

Effects of prismatic glasses including optometric correction on head and neck kinematics, perceived exertion and comfort during dental work in the oral cavity – A randomised controlled intervention

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ABSTRACT

Aim: To quantify the effects of using prismatic glasses including optometric correction, on head and neck kinematics, perceived exertion and comfort, during work in the oral cavity.

Methods: The study population consisted of forty-five participants. After a basic ergonomic education, baseline measurements of head and neck kinematics were made using inclinometers. Perceived exertion and comfort were rated by the participants. An intervention group ($n = 25$), selected at random from the participants, received prismatic glasses and optometric correction when needed and were compared with a control group ($n = 20$). Follow up assessments were made after the intervention.

Results: At follow up there was a reduction in both the intervention group (8.7°) and in the control group (3.6°) regarding head flexion. Neck flexion was reduced by 8.2° in the intervention group and 3.3° in the control group. The difference between the intervention and the control groups, i.e. the effect of the intervention, was statistically significant for both head (5.1° ; $p = 0.009$) and neck (4.9° ; $p = 0.045$) flexion. No effect of the intervention was seen regarding perceived exertion and comfort.

Conclusion: The reduction in head and neck flexion achieved by the prismatic glasses is likely to reduce the risk of neck pain during dental work. The effect of the prismatic lenses could not be separated from the effect of the optometric correction. The possible effect of the ergonomic education was not evaluated.

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1. Introduction

Neck/shoulder musculoskeletal disorders (MSDs) are very common among dentists and dental hygienists all over the world (Ayers et al., 2009; Hayes et al., 2009). A 12 month prevalence among dentists of over 60% has been reported (Alexopoulos et al., 2004). Various physical and psychosocial exposures such as working postures, workplace layout and working technique have in earlier studies been identified as potential risk factors for work related MSDs (Andersen et al., 2003; Ariens et al., 2001; Bernard, 1997; Feuerstein, 2002; Gangopadhyay et al., 2010; Gerr and Marcus, 2000; Juul-Kristensen and Sögaard, 2004; Rempel et al., 2007, 2006). All risk factors, mentioned above, are frequently encountered during dental work. Furthermore, studies among dentists have shown that head flexion exceeding 45° , are present during 10% of the total working time (Jonker et al., 2009; Åkesson et al.,

submitted). The relationship between exposure to pronounced neck flexion ($>20^\circ$), and the risk of developing neck pain has been investigated in earlier studies. The results indicated a relative risk of 2.0 for neck pain when working with neck flexion exceeding 20° (Ariens et al., 2001). Moreover, that time spent with neck flexion $>20^\circ$ was a risk factor for neck pain (Andersen et al., 2003).

Regarding other risk factors such as psychosocial conditions and their contribution to the development of work related neck/shoulder MSDs a review from 2006 has concluded that this relationship was neither very strong nor very specific (Bongers et al., 2006). Likewise, a recently conducted study investigating the impact of psychosocial factors on neck pain concluded that although these factors were of importance for the development of neck pain, physical exposures seemed to be a more significant risk factor (Canjuga et al., 2010).

In the literature pertaining to ergonomic interventions, few high quality reports have evaluated the effects of technical solutions in order to reduce the risk for neck and upper extremity MSDs, according to recent reviews (Bonfiglioli et al., 2008; Leyshon et al., 2010; Van Ooström et al., 2009).

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Most workplace interventions have previously focussed on ergonomic education and individual training programs. Although, to our knowledge, no studies have evaluated “technical interventions” and their impact on hazardous exposures in dentistry, some studies have evaluated technical solutions connected to specific work tasks in other professions. For example the effects of arm supports and different input devices on neck and upper extremity symptoms among computer users has been assessed (Conlon et al., 2008; Gustafsson and Hagberg, 2003; Rempel et al., 2007, 2006; Slot et al., 2009).

Dental work in the oral cavity accounts for approximately 60% of the total working hours among dentists, (Jonker et al., 2009) and requires both extreme head and neck flexion ($>45^\circ$) in combination with high visual demands (Jonker et al., 2009). Earlier studies have demonstrated some evidence for the effects of optometric corrections with respect to head, neck and shoulder pain among computer workers (Aarås et al., 1998; Konarska et al., 2005).

