Document holder usage when reading and writing

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Summary

The posture of the head and neck and subjective ratings of comfort were investigated while notetaking on a horizontal writing surface from a source document held either flat at 0° or on a document holder inclined at 29°. Twelve subjects performed the task for 20 minutes with and without the document holder, while photographs were taken every 5 minutes. The angle of the head to the neck was not found to differ ($P > 0.05$) but the neck was inclined significantly ($P < 0.001$) more vertically when using the document holder. The moment of the head about the atlanto-occipital joint was $38.0 \times$ body mass (BM) N.mm in both conditions, while the moment of the head and neck about C_7-T_1 was $88.2 \times$ BM N.mm without, and $79.1 \times$ BM N.mm with, the document holder. This difference was significant ($P < 0.01$). Subjective ratings showed the document holder to be significantly preferred ($P < 0.05$). It was hypothesized that this preference occurred as a result of the decreased moment at the neck. Thus working posture can be influenced by environmental changes and the use of a document holder while notetaking may be beneficial.

Relevance

The posture adopted while working has been commonly identified as contributing to the development of musculo-skeletal disorders arising from occupational tasks. This study examines an inexpensive change to the workstation which may aid in the prevention of such disorders in a frequently performed task.

Key words: Work posture, cervical spine, document holder, ergonomics

Introduction

Evidence that manipulation of the work surface slope has an effect on the posture of the head and neck has been found for assembly tasks[1,2], reading[3-5] and writing[3,6]. Bendix and Hagberg[4] assessed subjective ratings of acceptability when the reading and writing tasks were performed independently at desks angled at 0°, 22° and 45° to the horizontal. It was found that subjects preferred an inclined desk surface while reading but that a horizontal surface was preferred when writing. For this reason Bendix and Hagberg[4] proposed that a sloping desk or document holder placed on a horizontal table might provide an appropriate workstation where reading and writing tasks are both performed.

The purpose of this study was to investigate whether the use of a document holder has an effect on the posture of the neck, how any such changes are reflected in the moment of the head and head–neck segments about their axes of rotation, and whether this workstation was preferred by subjects when notetaking.

Methods

Subjects

The subjects were 12 volunteer undergraduate female and male students aged 16–30 years.

Workstation dimensions

The workstation consisted of a seat of height 490 mm situated at a desk of height 760 mm. The seat to desk height difference (270 mm) was chosen as that most commonly found in the university libraries. An opaque acrylic document holder was available to hold source documents at an angle of 29° to the horizontal.

Protocol

The subjects undertook the task in each of two conditions. In the flat condition (0°) the source documents were placed on the desk and the subjects were instructed that while these could be moved to any position, they must remain on the desk. In the elevated condition the source documents were placed on the document holder (29°), which could also be moved to any position on the desk.

Notetaking under each condition was performed for 20 minutes and photographs were taken at 5-minute intervals. The order of presentation of these conditions was randomized and balanced across subjects. Subjective ratings of comfort were assessed at the completion of the experiment.

Posture and moments

The head and neck were modelled as two rigid segments articulated at the atlanto-occipital joint and at the level of the C_7–T_1 vertebrae, respectively[7]. The mass of the head and neck has been determined to be 7·9% body mass (BM)[8] and the projection of its centre of gravity in the sagittal plane to be 8 mm anterior to the tragus. The mass of the head alone amounts to 6·9% BM[8] and the centre of gravity has been determined to be 2 cm superior and 1 cm anterior to the centre of gravity of the head and neck[8].

Markers were placed on each subject at the following locations: anterior portion mastoid process; spinous process of C_7; frontal cervical groove of the head of the clavicle; the tragus; a point 2 cm superior and 1 cm anterior to the tragus.

The inclination of the head to the neck was described by the angle formed by the line joining C_7–T_1 to the atlanto-occipital axis and the nose/lip junction (φ). The posture of the cervical spine was described by the angle subtended to the vertical by the line joining C_7–T_1 and atlanto-occipital centres of rotation (β). These angles are illustrated in Figure 1.

Included in each photograph was a plumb bob and a linear scale placed in the plane of the subject. The photographic prints obtained were scaled such that 1 mm on the photograph corresponded to 16·6 mm in the plane of the subject. The angular measurements were made by protractor to the nearest degree. The distance measurements were made to within 0·25 mm on the print and thus were accurate to within approximately 4 mm in the plane of the subject.

