2014•2015
FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
*master in de revalidatiewetenschappen en de kinesitherapie*

# Masterproef

## Endurance of the deep neck flexors and extensors in women with headache versus healthy women. A pilot study.

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Prof. dr. Marita GRANITZER

Copromotor :
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Jan Van Haesbroeck , Christophe Vercammen
*Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie*

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Universiteit Hasselt

Faculteit Geneeskunde en Levenswetenschappen

Masteropleiding Revalidatiewetenschappen en Kinesitherapie

# Masterproef deel 2:

## Endurance of the deep neck flexors and extensors in women with headache versus healthy women. A pilot study

Masterproef voorgedragen
tot het behalen van de
graad van Master of Science in de
Revalidatiewetenschappen en de Kinesitherapie

**door Christophe VERCAMMEN en Jan VAN HAESBROECK**

o.l.v.

**Prof. dr. M. Granitzer**, promotor
**S. Mingels**, co-promotor

Hasselt, 2015

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Opgesteld volgens de richtlijnen van The Journal of Cephalalgia

## WOORD VOORAF

Talrijke mensen hebben een bijdrage geleverd om deze masterproef te realiseren. Graag zouden we deze mensen willen bedanken.

Allereerst willen we graag onze oprechte dank betuigen aan Prof. Dr. M. Granitzer en S. Mingels, onze promotor en co-promotor. Doorheen het jaar hebben we kunnen genieten van hun deskundigheid, advies en steun wanneer we dit nodig hadden.

Ook willen we de hogescholen (PXL, Katholieke Hogeschool Limburg) en de Universiteit Hasselt (UHasselt) bedanken voor hun medewerking. Dankzij hen waren we in staat om de nodige proefpersonen te rekruteren.

Verder onze dank aan alle proefpersonen voor hun interesse en tijd. Zonder hen was het onmogelijk geweest om deze masterproef te volbrengen.

Als laatste willen we onze ouders en vrienden bedanken voor hun steun en hulp.

Lommel, 01-07-2015 V.C

Lommel, 01-07-2015 V.H.J.

## Background

Headache is prevalent all over the globe and well described in Europe, North America and Asia. Information concerning headache is sparse in Africa (Olajumoke et al. 2013) and the Arab countries (Benamer et al. 2010). Headache affects adults as well as adolescents. Lima et al. (2013) found a statistical significant relation between headache intensity, school absenteeism and impact on activities of daily living. Yu et al. (2012) reported a significant drop in quality of life, negatively affecting activities of daily living, school and work performance.

Despite the fact that headache is the most common neurological symptom and one of the most disabling diseases (World Health Organization, 2006), it is often simplified as a daily ailment. This leads to under recognition and under treatment (World Health Organization, 2006). Governments fail to recognize that the treatment costs of headache disorders are small compared to the loss of productivity (Steiner 2013).

This study is a sequel on a previous literature search, guided by Prof. Dr. M. Granitzer and S. Mingels. The main results were: 1) Patients with tension-type headache demonstrated a greater forward head position than control subjects (Fernandez-de-las-Penas et al. 2005; Fernandez-de-las-Penas et al. 2006; Fernandez-de-las-Penas et al. 2007; Sohn et al. 2010). 2) A forward head posture can induce shortening of the deep neck extensors muscles and weakening of the deep neck flexors (Alonso-Blanco et al. 2011). 3) Patients with tension-type headache seem to have a disturbed proprioception because of a reduced cross-sectional area in the rectus capitis posterior minor and major muscle (Fernandez-de-las-Penas et al. 2007). 4) At last, myofascial trigger points could be promoting or perpetuating factors in tension-type headache (Couppé et al. 2007; Fernandez-de-las-Penas et al. 2007; Fernandez-de-las-Penas 2010).

The study design was developed under supervision by Prof. Dr. M. Granitzer and S. Mingels. Christophe and Jan had an equal share in the recruitment and the discussion. The data-acquisition was mainly done by Christophe and the data-analysis by Jan. Christophe and Jan had an equal share in the writing process. Christophe dealt with the abstract, introduction and methods. Jan wrote the data-analysis and results. Prof. Dr. M. Granitzer and S. Mingels revised throughout the entire writing process.

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## Abstract

**Aim.** To compare the endurance of the deep neck flexors and deep neck extensors between women with posture related headache and matched healthy controls before and after a 30 minutes laptop task.

**Methods.** Eleven patients with posture related headache were recruited and compared with 11 age- and sex-matched healthy controls. The endurance of the deep neck flexors and deep neck extensors was measured before and after a laptop task with respectively the deep neck flexor endurance test and the modified Beering-Sørensen test.

**Results.** The modified Beering-Sørensen test holding time was significantly lower in the headache group compared to the healthy control group in both the pre- (p=0.000) and post-condition (p=0.004). The deep neck flexor endurance test was significantly lower in both the headache (p=0.003) and healthy control group (p=0.021) when comparing the post- with the pre-condition. The modified Beering-Sørensen test was only significantly lower in the headache group (p=0.006) when comparing the post- with the pre-condition. No significant correlations between the modified Beering-Sørensen test versus the deep neck flexor endurance test holding time were found with the exception of the post-condition in the healthy control group (p=0.001).

**Conclusion.** The headache group showed a significantly lower deep neck extensor muscle endurance time before and after the laptop task compared to the healthy controls. Within both groups a deterioration of the deep neck flexor endurance time after a laptop task of 30 minutes was found.