Since 2007 prismatic glasses designed to reduce head and neck flexion and maintain good visual acuity during dental work have been commercially available (Optergo/Multilens AB, Mölnlycke, Sweden; <http://www.optergo.com>). The prismatic glasses refract the visual angle by 4.6° . According to an experimental pilot study on dentists with long-lasting neck pain in the Netherlands, the results indicated that using prismatic glasses in combination with ergonomic education could reduce head and neck flexion, lead to less discomfort and reduced pain in the neck and shoulder area

during work in the oral cavity. (http://www.optergo.com/uk/the_concept/study_one.php?o=0|125|137).

In this study it is hypothesized that using prismatic glasses during work in the oral cavity will lead to less exposure to head and neck flexion, less exertion and higher comfort in the neck/shoulder area.

Hence, the aim of this intervention study was to quantify the effects of using prismatic glasses including optometric correction, on head and neck kinematics perceived exertion and comfort during dental work in the oral cavity.

2. Subjects and methods

2.1. Subjects

As a part of a prevention program, paid for by the publicly financed dental care organization and the Committee for Work Environment within the region of Västra Götaland, a random sample of 400 dentists and dental hygienists, equivalent to approximately half of the total number of dentists and dental hygienists employed by the dental care organisation in Västra Götaland region were asked to fill in a postal questionnaire concerning physical and psychosocial workplace factors, neck/shoulder symptoms and perceived exertion and comfort during work. Answers were returned by 283 subjects (71%).

