Source: Journal of Dental Hygiene, Vol. 81, No. 1, January 2007

Musculoskeletal disorders of the neck and shoulder in dental hygienists and dental hygiene students

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Purpose. Dental hygienists have been found to have high rates of neck and shoulder disorders, but there is very limited information on risk factors associated with those disorders, the level of risk for students, and the relationship of prior work as dental assistants for dental hygiene students. This study examines self-reported and physician-diagnosed neck and shoulder pain.

Methods. A cohort consisting of 27 dental hygiene students with no prior dental occupation experience (mean age 24, 6.2 SD), and 39 dental hygiene students with prior experience as dental assistants (mean age 28, 6.0) and 94 experienced dental hygienists (mean age 46, 8.8) completed a questionnaire on risk factors and self reported pain, and were examined by a physician in reference to upper extremity findings and diagnoses. Analysis included tabular, trend, and logistic regression analysis.

Results. There were significant differences for risks, symptoms, and physician findings. Risk factors had a stepwise progression for students, student/assistants, and experienced dental hygienists, including working with a bent neck often or very often (79%, 89%, 96%, respectively, p<.001), static posture (39%, 50%, 63%, p<.001), precise motions (58%, 67%, 90%, p<.001), and repetition (79%, 86%, 98%, p<.001). Neck symptoms were reported by 37%, 43%, and 72%, respectively (p<.001), and 11%, 20%, and 35% for shoulder symptoms (p<.05). Similar patterns were demonstrated in physician findings, particularly for neck disorders (18%, 36%, 50%, p<.01). In regressions, self-reported shoulder pain was significantly associated with working above shoulder height (OR=1.5, CI 1.0-2.4), and neck symptoms with working with a bent neck (OR=2.1, CI 1.3-3.4), with a protective effect from high supervisor support (OR=0.5, CI 0.2-1.0).

Conclusion. Risk factors and both self-reported and physician-diagnosed neck and shoulder symptoms increase in frequency from students to experienced hygienists, and students have higher prevalence if they are also dental assistants.

Keywords: Ergonomics, cumulative trauma disorders, musculoskeletal disorders, dental hygienists, dental assistants, risk factors, neck and shoulder disorders

Introduction

High rates of occurrence of upper extremity musculoskeletal disorders (MSDs) in dental professionals (dentist, dental hygienist, and dental assistant) are well documented, including regional neck and shoulder pain, shoulder tendonitis, neuropathy, tension neck syndrome,and trapezius myalgia,[1-15] with more recent attention given to students either as a control group or as a newly exposed group.[11,16] Much of the focus has centered on dentists and dental hygienists, while fewer studies attempt to estimate the prevalence of MSDs among dental assistants and dental hygiene students. The few studies that have examined MSD prevalence in dental assistants and dental hygiene students have found mixed evidence for appearance of early symptoms.[11,17-19]

It is likely that specific MSDs, such as those localized to the shoulder, elbow, and neck, have different risk factors.[2] Furthermore, different types of occupations, even within the same occupational category (dentists, dental hygienists, assistants all fall under the dental professional category), may be at risk for different types of cumulative trauma disorders of the upper extremities (CTDUE).[2]

This report characterizes neck and shoulder conditions for a sample of 94 experienced dental hygienists, 27 dental hygiene students, and 39 dental hygiene students who are also dental assistants, utilizing both survey and physician physical exam, and evaluates associations with self-reported risk factors.

Literature Review

Historically, researchers have focused on the overall prevalence of musculoskeletal disorder (MSD) in dental professionals. The reported prevalence of general MSD pain and neuropathy in dental hygienists ranges from 60% 4 to 96%.[2,20] depending on the specific population studied and the research measures employed. The 96% prevalence was from a mailed survey in Kentucky to 433 licensed dental hygienists (n=245 responses) utilizing a body diagram, with the neck, shoulder, and back as the most frequent symptom locations.[20] A written questionnaire completed by all 109 attendees at a dental hygiene continuing education conference found 93% reporting at least one job-related ache, pain, or discomfort in the previous 12 months.[6] Approximately 60% of 260 practicing hygienists (56% response rate) reported symptoms related to upper extremity neuropathy (self-reported "altered sensations," with the most common being pain, tingling, and numbness) based on a survey of licensed dental hygienists in Nebraska; sixteen percent indicated they had been medically diagnosed with an upper extremity neuropathy.[21]

Fewer studies have examined the prevalence of MSDs in specific body regions and the specific risk factors (biomechanical and psychosocial) associated with pain in these regions. The neck/shoulder region has been reported as of concern but not studied in depth. Werner et al found that 13% of a sample of 305 dental hygienists had shoulder tendonitis based on a physical examination.[22] Al-Wassan et al found that 54.4% of a sample of 204 dental professionals (85% response rate) in 5 dental offices in Saudi Arabia (dentists and dental professionals, including 12 dental hygienists) experienced neck pain, although the frequency of neck pain was significantly higher (p=.01) in dentists than other dental professionals.[15] Szeluga found subjective neck pain prevalence rates as high as 82% (75.9% for shoulder) in a mailed survey of 433 dental hygienists in Kentucky, although only 5.4% reported missing work because of the pain.[20] Akesson reports that 81% of a sample of 30 dental hygienists had specific neck/shoulder findings on physical examination, and 43% were diagnosed with specific neck/shoulder MSDs, including tension neck syndrome and trapezius myalgia.[1] Yee found 75% of 529 dental hygienist respondents (37% response rate) reporting neck discomfort over the prior 12 months, and 61% reporting shoulder discomfort

in a mailed survey of licensed hygienists in 2 California counties.[13] Clearly, wide disparities exist in the measuring and reporting of neck pain, as well as other MSDs, among dental hygienists.