**Keywords**

Postural related headache, tension-type headache, cervicogenic headache, deep neck flexor endurance test, modified Beering-Sørensen test

## Introduction

Headaches are worldwide prevalent and disabling. Even though regional differences are seen in headache prevalence, all races, ages and income levels are affected (Steiner 2013). Headache can be classified as either primary (headaches without an underlying cause) or secondary (headaches with an underlying cause) (Robins & Lipton 2010). Tension-type headache (TTH) is the most common primary headache. Stovner and Colette (2010) studied the prevalence of TTH, migraine, cluster headache and medication overuse headache in Europe. Overall, the current prevalence of TTH among adults was 62.6%. Chronic TTH occurred in 3.3%. Antilla (2006) described the TTH-prevalence among adolescents, ranging from 10% (Sweden) to 73% (Brazil). Secondary headaches such as cervicogenic headache (CeH) showed a smaller prevalence (4.1%) as discussed by Sjaastad and Bakketeig (2008). In general women report a significant higher prevalence of TTH compared to men. The female predisposition was less obvious for CeH (Sjaastad & Bakketeig 2008). Both primary and secondary headaches have a major impact on the individual and the society.

Treatment of TTH and CeH seems difficult because of overlapping features such as their relation with posture viz. the forward head posture (FHP). Increase in our sitting behavior, e.g. the augmented laptop use, provokes a FHP (Straker et al. 1997). A larger FHP in standing but not in sitting is seen in chronic TTH compared to controls (Fernandez-de-las-Penas et al. 2007). This differs from episodic TTH in which for both sitting and standing a greater FHP was observed compared to control subjects (Fernandez-de-las-Penas et al. 2007). Concerning CeH, symptoms can be provoked by prolonged deviant head positions, movements and postures like the FHP (Vincent 2010). Since both types of headache, i.e. TTH and CeH, are triggered by posture they could be referred to as posture related headache (PHA). The prolonged FHP in TTH and CeH may lead to e.g. shortening of the suboccipital muscles, weakening of the deep neck flexors and more tension around cervical vertebra 7, the M. trapezius pars descendens and the M. splenius capitis (Rempel et al. 2007). Furthermore, individuals with chronic TTH showed a reduced endurance of the deep neck flexors when using the cranio-cervical flexion test (Fernandez-de-las-Penas et al. 2007). Dumas et al. (2001) found similar results in patients with traumatic and non-traumatic chronic

CeH. The neck flexor strength, the short neck flexor endurance and the isometric strength of the neck extensors were significantly lower in patients with CeH compared to controls. Reduced endurance of the deep neck musculature seen in patients with headache might be a consequence of an enlarged FHP. Weakening of the deep neck muscles may influence the stability of the cervical spine in patients with headache. These dysfunctions may create an increased load on several cervical structures, e.g. the zygapophysial joints, intervertebral discs, ligaments and muscles, innervated by the upper cervical nerves. Convergence of nociceptive information from these cervical structures at the trigemino-cervical complex can cause headache (Bogduk 2001).

To our knowledge not a single study investigated the neck extensor endurance in patients with PHA. Nor is there a study comparing the deep cervical flexor endurance to the deep cervical extensor endurance in patients with PHA.

Therefore, the primary goal of this study was to compare the deep cervical flexor endurance and the deep cervical extensor endurance before and after completing a laptop task between patients with PHA and healthy controls (HC). A secondary goal is to compare the deep cervical flexor endurance with the deep cervical extensor endurance in both groups before and after completing a laptop task.

This study expects to find a deterioration in muscle endurance of both muscle groups in both groups and an overall lower muscle endurance in the PHA-group.

## Material and methods

*Objective*

To compare the endurance of the deep neck extensors and the deep neck flexors between a posture related headache (PHA) and healthy control (HC) group before and after completing a 30 minutes laptop task in habitual sitting.

*Design*

Muscle endurance of the deep neck flexors and deep neck extensors will be compared between and within the PHA-group and the HC-group with a longitudinal design.

*Participants*

Participants are recruited through e-mail and advertising on information boards in the university colleges and the University of Hasselt. For participants outside the university colleges and the University of Hasselt a call was launched on the internet (Facebook). Only women between 18 and 39 years are included. Screening and selection of the participants was done using a headache questionnaire and a headache diary in cooperation with a clinical experienced physical therapist. The **PHA-group** consists of 11 female participants who meet the diagnostic criteria for chronic or frequent episodic TTH or CeH according to the International Headache Society (2013). Participants of the PHA-group are excluded when one of the following characteristics are present: pregnancy, treatments of physiotherapy or manual therapy for head or neck problems in the last 12 months, neck-related neurological symptoms, medication-overuse headache and a history of neck/head trauma and surgery. The **HC-group** consists of 11 age-matched female participants without a headache history. Participants of the HC-group are excluded when one of the following characteristics are present: headache, pregnancy, treatments of physiotherapy or manual therapy for neck problems in the last 12 months, neck-related neurological symptoms and a history of neck/head trauma or surgery. This study was approved by the Medical Ethical Committee of the Hasselt University and the University hospital of Leuven. All participants will be given a written informed consent before participating.