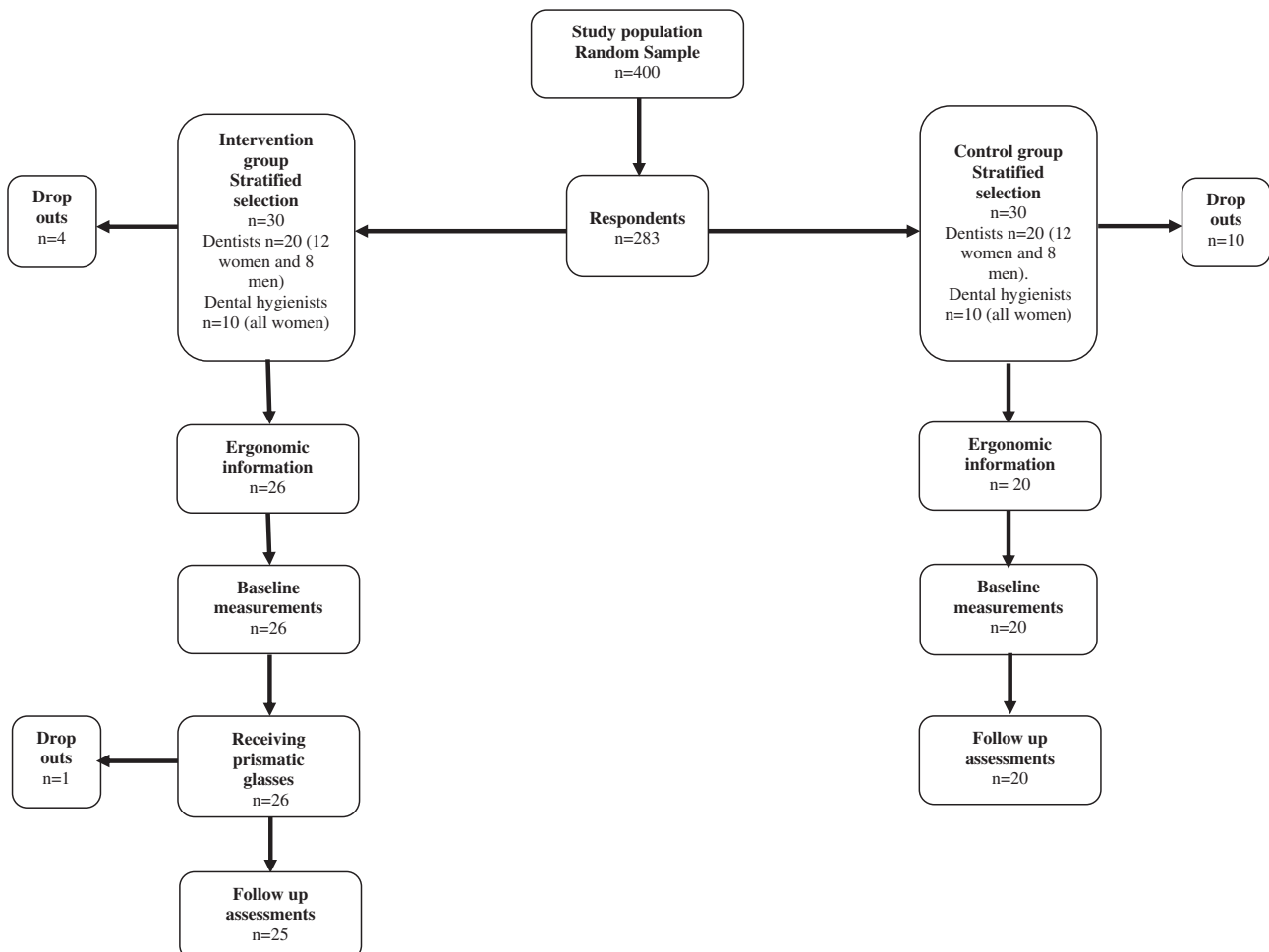


Fig. 1. Flow chart of participants enrolled in the study and the logistics regarding the two groups.

Sixty dentists/dental hygienists out of these 283 were invited to participate in the present study (Fig. 1). A stratified selection was made according to the proportions of dentists and dental hygienists (40 dentists and 20 dental hygienists) and, in the case of the dentists, also according to sex (24 women and 16 men). In the hygienist group only women were included due to the paucity of men in the profession. A random selection was made within each stratum. Half of the subjects in each stratum were randomly allocated to either the intervention group or the control group (Fig. 1). The group belonging was not known neither by the participants nor by the ergonomist involved in the study, at this stage, during the ergonomic education or during the baseline assessments (see below). The subjects were invited to participate in an ergonomic intervention by mail. Fourteen of the invited participants declined participation (4 from the intervention group and 10 from the control group) due to time pressure at work, leave of absence, sick leave or pregnancy, the others signed an informed consent. One of the subjects (in the intervention group) who participated in the baseline assessments was unable, for logistic reasons, to be involved in the follow up assessments. Hence, 45 participants (25 belonging to the intervention group and 20 belonging to the control group) completed the study. The mean age in the intervention group was 43 years (range 26–61) and in the control group 42 (range 26–58). In the intervention group 56% were using glasses on regular basis during work. In the control group the corresponding figure was 30%.

2.2. Procedure and intervention

First, all participants, in groups of “a number less than fifteen” (or maximum fifteen) attended a comprehensive 1.5 h information session concerning dental ergonomics including working postures, working technique and visual ergonomics. Since the main focus of this study was to quantify the effects of the prismatic glasses per se, the rationale behind this procedure was to make sure that both groups had received identical ergonomic education before the baseline assessments in order to avoid the possible confounding effects of the ergonomic education included in the concept of the use of the prismatic glasses. The information was presented by a specialist in dental and visual ergonomics. Then, baseline assessments of head and neck kinematics and perceived exertion and comfort (see below) were performed during work in the oral cavity at the participant’s own workplace. These assessments were carried out during a period of approximately 16 weeks. All assessments were made by the same ergonomist. Directly after the baseline assessments, the group belonging was revealed for the participants and the ergonomist.

The participants in the intervention group were asked to contact an optician with special education in visual ergonomics directly after the baseline assessments. The time from baseline measurements to the first appointment with the optician was about 3–4 weeks. These participants then were prescribed individually modified prismatic glasses and optometric correction when needed (Fig. 2). The optical assessment also included a short information concerning the importance of nearer working distances during work in the oral cavity when using the prismatic glasses. In total the first session at the optician’s lasted 1.5 h. After receiving the prismatic glasses, the participants in the intervention group were called back to the optician for final adjustments. The total time between the baseline assessment and the time when each subject began to use the prismatic glasses on regular basis varied between six and ten weeks, depending on a variety of factors, from technical problems to “participants delay”.

The follow up assessments were performed between seven and eight weeks after the ergonomic information for the control group, and for the intervention group nine to eleven weeks after the first



Fig. 2. Prismatic glasses with lenses located just above the lower frames.

week of usage of the prismatic glasses by the same ergonomist performing the baseline assessments. In order to evaluate compliance and experiences regarding the prismatic glasses during the intervention period, a postal questionnaire was distributed to the participants in the intervention group 12 months after the intervention.

