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School of Allied Health Professions

Disability Self-Assessment and Upper Quarter Muscle Balance in Females

by


Eric Glenn Johnson

A Publishable Paper in Lieu of a Thesis in Partial Fulfillment of the Requirements for
the Degree Doctor of Physical Therapy Science

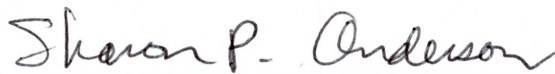
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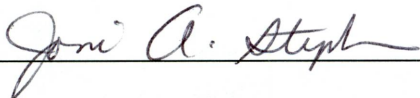
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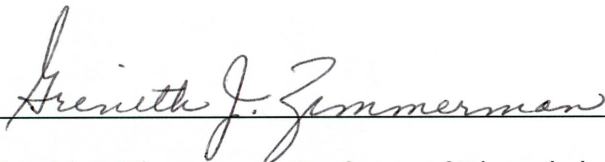
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ABSTRACT

Disability Self-Assessment and Upper Quarter Muscle Balance in Females

Eric Glenn Johnson

Background and Purpose. This study compared upper quarter muscle balance of working female dental hygienists and non-dental hygiene females who had no history of upper quarter pathology. The upper quarter was operationally defined as the shoulder and neck region; and muscle balance, as muscular flexibility and muscular performance. Muscular performance was operationally defined as a combination of strength and endurance. **Subjects.** The study group consisted of 41 working dental hygienists between the ages of 22 and 60 years with a mean age of 38 years. The control group consisted of 46 non-dental hygienists between the ages of 20 and 54 years with a mean age of 29 years. **Methods.** Passive muscular flexibility of the upper trapezius and levator scapula was measured using an inclinometer. Passive muscle length testing of the pectoralis major and minor was assessed using the Kendall Technique. Subjects were also instructed to maintain four different positions using isometric muscular contractions, each position representing a different group of scapular stabilizers. Muscle performance was measured by timing the duration, in seconds, of each of the four positions held. Additionally, all subjects filled out the Northwick Park Neck Pain Questionnaire (NPNPQ). Analysis of Covariance

(ANCOVA) was used during data analysis to adjust for the age difference between groups. **Results.** The results of this study suggest that female dental hygienists are more likely than non-dental hygiene females to develop tightness in the upper trapezius ($p=0.007$) and the levator scapula ($p=0.01$) of the non-dominant upper quarter. Muscle performance trends in the dental hygiene group for the serratus anterior position, upper trapezius and levator scapula position, and the pectoralis minor and lower trapezius position supported popular muscle balance theory that short muscles remain strong while lengthened muscles become weaker. Statistical significance was not achieved in any of the muscular performance measures because of high variability in the holding times for the testing positions. The dental hygiene group had higher totals in all nine parts of the NPNPQ (higher totals represent more pain complaints) compared to the non-dental hygiene group. Mean differences for five of these parts were statistically significant ($p<0.05$). **Conclusion and Discussion.** The results of this study suggests that muscular imbalances in the upper quarter are more common in female dental hygienists than in female non-dental hygienists and may contribute to the numerous upper quarter pathologies associated with the profession of dental hygiene.

Key Words: Dental hygiene, Over-use disorder, Muscle balance, Disability

Dental hygienists routinely position themselves in static postures for extended periods of time and muscles in the upper quarter are often required to endure high workloads. As a result, dental hygienists suffer from many different musculoskeletal disorders, including overuse disorders.¹⁻¹⁰ Oberg and Oberg⁹ have identified the upper quarter as the most frequently injured region in dental hygienists. According to the National Institute for Occupational Safety and Health (NIOSH), there is a strong relationship between upper quarter musculoskeletal disorders and the static contractions and postures maintained by dental workers.¹⁰ Faulty body mechanics may lead to musculoskeletal disorders because they contribute to muscular imbalance. Kendall¹¹ states that “inherent in the concept of good body mechanics are the inseparable qualities of alignment and muscle balance.”

Janda^{12, 13} has defined muscle balance as the relationship between muscular strength and muscular flexibility. The term flexibility has been described in the literature as "the ability of a muscle to lengthen, allowing one joint (or more than one joint in a series) to move through a range of motion."¹⁴ Muscle balance has been defined by Kendall et al¹¹ as "a state of equilibrium that exists when there is a balance of strength of opposing muscles acting on a joint, providing ideal alignment for movement and optimal stabilization." Muscle balance, therefore, is a very desirable state to maintain. Deviations away from this state may affect joint position and contribute to musculoskeletal dysfunction.¹³

The purpose of this study was to compare upper quarter muscular balance and self-disability assessment between female dental hygienists and non-dental hygiene females. The upper quarter was operationally defined as the shoulder

and neck region and muscle balance consisted of muscular flexibility and muscular performance. Muscular performance was operationally defined as a combination of strength and endurance.

METHODS

Subjects

The primary investigator selected female subjects from the southern California area via a convenience sample. Dental hygiene subjects currently working at least three days per week in a general dentistry practice and non-dental hygiene subjects without a history of neck or shoulder pathology were included in the study. Age was limited to 60 years to control for possible variations in muscular torque production capabilities. Research suggests that muscular strength does not begin to decline until the beginning of the sixth decade of life.^{15, 16} Exclusion criteria for both groups included pregnancy, multiple sclerosis, post-polio syndrome, or other medical diagnoses that may affect the neuromuscular system. Prior to participation in this study, all subjects signed an informed consent form approved by the Loma Linda University Institutional Review Board.