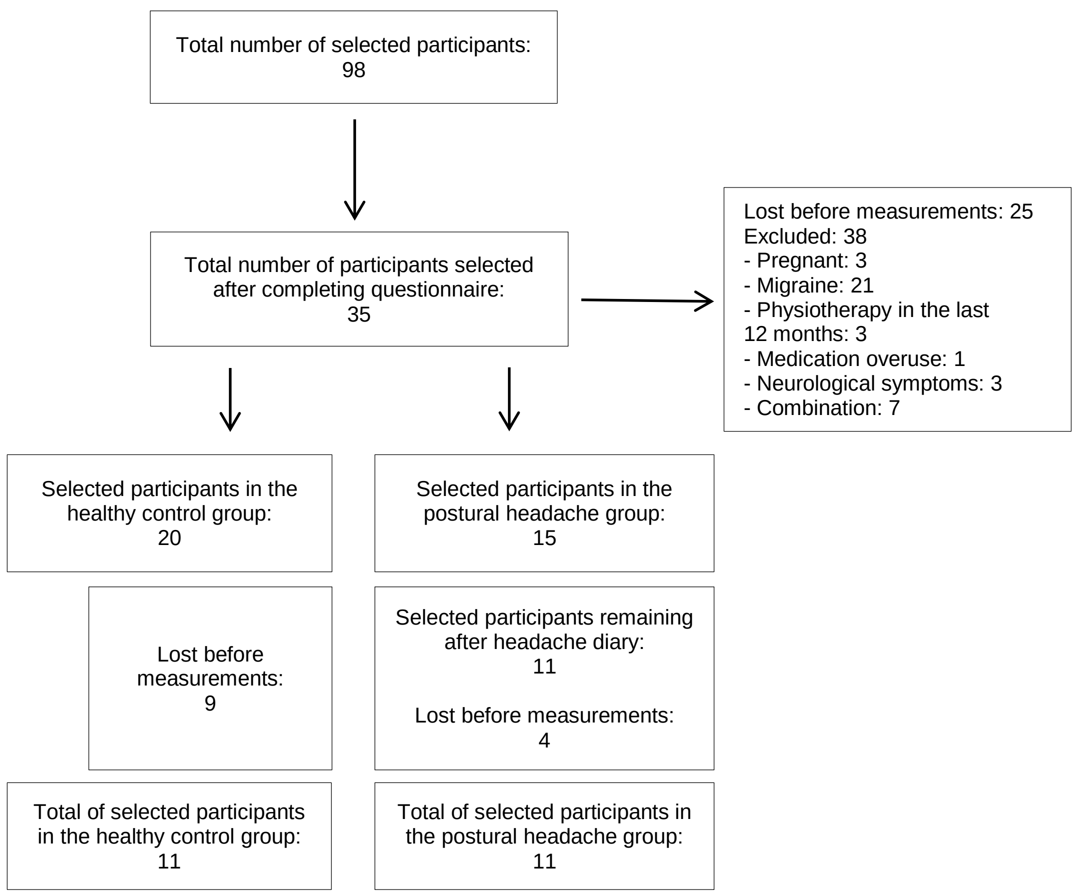


**Figure 1.** Flow diagram of the participants throughout the course of the study.

*Outcomes*

The primary outcomes are the endurance (sec) of the deep neck flexors and the endurance of the deep neck extensors and will be measured respectively by the deep neck flexor endurance test (DNFET) and the modified Beering-Sørenson test (MBST). Headache intensity, duration and frequency calculated from the headache diary are the secondary outcomes.

*Instruments*

The endurance of the deep neck flexors will be measured by the isometric DNFET. According to Edmondston et al. (2008) the inter-reliability was excellent (intraclass correlations coefficient (ICC) =.86-.97) in participants with postural neck pain. The inter-reliability described by Harris et al. (2005) was moderate to good (ICC= .67-.78) for participants without neck pain and moderate (ICC=.67) for participants with neck pain. The intra-reliability described by Harris et al. (2005) ranged from good to excellent (ICC= .82-.91) for participants without neck pain.

The endurance of the deep neck extensors will be measured by the isometric MBST. A fluid/bubble inclinometer was used to measure the cervical range of motion during the MBST. Pringle (2003) found an inter-rater reliability ranging from good to excellent (ICC=.86-.95) when measuring combined flexion and extension of the cervical spine with a fluid inclinometer in healthy students. A moderate (ICC=.61) intra-observer reliability for cervical flexion-extension movements was found by Alaranta et al. (1994) in blue/white-collar employees. The inter-reliability of the MBST according to Edmondston et al. (2008) was good in participants with postural neck pain (ICC=.88).

*Test protocol*

*Headache diary.* Participants with PHA receive a diary prior to the study to register the headache characteristics on a daily basis. The headache intensity is registered on a 10-point VAS-scale ranging from 0 (no pain) to 10 (maximum pain) (Jensen et al. 1999). Headache duration is registered in hours per day and headache frequency in days per month. The headache diary is retrieved after 4 weeks.

*Test procedure.* Each participant starts with the DNFET followed by an interval of 5 min rest. Next the MBST is performed, followed by the 30 minutes laptop task in habitual sitting. After the laptop task the DNFET and the MBST are repeated. Before testing the procedure of each test is explained. The protocol time is estimated to be maximum one hour.

The standard procedures of the two tests are the following:

*DNFET.* The participant lies in a supine, hook position with the hands on the abdomen. Next the participant brings her chin in a maximal tucked position and maintains this position isometrically. The participant lifts her head and neck about 2.5 cm from the resting position (Figure 2(a)). In this position a line will be drawn across 2 approximated skin folds at the participant's anterior-lateral neck to control the maximal tucked position. The tester slides his stacked middle and index finger under the posterior aspect of the participant's occiput (Figure 2(b)). Next, the participant relaxes her neck, and places her head on the tester's hand. The participant performs a maximal tucked chin position and raises her head without losing contact with the tester's fingers. Time is recorded when the participant lifts her head. One deviation from the test position is allowed and corrected with verbal feedback ("tuck your chin" or "hold your head where you slightly feel my fingers"). The test is terminated if a second deviation occurs. Deviations to be considered are:

- The head of the participant rested for more than one second on the tester's hand.
- The participant was unable to hold the testing position.
- The participant raised her head in such way there was no longer contact with the tester's stacked fingers.
- The edges of the drawn lines across the skin folds no longer approximated each other because of a loss of chin tuck.