2.3. Work tasks and procedure

The assessments were performed at the participants’ ordinary workplace while treating regular patients. The recorded work tasks were representative of those performed by the dentists and dental hygienists, and comprised dental work in the upper jaw and lower jaw. The ergonomist supervised the technical measurements of the head and neck kinematics (see below) and noted the time of the beginning and end of the different work tasks. This information was used to identify the periods when the dentists/dental hygienists were working in the oral cavity; such activity was chosen for measuring the effect of the intervention on head and neck kinematics. The individual evaluations of perceived exertion and comfort (see below) were made immediately after the recorded work task. The period during which measurements were collected lasted for about 1 h, of which about half an hour involved work in the oral cavity. The type of oral cavity work performed was for dental hygienists primarily removing calculus and for dentists primarily drilling, filling and polishing.

2.3.1. Head and neck kinematics

Inclinometers, based on triaxial accelerometers (Logger Teknologi HB, Åkarp, Sweden), were used for recording the inclination relative to the line of gravity for the head and the upper back (Hansson et al., 2001, 2006). The inclinometers were fixed using double-sided adhesive tape; one was mounted on the forehead and one on the upper part of the back at the level of the 7th cervical vertebra. Data from the inclinometers were sampled at 20 Hz by a data logger (Logger Teknologi HB, Åkarp, Sweden). The fundamental inclinometer output is two angles, one describing the inclination (range 0°–180°; 0° representing the upright neutral position), and the other angle the direction of the inclination (range –180° to +180°; 0° representing forward, –180° and +180° backward, –90° right, and +90° left); to adhere to the conventional forward/backward (flexion/extension) and sideway (lateral flexion) angle representation, which is consistent with the intuitive notion of how to comprehend head and upper back inclination, these data were derived and used for the presentation (for details see paragraph 2.3 in Hansson et al., 2001). Moreover, neck flexion/extension and lateral flexion, was derived as the corresponding sample by sample difference between the head and the upper back i.e. the neck was considered as the joint between the head and the

Table 1

Head and neck kinematics during work in the oral cavity, before (pre) and after (post) the introduction of the prismatic glasses, as well as the differences between pre and post intervention, are shown as mean values and, within brackets, standard deviations (SD) in the intervention and the control groups. The effects of the intervention are shown as mean values, 95th percentile confidence intervals (95% CI) and *p*-values. For flexion/extension positive angles denote flexion and negative angles extension; for lateral flexion positive angles denote right and negative angles left; *n* = number of subjects.