Instruments

In this study, passive range of motion (PROM) was measured in one of two ways. The first method of measurement was inclinometry. An inclinometer is a plastic device with a fluid-filled center that is placed on the subject's head for cervical PROM testing. It displays the amount of movement in degrees. Reliability of

inclinometry has been previously reported in the literature; however, it was not found to have intertester validity.¹⁷ The second method of PROM measurement was muscle length testing as defined by Kendall.¹¹ Reliability and validity studies for muscle length testing as defined by Kendall were not found in the review of literature.

The Northwick Park Neck Pain Questionnaire (NPNPQ)¹⁸ was used for collecting subjective information about neck pain and activities of daily living from each subject. The NPNPQ is a questionnaire that was modeled after the Oswestry Low Back Pain Disability Questionnaire and it has been shown to be a valid semi-objective assessment tool for quantifying neck pain.¹⁸ It consists of nine five-part questions that extract information relating neck pain to interference with activities of daily living. Each question has five possible answers (score values between 0-4 points) that range from nil to significant effect of pain on activities of daily living (Appendix B).

Reliability Studies

Five subjects were selected via a convenience sample from Loma Linda University for reliability studies. All reliability tests for inclinometry and muscle length assessment were performed on the same day with approximately 30 minutes between the first and second test. The subjects were asked not to perform any exercise or stretching between tests. The short duration between tests and the request to refrain from stretching or exercising between tests served to limit possible changes in muscular flexibility. The details of inclinometry and muscle length testing are explained in the procedures section.

Intratester reliability of the inclinometer measurements was established by performing all flexibility measurements twice on five different subjects. To increase accuracy of the inclinometry, as previously described in the literature, the inclinometer was held with fingers spread along the base of the device while the other hand stabilized the shoulder of the opposite side to prevent shoulder elevation during testing.¹⁸ The intratester reliability standard was for the second measurement to be within 5 degrees of the examiner's first measurement.¹⁹

Intertester reliability of inclinometry measurements could not be established between two examiners in three separate trials with five subjects in each trial. It is the opinion of the primary investigator that variability in determining the end range of motion of the upper trapezius and levator scapula between therapists prevented intertester reliability from being established. Because of this, all inclinometry measurements were taken by the primary investigator.

Intratester and intertester reliability of muscle length testing were established with two examiners. All muscle length tests were performed twice on five different subjects and the results were compared. There were no differences in results between or within examiners. It was decided that the primary investigator would perform all muscle length tests.

Procedures

A brief history was taken from all subjects to determine that they met inclusion criteria. Subjects then filled out the NPNPQ and were measured for muscular flexibility and muscular performance. Muscular flexibility of the upper

trapezius, levator scapula, serratus anterior, rhomboids, middle trapezius, lower trapezius, and pectoralis minor was measured. These muscles have been cited by several authors as being important muscular contributors in upper quarter imbalances.^{12, 13, 20-22}

Muscular Flexibility

Muscular flexibility of the upper trapezius was measured by having the subject sit in a mid-back height chair and verbally assisting them into the ideal postural alignment, as stated by Kendall et al.¹¹ A McKenzie lumbar support roll was placed between the lumbar spine and the back of the chair. A fluid-filled inclinometer was placed on the top of the cranium and set to zero degrees. The head and neck were then passively laterally flexed to the contralateral side while stabilizing the ipsilateral scapula. The passive movement was taken to the terminal position of lateral flexion (defined as the point at which the researcher perceived resistance to stretch), and a measurement in degrees was taken at that point. Bandy and Lohman^{23, 24} have described this passive terminal position in the literature. The literature has inconsistently reported the exact amount of head rotation toward the opposite side during passive elongation of the upper trapezius. Because of this inconsistency, testing of the upper trapezius flexibility was performed with the head facing straight forward (no rotation).

The sitting position and inclinometry techniques for measuring muscular flexibility of the levator scapulae were the same as for the upper trapezius. The subject's head was passively positioned into 45 degrees of rotation to the contralateral

side using a standard goniometer. The head and neck were then laterally flexed passively to the contralateral side while stabilizing the ipsilateral scapula. The passive movement was taken to the terminal position of lateral flexion and a measurement in degrees was taken at that point. Since the exact amount of head rotation toward the opposite side during passive elongation of the levator scapula was inconsistently reported in the literature reviewed, it was decided that testing of the levator scapula flexibility would be performed with the head and neck rotated 45 degrees toward the contralateral side.

The pectoralis major was isolated into upper and lower fibers. Muscular flexibility of the lower fibers of the pectoralis major was tested by having the subject lie in a hooklying position on a firm table. The subject's arm was placed in approximately 135 degrees of humeral abduction with the elbow extended and the humerus externally rotated. The subject's arm was passively lowered toward the table until either the terminal position of the muscle was met or the arm reached the table. The subject was given a positive recording if the arm did not reach the table and a negative recording if the arm did reach the table.

Muscular flexibility of the upper fibers of the pectoralis major was tested by having the subject lie supine on a firm table with knees bent and the lumbar spine flat on the table. The subject's arm was placed in horizontal abduction with approximately 90 degrees of humeral abduction, the elbow extended, and the humerus externally rotated. The subject's arm was passively lowered toward the table until either the terminal position of the muscle was met or the arm reached the table.

The subject was given a positive recording if the arm did not reach the table and a negative recording if the arm did reach the table.

Muscular flexibility of the of the pectoralis minor was tested by having the subject lie supine on a firm table with knees bent and the lumbar spine flat on the table. The subject's arms were placed in a neutral position along either side of the subject. The subject's shoulders were passively lowered toward the table until either the terminal position of either muscle was met or any part of either scapula reached the table. The subject was given a positive recording if the scapula did not reach the table and a negative recording if the scapula did reach the table.

Muscular Performance

The subjects were given a one-page written instruction sheet explaining the testing procedure. They were then shown pictures of each exercise and given an opportunity to try the exercise prior to testing. Once the subject clearly understood the exercise, she began by saying "go". The position was held until the subject could no longer maintain the gravity-resisted position without compensating or the subject said "stop". The duration of the hold was timed in seconds with a digital stopwatch.

