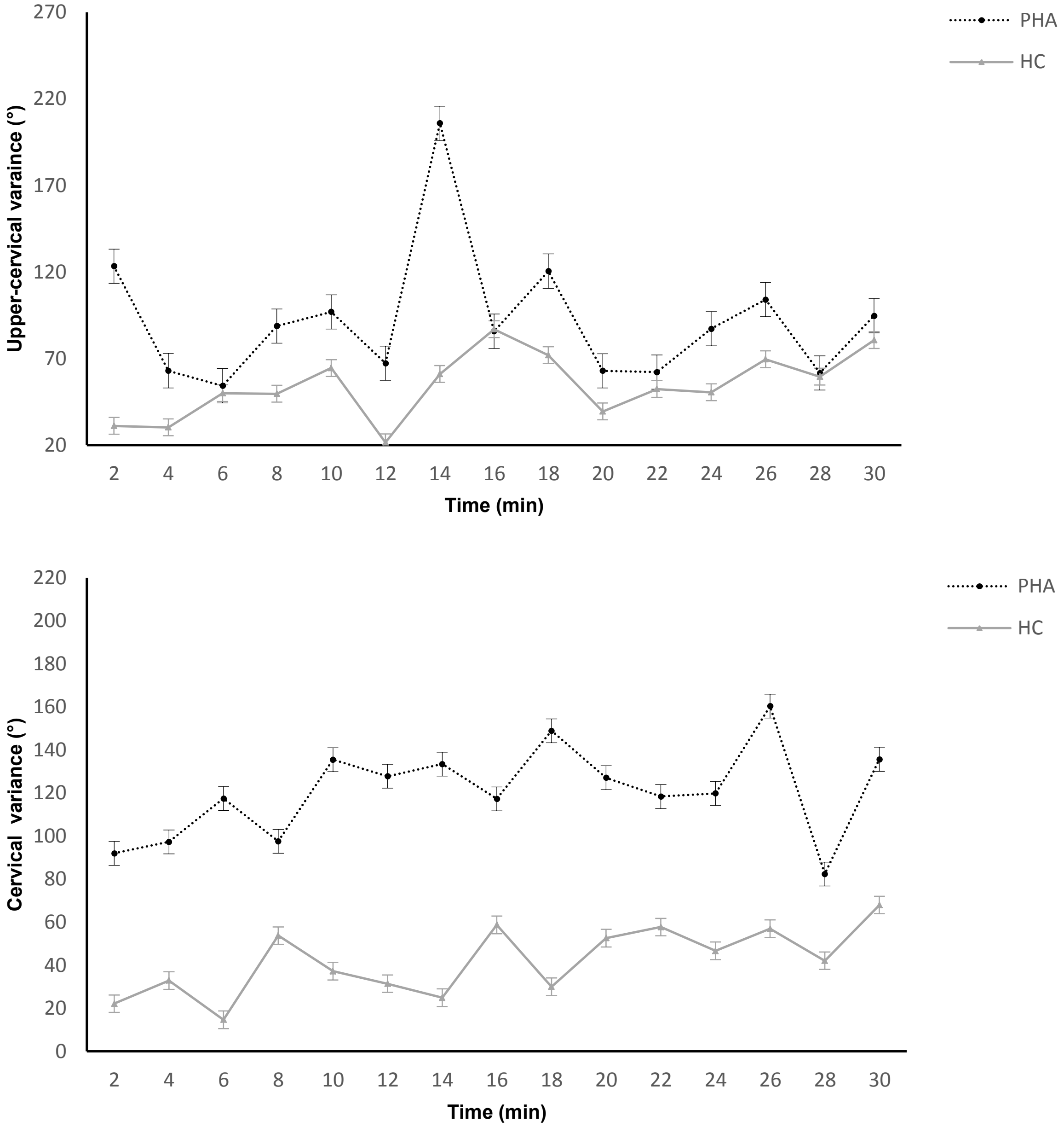


[insert caption to illustration 'Figure 2' here]

[insert Table 3 here.]

Difference in fluctuation between groups

Differences in fluctuation for upper-cervical and cervical spine during the laptop task between both groups were analysed by calculation of the correlation (TOEPH) between the measurements taken two minutes apart. Fluctuation of the upper-cervical spine within the PHA-group were larger compared to the HC. The cervical spine on the other hand fluctuated less in the PHA-group (Figure 3). All p-values were significant ($p < 0.05$).



[insert caption to illustration 'Figure 3' here]

Head-tilt and forward head position correlation within groups

HT and FHP were highly negatively correlated (r_E = - 0.927) within groups during the 30 minutes laptop task, i.e. a more pronounced cervical flexion correlated with a stronger upper-cervical extension.

4. DISCUSSION

4.1 Characteristics subjects

The present study evaluated posture between female students with PHA and HC. Since age could influence the measurements only subjects between 19 and 30 years were included. Quek et al 2013 reported that older age (60 to 78 years) was associated with a larger forward head position and less cervical mobility. In contrast, Seacrist et al 2012 demonstrated increased passive cervical mobility in younger ages (6 to 12 years). Also, younger children (5 to 6 years) had an increased head flexion while working on a computer (Maslen et al 2009).

