ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2023, 31(1), 1–5

Effect of a mask-type craniocervical brace on head posture during computer typing in individuals with forward head posture

DOI: https://doi.org/10.5114/pq.2023.116194

Taelim Yoon[1], **Jihyun Lee**[2]
[1] Department of Physical Therapy, Cheongju University, Cheongju, Republic of Korea
[2] Department of Physical Therapy, Baekseok University, Cheonan, Republic of Korea

Abstract

Introduction. Craniocervical braces decreased poor posture, but they were uncomfortable and difficult to wear. Thus, the purpose of this study was to (1) design a new forward head posture (FHP) brace that would be comfortable and aesthetically pleasing, (2) analyse the immediate effect of using a mask-type craniocervical brace, (3) analyse the time interval when FHP may become worse in individuals with FHP.
Methods. The mask-type brace was made of very light flexible plastic with the use of a 3D printer. Uverall, 32 volunteers typed for 15 minutes with and without the brace. Photogrammetric analysis was applied to calculate forward head angle. A greater forward head angle indicates a less protracted head.
Results. Wearing the brace for 15 minutes significantly increased the forward head angle as compared with when the brace was not worn. The forward head angle significantly decreased at 15 minutes compared with the status at 0 and 1 minutes.
Conclusions. The use of the mask-type craniocervical brace is a viable option for preventing deterioration of FHP during typing activities that last for more than 15 minutes.
Key words: braces, masks, posture

Introduction

The time of working in an office with a computer has dramatically increased over the past decade. When the high job demands, low skill discretion, low decision authority, or low peer support combine with increased duration of computing tasks, musculoskeletal symptoms are likely to occur. Also, the changing work environment may be accompanied by an increased prevalence of poor posture and resultant neck pain. The prevalence of neck pain in office workers has been estimated to be 24–44% throughout the year [1–3]. A risk factor of neck pain that has been identified is prolonged poor posture, such as a forward head posture (FHP) [4–6]. FHP is defined as an upper cervical extension, lower cervical flexion, and protrusion of the head in the sagittal plane [7, 8].

Many previous studies have investigated methods for rehabilitating FHP, including cervical spinal manipulative therapy [9], suboccipital release with craniocervical flexion exercise [10], modification of work station (monitor tilting angle [11] and different seat support [12]), manual material handling [13], and the use of a brace [14–18]. Of these methods, using a brace has been included in rehabilitation to improve posture, muscle activity, instability of joints, and proprioceptive capability, as well as to prevent worsening of symptoms [19]. Especially, an FHP brace developed by Yoon immediately decreased FHP during work at a computer monitor [14]. However, some participants in the study complained that the brace was uncomfortable and difficult to wear because of tackling [14]. Consequently, there is a need to develop a brace that can be comfortably worn in real-life situations.

Tasks with static posture, like sitting and typing, require workers to maintain fixed positions for certain time durations [20]. Keeping a static posture for a long time may, in turn, lead to discomfort and worsen posture [21]. Knowing when posture is deteriorating may help reduce the risk of work-related musculoskeletal disorders. A previous study recommended maximum holding times for the prevention of discomfort in static standing postures [21]. Comfortable standing postures with moderate working height (distance from acromion to the floor in the upright position) should be maintained for not more than 2 minutes without rest pauses and external load. There are no similar studies that analyse time intervals when FHP may become worse during tasks with static sitting postures, such as typing or viewing a computer monitor.

Thus, the purpose of this study was to (1) design a new FHP brace that would be comfortable and aesthetically pleasing, (2) analyse the immediate effect of using the mask-type craniocervical brace on forward head angle (FHA), and (3) analyse how the FHP changes over a set time interval in individuals with FHP. We hypothesized that wearing the brace while performing typing work would modify FHA.