The participant will perform the test twice with an interval of 5 minutes. Scores are averaged for the final score. Before actual testing a practical session is exercised (Harris et al. 2005; Olson et al. 2006 and Domenech et al. 2011).

a b

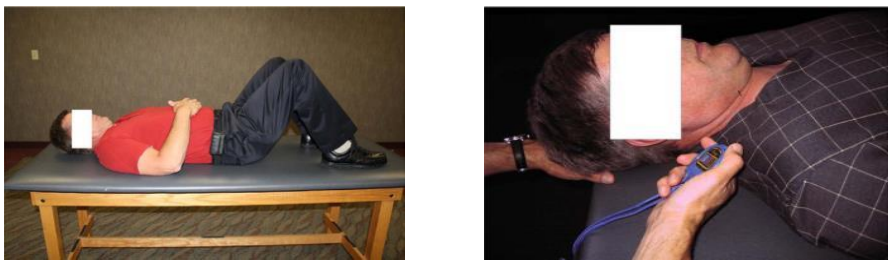

**Figure 2.**

(a)The deep neck flexor endurance test in supine lying hook position (Domenech et al. 2011)

(b) The deep neck flexor endurance test: Position of the cervical spine and tester. Note the chin tuck and the testers stacked fingers under the posterior part of the occiput (Domenech et al. 2011)

*MBST.* The participant lies prone on the table, with correction of lumbar (hyper)lordosis and with a roll placed underneath the ankles. The head and cervical spine are supported and the arms lay alongside the trunk. To keep the participant in the correct testing position a strap is fixated around the thoracic spine (T6). Thereafter a strap is positioned around the participants head on a horizontal line just above the eyebrows. The bubble inclinometer was attached to the strap and a pendulum with a two kg weight is connected with the strap (Haejung et al. 2003; Edmondston et al. 2008). The test starts when the tester removes the head support. The participant is required to hold her head in a position where the chin is retracted and the cervical spine remains horizontal (Edmondston et al. 2008) (Figure 3) as long as possible.  Time is registered.

The achieved time is defined as holding time. Actual testing is preceded by a practical session. Verbal feedback and tactile cues are given to correct the participant's position during the practical session. The actual test ends when the following occurs:

- The participant is not able to stabilize her head horizontally.
- The participant has lost 5° of retraction of the upper cervical spine for over five seconds.

Each participant performs two trials, with an interval of 5 minutes. Scores were averaged for further analysis.

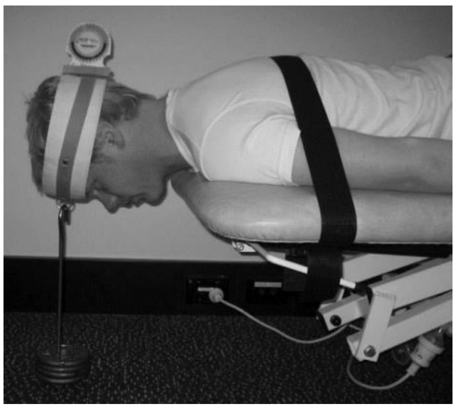

**Figure 3.** Participant's position for the neck extensor muscle endurance test. The inclinometer is used to monitor the position of the head during the test (Edmondston et al. 2008).

*Laptop task.* After the DNFET and MBST the participants perform a 30 min laptop typing task on a Medion laptop (Notebook MD 98200). The workstation is adjusted to the participant's convenience to simulate habitual sitting posture. Three workstation components could be adjusted: (1) the position of the laptop on the desk, (2) the inclination of the laptop screen and (3) the distance between chair and desk (Moffet et al. 2002). The desk and chair where not adjustable, considering that laptops are often used in places where adjustable furniture is not available.

*Risks and duration of the protocol*

The tests can be performed safely without a prolonged increase in symptoms. In most cases the tests are interrupted because of muscle fatigue rather than pain (Edmondston et al. 2008).

## Statistical analysis

Statistical analysis was performed with a 95% confidence level with p-value ≤ 0.05. Statistical analysis was done using SPSS, version 22 software (SPSS Inc., Chicago, IL, USA). Equality of groups was tested by the Mann-Whitney U-test.

Variances between groups were analyzed with the F-test (Levene's test). The samples showed equal variances when $p > 0.05$.

The statistical questions were the following:

*Cross-sectional comparison*

*Is there a difference in the DNFET and MBST in the pre-condition (baseline) between the PHA- and the HC-group? Is there a difference in the DNFET and MBST in the post-condition (after a 30 min laptop task) between the two groups?*

The difference in the pre-DNFET, the pre-MBST between the PHA- and HC group was analyzed using the Mann-Whitney U-test. The difference in the post-DNFET and the post-MBST between both groups was also analyzed with the Mann-Whitney U-test.

*Is there a correlation between the DNFET and MBST within each group in the pre-condition? If yes, is this correlation different from the correlation in the post-condition within each group?*

Correlation within each group in the pre- (baseline) and post-conditions were calculated using the Spearman Rank Correlation Coefficient.

*Longitudinal comparison*

*Is there a difference in the DNFET between the pre- and post-condition within the PHA- and the HC-group?*

The difference of the DNFET in the pre- and post-condition within groups was calculated using the Wilcoxon Signed-Rank Test.

*Is there a difference in the MBST between the pre- and post-condition within the PHA- and the HC-group?*

The difference of the MBST in the pre- and post-condition within groups was calculated using the Wilcoxon Signed-Rank Test.

*Is there a difference in DNFET- and MBST-evolutions between the PHA- and HC-group?*

Differences in DNFET- and MBST-evolutions between groups were calculated using the Mann-Whitney U-test.

## Results

*Baseline group characteristics*

Table 1 summarizes the characteristics of the eleven subjects with postural related headache and 11 matched controls which participated in this study. The mean age of the PHA-group was 24.55 (±3.24) years and 24.29 (± 3.99) years for the HC-group. Of all the participants there were 12 students (seven in the PHA- and 5 in the HC-group). Remaining participants were professionally active. There was no statistical significant difference in age between both groups.

**Table 1.** Group characteristics.

| | PHA-group (n=11) (mean ± SD) | HC-group (n=11) (mean ± SD) | p-value (Mann-Whitney U) |
|---|---|---|---|
| Age (years) | 24.55 (± 3.24) | 24.29 (± 3.99) | 0.606 |
| Average HA Frequency (Days/Month) | 15.68 (± 5.33) | N/A | N/A |
| Average HA duration (hours), | 4.11 (± 2.01) | N/A | N/A |
| Average HA intensity (VAS) | 3.76 (± 0.98) | N/A | N/A |

PHA, Postural headache; HC, Healthy Controls; HA, headache; SD, Standard Deviation; n, number of subjects; VAS, Visual Analogue Scale; N/A, not applicable.