Since we aimed to have homogenous groups this study used a female sample. It is know that pain-thresholds for mechanical stimuli are lower in females. This could implicate that static cervical postures force females to use compensatory postures faster (Kroner-Herwig et al 2012).

4.2 Baseline maximum head protraction, forward head position and head-tilt

A new postural variable, i.e. the ratio of FHP relative to the end-range position, was introduced. This end-range posture of the cervical spine may be considered more relevant to the development of headache because of the increasing load on the supporting structures (White & Taiwo 1991). Our findings show a borderline significant larger maximal cervical flexion in the PHA-group. Although this range of motion (ROM) is larger in subjects with PHA, the habitual head position was further away from the end-range. A larger cervical flexion during habitual sitting could increase the neutral zone and thereby creating an enlarged ROM.

At baseline the PHA-group tended to adopt an upper-cervical flexion and a cervical flexion. These findings confirm previous observations in patients with neck pain and tension-type headache

(Edmondston et al 2007, Fernández-de-Las-Peñas et al 2007, Yip et al 2008). A recent study by Ernst et al 2015 emphasizes that a restriction in active upper-cervical flexion correlates with a higher headache frequency and intensity. The increased upper-cervical flexion in the PHA-group might therefore be a preventive manoeuvre.

4.3 Head-tilt and forward head position during the laptop task

Differences in head-tilt and forward head position profiles between groups

The PHA-group showed a biphasic profile in HT which shifts from a upper-cervical extension to an upper-cervical flexion during the task. The more upright head position in the PHA-group towards the end of the task might be a compensation for the increased load on the cervical region. In contrast, the HC showed a consistent gradual increase in upper-cervical extension.
In the PHA-group the FHP also behaved in a biphasic way, i.e. cervical flexion evolved into cervical extension. The FHP in the HC-group gradually decreased which was represented by an increase in cervical flexion towards the end of the laptop task. An augmented FHP is a typical feature in tension-type headache (Fernández-de-Las-Peñas et al 2007) and a provocative posture in cervicogenic headache (Vincent 2010).

Difference in fluctuation between groups

The PHA-group showed more fluctuation in the upper-cervical movements and less fluctuation in the cervical movements. A possible explanation for the smaller cervical fluctuations could be a disturbed proprioception caused by muscular imbalance (Giacomini et al 2004) which may lead to difficulties in controlling the neutral zone. Less isometric strength and endurance of the upper-cervical flexors and atrophy of the suboccipital muscles have been observed in studies on patients with headache and neck pain (Szeto et al 2005, Yoo & An 2009, Fernández-de-Las-Peñas et al 2010, Ernst et al 2015). The rather static posture of the cervical spine in this study could be a compensation for the upper-cervical fluctuations.

Head-tilt and forward head position correlation within groups

HT and FHP were negatively correlated. In the PHA-group this increase in cervical flexion correlated with an increased upper-cervical extension. The increased cervical flexion combined with a more pronounced upper-cervical extension at the end of the laptop task could be a consequence caused by relaxation of the cervical spine supporting postural muscles (Ernst et al 2015).

5. CLINICAL IMPLICATIONS

Several clinical implications arise from this study. Firstly, the upper- and lower-cervical spine and their relationship seem to play a role in the mechanism of PHA. Next, passive examination of the cervico-thoracic region in patients with PHA should include end-range postures. Thirdly, it is also recommended to consider longitudinal postural analysis when evaluating patients with PHA. Further, physiotherapy in patients with PHA should involve patient-centred exercise therapy with proprioceptive exercises that address the cervical and thoracic spine. Finally, physiotherapists must also provide the patient with ergonomic advice concerning posture when using a laptop.

6. LIMITATIONS

This study has some limitations. The small female sample size and the laboratory setting might be limiting factors. Postural awareness of the subjects could be influenced since the students were informed that their posture was monitored.

Since age and gender could impact test results our study only included female subjects between 18 and 39 years (Maslen et al 2009, Seacrist et al 2012, Kroner-Herwig et al 2012, Karli et al 2012, Quek et al 2013). Previous studies on employers, working on computers, reported more discomfort in females (Noack-cooper et al 2009). The present study anticipated the influence of hormonal fluctuations on headache intensity and frequency (Karli et al 2012) by excluding patients with menstrual headache.

The short time of the laptop task during the testing does not reflect the actual time normally spent in front of the laptop. Although existing literature supports shorter duration tasks (Straker et al 1997, Villanueva et al 1997, Szeto & Lee 2002, Nakazawa et al 2002). Furthermore, these laptop tasks of shorter duration were able to provoke a specific posture and symptoms. Postural differences in the present study were examined during a 30 minutes laptop task between subjects with PHA and HC. The assessment period was based on previous studies in which participants performed a laptop task for 15 or 20 minutes (Straker et al 1997, Villanueva et al 1997, Szeto & Lee 2002). Nakazawa et al 2002 suggests that working on a computer for less than one hour could induce complaints such as mental, physical and sleep problems. These complaints significantly aggravate with an increasing duration.