Musculoskeletal Disorders in Dental Assistants and Dental Hygiene Student

The prevalence data on MSDs in students is sparse in comparison to prevalence data for dental hygienists. A prospective cohort study conducted by Akesson et al in female dental personnel found that 65% of dental assistants reported overall MSD pain; thirty-five percent of those fit the clinical criteria for specific MSD diagnoses, and 42% of the cohort reported subjective pain. The same study reported a Tension Neck Syndrome (TNS) prevalence of 21.4% in dental assistants.[1]

Although dental hygiene students generally have less cumulative duration of exposures, they gradually increase their exposures throughout their clinical training, and some studies found a corresponding increase in symptom prevalence. Morse et al, in the pilot phase for this study, found 46% of dental hygiene students reporting upper extremity pain, with increasing symptoms in later years of training.[19] Barry et al noted an increase in musculoskeletal pain and an increase in non-neutral posture for 9 students over the course of dental hygiene education, extending into the first 2 practicing years.[18] In a 3-year study following dental hygiene students through their clinical education and the start of their career, Conrad et al found no change in median nerve velocity but a shift in vibrotactile thresholds characteristic of injury to fingertip nerve receptors.[9] However, Werner et al reported relatively low levels of MSD in dental hygiene students (16% neck and shoulder symptoms for a combined sample of dental and dental hygiene students), and no differences by year in school.[11]

Risk Factors

The diagnoses and risk factors related to shoulder and neck MSDs are often separated into 2 groups: one involving problems confined to the shoulder joint area and the other involving problems confined to the upper shoulder and neck area. The first group, including such diagnoses as rotator cuff syndrome, has been well documented in the literature as being associated with dynamic work with heavy loads.[23] Problems of the upper shoulder and neck are thought to be associated with repeated or sustained exertion in awkward or static postures, even with low external loads.[23] Diagnoses such as tension neck syndrome (TNS), involving painful neck spasms and trigger points, have also been associated with this type of loading pattern, which is common in dental hygiene work.[2]

Sanders and Michalak-Turcotte have noted that dental hygienists frequently work with neck flexion over 30 degrees, with side bending or rotating, and shoulder abduction over 45 degrees.[2] In an observational study of 10 dentists and 10 dental hygienists, Marklin and Cherney found that hygienists flexed their necks at least 30 degrees 86% of the time, with shoulders abducted (elevated to the side of the trunk) at least 30 degrees for 45% and 34% of the time (left and right side, respectively).[24] These postures may be combined with high static loads and fatigue in the trapezius muscles.[25] In addition, there may also be relationships to personal characteristics (such as height), high visual demands,[26] workplace organizational and psycho-social factors,[14] and lack of recovery time.[2,27] Smith et al note that dental hygiene tasks are similar to dental tasks, where high levels of flexion and rotation of the neck have also been observed.[26] Barry suggests in a small longitudinal study that there may be a change to forward-leaning posture when dental hygienists move into the working environment, which may contribute to an increase in neck and shoulder pain.[28] Yee et al suggest that amount of usage is more important than workstation design, since they found that handedness was a clear determinant of whether dental hygienists had left sided or right sided pain.[13] Bramson et al found in an videotape ergonomic analysis of 15 dental hygienists that shoulder risks averaged 4 on a 7-point scale (based on a combination of postures, force, frequency, duration, past injuries, and present discomfort), and neck risks averaged the maximum of 7.[29]

In summary, no studies have focused specifically on neck or shoulder disorders in dental hygienists or dental assistants, and detailed studies have had very small sample sizes, resulting in an inability to test for differences in prevalence rates between groups and to discover associations with specific risk factors. This study combines both a large sample size with questionnaire and detailed physician assessment, providing the first opportunity to confirm suggestions raised by previous

studies and test for differences. The aim of the present study was to (1) test for differences in prevalence of both subjective and objective neck symptoms (including pain, aching, burning, numbness and tingling, and spasm) between dental hygienists, dental assistants and dental hygiene students; (2) to test if higher (longer) exposures result in higher prevalence (ie, between students and experienced hygienists); and (3) to identify risk factors significantly associated with neck MSDs in dental professions and clinical training in order to better target preventive measures.

Materials and Methods

The dental hygienists (DH) and dental hygiene students (DS) were part of an international, longitudinal multi-cohort study (the HAVIC, or Hand-Arm Vibration International Consortium study) funded by NIOSH, specifically focused on the effects of vibration on the development of MSDs. The study and all associated tests were approved for human subjects by the University of Connecticut Health Center Institutional Review Board (Study #01-093). Dental hygienists and dental hygiene students comprised 2 of the 5 cohorts examined; other groups included auto assembly line workers, forestry workers, and shipyard employees. Practicing hygienists were required to have at least 5 years experience and could not be retired. Based on preliminary prediction of a 20% response rate and a target of 80 subjects, 400 individuals were randomly selected from a licensure list from the local area and contacted by mail and phone. The recruitment goal was exceeded, thus the excess of participants. In all, 92 women and 2 men consented to participate (24% response rate). Dental hygiene students were orally recruited by faculty at each of the 3 dental hygiene schools in Connecticut. Participants were asked to volunteer for an approximate 3-4 hour set of medical procedures and a questionnaire, and were offered a modest honorarium of $50 ($100 for those driving a long distance) for participation. After obtaining informed consent, participants completed a 40-page questionnaire and an extensive upper extremity physical examination. A battery of diagnostic tests were also performed but are not included in this report, including surface nerve conduction, tactometry, and plethysmography.