Region, Direction, Angle/velocity, Measure	Intervention group (<i>n</i> = 25)			Control group (<i>n</i> = 20)			Effect of intervention			
	Pre	Post	Post – Pre	Pre	Post	Post – Pre	Mean	95% CI	<i>p</i> -value	
Head										
Flexion/extension										
Angle (°)										
Percentile	1st	–1.6 (9.3)	–1.7 (8.1)	–0.1 (9.2)	–0.3 (6.7)	1.2 (8.4)	1.5 (7.9)	–1.6	–6.8 to 3.6	0.543
	10th	16.3 (11.5)	15.5 (8.0)	–0.8 (10.5)	17.6 (8.5)	18.2 (7.7)	0.6 (7.8)	–1.4	–7.1 to 4.3	0.614
	50th	37.7 (9.5)	31.2 (6.4)	–6.5 (9.8) *	42.1 (8.5)	39.7 (9.0)	–2.4 (6.0)	–4.0	–9.1 to 1.0	0.113
	90th	48.8 (7.6)	40.2 (6.7)	–8.7 (6.3) *	53.0 (9.7)	49.4 (10.3)	–3.6 (6.1) *	–5.1 *	–8.9 to –1.3	0.009
	99th	57.0 (8.8)	49.3 (8.1)	–7.7 (7.2) *	61.3 (10.0)	56.8 (10.4)	–4.5 (5.6) *	–3.2	–7.1 to 0.8	0.114
Velocity (°/s)										
Percentile	50th	3.88 (0.94)	3.49 (0.75)	–0.38 (0.90) *	4.14 (1.51)	3.49 (1.19)	–0.65 (0.70) *	0.27	–0.22 to 0.76	0.280
Lateral flexion ^a										
Angle (°)										
Percentile	10th	–14.8 (6.5)	–14.4 (6.5)	0.4 (5.9)	–18.2 (8.7)	–13.3 (7.1)	5.0 (9.4) *	–4.6	–9.2 to 0.1	0.056
	90th	13.9 (7.8)	12.1 (8.0)	–1.8 (8.0)	15.6 (7.2)	15.7 (9.2)	0.1 (10.3)	–1.9	–7.5 to 3.6	0.489
Neck										
Flexion/extension										
Angle (°)										
Percentile	1st	–14.6 (10.5)	–16.0 (9.9)	–1.4 (12.4)	–15.1 (7.4)	–12.4 (8.7)	2.8 (8.2)	–4.1	–10.6 to 2.4	0.208
	10th	2.6 (11.7)	0.4 (9.5)	–2.1 (10.8)	2.6 (9.0)	3.3 (7.3)	0.7 (8.5)	–2.9	–8.8 to 3.1	0.338
	50th	18.4 (10.7)	12.9 (7.6)	–5.5 (10.7) *	20.3 (7.2)	18.1 (6.5)	–2.2 (7.9)	–3.3	–9.1 to 2.5	0.258
	90th	27.7 (8.3)	20.1 (7.6)	–7.6 (8.3) *	29.4 (8.2)	26.3 (7.0)	–3.1 (7.3)	–4.5	–9.3 to 0.2	0.062
	99th	34.8 (9.1)	26.6 (8.2)	–8.2 (8.0) *	35.9 (9.0)	32.5 (7.0)	–3.3 (7.7)	–4.9 *	–9.6 to –0.1	0.045
Velocity (°/s)										
Percentile	50th	3.35 (1.03)	3.00 (0.76)	–0.35 (1.1)	3.38 (1.22)	2.78 (0.94)	–0.59 (0.72)	0.24	–0.34 to 0.83	0.402
Lateral flexion ^b										
Angle (°)										
Percentile	10th	–10.7 (6.1)	–8.7 (4.8)	2.0 (5.1)	–11.8 (6.7)	–7.7 (4.5)	4.0 (7.0) *	–2.0	–5.8 to 1.7	0.284
	90th	10.6 (6.5)	11.5 (6.8)	0.9 (7.3)	12.6 (6.9)	13.2 (8.6)	0.6 (7.6)	0.3	–4.3 to 4.9	0.892

* Statistically significant difference ($P < 0.05$).

^a Data on lateral flexion missing for one subject in the intervention group.

^b Data on lateral flexion missing for two subject in the intervention group.

upper back, distributed across the seven cervical vertebrae. The absolute value of the angular velocity was calculated as the time derivative of the flexion/extension angles for the head, upper back and neck. The reference position of the head and upper back and hence also for the neck (0° flexion/extension and lateral flexion) was recorded with the subject standing in an upright position, looking straight ahead. Positive angles denote flexion and lateral flexion to the right, negative angles extension and lateral flexion to the left. The error of the inclinometers is small (1.3°), and independent of the orientation of the device. For details about the measurement method see Bernmark and Wiktorin, 2002; Hansson et al., 2001 and Hansson et al., 2006.

The 1st, 10th, 50th, 90th and 99th percentiles of the flexion/extension angular distribution, and the 10th and 90th percentiles of the lateral flexion angular distribution for the head and neck were used to describe postures, and the 50th percentile of the flexion/extension absolute angular velocity distributions was used to describe head and neck movements (Jonsson, 1982). For flexion/extension the 1st and 10th percentiles represent the backward postures, the 50th percentile the median posture, and the 90th and 99th percentiles the forward bent postures; for example, the 90th percentile is the angle exceeded in the forward direction for 10% of the time. The various percentiles, although interrelated with high correlations between adjacent percentiles (Hansson et al., 2010) reflect different aspects of the head and neck postures (Arvidson et al., 2006; Hansson et al., 2010).

2.3.2. Ratings of perceived exertion and comfort

Perceived exertion was rated on a modified Borg RPE scale ranging from 0 to 14 (very, very light to very, very strenuous) for the neck, and the right and left scapular areas (Wahlström et al., 2000,

2002). The sum of the scores for the three regions was calculated, giving a range of 0–42 (Lindegård Andersson, 2007). Rating of perceived comfort was made using a nine-point scale ranging from –4 (very, very poor comfort) to +4 (very, very good comfort) (Karlqvist et al., 1999).

2.4. Statistics

For all technical measures, which showed reasonable normal distributions, descriptive data are presented as mean values and standard deviation; 2-sided *t*-tests were used to evaluate the differences. The effects of the intervention were assessed as the effects (i.e. the values at follow up minus the values at baseline) in the intervention group minus the corresponding effects in the reference group.