The moment of the head about the atlanto-occipital joint was calculated as the product of the mass of the head and the horizontal distance of the centre of mass of the head from the axis of rotation at the atlanto-occipital joint. Similarly, the moment of the head and neck about C_7–T_1 was calculated as the product of the mass of the two segments and the horizontal distance of the centre of mass of the combined segments from the axis of rotation at the level of C_7–T_1.

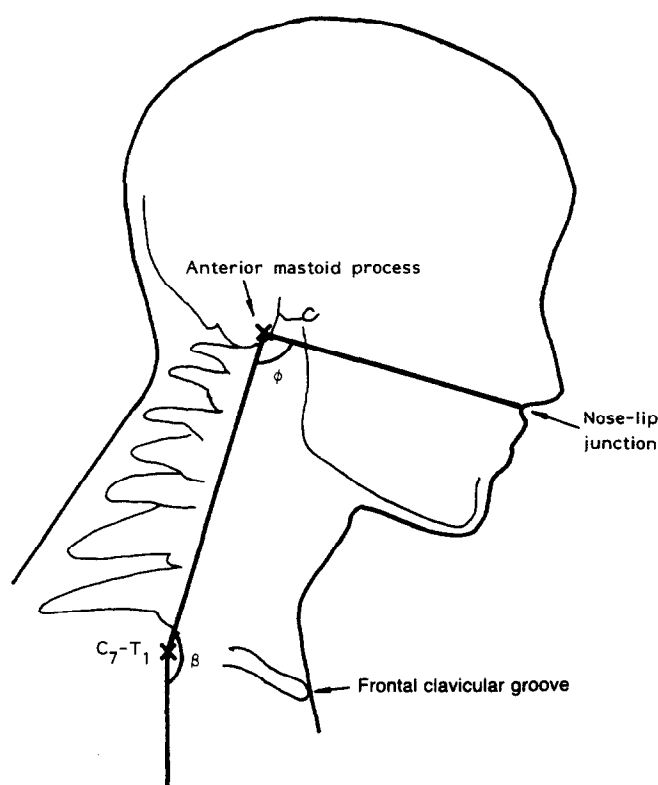Two-way repeated measures analysis of variance

Figure 1. Definition of the two angles used to describe the posture of the head and head—neck segments.

(ANOVA) was used to examine differences between conditions and across time in terms of the two angular and two distance measurements taken from the film records.

Subjective ratings

At the completion of the experiment the subjects were administered a simple questionnaire. Comfort ratings for each condition were made on a 7-point Likert scale as suggested by Corlett and Bishop[9], ranging from very uncomfortable (1) to very comfortable (7). A Wilcoxon matched-pairs signed-ranks test was applied to these data to determine whether differences existed between subjective ratings of comfort.

Results

Postural angles

Table 1 shows the mean postural angles, moment arm lengths and moments for the head and head—neck segments. The mean inclination of the head to the neck differed by 1·6° between flat and elevated conditions and the ANOVA revealed this difference to be non-significant ($F(3,33) = 2·239$, $P > 0·05$). The mean angle of the neck to the vertical increased (i.e., it became more vertical) by 14·4° in the elevated condition (Table 1) and this difference was significant ($F(3,33) = 27·97$, $P < 0·001$). No significant differences were found across time for the head angle ($F(3,33) = 0·328$, $P > 0·05$) or the neck angle ($F(3,33) = 0·567$, $P > 0·05$), nor were there any significant interactions between condition and time for these same angles (head, $F(3,33) =$

Table 1. Postural angles, moment arms and moments for the flat (0°) and elevated (29°) document positions, given by mean (s.d.)

	Condition	
	Flat (0°)	Elevated (29°)
Head angle (°)	93·3 (1·52)	94·9 (1·13)
Neck angle (°)	132·2 (1·49)	146·6 (1·11)**
Moment arm of head (mm)	56·3 (1·16)	56·3 (1·22)
Moment arm of head–neck (mm)	113·9 (3·77)	102·2 (3·06)*
Moment of head (N.mm)	38·0 (0·78)×BM	38·0 (0·78)×BM
Moment of head–neck (N.mm)	88·2 (2·94)×BM	79·1 (2·35)×BM*

BM = Body mass
*Significant at $P < 0.01$
**Significant at $P < 0.001$

0.338, $P > 0.05$); (neck, $F(3,33) = 0.672$, $P > 0.05$).