The scapular stabilizers were tested in isolated positions for muscle performance against gravity.^{21, 22} A standard high-low table, a standard height chair, and a digital stopwatch were used for testing purposes. The serratus anterior was tested by having the subject lie prone on a table. On the subject's command of "go", the subject would perform a push-up with a "plus". The "plus" refers to abducting

and protracting the scapula to maximize the contraction of the serratus anterior (Figure 1).

The middle trapezius and rhomboids were tested by having the subject lie prone on a table with the trunk supported on a stable platform with one pillow between the trunk and platform for comfort. The beginning position was with the arms in horizontal abduction, humerus abducted approximately 90 degrees, and elbows extended. On the subject's command of "go", the subject would maximally retract the scapulae and lift the arms off the table (Figure 2).

The upper trapezius and levator scapula were tested by having the subject lie prone on a table with the trunk supported on a stable platform with one pillow for comfort. The beginning position was with the arms along the trunk and elbows flexed approximately 90 degrees. On the subject's command of "go", the subject would maximally elevate the scapulae (Figure 3).

The lower trapezius and pectoralis minor were tested by having the patient sit on the floor (legs straight out in front of the body with hips flexed approximately 90 degrees and knees extended). The hands were placed on stable platforms along either side of the subject. On the subject's command of "go", the subject would push through the hands to lift her bottom off the floor. She performed an additional push at the end of the range to maximally contract the lower trapezius and pectoralis minor muscles (Figure 4).

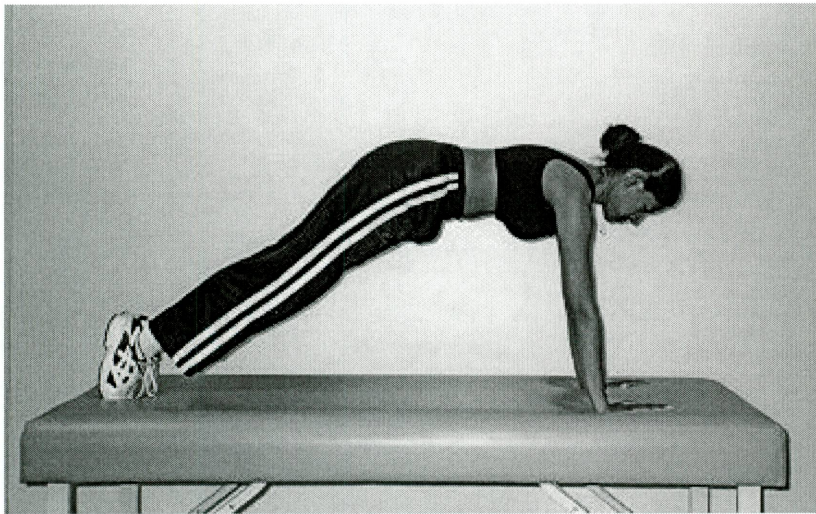


Figure 1. Testing Position for Muscle Performance of the Serratus Anterior Muscle.

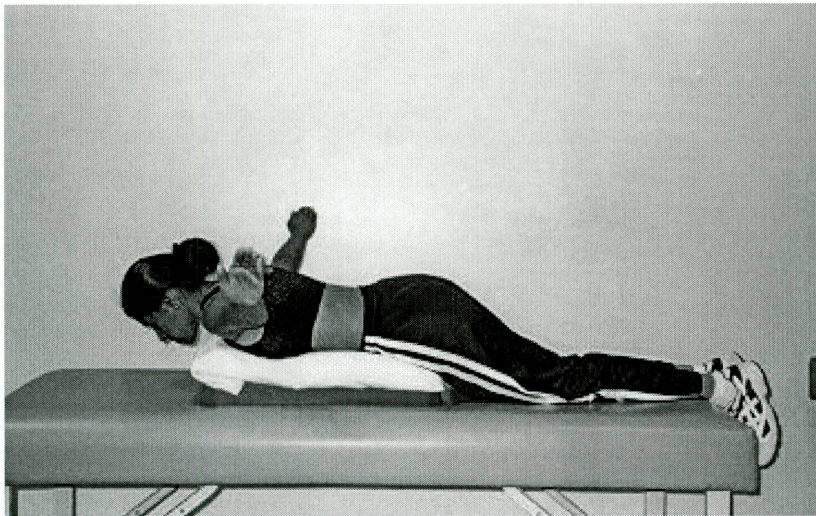


Figure 2. Testing Position for Muscle Performance of the Rhomboids and Middle Trapezius Muscles.

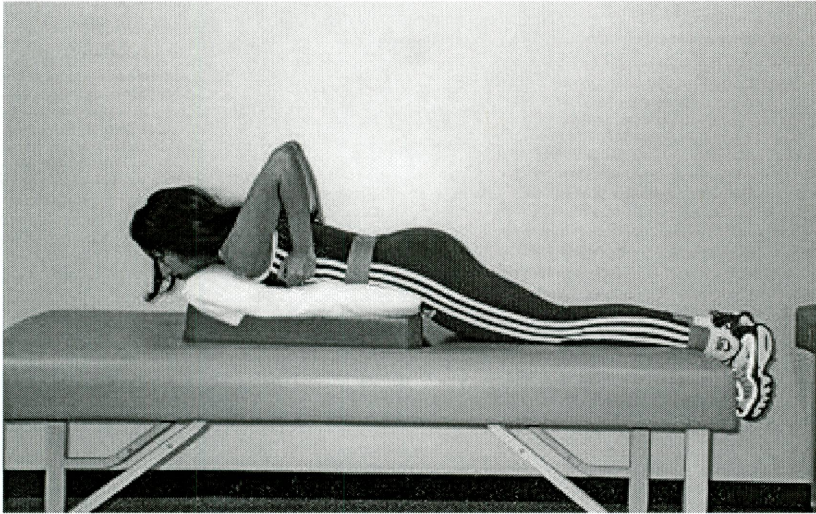


Figure 3. Testing Position for Muscle Performance of the Upper Trapezius and Levator Scapula Muscles.