Perceived exertion and comfort, which were not normally distributed, are presented as median values and ranges (min and max values). Significant differences between the groups were identified by the Mann–Whitney test. Differences between baseline and follow up are presented as the median values and ranges of the individual differences, and statistical significance was tested by Wilcoxon matched-pairs signed-ranks test (Altman, 1991). Differences between the groups, in the above described differences between baseline and follow up, were used to evaluate the effects of the intervention. *P*-values < 0.05 were considered statistically significant.

3. Results

In this study, dental work in the oral cavity represented approximately 50% of the total working hours. The rest of the time the participants were involved in different kinds of clinical and

non-clinical work, like paper work, X-ray examinations and computer work.

3.1. Head and neck kinematics, perceived exertion and comfort at baseline

The head and neck kinematics at baseline are shown in Table 1. The mean recorded duration for work in the oral cavity for the 45 subjects was 33 min (range 8–82; SD 16 min). There were no statistically significant differences between the eight male and 22 female dentists for any of the measures. The only significant difference between the 22 female dentists and the 15 female dental hygienists was that, for the 10th percentile, the hygienists worked with a more flexed head than the dentists (22° vs. 14°; not in table). There were no significant differences between the intervention and control group regarding the duration of the measurements or for any of the measures at baseline.

The median value for perceived exertion for the 45 participants was 13 (range 0–33). With respect to comfort, the median value for the subjects was 0 (–3 to 4). There were no significant differences between the intervention group and the control group at baseline (Table 2).

3.2. Head and neck kinematics, perceived exertion and comfort at follow up

At follow up there was a reduction in head flexion for the 50th, 90th and 99th percentiles in both groups, however less pronounced (and not statistically significant for the 50th percentile) in the control group, e.g. for the 90th percentile the reductions were 8.7° and 3.6° in the intervention and control groups, respectively (Table 1). With respect to lateral flexion there was a 5.0° reduction in left lateral flexion in the control group, but no indication of any corresponding difference for the right side. Furthermore, almost no effect on lateral flexion was apparent in the intervention group. Movement velocity was reduced in both the intervention and the control groups, by 10% and 16%, respectively.

Regarding neck flexion a significant reduction was seen for the intervention group for the 50th, 90th, and 99th percentiles, while only a smaller and statistically insignificant reduction was present in the control group; for the 99th percentile the reductions were –8.2° and –3.3°, in the intervention and control groups, respectively. The neck showed a similar reduction in left lateral flexion (4.0°) in the control group as the head did. Neck movements were reduced by almost the same amount as for the head, in both the intervention (10%) and the control group (17%), although the reduction in the intervention group was not statistically significant.

Within the intervention group there was a statically significant decrease (by 4 units) in perceived exertion at follow up compared with the baseline ratings (Table 2). The corresponding decrease for the control group was 2 units, although this was not statistically significant. With respect to perceived comfort, there were no significant differences at follow up for any of the groups.

3.3. Effects of the intervention on head and neck kinematics, perceived exertion and comfort

The reduction in head flexion for the intervention group was more pronounced than for the control group, i.e. the intervention had an effect (Table 1). For the 90th percentile this effect was 5.1° and statistically significant ($p = 0.009$). Numerical smaller effects with p -values of 0.11 occurred for the adjacent 50th and 99th percentiles. With respect to neck flexion the reduction was likewise more pronounced in the intervention group than in the control group. The effect of the intervention was significant ($p = 0.04$), with a reduction of 4.9° for the 99th percentile. The reduction for the 90th percentile was also high and near significant ($p = 0.062$). No significant differences were identified with respect to head and neck extension (1st and 10th percentiles) or head and neck movements.

Moreover, no significant differences could be seen between the two groups concerning perceived exertion or comfort (Table 2).

3.4. Compliance and feasibility

Among the participants in the intervention group 21 out of 25 (84%) used the prismatic glasses on regular basis during all kind of work tasks in the oral cavity. Moreover, 20 participants out of 25 (80%) reported that the prismatic glasses were feasible during work and facilitated work in the oral cavity.