Questionnaire Instrument

The full questionnaire contained questions representing each of the following content areas:

- A full occupational history for the previous 10 working years.
- Duration of time spent in specific tasks related to biomechanically related postures and risk factors, including force, repetition, static posture, and awkward postures, such as bent and twisted neck.
- The Job Content Questionnaire (JCQ), an assessment of psychosocial risk factors for MSDs, including job control, job demands, and social support.30,31
- Specific questions detailing the type, location, and severity of symptoms of pain, paresthesia, or whiteness in hands or fingers, and pain, paresthesia, limited movements, or spasm in shoulders, elbows, neck, forearms, and lower back.

The self-administered questionnaire had student and practicing hygienist versions, with questions adapted as necessary for the 2 backgrounds. There were detailed questions concerning both student and job history in relation to years, exposures, level, type, and amount of time in clinical practice or training, etc. Questionnaires were individually reviewed for completeness and consistency by study managers upon completion, with missing data and inconsistencies corrected by the participant before departure from the study location. All questions for practicing dental hygienists were in reference to their jobs. Dental students were asked about their year in school, clinical experience as part of school, dental job experience outside of school, and other current jobs outside of school. Students were instructed to answer exposure questions (such as use of scaling instruments, bent necks, etc.) in relation to current dental jobs and/or clinical experience as part of clinical training. First-year students with no clinical exposures responded as zero exposure to the dental instrument use questions; for job stress-related questions they responded in relation to either other jobs or student status if there was no outside job. Exposure-specific questions were developed to profile each work environment. These were originally profiled by 2 members of the study team experienced in dental hygiene (C M-T, M A-S), revised in numerous focus groups, distributed in an exploratory questionnaire,[19] and refined for the final version. Particular attention was paid to historical variability in work schedules, equipment and procedural changes, and multi-site employment. Mannequin type drawings for purposes of symptom localization were used, with emphasis on each upper extremity region with symptom specific

dermatomes,[32] in order to better define self-reported CTS related symptoms.[33] The musculoskeletal symptom questionnaire was formulated from multiple sources, in particular from the Connecticut Upper Extremity Surveillance Project (CUSP), a population-based random phone survey of 3200 Connecticut workers,[34,35] which in turn was taken largely from previously validated instruments including the US Department of Health 1988 National Health Interview Survey (NHIS), the Occupational Safety and Health Administration (OSHA) Draft Checklist,[36] the Dutch Monitor Survey,[37] the Job Content Questionnaire (JCQ),[30,31] and the Standardized Nordic Questionnaire.[38] We included sections of the validated Levine Functional Status and Symptom Severity Scales.[39] The JCQ is composed of 33 questions that address job demands, job control, and social support. Supervisor support, for example, is composed of the sum of responses to 5 questions on a 4-point Likert scale: (1) My supervisor is concerned about the welfare of those under him/her; (2) My supervisor pays attention to what I am saying; (3) I am exposed to hostility or conflict from my supervisor (reverse coded); (4) My supervisor is helpful in getting the job done; and (5) My supervisor is successful in getting people to work together.

Perceived biomechanical risk factors were evaluated utilizing a 4-point Likert scale consisting of never, seldom, often, and very often. Respondents were asked "Does an average working day in your current job involve any of the following conditions?" for the following:

(1) Is the neck repeatedly or for long periods (a) bent forwards, backwards or sideways, (b) twisted, (c) bent and twisted simultaneously;

(2) Is prolonged or recurrent work performed with the arms stretched forwards or outwards, unsupported, or above shoulder height;

(3) Is work repeatedly done with the forearms and hands with (a) twisting movements, (b) forceful movements, (c) uncomfortable hand positions/grips, (d) heavy demands on precision; and

(4) Is prolonged or recurrent work done with repeated similar working movements?

Physical Examination

The physical examination was a 30-minute intensive upper extremity evaluation performed by a physician specifically trained in assessing musculoskeletal symptomatology, with a written protocol and decision guide, with a video made of the exam to assure consistency. The physical examination had 4 stated purposes: elicitation of clinical signs, the assessment of neuromuscular, vascular and musculoskeletal function, the recognition of possible signs of Hand-Arm Vibration Syndrome (HAVS), and the developmental of differential diagnoses based on clinical findings. A standardized upper extremity clinical instrument was developed, incorporating proximal and distal evaluation.[40,41] It included a structured clinical examination involving 32 muscle groups, and an integrated assessment of function within anatomic zones, and assessments of mobility, motion derived discomfort, and postural integrity. Elicitation of more than 20 recognized clinical signs are included, such as the Adson's test, Roos test, Allen's test, Wright's test, Tinel's sign, Phalen's test, and Finkelstein's test. Each clinical test and detailed procedure was reviewed for consistency with other standardized examinations.[42-44] The training of physician examiners across multiple international sites was accomplished through a video-taped instructional examination coupled to a written script.

This paper will focus on shoulder and neck diagnoses and findings, including impingement syndrome, rotator cuff tendonitis, range of motion abnormalities, scapular winging, superior trapezius pain and trigger points, and findings for the Adson's, Roos, and Spurling tests.