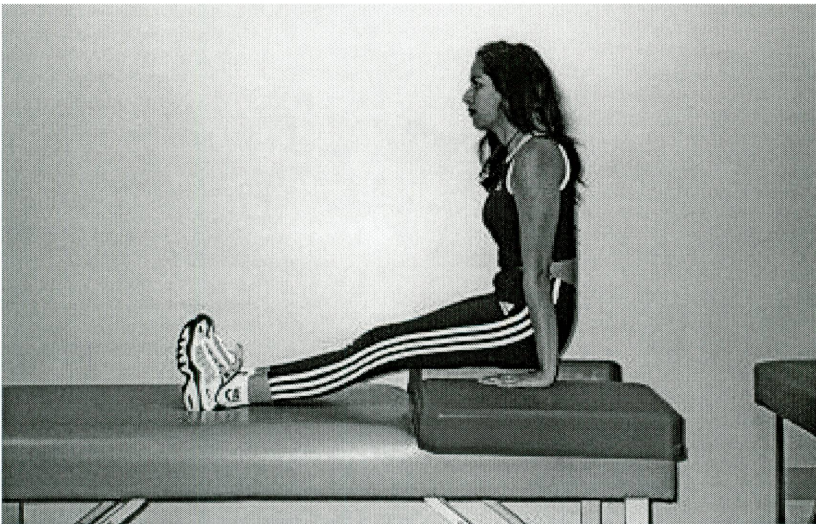


Figure 4. Testing Position for Muscle Performance of the Lower Trapezius and Pectoralis Minor Muscles.

DATA ANALYSIS

Means and standard deviations were calculated for each flexibility measurement by group. Using independent two-tailed t-tests, flexibility measures of the upper trapezius, levator scapula, and pain measures were compared for the two groups. To determine if age was a significant factor between groups, Analysis of Covariance (ANCOVA) was used with age as the covariate. Chi square tests for homogeneity were used to compare muscle length tests for the pectoralis major and pectoralis minor.

RESULTS

A total of 87 subjects between the ages of 20 and 60 years were enrolled in the study and all subjects completed the study. Forty-one dental hygiene subjects were in the study group, (mean age = 38.0 years, SD = 10.3) and 46 subjects were in the control group (mean age = 29.3 years, SD = 8.2). Age was significantly different between groups ($p < 0.001$). ANCOVA, with age as the covariate, was used in all quantitative statistical analyses to determine if age influenced any statistical differences found.

Muscular Flexibility

Differences in mean flexibility were not significant for the upper trapezius or the levator scapula on the right side ($p=0.06$, $p=0.08$, respectively). Mean differences were statistically significant when comparing the left upper trapezius and levator scapula ($p=0.007$, $p=0.01$, respectively). The dental hygiene group had a mean

difference of 5.9 ° less flexibility for the left upper trapezius compared to the non-dental hygiene group. The dental hygiene group also had a mean difference of 5.4 ° less flexibility for the left levator scapula compared to the non-dental hygiene group (Table 1).

The difference in proportion of positive test results was not statistically significant for the pectoralis minor on the right side ($p=0.08$). Statistical significance was found when comparing the proportion of positive test results for the left pectoralis minor ($p=0.001$). The pectoralis minor on the left side was positive in 70.7% of the subjects tested in the dental hygiene group as compared to 30.4% of the non-dental hygiene group (Table 2). Muscle length tests for the upper fibers of the pectoralis major were not significantly different ($p>0.05$).

Statistically significant differences were found between groups in muscle length testing of the lower fibers of the pectoralis major on the right side. The dental hygiene group had 9.8% positive findings compared to no positive findings in the non-dental hygiene group (Table 3).

Muscular Performance

Muscular performance was measured for the following four groups: serratus anterior, rhomboids/middle trapezius, upper trapezius/levator scapula, and lower trapezius/pectoralis minor. Due to high variability in the holding times of each of the four positions, statistically significant differences were not found (Table 4).

Table 1. Results of the Passive Muscular Flexibility Using Inclinometry

Muscle	NDH (n = 46)	DH (n = 41)	P-value*
	Mean (SD)	Mean (SD)	
Upper Trapezius Right	41.2 ° (6.4)	35.2 ° (9.5)	0.06
Upper Trapezius Left	35.3 ° (5.7)	29.4 ° (7.0)	0.007
Levator Scapula Right	37.5 ° (7.1)	34.0 ° (8.1)	0.08
Levator Scapula Left	30.4 ° (8.0)	25.0 ° (7.0)	0.01

*ANCOVA was used to determine significance with age as the covariate.

Table 2. Results of Passive Muscle Length Testing for the Pectoralis Minor Muscle

Muscle	NDH (n = 46)	DH (n = 41)	P-value
Pectoralis Minor Right	52.2%*	70.7%	.08
Pectoralis Minor Left	30.4%	70.7%	.001

*Percentages represent positive test result.