4. Discussion

4.1. Effects at follow up

For the intervention group the reduction in head and neck flexion at follow up was for the 50th, 90th, and 99th percentiles considerably higher than the maximal expected effect of 4.6°, corresponding to the refraction angle of the prisms. However, the control group also showed an unexpected considerable reduction in head and neck flexion for these percentiles. The reason for these concurrent changes in both groups is not obvious. One factor that might be considered as a possible explanation could be the impact of the time frame from the ergonomic education to the follow up assessments. The time lag might influence the results in both directions, either by an increased effect over time due the participant's ability to integrate new knowledge and convert it into behaviour changes or a decreased effect over time due to reduced motivation for behaviour changes. Seasonal variations and organisational changes may contribute too changes in workload and other unknown factors could also have influenced the results.

For both groups there was a numerical decrease in movement velocities of the head and neck. Low movement velocities indicate that the work task is performed in a static posture (Bernmark and Wiktorin, 2011; Arvidson et al., 2006). Surprisingly, the reduction in head flexion was not mirrored by the effect on perceived exertion and comfort, which had been expected. One plausible explanation

Table 2
Perceived exertion, summed for the neck and the right and left scapular areas and perceived comfort, rated after work, for both groups, before (pre) and after (post) the introduction of the prismatic glasses, are shown as median values and, within brackets, ranges. The differences, and the corresponding p -value, between pre and post intervention, as well as the p -value for the effect of the intervention, i.e. the difference between the groups regarding their differences between pre and post intervention, are also shown.

Measure	Intervention group ($n = 25$)			Control group ($n = 20$)			Effect of intervention
	Pre	Post	p -value	Pre	Post	p -value	p -value
Perceived exertion	11 (0–33)	14 (0–28)	0.049	13.5 (0–31)	7 (0–32)	0.152	0.891
Perceived comfort ^a	0 (–3 to 4)	0 (–2 to 3)	0.260	0 (–3 to 3)	0 (–2 to 3)	0.471	0.922

^a Data missing for two subject in the intervention group before (pre) the introduction of the prismatic glasses.

could be that perceived exertion reflects changes in the velocity of movements to a greater degree than changes in position. In fact decreased velocities have been shown to correlate negatively to “perception of workload”, including the item “uncomfortable working positions”, among dentists (Jonker et al., 2009).

The present design for estimating the effect of the intervention, as the differences between the effect in the intervention and the control group, accounts for the effects of unknown and/or unobserved factors, which otherwise may have obscured the effects and invalidated the study.

4.2. Effects of the intervention

The intervention resulted in 5° less head and neck flexion in the upper part of the distribution, which represent the more pronounced flexed positions during work. In comparison with the results of inclinometry measurements of head flexion for both dental personal and other comparable professionals where head flexion varied between 45 and 50° (Hansson et al., 2010), our intervention shifted the participants' measurements from being among the highest values to among the lowest values recorded for other dentist/dental hygienist groups. Compared to repetitive industrial work in general, the head flexion after the intervention in our study corresponds roughly to the mean value for the different professions represented in this category (Hansson et al., 2010). In conclusion, the size of the reduction of head and neck flexion accomplished by this intervention is significant in relation to the range occurring in working life. Referring to earlier studies concluding that exposure to pronounced neck flexion (>20°), constituted a relative risk of 2.0 for developing neck pain (Ariens et al., 2001) and, that time spent with neck flexion exceeding 20°, in another study, was related to an increased risk for neck pain (Andersen et al., 2003), the ISO standard 11226 (International Organization for Standardization) regarding working postures has stated that neck flexion exceeding >25° is “not recommended”. Thus, reductions of extreme postures most likely contribute to a decrease in the prevalence of neck pain. However, since the quantitative exposure–response relationship is not known we are not able to predict the size of the probable preventive effect of introducing the prismatic glasses.

This study focussed on head and neck kinematics during work in the oral cavity, which in our study represented about 50% of the total working hours. This is in concordance with results from an earlier study showing that dentists perform work in the oral cavity 59% of the total amount of working hours (Jonker et al., 2009). The same study also concluded that work in the oral cavity entails more head and neck flexion than other work tasks present in dentistry (Jonker et al., 2009). Thus, our conclusion is that the reduction of head and neck flexion accomplished by the prismatic glasses is likely to reduce the risk of neck pain during dental work in general.