Distances and moments

The mean perpendicular distance of the centre of gravity of the head from the axis of rotation about the atlanto-occipital joint differed by 0·03 mm (Table 1) between flat and elevated conditions and this difference was not significant ($F(3,30) = 0.000$, $P > 0.05$). Thus, no difference existed between these conditions in terms of the moment of the head about the atlanto-occipital joint. This moment was calculated to be 6·9% BM×gravitational acceleration×the perpendicular distance, or 38·0×BM N.mm in both conditions.

The mean perpendicular distance of the centre of gravity of the combined head and neck segments to the centre of rotation at the level of C_7–T_1 was found to increase by 11·8 mm (Table 1) in the elevated condition. This difference was shown to be significant ($F(3,33) = 7.72$, $P < 0.01$). The moment of the head and neck about C_7–T_1 in the flat condition was 88·2×BM N.mm and in the elevated condition was 79·1×BM N.mm.

No significant differences were found across time for the moment arm of the head alone ($F(3,30) = 0.559$, $P > 0.05$), or of the head and neck $F(3,30) = 1.510$, $P > 0.05$), nor were there any significant interactions between condition and time for either moment arm (Head, $F(3,33) = 1.531$, $P > 0.05$); (Head and neck, $F(3,30) = 1.772$, $P > 0.05$).

Subjective ratings

Nine of the 12 subjects rated the elevated condition as more comfortable than the flat condition. A Wilcoxon matched-pairs signed-ranks test showed that these results were significantly different ($t = 12$, $n = 12$; $P < 0.05$).

Discussion

The results of this study indicated that for a task involv-

ing simultaneous reading and writing, the orientation of the head with respect to the neck remained unchanged despite a change in document angulation from 0° to 29°. The angle of the neck to the vertical increased (became more vertical) as the angulation of the document increased from 0° to 29°, suggesting that the amount of cervical flexion or perhaps whole trunk flexion decreased with the use of a document holder at 29°.

Bendix and Hagberg[4] measured a decrease in cervical flexion of 8·4° while reading only from 0° to 22° of desk slope. Similarly, Weber et al.[5] reported a 8·0° decrease when reading only from 0° to 30° of desk slope. Thus the difference of 14·4° found between 0° and 29° of desk slope while notetaking suggests that the addition of writing to the reading task may increase the effect of an inclined document holder, perhaps by bringing the subject closer to the writing surface.

As a result of the change in the inclination of the neck to the vertical, the moment of the head and neck about the axis of rotation at the level of C_7–T_1 was decreased with the use of a document holder while notetaking. The moment of the head alone was not found to be significantly altered by the use of a manuscript holder.

The increased moment of the head and neck about the axis of rotation in the neck must be balanced by increased tension in active and/or passive connective tissues if the system is to remain in equilibrium. Regardless of whether the added load is resisted by isometric contraction of the neck extensors or by increased tension in the ligaments of the neck, even small increases may be potentially deleterious to the tissues if maintained for long periods of time.

Nine of the 12 subjects reported that they preferred the source document to be inclined when taking notes and the inclined condition was significantly preferred to the flat condition. These results support the notion of Bendix and Hagberg[4] that where both reading and writing are to be carried out, an arrangement will be preferred in which the source documents are inclined and the writing is carried out on a horizontal desk. Why then did three subjects not prefer this arrangement?

A brief interview with the subjects who did not prefer the document holder revealed a possible explanation for this anomaly. These subjects agreed that the document holder would have been preferable if the task had involved reading only. However, since they bent over their work to write, notetaking with the document holder required repetitive movements of flexion and extension of the neck to first fixate on the document and then on their own writing. In the flat condition, movement was still required to change fixations but this movement was rotation in a horizontal plane and thus no work was done against gravity. Even though in the elevated condition these subjects also spent more time in an extended position, with a correspondingly decreased moment about the neck, this condition was perceived as more uncomfortable than the flat condition because of the movement required against gravity. Thus, the document holder may not be beneficial for all, or alternatively some instruction in its proper use may be required.

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