*Cross-sectional comparison*

Table 2 summarizes the mean and the standard deviation of respectively the pre- and post-DNFET, the pre- and post-MBST in both the PHA- and the HC-group.

**Table 2**. Cross sectional comparison of the pre DNFET, Pre MBST, post DNFET and post MBST between the PHA-group and the HC-group.

| | PHA-group (n=11) (mean ± SD) | HC-group (n=11) (mean ± SD) | p-value (Mann-Whitney U) |
|---|---|---|---|
| Pre- DNFET (sec) | 11.85 (± 5.68) | 15.73 (± 7.66) | 0.178 |
| Pre- MBST (sec) | 52.64 (± 9.73) | 79.47 (± 14.77) | 0.000* |
| Post- DNFET (sec) | 7.75 (± 2.61) | 10.68 (± 4.80) | 0.140 |
| Post- MBST (sec) | 41.73 (± 8.04) | 107.50 (± 24.27) | 0.004* |

PHA, Postural headache; HC, Healthy Controls; DNFET, Deep Neck Flexor Endurance Test; MBST, Modified Beering-Sørensen Test; sec, seconds; SD, Standard Deviation; *p<0.05; n, number of subjects.

There is a significant difference for the MBST between groups resp. at the pre measurement and after a 30 min laptop task (p=0.000). However there is no significant difference in the DNFET between groups in both conditions (p=0.178; p=0.140). Yet, a trend is observed: scores for the pre- and post-DNFET are lower in the PHA-group.

Figure 4 shows the scatterplot of the endurance of the neck extensors versus the endurance of the deep neck flexors of both the PHA- and the HC-group and the correlation coefficients in the pre- and the post-condition.

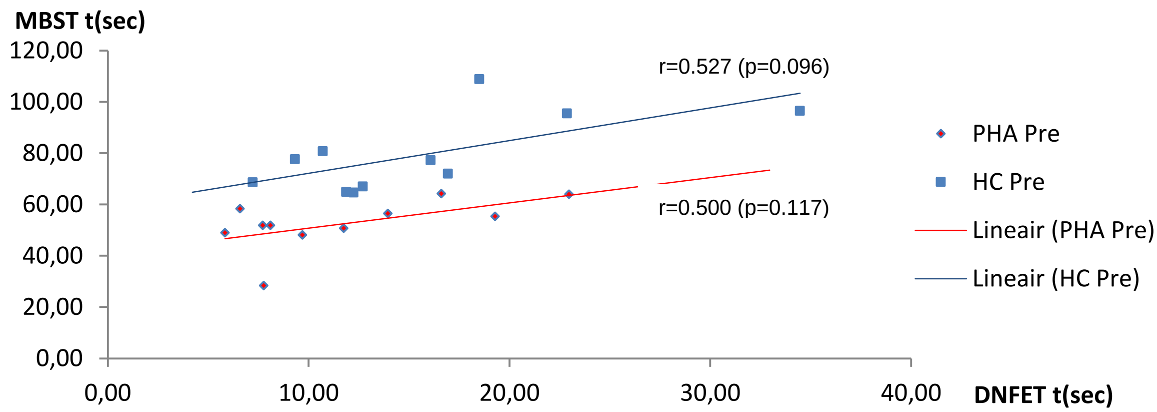


**Figure 4a.** Scatterplot with linear regression lines and correlation coefficient of the DNFET and the MBST of the PHA-group and the HC-group in the pre-condition. PHA, Postural headache; HC, Healthy Controls; DNFET, Deep Neck Flexor Endurance Test; MBST, Modified Beering-Sørensen Test; sec, seconds.

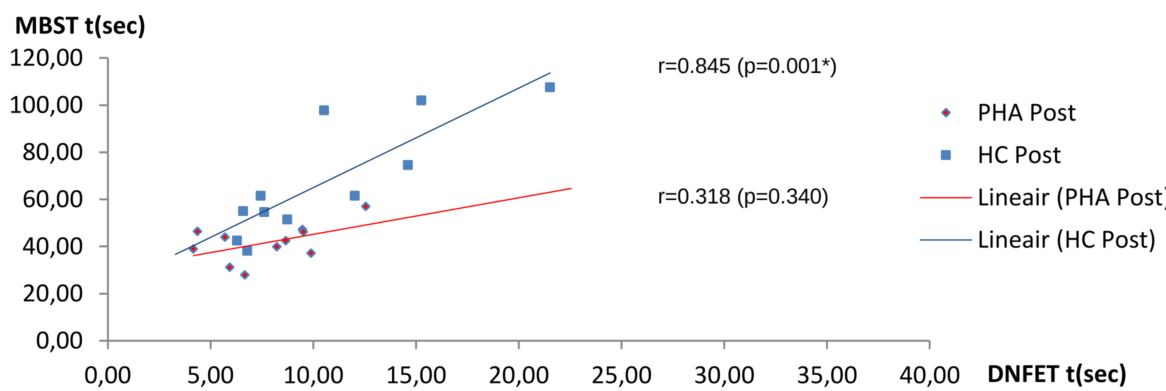


**Figure 4b.** Scatterplot with linear regression lines and correlation coefficient of the DNFET and the MBST of the PHA-group and the HC-group in the post-condition. PHA, Postural headache; HC, Healthy Controls; DNFET, Deep Neck Flexor Endurance Test; MBST, Modified Beering-Sørensen Test; sec, seconds; *p<0.05.

*Longitudinal comparison (within groups)*

Table 3 summarizes the mean and the standard deviation for the pre-DNFET, the post-DNFET, the pre-MBST and the post-MBST in both the PHA- and the HC-group. There is a significant decrease of the endurance of the deep neck flexors in both the PHA-group (p=0.003) and the HC-group (p=0.021) when comparing the post- to the pre-condition. Only the PHA-group shows a significantly lower endurance time for the MBST in the post-condition (p=0.006). There is however no significant difference in the MBST within the HC-group between the post- and pre-condition (p=0.213).