Subjects and methods

Participants

The G*Power software was used for power analyses (Heinrich-Heine-Universität, Düsseldorf, Germany). The necessary sample size of 6 participants was calculated from data obtained in a pilot study of 5 participants to achieve a power of 0.80 and an effect size of 0.68 (calculated from the partial η^2 of 0.32 from the pilot study), with an α level of 0.05. Thus, there were 32 participants (age: 21.41 ± 2.00 years, height: 170.00 ± 3.41 cm, weight: 62.78 ± 12.61 kg, body mass index: 21.62 ± 2.70, FHA: 56.74 ± 7.59°). Included

Correspondence address: Jihyun Lee, Department of Physical Therapy, Baekseok University, 1, Baekseokdaehak-ro, Dongnam-gu, Cheonan-si, Chungcheongnam-do, Republic of Korea, e-mail: jihyun.lee@bu.ac.kr, https://orcid.org/0000-0002-9864-5485

Received: 27.01.2021
Accepted: 14.08.2021

Citation: Yoon T, Lee J. Effect of a mask-type craniocervical brace on head posture during computer typing in individuals with forward head posture. Physiother Quart. 2023;31(1):1–5; doi: https://doi.org/10.5114/pq.2023.116194.

were individuals aged 18–60 years who used computers daily. FHP was defined as an FHA equal to or greater than 46° relative to the vertical line extending from C7 to the line connecting C7 to the tragus [22]. The greater FHA side was adopted if both sides showed FHA. The exclusion criteria were: (1) pain, discomfort, or stiffness around the head, neck, or shoulders; and (2) history of trauma in the head, neck, or shoulders [14, 22].

Methods

Our newly designed mask-type brace was intended to correct the cervical posture in individuals with FHP. A 3D modelling mask was downloaded and modified ergonomically in a CAD program (Rhino 6) to build a 3D modelling of a custom-made mask-type brace. We engaged a 3D printer (3DWOX 2X; Sindoh, Seoul, Korea) and its slicer software (3DWOX Desktop; Sindoh, Seoul, Korea) for model fabrication. The printer works in the fused deposition modelling mode, extruding with flexible cartridges as the material of choice. Ultimately, we confirmed the clinical potential of a 3D-printed mask-type brace for correcting the posture (Figures 1 and 2).

Figure 1. Wearing the mask-type craniocervical brace, sagittal plane

Figure 2. Wearing the mask-type craniocervical brace, frontal plane

Typing task

The participants were asked to copy-type at a comfortable pace and ignore errors using typing test software (G Sanghani, Darshan Institute of Engineering & Technology). The subjects first performed a 5-minute typing task on a computer to familiarize themselves with the workstation. After a 5-minute rest, the 15-minute typing task was conducted in each condition (with and without the brace).

Forward head angle measurement

FHA was measured at the starting point and at 1, 5, 10, and 15 minutes in 2 different conditions (with and without the brace) in a sitting posture. An iPhone (Apple Inc., Cupertino, CA, USA) and the ImageJ software (National Institutes of Health, Bethesda, MD, USA; available at https://imagej.nih.gov/ij/download.html) were used [23–25]. Two light-reflective markers, 1.5 cm in diameter, were placed at (1) the tragus of the participant's ear (the centre of the flexible ear hook of a headphone piece), (2) C7 (while flexing the head and neck, the spinous process of C6 was felt to move forward and that of C7 remained stationary) [14, 22]. The angle between the line connecting the 2 markers and the horizontal line was defined as FHA and was used for statistical analysis. Photographs were taken at a distance of 80 cm to record sagittal sitting postures at the worse side of FHA. To minimize image distortion, the camera was mounted on a tripod to ensure that it was perpendicular to the horizontal level. The lens of the camera was adjusted at the level of the external auditory meatus by regulating the height of the tripod. Before taking the photograph, the participant (in a neutral position) was asked to completely flex and extend their neck 3 times and rest in the most comfortably balanced position [26]. All photographs were taken by one researcher. FHA was measured as the angle between a line drawn from the tragus to the C7 spinous process and a horizontal line through C7 [22]. A smaller FHA indicated a relatively protracted head in relation to C7, which represented a more protracted head [15]. FHA showed moderate to excellent intrarater reliability in a previous study (intraclass correlation coefficient of 0.92 in intra-day and 0.78 in inter-day) [14, 22] (Figure 3).