The muscles of the rotator cuff function to stabilize the shoulder, rotate the shoulder, and abduct the shoulder beyond 20 degrees. Inflammation or a tear at this site may lead to weakness and pain in the shoulder, typically exacerbated by shoulder joint movement such as reaching.[45,46] Causes of rotator cuff tendonitis include hard and/or repetitive movement of the shoulder.[47] Shoulder impingement implies a loss in range of motion, with risk factors including poor muscle conditioning, flexed forward postures, and overhead work.[45,46] Pain with resisted shoulder abduction or resisted external rotation is characteristically elicited with rotator cuff tendonitis and not with impingement syndrome.[45,46]

Thoracic outlet syndrome is caused by the compression of the brachial plexus and/or subclavian artery. This results in pain and abnormal nerve sensations in the neck, shoulder, arm, and/or hand. This condition can be seen in workers with abnormal postures, such as performing extensive overhead work or computer workers with weak proximal musculature. Abnormal provocative physical exam maneuvers such as a Roos test or an Adson's test are consistent with thoracic outlet syndrome. [45,46]

Neck pain is a nonspecific finding. It is often due to muscle spasm of the neck muscles or trapezius muscles, although multiple other causes exist. A Spurling test is a physical exam maneuver that compresses the neck in order to evaluate the possibility of nerve root involvement.[45]

Data Analysis

All statistics were generated using SPSS version 10.1 for Windows. Tabular analysis was used for symptoms reports, diagnoses, and biomechanical factors. Chi-squares were calculated, using 95% confidence levels (2-tailed). Trend analysis across the 3 occupational groupings was calculated using Gamma coefficients where there was sufficient sample size in the observed categories. Confidence intervals and gamma values were calculated for physician diagnosis percentages to account for sample size. Bivariate analysis was utilized to define zero order correlations. Multivariate analysis (binary logistic regression) was performed on all 29 independent variables (occupation, demographics including age, height and weight, biomechanical, and psychosocial variables) by determining statistically significant (using $p<.10$ for inclusion in the equation to allow for keeping in variables of interest for final models) variables using forward conditional analysis. Those variables (including age in all models) were then used in an enter method binary logistic regression, with age included in all models. Groups (ie, occupation) were added into the model as dummy variables. Final models using only significantly associated variables (at $p<.05$ level) were run to minimize missing values.

Results

Participants

Ninety-four (94) experienced (minimum of 5 years in the field) Connecticut dental hygienists and 66 dental hygiene students from the 3 accredited Connecticut dental hygiene schools participated in the study. The overall response rate for the experienced hygienist mailings was 23.5% (94 participants out of approximately 400 valid initial mailings). The overall response rate for the dental hygiene students was 46% based on the approximately 145 eligible students.

For analytic purposes, the 66 dental hygiene students were split into 2 groups: 27 whose exposures were based on current education only (dental hygiene students, S) and 39 who also had exposures from present or previous work as a dental assistant in addition to exposures during dental hygiene education (SDA). Of the dental hygiene students, 45% (n=29) were first-year students, with the rest second-year or third-year students.

Experienced hygienists were significantly older, had more years in the field, worked more hours per week, saw more patients per day, and had more usage of both manual and vibrating instruments (Table I). Dental hygiene students who were also assistants had averages between those of nonassistant students and experienced hygienists.

Table I: Demographic and work characteristics of experienced dental hygienists (DH), dental hygiene students (S), and dental hygiene students who are/were also assistants (SDA).

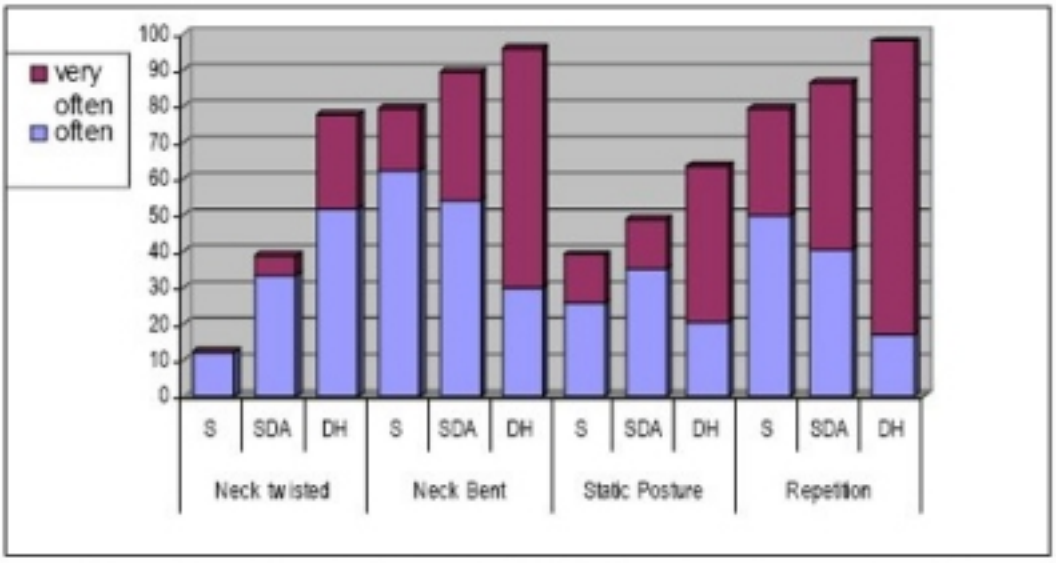
	S (n=27)	*SDA* (n=39)	*DH* (n=94)
	X (+/- SD)	**X** (+/- SD)	**X** (+/- SD)
Age (mean)**	**23.6 (6.2)**	**27.9 (6.0)**	**45.6 (8.8)**
Height (mean. cm)	163.2	163.4	163.9
Female (%)	96	100	98
White, non-Hispanic (%)	89	92	97
Years in dental field**	**0.3 (0.8)**	**5.0 (4.9)**	**21.8 (8.3)**
Dental hours/week (mean)**	**1.19 (4.1)**	**15.9 (11.8)**	**26.9 (9.6)**
Over 5 Patients treated/day (%) **	**0.0**	**25.0**	**96.0**
Number manual hours/week (mean)**	**4.4 (4.8)**	**5.8 (5.9)**	**12.0 (7.3)**
Number vibration hours/week (mean)*	**2.4 (3.4)**	**3.4 (4.2)**	**5.1 (5.4)**