**Table 3.** Differences within the PHA- and the HC-group between the pre- and the post-DNFET and the pre- and post-MBST.

| | PHA-group (n=11) (mean ± SD) | HC-group (n=11) (mean ± SD) |
|---|---|---|
| Pre- DNFET (sec) | 11.85 (± 5.68) | 15.73 (± 7.66) |
| Post- DNFET (sec) | 7.75 (± 2.61) | 10.68 (± 4.80) |
| p-value (Wilcoxon Signed-Rank) | 0.003* | 0.021* |
| Pre- MBST (sec) | 52.64 (± 9.73) | 79.47 (± 14.77) |
| Post- MBST (sec) | 41.73 (± 8.04) | 67.86 (± 24.27) |
| p-value (Wilcoxon Signed-Rank) | 0.006* | 0.213 |

PHA, Postural headache; HC, Healthy Controls; DNFET, Deep Neck Flexor Endurance Test; MBST, Modified Beering-Sørensen Test; sec, seconds; SD, Standard Deviation; *p<0.05; n, number of subjects.

Figure 5 illustrates the individual and mean evolutions of the DNFET for the PHA- and the HC-group. Both groups show an overall decline in the DNFET.

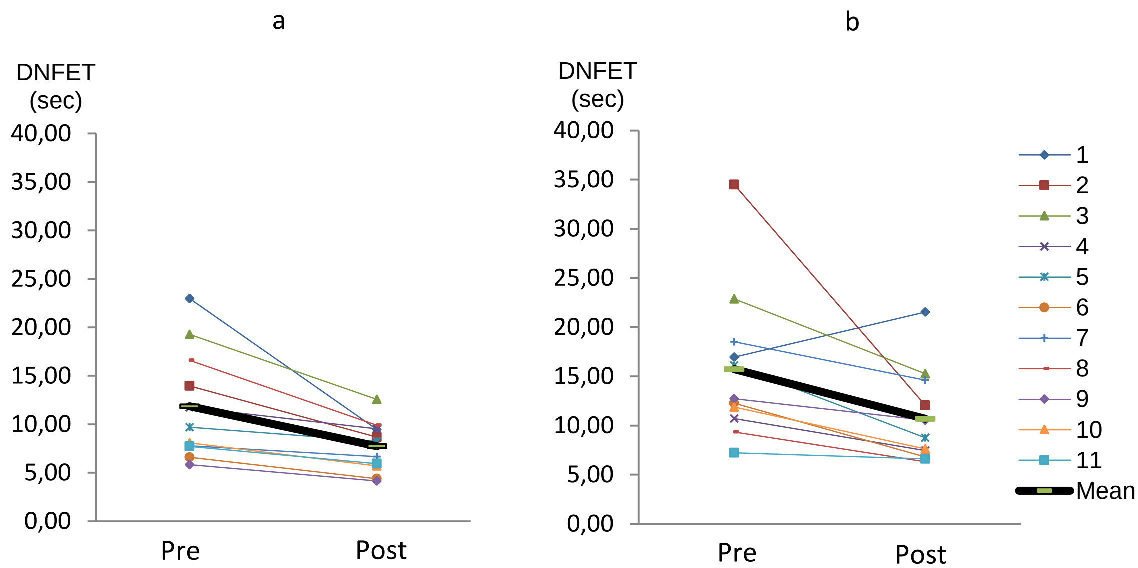


**Figure 5.** Deep neck flexor endurance before (Pre) and after (Post) the laptop task in the PHA-group (a) and the HC-group (b). PHA, Postural headache; HC, Healthy Controls; DNFET, Deep Neck Flexor Endurance Test; sec, seconds.

Figure 6 illustrates the individual and mean evolution of the MBST for the PHA- and the HC-group. Both groups show an overall decline in the MBST**.**

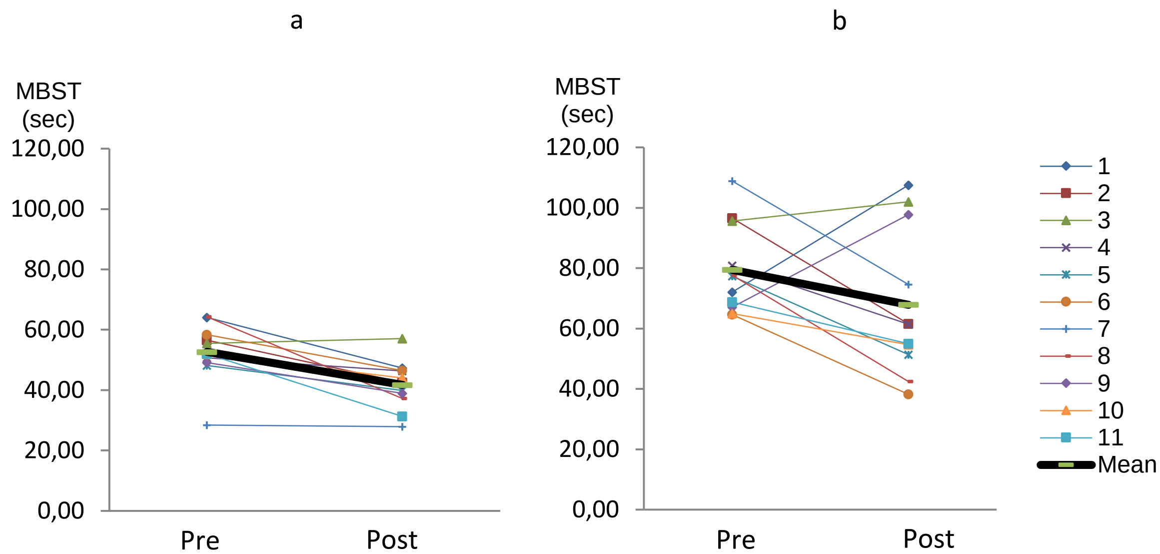


**Figure 6.** Deep neck extensor endurance before (Pre) and after (Post) the laptop task in the PHA-group (a) and the HC-group (b). PHA, Postural headache; HC, Healthy Controls; MBST, Modified Beering-Sørensen Test; sec, seconds.