4.3. Strengths and limitations

In this study we tried to meet the criteria for a good quality intervention study, as outlined in the recently published Cochrane review concerning the effects of workplace interventions (Van Ooström et al., 2009). Hence, this study comprised an intervention and a control group. After a first step selection, stratified by occupation and gender, the participants were randomly allocated to the groups. Both dentists and dental hygienists and both males and females were represented in the study groups. All participants and the ergonomist were unaware of group allocation during the baseline assessments. Furthermore, all assessments were made during actual dental work at each participant's own workplace and the work tasks performed involved real patients. Relevant

exposures were assessed by direct measurements, which provide generic measures on continuous scales with a high accuracy and precision, rather than by observations generally considered as a less precise measurement instrument (Bernmark and Wiktorin, 2002; Bernmark and Wiktorin, 2011; Hansson et al., 2001; Spielholtz et al., 2001; Delooze et al., 1994; Takala et al., 2010). Moreover, since using diverse methods in order to capture all dimensions of different exposures is desirable (David, 2005; Li and Buckle, 1999; Van der Beek and Frings-Dresen, 1998) we also used subjective ratings of perceived exertion and perceived comfort during work. In previous epidemiological prospective studies, high perceived exertion and low comfort have been identified as predictors of neck and upper extremity symptoms (Lindegård Andersson, 2007; Tornqvist et al., 2009). Thus, it is essential to assess these subjective parameters in combination with objective measures of head and neck kinematics to be able to assess the potential future effects on neck pain due to a reduced exposure.

One weakness of the study is that blinding at follow up was not possible since the participants in the intervention group used prismatic glasses, which was evident also to the ergonomist. The possible anticipation in the intervention group that the prismatic glasses would have an effect, commonly referred to as the Hawthorne effect, (Wickström and Bendix, 2000), might in this case have influenced the results. However, no effect of the intervention was observed for perceived exertion and comfort, which are self reported and presumably more susceptible to subjective bias than the objectively measured head and neck kinematics. Thus, the effect, of the participants' anticipation, on the recorded kinematics is, if it exists, most probably small in relation to the observed effect of the intervention. Moreover, since direct measurements were used for assessing head and neck kinematics, there is, contrary to if observational methods had been used, no obvious way that the observer may bias the recordings.

Another weakness is that the subjects in the control group did not receive any optometric correction during the intervention period. The importance of accurate visual correction, especially in connection with work tasks imposing high visual demands, is well known (Aarås, 2001; Aarås et al., 2005). In a study of computer workers Aarås et al. have shown a significant reduction in shoulder complains combined with a decrease in trapezius load after an intervention involving ergonomic information and optometric correction (Aarås, 2001). It would have been desirable to give the participants in the control group optometric correction, this was however not possible due to limited financial resources. However, it is not shown in the scientific literature that optometric correction is likely to have an effect on head and neck postures during work. Hence, the possible additional contribution of the optometric correction to the effect of the prismatic lenses can not be evaluated.

Ergonomic improvements comprises many aspects and interventions are commonly performed as packages, incorporating information/education, training, redesigned/new tools and technical aids. To enable optimal allocation of resources, knowledge about the effect of the different items is needed. This study was designed to evaluate the effect of the prismatic glasses per se, disregarding the effect of the ergonomic education incorporated in the prismatic glasses concept. To accomplish this, both groups got the ergonomic education before the baseline assessments were performed. The obvious limitation is that the possible effect of the ergonomic education is not assessed. However, the scientific evidence for positive effects of educational interventions on work postures and neck/shoulder pain is not very strong, and the results from both observational and randomised controlled studies are inconsistent (Elders et al., 2000; Linton and Van Tulder, 2001; Veiersted et al., 2008). Most of the studies conclude that there is no evidence that educational worksite interventions are effective in

reducing pain and increase function (Grooten et al., 2007; Tveito et al., 2004). Moreover, concerning possible effects of an educational intervention on neck postures during work in the oral cavity it is likely to believe that neck postures is ruled by visual demand and not easily adjusted despite ergonomic knowledge.

The follow up was performed only once; of course additional assessment would show if the assumption, that the effect would remain, since it is instrumental (glasses) and consequently not as sensitive to for example changes in cognitive ability as an educational intervention, is true. No follow up on pain/disorders can be reported in this paper which would have been interesting since it would show if the effect of exposure is accompanied by a reduction in pain.

4.4. Conclusion

Prismatic glasses decrease the risk of exposure to high risk working postures in the neck during dental work. The reduction in head and neck flexion accomplished is likely to contribute to a reduced risk of developing neck pain among dentists and dental hygienists. The possible effect of the ergonomic education was not evaluated.

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