**=sig at .05; **=sig at .01; Number of hours per week were self-assessed based on hours of work or combined use of specific lists of vibrating/non-vibrating instruments*

Risk Factors Reported by Hygienists

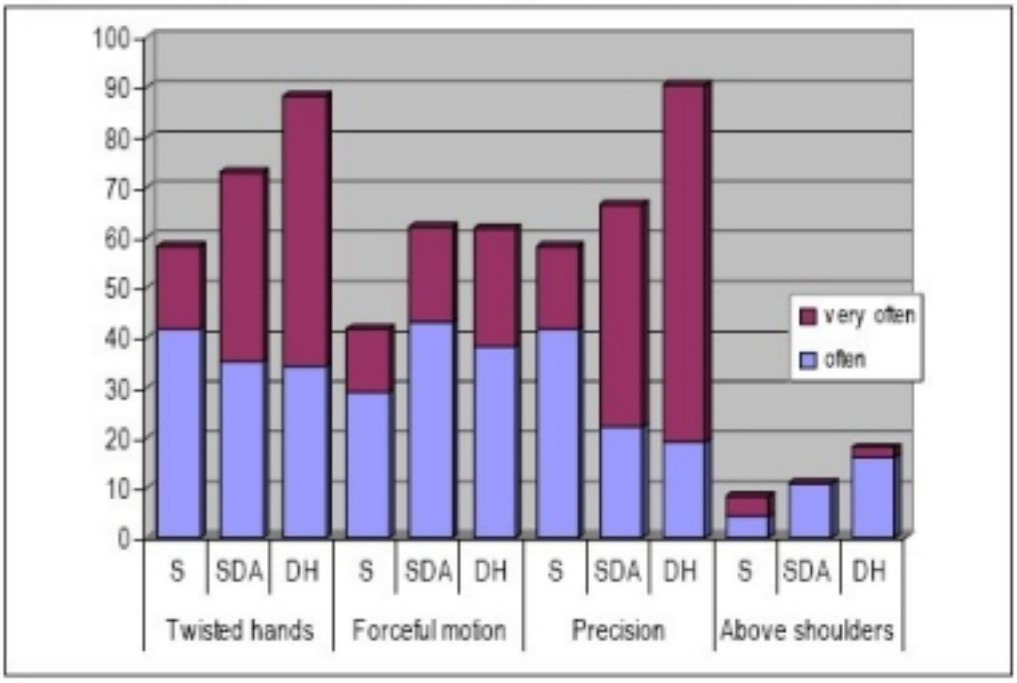
Respondents reported on their perceptions of the frequency of biomechanical risk factors that have been classically considered in relation to upper-extremity MSD, including bent and/or twisted neck, static posture (holding the same position, un-supported), hand/arm repetition, twisting the hands or wrists, using forceful hand motion, precise hand work, and holding the hands above shoulder height (see Methods for question wording). Figures 1 and 2 present the proportion of respondents who responded with "often" or "very often," categorized by dental hygiene students (S), dental hygiene students who also work as dental assistants (SDA), and experienced dental hygienists (DH).

Figure 1: Proportion reporting risk factors by occupation (1)



Note: Experienced dental hygienists (DH), dental hygiene students (S), and dental hygiene students who are/were also assistants (SDA)

Figure 2: Proportion reporting risk factors by occupation (2)



Note: Experienced dental hygienists (DH), dental hygiene students (S), and dental hygiene students who are/were also assistants (SDA)

The distributions of most exposures exhibit statistically significant differences (see chi-square and corresponding p-values in Table 2) between the 3 groups. These include working with a twisted neck, bent neck, static posture of the arms, twisted arms, using precise motion, and repetition ("repeated similar working movements"). Forceful motion of the arms and

working with arms above shoulder height were not significantly different. Differences were typically even more pronounced for the most extreme ("very often") category (Figures 1 and 2).

Table II: Significance statistics for risk factors (very often and often vs. never and seldom), comparing students, students/assistants, and experienced hygienists

	Chi-square	Gamma coefficient
Neck twisted	41.7**	.8**
Neck bent	24.8**	.6**
Static posture	24.0**	.2
Repetition	31.6**	.7**
Twisted hands	16.3*	.4**
Forceful motion	3.9	.2
Precision	28.8**	.6**
Above shoulder	3.9	.3