*Longitudinal comparison (between groups)*

Table 4 summarizes the mean difference in evolution and the standard deviation of the DNFET- and MBST. There are no significant differences in the DNFET-evolution (p=0.490) and the MBST-evolution (p=0.341) between the PHA-group and the HC-group.

**Table 4.** Differences in evolution of (Δ = post minus pre) DNFET and in evolution of (Δ = post minus pre) MBST between the PHA-group and the HC-group.

| | PHA-group (n=11) (mean ± SD) | HC-group (n=11) (mean ± SD) | p-value (Mann-Whitney U) |
|---|---|---|---|
| Δ DNFET (sec) | -4.1 (± 3.75) | -5.05 (± 6.67) | 0.490 |
| Δ MBST (sec) | -10.91 (± 8.52) | -11.62 (± 25.37) | 0.341 |

PHA, Postural headache; HC, Healthy Controls; Δ DNFET, evolution of the Deep Neck Flexor Endurance Test; Δ MBST, evolution of the Modified Beering-Sørensen Test; sec, Seconds; SD, Standard Deviation; *p<0.05; n, number of subjects.

Figure 7 illustrates the dependency of the difference post minus pre DNFET and MBST holding of the pre values.

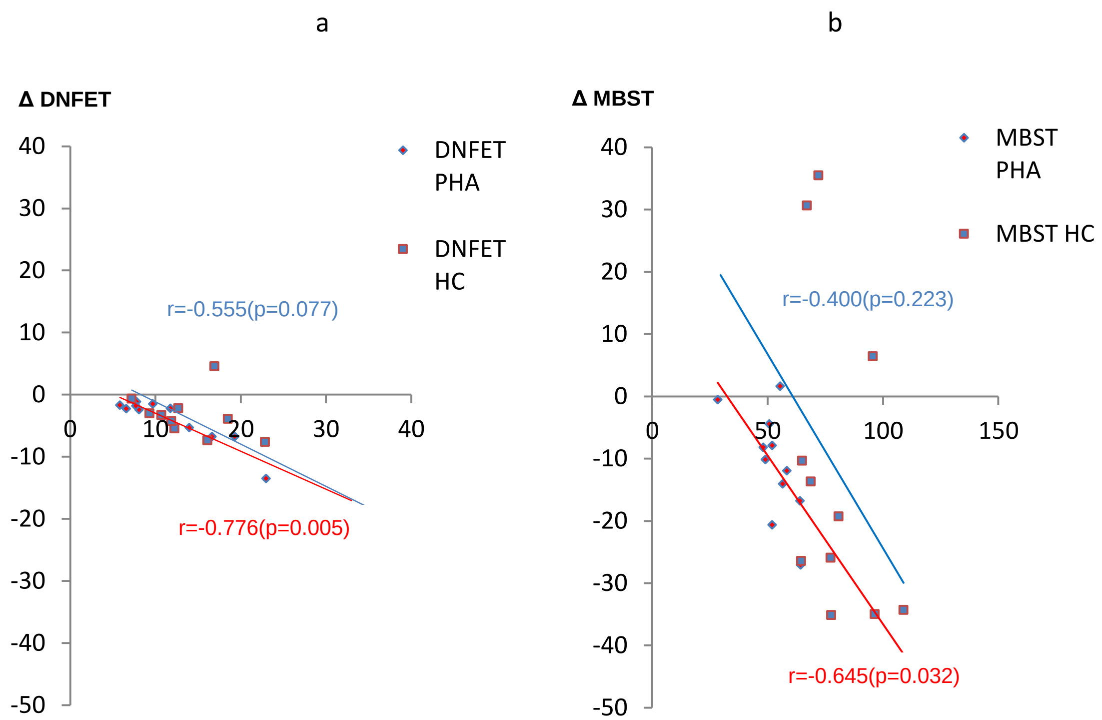


**Figure 7.** Difference of (post minus pre) DNFET versus the Pre-DNFET with the linear regression lines (a). Difference of (post minus pre) MBST versus the Pre-MBST with the linear regression lines (b). PHA, Postural headache; HC, Healthy Controls; DNFET, Deep Neck Flexor Endurance Test; MBST, Modified Beering-Sørensen Test.

## Discussion

The purpose of the present study was to compare the endurance of the deep neck extensor and deep neck flexor muscles in women with PHA before and after a 30 min laptop task with matched healthy controls. The results indicate within the cross sectional comparison a significant lower endurance of the deep neck extensors of the PHA-group versus the HC-group before and after a 30 min laptop task. After the laptop task both the PHA- and HC-group showed a significant deterioration of the deep neck flexor endurance. This deterioration was also present for the deep neck extensor endurance in the PHA-group. No significant difference in both the deep neck flexor endurance evolution and deep neck extensor endurance evolution could be demonstrated.

*Differences in deep neck extensor endurance between groups (cross-sectional comparison)*

The present study found a significant difference for the deep neck extensor endurance between the PHA- and HC-group at both the pre- and post-condition (p=0.000, p=0.004). This could possibly reflect overall weaker deep neck extensors in the PHA-group compared to the HC-group (Figure 4). The decrease of the deep neck extensor endurance could be explained by bilateral atrophy of the rectus capitis posterior Minor and Major muscles (Fernandez-de-las-Penas et al. 2007). The latter explanation is rather contradictive with the theory of the deep neck extensor hyperactivity (Watson et al. 1993). Yet, the contradictive result might be related to each other as follows. The hyperactivity theorized by Watson et al. (1993) could lead to faster onset of fatigue in the deep neck extensors. Consequently, superficial neck extensors are used to stabilize the neck. The activity of the superficial neck extensors and inactivity of the deep neck extensors could, over a prolonged period, result in atrophy of the latter. The results from Fernandez-de-las-Penas et al. (2008) could partially reinforce this hypothesis. In this study women with chronic TTH showed a greater co-activation of the M. sternocleidomastoid (during cervical extension contractions) and the M. splenius capitis (during cervical flexion contractions).