Table 3. Results of Passive Muscle Length Testing for the Pectoralis Major Muscle

	NDH (n = 46)	DH (n = 41)	
Muscle	%	%	P-value
Pectoralis Major Upper Fibers (L)	2.4*	0.0*	0.29
Pectoralis Major Upper Fibers (R)	0.0	0.0	
Pectoralis Major Lower Fibers (L)	4.3	14.6	0.10
Pectoralis Major Lower Fibers (R)	0.0	9.8	0.03

*Percentages represent positive test result

Table 4. Results of Active Muscle Performance Measured in Seconds

	NDH (n = 46)	DH (n = 41)	
Muscle(s)	Mean (SD)	Mean (SD)	P-value**
Position 1*	115.0 (84.0)	97.1 (49.0)	0.22
Position 2	116.2 (62.0)	144.1 (75.0)	0.06
Position 3	109.0 (55.0)	115.0 (69.0)	0.67
Position 4	98.0 (67.0)	75.1 (42.0)	0.07

*Position 1 is serratus anterior, Position 2 is rhomboids and middle trapezius, Position 3 is upper trapezius and levator scapula, and Position 4 is lower trapezius and pectoralis minor. **ANCOVA was used to determine significance with age as the covariate.

Pain Questionnaire

The NPNPQ was compared between groups. Significant differences ($p < 0.05$) between groups were found for five of the nine sections. The five sections were intensity level, numbness, duration, working, and driving. See Table 5. No significant correlations ($p > 0.05$) were found between self-disability assessment and muscle balance.

Table 5. Results from the Northwick Park Neck Pain Questionnaire

	NDH (n = 46)	DH (n = 41)	
Section	%*	%	P-value
Intensity	15.2	34.1	0.04
Sleeping	21.8	39.0	0.08
Numbness	28.3	58.6	0.005
Duration	28.2	65.0	0.001
Carrying	15.2	21.9	0.42
Reading/T.V.	34.8	41.5	0.43
Work	2.0	31.7	0.001
Social	8.7	14.6	0.34
Driving	4.3	24.4	0.006

*Percent represents the number of subjects who reported that pain or numbness affected their activities of daily living to some degree.

DISCUSSION

The results of this study identified statistically significant differences in muscular flexibility in the upper quarter between female dental hygienists and female non-dental hygienists. The results suggest that dental hygienists are prone to develop tightness of the upper trapezius and levator scapula of the non-dominant side. In the dental hygiene group, 90.2% of the subjects were right handed compared to 95.7% in the non-dental hygiene group. While the dental hygiene group had decreased passive muscular flexibility in the upper trapezius and levator scapula of both the dominant and non-dominant sides, only the non-dominant side was significantly decreased ($p < 0.05$). Dental hygienists typically use the dominant upper quarter and extremity for scaling and hand-intensive activities. The non-dominant or assisting upper quarter is frequently maintained in static positions that elevate the scapula.

Muscle length tests of the pectoralis minor were positive in the majority of the dental hygiene subjects. This is consistent with the decreased passive flexibility findings of the non-dominant upper trapezius and levator scapula in this group. Pectoralis minor tightness of the non-dominant side was found in 70.7% of the dental hygiene group as compared to 30.4% of the non-dental hygiene group. Although a significant difference for the pectoralis minor was not found in the dominant side, the dental hygiene group had 18.5% more positive findings than the non-dental hygiene group (70.7%, 52.2% respectively). Once again, these results suggest that work-related static positions of the non-dominant upper quarter contribute to the muscular imbalances found in the dental hygiene group. The muscle length tests of the upper fibers of the pectoralis major revealed just one positive finding from both groups.

The muscle length tests of the lower fibers of the pectoralis major on the dominant side revealed positive tests in 9.8% of the dental hygiene group as compared to no positive tests in the non-dental hygiene group. The muscle length tests of the lower fibers of the pectoralis major on the left side revealed positive tests in 14.6% of the dental hygiene group as compared to 4.3% positive tests in the non-dental hygiene group. It was surprising to find such a small percentage of positive tests in the dental hygiene group because the amount of humeral flexion and internal rotation of the dominant upper extremity performed in the occupation of dental hygiene would suggest much larger percentages.

The results of active muscle performance revealed high variability in the length of time individual subjects were able to hold each of the four positions. This was consistent with the results of another study that measured isometric muscular strength and endurance.¹⁸ Because of this high variability, statistical significance was not achieved for any of the four testing positions. Despite the lack of statistical significance, some clinically important trends were noted. Position 1 required the subject to maintain an isometric contraction of the serratus anterior. The mean holding time for non-dental hygiene group was 115.0 seconds (SD = 84.0 seconds) compared to the dental hygiene group mean holding time of 97.1 seconds (SD = 49.0 seconds). This is clinically significant because the serratus anterior is an important scapular stabilizer and part of the scapular force couple that allows for normal scapular upward rotation during humeral flexion.

Position 2 required the subject to maintain an isometric contraction of the rhomboids and middle trapezius. The mean holding time of the dental hygiene group

was 47.9 seconds more than the mean holding time of the non-dental hygiene group. Position 3 required the subject to maintain an isometric contraction of the levator scapula and the upper trapezius. The mean holding time of the dental hygiene group was 6.0 seconds more than the mean holding time of the non-dental hygiene group. This is clinically significant because both position 2 and position 3 required scapular adduction as part of the testing position and the literature has identified all four of the muscles involved with positions 2 and 3 as being primary scapular adductors.²² Since the upper trapezius and the levator scapula were less flexible in the dental hygiene group, this supports popular muscle balance theory that shortened muscles remain strong while lengthened muscles become weak.

Position 4 required the subject to maintain an isometric contraction of the scapular depressors (lower trapezius and pectoralis minor). The mean holding time for the non-dental hygiene group was 98.0 seconds (SD = 67.0 seconds) compared to the dental hygiene group mean holding time of 75.1 seconds (SD = 42.0 seconds). This is clinically significant because the scapular elevators (upper trapezius and levator scapula) were less flexible in the dental hygiene group (statistically significant for the non-dominant side only). The trend of markedly weaker holding times by the dental hygiene group (22.9 seconds) again supports popular muscle balance theory.