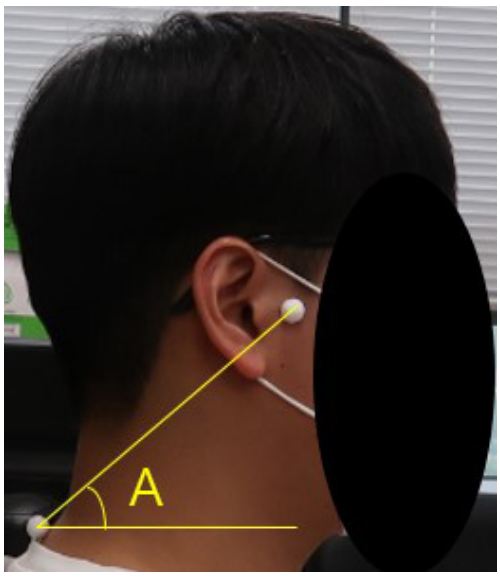

Figure 3. Forward head angle, defined as the angle between a line drawn from the tragus to the C7 spinous process and a horizontal line through C7 (A angle)

Procedures

Data collection was completed in a laboratory setting. First, the workstation was arranged for a work typing task with a computer. The workstation included a desktop computer, a 17-inch LCD monitor, and a keyboard. Before data collection, a height-adjustable table and standard office chair without armrests were used to establish the sitting posture. The participants sat on the chair and allowed the forearms to rest comfortably on the desk while typing. The hip, knee, and elbow joints were approximately 90° flexed [27]. The computer monitor height was adjusted for each participant to enable them to undertake an erect neck-head posture. The keyboard was positioned directly in front of each participant. The individuals were asked to expose their neck and shoulder regions. They adopted a comfortable and natural working posture and performed the computer work. Second, 2 reflective markers were attached to the tragus and C7 spinous process. FHA was captured at the starting point and at 1, 5, 10, and 15 minutes of the typing task for each condition (with and without the brace). The mask-type brace was made of very light flexible plastic with the use of the 3D printer (3DWOX 2X; Sindoh, Seoul, Korea), with an adjustable strap (length: 38 cm, width: 7.6 cm, weight: 70 g). It was placed at the ridge of the nose (front upper part), the philtrum (front middle part), and the chin (front lower part). The philtrum was connected to the atlanto-occipital joint (back part) with the strap snug but not tight to provide a low-level retraction force. Almost no pressure was applied to the nose and chin (Figure 1) [28]. This orthosis was produced in 3 sizes (small, medium, and large), and the subject selected the one that was comfortable to wear and used for the measurement. The order of tests (with and without the brace) was randomly selected by drawing a card from a box to reduce any order effect. The collection of data from ImageJ was repeated 3 times and the average value was calculated to reduce measurement errors. A 5-minute rest was provided between the 2 conditions to avoid muscle fatigue [29, 30].

Statistical analyses

The Predictive Analytics SoftWare (PASW) 18 (IBM, Chicago, IL, USA) was used to perform all statistical analyses. FHP data were normally distributed according to a one-sample Kolmogorov-Smirnov test; hence, we used parametric statistics. A repeated two-way analysis of variance (ANOVA) was conducted to assess the statistically significant differences in the condition, time, and condition × time interaction for FHA. The condition factor had 2 levels (with and without the brace), and the time factor had 5 levels (starting point, 1, 5, 10, and 15 minutes). Significant main effects were only considered in the absence of significant interaction effects. If a significant time × condition interaction was revealed, a simple effect was used. Tukey's post-hoc analyses were run for post-verification [31]. A paired *t*-test was conducted to examine the differences between the 2 conditions according to time. Statistical significance was set a priori at $p < 0.05$ for all analyses.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Cheongju University Institutional Review Board (approval No.: 1041107-161228-HR-008-05).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Condition and time did not show any interaction effects on FHA ($F = 0.113$, $p = 0.978$). Wearing the brace for 15 minutes significantly increased FHA as compared with when the brace was not worn ($p = 0.018$) (Table 1). A significant main effect was observed with time ($F = 0.273$, $p = 0.029$). FHA significantly decreased at 15 minutes compared with the status at 0 and 1 minutes ($p = 0.004$, $p = 0.014$, respectively).