*Differences in deep neck flexor endurance between groups (cross-sectional comparison)*

There were no significant differences regarding the deep neck flexor endurance between the PHA- and HC-group at the pre- and post-condition (p=0.178, p=0.140, Figure 4) but the endurance time seems lower in the PHA-group. Jull et al. (1999) found inferior cranio-cervical test results for subjects with cervical headache compared to HC. These results were confirmed by Fernandez-de-las-Penas et al. (2007) in subjects with chronic TTH and by Dumas et al. (2001) in subjects with CeH. The decrease of deep neck flexor endurance could partially be explained by the FHP. An increase of the head flexion moment could increase the tonic activity of the deep neck extensors which eventually might lead to an inhibition of the deep neck flexors muscle activity (Watson et al. 1993; Grimmer & Trott 1998).

*Correlation between the deep neck flexor endurance and deep neck extensor endurance for both groups in both the pre- and post-condition (longitudinal within group comparison)*

A decrease in the correlation coefficient of the PHA-group (0.500 → 0.318) and an increase of the HC-group (0.527 → 0.845) was seen after 30 min (Figure 4). This indicates a decline of neck control in subjects with PHA which is in contrast with the improvement of neck control seen in the HC-group. Peolsson et al. (2007) found a decreased neck control in subjects with neck pain. This could also be the case for subjects with PHA in this study. It could be hypothesized that a similarity is present between both pathologies. A better neck control in the HC-group was not expected. A possible explanation for this result is an adaptation of the neck muscles to a specific task (laptop task). Finally resulting in a more efficient co-activation and motor control. To our knowledge this is the first study to find this unexpected result.

*Differences in deep neck extensor endurance and deep neck flexor endurance within groups (longitudinal within group comparison)*

In this study a significant deterioration of the deep neck flexor muscles within both the PHA-group (Figure 5a) and the HC-group (Figure 5b) after the laptop task is seen. Concerning the MBST, the PHA-group showed a significant decline (p=0.006, Figure 6a), while only a declining trend was seen in the HC-group (p=0.213, Figure 5b). Juul et al. (2013) however found no difference for both the deep neck flexor endurance and deep neck extensor endurance in healthy subjects between two measurements taken six hours apart.

However, in subjects with cervical headache and TTH a decreased upper cervical flexor endurance is reported (Watson et al. 1993). This could be an explanation for the results of the DNFET in the PHA-group. A switch in muscle fiber type from type I (slow twitch fibers) to type II (fast twitch fibers) might explain the decrease in endurance. Type II fibers are known to be less resistant to fatigue and have a higher contraction rate. This theory, also mentioned by Oksanen et al. (2007), in a study with patients with PHA could partially explain the loss in endurance of the deep neck flexors. Regarding the deep neck extensor endurance, no longitudinal studies were found which could explain the loss in deep neck extensor endurance. The greater decline in both the deep neck flexor endurance and the deep neck extensor endurance after a 30 min laptop task raise the question if subjects with PHA need more time to recover compared to the HC.

*Is there a difference in deep neck flexor endurance and deep neck extensor endurance evolution? (longitudinal between group comparison)*

No significant differences in evolution of the deep neck flexor endurance (p=0.490) and the deep neck flexor endurance (p=0.341) was found (Table 4). This might be explained, in particular for the endurance of the deep neck extensors, to the fact that the deep neck flexor endurance evolution and deep neck extensor endurance evolution seem to be dependent on the pre-value of the tested participant (Figure 7). The endurance of the deep neck extensors of the PHA was significantly lower than the HC before the laptop task (Table 2). Lower endurance values of the deep neck extensors correlate with lower differences in evolution of the deep neck extensors (i. e. lower values post minus pre). To our knowledge no studies investigated this phenomenon

*Finishing remarks*

The day after testing almost every subject with PHA complained of having headache (VAS-score between 2-7) and a small number of subjects even complained of having headache directly after the DNFET. Similar findings were reported by Edmondston et al. (2008). This increase in pain intensity could affect test performance. However in most cases muscle fatigue rather than pain was the main cause of test termination (Edmondston et al. 2008). Furthermore, almost every subject (PHA-group and HC-group) had trouble (trembling) when performing the DNFET. These previous two reasons raise doubts about the specificity of the test. There is no literature available concerning this topic. The overall quality of performing was better for the MBST. No subjects complained of headache or neck pain after the MBST. Lastly the DNFET and the MBST are commonly used in patients with cervical disorders. Since there appears to be a relation between cervical disorders, CeH and TTH the tests were applied to a PHA-population.

## Limitations and suggestions

First of all, although significant differences were found between the PHA and the HC, the results of this study should be interpreted with caution because of the small female sample size.

The present study found no significant difference for the DNFET between the PHA- and HC-group, in contrast to several other studies (Jull et al. 1999; Fernandez-de-las-Penas et al. 2007; Dumas et al. 2001). A possible explanation could be the difference in test procedure used in the present study (Domenech et al. 2011).

Future research should focus more on 1) similarities between patients with PHA and patients with neck disorders, 2) the decrease of the correlation coefficient between the deep neck flexor muscles (DNFET) and the deep neck extensor muscles (MBST) in the PHA-group and the improvement of this correlation coefficient in the HC-group and 3) the dependency of the evolution of the deep neck flexor endurance and the deep neck extensor endurance to the pre-values of respectively the DNFET and the MBST.

## Conclusion

Women with PHA demonstrated a significant difference of the endurance of deep neck extensors compared with the HC. An overall deterioration within each group was found for the endurance deep neck flexors. The endurance of the deep neck extensors on the other hand deteriorated only in the PHA-group after the laptop task. To our knowledge this study is the first that indicates a loss in deep neck extensor and flexor muscle endurance in women with PHA. Future research should confirm these results.

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