The NPNPQ revealed statistically significant differences between groups in 5 of the 9 categories. The dental hygiene group reported consistently higher frequencies of pain involvement throughout all applicable categories of the questionnaire. This suggests that female dental hygienists are more likely to develop some degree of

upper quarter pain that may impact activities of daily living when compared to female non-dental hygienists.

No correlations were found between upper quarter muscle imbalance and self-disability assessment. This is most likely due to the fact that all subjects in the dental hygiene group were working a minimum of three days per week, which suggests that they were not a very disabled group of individuals.

This reduction of upper quarter muscular flexibility coupled with abnormal muscular performance of the scapular stabilizers sheds light on the role that muscular imbalance may play in the abundance of upper quarter musculoskeletal disorders seen in female dental hygienists. Physical therapists who treat upper quarter disorders in female dental hygienists could use the results of this study as one part of the hypothesis-oriented algorithm for clinicians (HOAC), which could lead to more effective treatment outcomes.²⁵

Future research should be conducted to explore the relationship between the non-dominant upper quarter working position and muscular imbalance in female dental hygienists. Also, correlational studies should be conducted on disabled groups to look at the relationship between self-disability assessment and muscle imbalance in the upper quarter.

CONCLUSION

The results of this study suggest that muscular imbalances in the upper quarter exist in the female dental hygiene population and may contribute to upper quarter pain and musculoskeletal disorders. Statistically significant muscular tightness was

found in the dominant pectoralis major (lower fibers) and non-dominant upper trapezius, levator scapula, and pectoralis minor of the dental hygiene group. This suggests that the non-dominant upper extremity is performing activities that either statically elevate the scapula and/or side bend the head and neck toward the non-dominant shoulder. It also suggests that the dominant upper extremity performs activities that require extensive humeral internal rotation and/or adduction.

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Appendix A

Literature Review

Muscle Balance and Musculoskeletal Disorders of the Upper Quarter in Dental Hygienists: A Review of the Literature

Physical therapists represent a group of health care professionals who are trained to evaluate and treat musculoskeletal disorders in the upper quarter. Dental hygienists are at risk for developing muscular imbalances that can contribute to problems of this nature. Much has been written regarding the occurrence of work-related injuries in dental hygiene; however, there is a need for more knowledge in the area of predisposing musculoskeletal impairments that can lead to functional limitations and disability. The purpose of this paper was to review the literature in order to ascertain the prevalence of upper quarter disorders in the dental hygiene profession and discuss the relationship between these disorders and upper quarter muscle balance.

Key Words: dental hygiene, musculoskeletal disorder, muscle balance

Dental hygienists provide a service that is both unique and very specialized. This specialization requires the dental hygienist to perform repetitive upper extremity movements while maintaining static postures in the trunk. According to the National

Institute for Occupational Safety and Health (NIOSH) Executive Summary,¹ there is a strong relationship between neck musculoskeletal disorders and static (isometric) muscle contractions, prolonged isometric loads, and extreme neck and shoulder working postures. Evidence also suggests that shoulder musculoskeletal disorders are related to static and repetitive shoulder motions above 60° of glenohumeral flexion or glenohumeral abduction.¹ Over time, muscle imbalances in the upper quarter (the neck, shoulder, and upper torso region) can affect posture, upper quarter movement, and pain in the dental hygienist. The purpose of this paper is to discuss the literature regarding upper quarter musculoskeletal disorders in the dental hygienist and muscle balance theory as it relates to the upper quarter. This review has been divided into three sections: 1) upper quarter musculoskeletal disorders in the dental hygienist, 2) muscle balance theory, and 3) muscles making up the upper quarter and the common muscle imbalances affecting this area.

Upper Quarter Musculoskeletal Disorders in the Dental Hygienist

Musculoskeletal disorders in the dental care profession are well documented in the literature.^{2-6, 8-13} According to the Bureau of Labor Statistics,² dental hygienists are much more likely to develop a repetitive musculoskeletal injury or disorder than dentists or dental assistants. Dental hygienists maintain prolonged working postures and their work is highly repetitive.³ The upper quarter is significantly more at risk for injury than other areas of the body. In a study of 28 female dental hygienists, Oberg and Oberg³ reported 62% of the subjects had complained of neck pain and 81% had complained of shoulder pain over the previous twelve months. Liss et al⁴ surveyed

2142 dental hygienists and 305 dental assistants and found that the dental hygienists were almost three times more likely to have a shoulder disorder and almost twice as likely to have a neck disorder. In another survey by Stentz et al,⁵ 260 dental hygienists were asked to respond to questions regarding upper extremity disorders. Sixty-one percent indicated that they experienced upper extremity pain, tingling, and/or numbness.

Ergonomics has been described by Murphy⁶ as a “multidisciplinary applied science that involves studying ways of optimizing the design of people-technology systems through knowledge of human physical and mental abilities, human performance limits, factors affecting human reliability and errors, anthropometrics (the science of anatomy), work physiology, biomechanics, work environment conditions, human behavior as individuals and in teams, industrial design and engineering, skills learning and training, and management and organizational behavior.” The National Institute for Occupational Safety and Health (NIOSH)⁷ describes six basic elements for an ergonomic program, one of which is risk factor and hazard identification. Michalak-Turcotte and Atwood-Sanders⁸ describe workplace hazards for dental hygienists as excessive force, high repetition, awkward and static posture during instrumentation, frequent use of vibratory instrumentation, mechanical stresses to a part of the body, and cold temperature. It is widely acknowledged that the dental hygienist frequently maintains static working postures over extended periods of time. Additionally, the dental hygienist performs repetitive actions involving the upper extremity while standing or sitting in poor static postures. The Occupational Safety and Health Administration (OSHA)⁹ describes four primary

risk factors associated with ergonomically related injuries: repetitive motion for greater than two hours at a time, awkward postures for greater than two hours at a time, unassisted frequent manual handling, and unassisted forceful manual handling. Nunn¹⁰ states that dental hygienists routinely practice at least three of the four risk factors.