Table 1. Statistical analysis and comparison of forward head angles with and without the brace ($n = 32$)

Typing time	FHA without brace (mean ± *SD*)	FHA with brace (mean ± *SD*)	*t*	*p*
0 minutes	34.47 ± 7.26	35.09 ± 7.74	–0.642	0.525
1 minute	34.47 ± 8.93	34.41 ± 8.22	–0.452	0.654
5 minutes	31.69 ± 7.76	33.31 ± 7.94	–1.921	0.064
10 minutes	31.28 ± 8.31	32.72 ± 8.17	–1.934	0.062
15 minutes	29.69 ± 8.26	31.69 ± 7.9	–2.510	0.018*

FHA – forward head angles
* $p < 0.05$

Discussion

To the best of our knowledge, this is the first study introducing a mask-type craniocervical brace to correct FHP and reporting the results of a trial investigating its immediate effects on FHA. We also determined the time interval at which FHP began to deteriorate in the study participants.

A greater FHA indicates a less protracted head [15]. The FHA of the individuals involved in this study was significantly greater when they had the brace on as compared with the condition without the brace at 15 minutes (2.00°, 6.74%). These findings support our research hypothesis and are consistent with the results of the previous work, which reported that wearing a collar-type brace improved FHP during work at a visual monitor in subjects with FHP [14]. A study revealed that participants with FHP who wore a cervical collar had decreased FHP during work as demonstrated by a visual monitor. Another study showed that individuals who used an assistive device for neck retraction (a tubing band provided resistance against neck extension) exhibited significantly increased lower cervical extensor activation and decreased sternocleidomastoid (SCM) activation compared with the control subjects, although it did not measure lower cervical extensor and SCM muscle activity [16]. This change was believed to be caused by a direct retraction force that the brace applied on the cervical vertebrae, thereby correcting FHP during typing work. These results suggest that the mask-type craniocervical brace is effective in preventing the deterioration of FHP.

Irrespective of whether the participants wore the brace or not, FHA decreased gradually with time in this study. FHA was significantly decreased at 15 minutes compared with the values recorded at the starting point (9.69% with and 13.87% without the brace) and at 1 minute (7.90% with

and 13.87% without the brace). These results indicate that FHP significantly deteriorated after 15 minutes of typing. A previous study also reported that the head flexion and shoulder internal rotation angles gradually increased with time during keyboard activity [32]. This change was attributed to the atlanto-occipital joint, where the head was tilted forward because of its weight. The anterior transition of the head increased the length of the external movement arm owing to gravity. Patients with FHP who exhibit a weak cervical extensor lost the ability to counteract the increased external torque. These observations suggest that FHP worsens after 15 minutes of typing without the brace. However, FHP could worsen after this time even with the brace on. Thus, taking a break every 15 minutes is advisable to prevent FHP deterioration.

Limitations

The current study has several limitations. First, it followed a cross-sectional design. Thus, the long-term effect of the brace may change. Second, as only participants aged 19–29 years were included, generalization is limited. The results may change when the study is replicated in individuals with pain and advanced age. Third, we measured only the kinematic data. We did not evaluate other kinetic parameters, such as the upper trapezius, cervical extensor activation, and decreased SCM activation. However, a previous study reported that an assistive device for neck retraction increased lower cervical extension and decreased SCM activation [16]. Future research should investigate the long-term effects of the brace and measure kinetic data in patients with various pathologies and ages.

Conclusions

This study (1) tested a new design for an FHP brace that was comfortable and aesthetically pleasing, (2) found evidence of its immediate positive effect on FHA in individuals with FHP, and (3) analysed the time interval at which FHP might begin to worsen in FHP subjects. The mask-type craniocervical brace that we describe herein is convenient to wear and has a straightforward design which does not require additional adjustments to be made by the users. Our study participants showed a significantly increased FHA when they wore the brace for 15 minutes as compared with when they did not wear it, and a significantly decreased FHA at 15 minutes compared with the starting point and the point at 1 minute. These findings imply that the use of the mask-type craniocervical brace is a viable option for preventing deterioration of FHP during typing activities that last for more than 15 minutes.

Acknowledgements

This research was supported by the Basic Science Research Program of the National Research Foundation of Korea, funded by the Ministry of Education (2017R1C1B5017611).

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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