In our study, the average time spend daily working at a laptop was between 3.2 and 4 hours for the PHA-group and the HC respectively. This was similar to previous studies (Noack-Cooper et al 2009).

Finally, students who had consulted or were consulting a physical or manual therapist for their headache were excluded (Edmondston et al 2007).

Due to these limitations caution is required to generalize the results. Nevertheless, this study was able to detect significant differences in postural control between a PHA-group and HC using the ratio FHP to MHP and a longitudinal measurement. Both measurements seem sensitive enough to detect small differences between the groups.

7. SUGGESTIONS

This study measured HT referenced to the vertical axis and FHP referenced to the horizontal axis. It would be more relevant from a clinical point of view to measure the angles relative to one axis. Because of the increasing incidence and rejuvenation of PHA more attention should be given to the early detection of PHA-risk factors involved in chronification. Future research should also target therapies focusing on proper autoregulation such as postural awareness (proprioception) and dynamic postural training. Differences seen between groups could be related to a muscular component. Increased tenderness and tension of the peri-cranial muscles and decreased deep neck flexor muscle contraction have been reported in subjects with chronic cervical and tension-type headache (Jensen 1996, Jull et al 1999, Fernández-de-Las-Peñas et al 2007b).

8. ACKNOWLEDGEMENTS

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9. CONFLICTS OF INTEREST

None

10. FUNDING SOURCE

No involvement

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12. TABLES

Table 1. Characteristics of all subjects presented as a group mean.

Characteristics	PHA (n = 12)	HC (n = 12)	p-value
Age (years ± SD)	21 (± 0.90)	21.5 (± 1.92)	0.50
Duration of headache 2 weeks prior the study (hours/day ± SD)	2.5 (± 1.25)	0	N/A
VADS 2 weeks prior the study (average/day ± SD)	4.7 (± 2.04)	0	N/A

PHA = postural induced headache, HC = healthy controls, n = number of subjects, SD = standard deviation, N/A = not applicable, VADS = Visual Analogue Discomfort Scale, p-value = significant difference level determined by the independent sample t-test ($p < 0.05$;95%).

Table 2. Summary of postural variables for the PHA-group and the HC (± standard deviation).

Angle (°)	Spinal region	PHA (n = 12)	HC (n = 12)	p-value
HT during habitual sitting	Upper-cervical spine	88.8 (± 6.4)	91.4 (± 4.7)	0.26
FHP during habitual sitting	Cervical spine	31.0 (± 9.8)	33.3 (± 6.9)	0.44
MHP during neutral sitting	Maximum ROM cervical spine	23.7 (± 7.9)	30.5 (± 6.0)	0.069
Ratio FHP during habitual sitting/MHP	Cervical spine/maximum ROM	1.4 (± 0.4)	1.1 (± 0.2)	0.046*

PHA = postural induced headache, HC = healthy controls, n = number of subjects, FHP = forward head position, HT = head-tilt, MHP = manually induced maximal head protraction, ROM = range of motion, (°) = degrees, p-value = significant difference level determined by the Wilcoxon Mann-Whitney test ($p < 0.05$;95%), *$p < 0.05$. Confidence interval (CI) MHP PHA [18.62-28.68]; HC [26.70-34.33], CI HT PHA [84.78-92.88]; HC [88.46-94.42], CI ratio PHA [1.14-1.6]; HC [0.96-1.14], CI FHP PHA [24.80-37.27]; HC [28.93-37.71]

Table 3. Comparison of differences in upper-cervical and cervical profiles between groups measured at 10 - 20 - 30 minutes.

Measurement	At 10th (Estimate° ±SE)	At 20th (Estimate° ±SE)	At 30th (Estimate° ±SE)
Upper-cervical differences (°)	-3.273 (± 0.938)	-2.735 (± 1.254)	0.518 (± 2.138)
p-value	< 0.001*	0.029*	0.81
Cervical differences (°)	3.485 (± 1.257)	2.530 (± 1.462)	6.015 (± 2.665)
p-value	0.005*	0.084	0.024*

° = degrees, estimate = differences corrected for the baseline, SE = standard error, min = minute, p-value = significant difference level determined by the F-test ($p < 0.05$;95%), *$p < 0.05$.

13. CAPTION TO ILLUSTRATIONS

Figure 1. Summary of the angle calculation of the MHP, HT and FHP (MHP = manually induced maximal head protraction, HT = head-tilt, FHP = forward head position, A = head protraction, B = head retraction, a = spinous processus C7, b = tragus, c = lateral orbital margin, I = angle of MHP and FHP or the cervical angle, II = angle of HT or the upper-cervical angle) (With permission of Neumann: Kinesiology of the Musculoskeletal System, 2nd edition, 2010).

Figure 2. Evolution of the mean upper-cervical ROM and cervical flexion during the laptop task (PHA = postural induced headache, HC = healthy controls, (°) = angle in degrees, ROM = range of motion).

Figure 3. Fluctuation of the upper-cervical ROM and cervical flexion during the laptop task (PHA = postural induced headache, HC = healthy controls, (°) = angle in degrees).