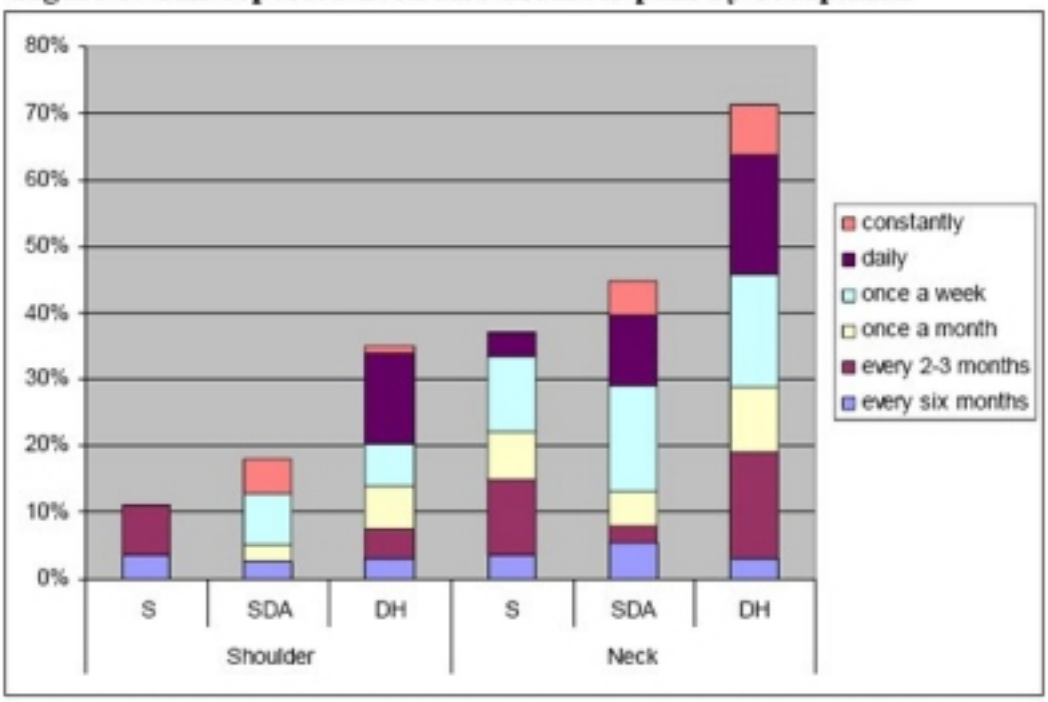
*=p<.01; **=p<.001

Most of the risk factors showed a clear stepwise increase from dental hygiene students, students who were also dental assistants, and experienced dental hygienists. The gamma coefficients in Table II indicate statistically significant increasing trends in the exposure severity as we progress from dental hygiene students to dental hygienists. The interpretation of gamma is similar to that of correlation coefficients such as Kendall's tau,[48,49] with 1.0 indicating perfect agreement; the statistically significant coefficients illustrate moderate to strong relationships, with gammas ranging from .4 (twisting hands) to .8 (twisted neck). Coefficients for forceful motion of the arms and working with arms above shoulder height were not significantly different, consistent with the chi-square tests results. On the other hand, even if there were differences in the distribution between groups for static posture, the differences were not consistent with an increasing trend.

Self-Reported Neck Symptoms

Point prevalence rates for subjective neck symptoms (defined as pain, aching, stiffness, spasm, inability to move head, burning, numbness, or tingling) were significantly different between the experienced hygienists and the 2 student groups (chi-square=14.9, p<.001), with hygiene students reporting 37.0%, assistants 43.2%, and experienced hygienists 72.3% (Figure 3). In addition to the increases in percentage of participants with reported pain from student to dental assistant/student to experienced hygienist, there was also an increase in the percentage that reported pain either daily or constantly (Figure 3).

Figure 3: Self-reported neck and shoulder pain by occupation



Note: Experienced dental hygienists (DH), dental hygiene students (S), and dental hygiene students who are/were also assistants (SDA)

Of those reporting pain, students and assistants both reported a median of 3.0 years of duration of the pain, with 9.5 years for experienced hygienists (F=10.4, p<.001). The mean neck pain for those reporting pain was not significantly different between groups, with 3.7 for students, 3.8 for assistants, and 3.2 for experienced hygienists (on a scale of 1-10, with 10 as worst pain). Of those reporting pain, 30% of students reported the neck pain traveled to the shoulder, compared to 60% for assistants and 67.6% for experienced; however, these differences were not statistically significant (chi-square=5.3, N.S.). Similarly, none of the students reported the pain traveling down to their arms, compared to 18.8% of assistants and 24.2% of experienced hygienists; these differences also were not statistically significant (chi-square=3.2, N.S.).

Self-Reported Shoulder Pain

Shoulder pain in the last 12 months was reported by 26.9% of respondents overall. This was also significantly different for the 3 groups (Pearson chi-square=8.2, p=0.016), with 11.1% for students, 17.9% for students/assistants, and 35.1% for experienced hygienists. Symptom frequency was increased monotonically across groups for daily/constant, increasing from 0% for students to 5% for student/assistants, to 15% for experienced.

Of those reporting shoulder pain, students reported a median of 5.0 years of duration of the pain, with nonsignificant differences of 2.5 years for student/assistants, and 5.0 years for experienced hygienists (F=1.7, N.S.). The mean intensity of pain (prior 7 days) for those reporting pain was 0.0 for students, 1.8 for student/assistants, and 3.4 for experienced hygienists (on a scale of 1-10, with 10 as worst pain; F=4.3, p=0.021).

Regression on Self-Reported Neck Pain

There was an odds ratio of 3.5 (95% CI 1.8-6.9) for experienced dental hygienists compared to all students (including dental assistants) for self-reported neck pain on the initial bivariate logistic regression (-2 log likelihood=200.8; Nagelkerke r2=.11). The odds ratio increased somewhat (OR= 5.0, CI=1.7-15.0) by controlling for age, even though age was not significantly associated with neck pain in the regression. This odds ratio for neck pain among experienced dental hygienists decreased to a below significance 2.0 (N.S.) when "working with a bent neck" (OR=2.1, CI 1.3-3.4) and supervisor support (OR=0.47, CI 0.22-1.0) are entered into the equation. These findings suggest that the differences found between the students

and the experienced dental hygienists may be explained by working with the neck flexed, with a protective effect from good supervisor support.

The number of hours of cleaning teeth was significantly related to neck pain when entered in an equation by itself (OR=2.1, CI=1.2-3.9); however, this lost significance when entered into the equation with the student/experienced variable.

None of the other biomechanical or psycho-social questions or factors achieved statistical significance in relation to self-reported neck pain.