In a study by Oberg et al,¹¹ continuous myoelectric signals were measured in the upper trapezius on 10 dental hygienists for half of a normal working day. They conclude that the dental hygienists in their study almost never took work pauses greater than 5 seconds, which they associated with significant muscle fatigue. Milerad et al¹² also conclude, using electromyography (EMG), that dental work generates high workloads in the upper trapezius. Abnormal or excessive use of muscles or muscle groups can contribute to muscular imbalance. This imbalance, in addition to influencing upper quarter movement, pain, and dysfunction, can affect posture. Barry et al¹³ looked at head posture and musculoskeletal pain complaints in nine dental hygienists. They found that postural changes and/or musculoskeletal pain can occur within as little as two years of clinical practice. Subjects in the study filled out a pain questionnaire during the beginning of their first year of dental hygiene school and at one and two year intervals post-graduation. Their study revealed that upper quarter pain complaints increased over the four-year study and were one of the most prevalent areas of increased pain reported.

Muscle Balance Theory

Janda¹⁴ defines muscle balance as the relationship between muscular strength and muscular flexibility. The term flexibility has been described in the literature as "the ability of a muscle to lengthen, allowing one joint (or more than one joint in a series) to move through a range of motion."¹⁵ Muscle balance has also been defined by Kendall et al¹⁶ as "a state of equilibrium that exists when there is a balance of strength of opposing muscles acting on a joint, providing ideal alignment for movement and optimal stabilization." Muscle balance, therefore, is a very desirable state to maintain. Deviations away from this state may affect joint position and contribute to musculoskeletal dysfunction.¹⁴

When a particular muscle or muscle group is used excessively, shortness or tightness may develop that can prevent a joint or series of joints from achieving a normal resting position.¹⁷ In other words, there is a reduction in muscle flexibility. Through continued or prolonged overuse, the agonist (a contracting muscle or muscle group) on one side of a joint can continue to shorten and intensify the muscular imbalance triggering a vicious cycle.¹⁸ The antagonist (muscle or muscle group on the opposing side of the joint) may lengthen in response to the shortening of the agonist. Gossman et al¹⁹ reported that sustained muscle shortness in animal models is associated with physiological shortening of muscle fibers and a decrease of up to 40% of sarcomeres (the contractile element of muscle tissue). Tardieu et al²⁰ found that sustained muscle elongation in animal models develops physiological lengthening of muscle fibers and an increase of up to 20% of sarcomeres. There is some debate in the literature regarding the result of muscular imbalance on muscles themselves.¹⁶⁻¹⁸

Janda¹⁷ states that tight muscles will usually maintain their strength. He does, however, point out that a markedly tight muscle may compromise the biomechanical and nutritional status and *tightness weakness* can develop. This terminology usually refers to the agonist component of the muscular imbalance. The term usually associated with the antagonist component is *stretch weakness* and was first described by Kendall.¹⁶ He defined stretch weakness as the weakening of muscles that are chronically elongated beyond their normal resting position but not beyond their normal length limits. Sahrmann,¹⁸ however, points out that *positional weakness* is a better way to describe the effect of prolonged elongation of a muscle. She maintains that the tightness in the agonist can alter normal joint position, which in turn may elongate the antagonist.

Upper Quarter Musculature

Muscle imbalances may significantly contribute to the abundance of musculoskeletal disorders seen in the upper quarters of dental hygienists. Schmidt and Snyder-Mackler²¹ report that weakness in the stabilizing muscles of the scapula has been implicated in numerous dysfunctions of the shoulder including supraspinatus impingement syndrome. A common and important muscular imbalance in the upper quarter has been described as the “proximal or shoulder crossed syndrome.”¹⁴ In this syndrome the levator scapulae, upper trapezius, and pectoral muscles are typically tight while the serratus anterior, rhomboids, middle and lower trapezius are typically weak. This imbalance will frequently lead to rounded and protracted shoulders (movement of the scapula away from the midline of the spine), forward head, and

internal rotation of the arms. Godges and Yakura²² have also identified protracted shoulders as being a common result of muscular imbalance. Weakness in the scapular muscles has been reported as a contributing cause of tissue damage in the upper quarter, particularly in the glenohumeral joint.²²

According to Paine and Voight,²³ normal function in the upper quarter is dependent upon a stable scapula. The scapula provides a stable base that allows the glenohumeral joint to move efficiently. Bradley and Tibone²⁴ have also reported on the importance of scapular stability and its influence on glenohumeral motion. Since the dental hygienist performs repeated motions of the glenohumeral joint throughout the day, it is important that a normal muscular balance exist in order to minimize the risk for developing an upper quarter disorder. The primary muscles that stabilize the scapula include the upper, middle, and lower trapezius, levator scapulae, rhomboids, serratus anterior, and the pectoralis minor.²² Mosely et al²⁵ identified these muscles as the primary scapular stabilizers and conducted EMG analyses of the scapular musculature. The results of their study identified movement patterns that recruited specific scapular muscles most effectively. This data has been used in at least one study to compare the upper quarter muscle balance of female dental hygienists to proposed normative values.²⁶ Upper quarter muscular performance (strength and endurance) and muscular flexibility were compared in female dental hygienists and healthy females who were not dental hygienists. Outcomes of this study suggested that female dental hygienists are more likely than female non-dental hygienists to develop muscular imbalance in the upper quarter. The dental hygiene group in this

study also reported more frequently that upper quarter pain interfered with their activities of daily living.