Regression on Self-Reported Shoulder Pain

There was an odds ratio of 2.7 (95% CI 1.2-5.9) for experienced hygienists compared to all students (including dental assistants) for self-reported shoulder pain on the initial bivariate logistic regression (-2 log likelihood=181.3; Nagelkerke r^2=.06). Age was not significantly associated with shoulder pain, and did not appreciably change the odds ratio for the cohort. When entered in a separate model, holding arms above shoulder height was significantly related to shoulder pain (OR=1.5, CI=1.0-2.4), but this dropped below significance when combined with the student/experienced variable, and reducing the cohort odds ratio slightly to 2.3. One dental task, the amount of polishing teeth, was significantly related to shoulder pain (OR=2.5, CI=1.4-4.5); this stayed significant even when student/experienced was entered in the equation.

Physician Diagnoses

Physician diagnosed neck and shoulder findings, based upon the standardized physical exam, are reported below. Table III presents specific neck and shoulder exam findings by the percentage in each cohort, 95% confidence intervals, and gamma estimates for trends across the 3 subgroups.

Table 3: Specific neck and shoulder diagnoses for dental hygiene students (S), dental hygiene students/dental assistants (SDA) and dental hygienists (DH).

Physician Findings	S (n=27)		SDA (n=39)		DH (n=94)		Gamma
	%	95% CI	%	95% CI	%	95% CI	
Shoulder							
Impingement syndrome	4	0-11	5	0-12	3	0-7	
Rotator cuff tendonitis	0	0-0	0	0-0	4	0-8	
Shoulder abduction abnormality	0	0-0	2.6	0-8	4.3	0-8	
Shoulder flexion abnormality	0	0-0	0.0	0-0	5.3	1-10	
Shoulder internal rotation abnormality	7.4	0-17	17.9	6-30	18.1	10-26	.204
Scapular winging	25.9	9-42	46.2	31-62	25.5	17-34	-.171
Any shoulder finding	**33.3**	**16-51**	**61.5**	**46-77**	**41.5**	**32-51**	-.063
Any shoulder finding no winging	**7.4**	**0-17**	**23.1**	**10-36**	**21.3**	**13-30**	.205
Neck							
Superior trapezius pain	14.8	1-28	33.3	19-48	44.7	35-55	.409[a]
Superior trapezius trigger pt	14.8	1-28	25.6	12-39	35.1	25-45	.335[a]
Neural foramen tenderness	7.4	0-17	5.1	0-12	4.3	0-8	
Spurling test abnormality	3.7	0-11	2.6	0-8	4.3	0-8	
Any neck findings	**18.5**	**4-33**	**35.9**	**21-51**	**50.0**	**40-60**	.424[a]
Neck/shoulder							
Positive Adson's test	14.8	1-28	15.4	4-27	19.1	11-27	.125
Positive Roos test	33.3	16-51	38.5	23-54	39.4	29-49	.070
Any finding	**70.4**	**53-88**	**82.1**	**70-94**	**86.2**	**79-93**	.298
Any finding excluding winging	**55.6**	**37-74**	**69.2**	**55-84**	**79.8**	**72-88**	.369[a]

* Neck angles denoted % of abnormal subjects; (defined as: lat rotation <80°, lat flexion <45°, flexion <50°, extension<60°)

For gamma: a – p-value < .05; b – p-value < .01. Gamma coefficients not calculated for small numbers of observed cases due to instability of estimates.

Note: Experienced dental hygienists (DH), dental hygiene students (S), and dental hygiene students who are/were also assistants (SDA)

There were not significant trends for shoulder findings across the 3 groups (Table III). In an epidemiological study of this occupation, scapular winging may be more a function of thin stature associated with younger age than a condition with medical significance, although it is taken into consideration clinically in someone with symptoms. As a result, overall findings are shown both including and excluding winging. Prevalence rates of rotator cuff tendonitis and limitations in shoulder abduction and shoulder flexion were low in all 3 groups.

Two specific neck findings (superior trapezius pain and trigger points) had significant moderately increasing trends, as did the combined category of "any neck findings" (Table III). The overall neck findings association (gamma=0.424, p<.01) is driven primarily by the superior trapezius findings. There were not significant trends in relation to either the Roos or Adson's tests. There was a significant trend for overall neck and shoulder findings only when the scapular winging finding was excluded.

There is a high level of agreement between self-reported neck symptoms and the physician-diagnosed findings. Eighty-three percent (83%) of subjects who reported no symptoms also had normal exams, and 57% of subjects who reported symptoms also had physical exam abnormalities (Kappa=0.37, p<.001).

However, the concordance between self-reported shoulder symptoms and physician diagnoses was not significantly correlated. Only 54% of subjects that reported no symptoms had a normal shoulder exam, and only 43% of subjects that reported symptoms had an abnormal physical exam (Kappa=-0.02, p=N.S.). A minor abnormality such as winging may not be physically limiting, and may therefore go unreported. In fact, concordance of negative findings improve somewhat if scapular winging is not included in the analysis, resulting in 81% agreement. However, concordance between physical

exam shoulder abnormalities in symptomatic subjects is even lower, with only 20% agreement if winging is not factored into the analysis (Kappa=.02, p=N.S.).

Regression on Physician Findings

Any Neck Findings

There were only 2 variables that were significantly associated with any physician findings for the neck: working with a bent neck had an odds ratio of 1.7 (95% CI 1.02-2.81) and a protective effect from perceived support from supervisors with an odds ration of 0.50 (95% CI =0.2-1.0); the Nagelkerke r square for the overall model was .086, with a -2 log likelihood=185.2. Neither age nor height was significantly associated with neck findings.

Experienced hygienists were 2.5 times (95% CI= 1.3-4.8) more likely to have some neck findings than the combined student groups when in a separate model; when the students were split, the student/assistants were 2.5 (95% CI= 0.76-8.0) times more likely, and experienced dental hygienists 4.4 (95% CI=1.5-12.6) times more likely, to have some neck findings than students (model r-square=.08; -2 log likelihood= 207.1).

Any Shoulder Findings

There were no significant associations with "any physician shoulder findings" in logistic regression, either with inclusion or exclusion of winging as the dependent variable.

Any Neck or Shoulder Findings

Experienced dental hygienists were 2.3 times (95% CI= 1.1-4.6) more likely to have some neck or shoulder findings (excluding winging) than the combined student groups when in a separate model. When the two student groups were split out, student/assistants had a non-significant odds ratio of 1.8 (95% CI=0.65-5.0, N.S.) and experienced a 3.2 odds ratio (95% CI= 1.3-7.9).

Discussion

This study examined the occurrence of neck pain among dental hygiene students, dental assistants, and experienced dental hygienists, and compares their relative exposures to biodynamic risk factors. The study found a significantly increased prevalence of reported neck pain and physical exam abnormalities related to the neck among experienced dental hygienists compared to dental assistants and dental hygiene students. Self-reported neck symptoms were 37% for DS, 43% for DA, and 72% for DH; physician neck findings ranged from 22% (DS), 38% (DA) and 47% (DH). These differences remained significant when controlled for age. Risk factors showing significant differences by group included working with a twisted neck, bent neck, static posture for the arms, using precise motions, and repetition. A supportive supervisory environment appeared to be protective. Experienced hygienists were 2.5 times more likely to have physician findings of the neck compared to the combined student group. Students who had previously worked as dental assistants demonstrated an intermediate risk of reported neck pain. This observation suggests that biodynamic hazards exist among dental assistants and that one cannot assume that students constitute a nonexposed population (and that, in addition, there are also substantial clinical exposures as part of training). Findings are consistent with prior research that neck and shoulder problems are apparent in this population and that low level loads are less associated with glenohumeral joint/rotator cuff issues than neck pain (as per physician findings). Neck issues are especially important to consider because they may be precursors to further problems in the more distal extremity.[50,51]

Significant associations between biodynamic exposures and abnormal physician exam findings were seen in each group when analyzed independently of the other groups. However, regression findings are more complex to interpret among the experienced hygienists who were by definition older and treated more patients per day than students (although age was not significantly associated with symptoms in most analyses). In addition, subject height and supervisor support were significantly associated with physician findings. A complex pattern emerges in which the relationship between biomechanical variables (such as bent neck, static posture, and repetition), anthropometric subject characteristics (taller height, which may result in more bending of the neck), and psychosocial support may combine to produce high levels of symptoms.

There are study characteristics that impact interpretation and generalizability. The unavoidable correlations between age and professional status make it more difficult to determine the proportion of the problem that is due to aging versus work (though the high level of symptoms and physician findings make it unlikely to be due primarily to aging, particularly given the associations with biomechanical variables). While the study included a longitudinal component, the great difficulty in follow-up of graduated students complicated interpretation of that component, thus it is not presented here.

While response rates were high for students, they were lower for experienced hygienists. While low response rates are not unusual for lab-based studies involving extensive time commitments, this raises the possibility of a sample of experienced hygienists that is biased towards more symptomatic (ie, that those with symptoms were more interested in participating). However, the rates of overall musculoskeletal disorder (MSD) symptoms, though very high, are in line with other studies of dental hygienists,[2,4,18] the stepwise increase with dental assistants in the middle, and the consistent relationship with exposures all suggest similar conclusions, even if the rates of symptoms for experienced hygienists were biased to high. In addition, there is a likely healthy worker effect, which would bias towards lower prevalence for experienced hygienists compared to students (ie, that more symptomatic hygienists may drop out of the profession or reduce hours).

Conclusions

This large study utilizing both subjective and objective assessments, found that risk of neck and shoulder disorders among dental hygienists increases with a background of dental assistant work, and that neck symptoms are considerably more prevalent than shoulder symptoms (with a very low prevalence of rotator cuff tendonitis), and that neck bending, supervisor support, and holding arms above shoulder height are the key risk factors to address in prevention programs.

These high rates of risk factors and symptoms have serious implications for career loss, discomfort, disability, and productivity for dental hygienists. Musculoskeletal disorder (MSD) symptoms for dental assistants also are high, particularly in relation to the relatively short number of years of exposure in this sample, indicating the likelihood of onset of symptoms early in one's career and progressing further with continued exposure. It appears that symptoms start as early as the second year of dental hygiene school as students move into clinical work.

Results point to a clear need for serious ergonomic evaluation and intervention in dental hygiene and dental assisting work, particularly (based on this analysis) focused on improving neck posture through improved dental equipment, proper client positioning, stretching, and technique training. Supervisor support should also be emphasized to assist in reducing symptoms. Results of this study are currently being combined with the results of a related lab simulation of dental hygiene work to detail ergonomic risks and suggest specific improvements for a future publication.

While a recent survey by the American Dental Association found that some ergonomic training was common in the dental professions (98% of dental hygiene programs reported some ergonomic training), the survey did not address the extent of the training, such as the number of contact hours; for example, there was not a separate course in ergonomics in any of the dental hygiene programs.[52] Given the magnitude of risk, further attention should be given to ensure adequate training as well as on-going assessments of practices in training, and specific attention should be given to students with previous experience as dental assistants, since risks appear to be higher.

Acknowledgements

This research was sponsored by the National Institute for Occupational Safety and Health, under Grant #: U01 OH07312. The research was also supported in part by a General Clinical Research Center grant from NIH (M01RR06192) awarded to the University of Connecticut Health Center, Farmington, CT. We would like to thank the other members of the HAVIC group who were instrumental in the design and conduct of the larger study, including Tony Brammer, Ronnie Lundstrom, John Meyer, Greg Neely, Tohr Nilsson, Donald Peterson, Esko Toppila, and Rochelle Fu.

Notes

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