Conclusion

Musculoskeletal disorders in the upper quarter are commonly seen in dental hygienists. Ergonomic considerations as well as muscular imbalances have been implicated as contributing factors. Researchers have described the important role that the scapular stabilizers play in maintaining healthy muscular balance of the upper quarter. The proximal crossed syndrome has been described as a common upper quarter muscular imbalance pattern. More research is needed regarding muscular strength, endurance and flexibility of the upper quarter in female dental hygienists.

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Appendix B

Northwick Park Neck Pain Questionnaire

Neck Pain Questionnaire

Date of Birth
Consultant:
Date Completed:

Please Read:

This questionnaire has been designed to give us information as to how your NECK PAIN has affected your ability to manage in everyday life.

Please answer every section and mark in each section ONLY THE ONE BOX, which applies to you. We realize you may consider that two of the statements in any one section relates to you, but PLEASE JUST MARK THE BOX, WHICH MOST CLOSELY DESCRIBES YOUR PROBLEM.

Remember; just mark ONE box in each section.

1. NECK PAIN INTENSITY

- I have no pain at the moment.
- The pain is mild at the moment
- The pain is moderate at the moment
- The pain is severe at the moment
- The pain is the worst imaginable at the moment.

2. NECK PAIN AND SLEEPING

- My sleep is never disturbed by pain
- My sleep is occasionally disturbed by pain
- My sleep is regularly disturbed by pain
- Because of pain I have less than 5 hours sleep in total
- Because of pain I have less than 2 hours sleep in total

3. PINS & NEEDLES OR NUMBNESS IN THE ARMS AT NIGHT

- I have no pins & needles or numbness at night
- I have occasional pins & needles or numbness at night
- My sleep is regularly disturbed by pins & needles or numbness
- Because of pins & needles or numbness I have less than 5 hours sleep in total
- Because of pins & needles or numbness I have less than 2 hours sleep in total.

4. DURATION OF SYMPTOMS

- My neck and arms feel normal all day
- I have symptoms in my neck or arms on waking, which last less than 1 hour
- Symptoms are present on and off for a total period of 1-4 hours
- Symptoms are present on and off for a total of more than 4 hours
- Symptoms are present continuously all day

5. CARRYING

- I can carry heavy objects without extra pain
- I can carry heavy objects, but they give me extra pain
- Pain prevents me from carrying heavy objects, but I can manage medium weight objects
- I can only lift light weight objects
- I cannot lift anything at all.

6. READING & WATCHING T.V.

- I can do this as long as I wish with no problems
- I can do this as long as I wish, if I'm in a suitable position
- I can do this as long as I wish, but it causes extra pain
- Pain causes me to stop doing this sooner than I would like
- Pain prevents me from doing this at all

7. WORKING/HOUSEWORK ETC.

- I can do my usual work without extra pain
- I can do my usual work, but it gives me extra pain
- Pain prevents me from doing my usual work for more than half the usual time.
- Pain prevents me from doing my usual work for more than a quarter the usual time.
- Pain prevents me from working at all

8. SOCIAL ACTIVITIES

- My social life is normal and causes me no extra pain
- My social life is normal, but increases the degree of pain
- Pain has restricted my social life, but I am still able to go out
- Pain has restricted my social life to the home
- I have no social life because of pain

9. DRIVING (Omit 9 if you never drive a car when in good health)

- I can drive whenever necessary without discomfort
- I can drive whenever necessary, but with discomfort
- Neck pain or stiffness limits my driving occasionally
- Neck pain or stiffness limits my driving frequently
- I cannot drive at all due to neck symptoms

10. Compared with the last time you answered this Questionnaire, is your neck pain:

- Much better
- Slightly better
- The same
- Slightly worse
- Much worse

Thank you very much for your help.

Date:

Time:

Appendix C

Data Collection Sheet A

Subject #	Date :	Exerciser : Y / N	Hand : L / R	Occupation :	Examiner :
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<i>MUSCLE</i>	<i>PROM (R) / PROM (L)</i>	<i>POSITION</i>
Upper Trapezius	/ /	Neutral sitting position, head facing forward, examiner passively side bends head away to terminal position while stabilizing the ipsilateral shoulder. Distance of soft tissue excursion is measured with inclinometer.
Levator Scapula	/ /	Same as above except the head is rotated 45 degrees away from neutral prior to performing PROM.
Pectoralis Major (Lower)	+ or - / + or -	Subject lies supine on a firm surface with knees bent and low back flat on table. The examiner places the ipsilateral upper extremity in a position of approximately 135 degrees of humeral abduction with the elbow extended and the humerus externally rotated. The subject's upper extremity is passively lowered to table. The test is considered positive if the humerus does not touch the table.
Pectoralis Major (Upper)	+ or - / + or -	Same as above except the humerus is placed in 90 degrees of horizontal abduction prior to lowering the upper extremity to the table.
Pectoralis Minor	+ or - / + or -	Subject lies supine on a firm surface with knees bent and low back flat on table. The examiner places the arms in a neutral position along either side of the subject. The subject's shoulders were passively lowered toward the table until either the terminal position of either muscle was met or any part of either scapula reached the table. The subject was given a positive recording if the scapula did not reach the table and a negative recording if the scapula did reach the table.

Appendix C

Data Collection Sheet B

<i>Position #</i>	<i>Subject Position</i>	<i>Duration and Termination Cause</i>
1	<ul style="list-style-type: none">• Push-up with a Plus• Prone Position	
2	<ul style="list-style-type: none">• Maximum Scapular Elevation with Horizontal Abduction and Elbows Extended• Prone Position	
3	<ul style="list-style-type: none">• Maximum Scapular Retraction with Horizontal Abduction Elbows Flexed• Prone Position	
4	<ul style="list-style-type: none">• Press-up with a Plus• Long-Sit Position	