SJIF Impact Factor: 5.464

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

ISSN: 2457-0400
Volume: 5.
Issue: 4.
Page N. 297-303
Year: 2021

Original Article www.wjahr.com

SHOULDER MUSCLE STRENGTH, PROPRIOCEPTION AND VIBRATORY SENSATION ASYMMETRY AMONG OFFICE WORKERS

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Received date: 17 June 2021 **Revised date:** 07 July 2021 **Accepted date:** 27 July 2021

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ABSTRACT

Shoulder-related disease complaints constitute a major health problem in the working population. In line with this, this study was conducted for between the extremities comparison of the shoulder muscle strength, proprioception, and vibration sense of the 35 female individuals who work at a desk for a long time. Shoulder muscle strength was measured with a hand-held dynamometer. Proprioception were determined with an isokinetic (Cybex Humac Norm) dynamometer. Vibration sense evaluation was performed with a Vibrometer-VPT (Diabetic Foot Care, India) device. While all parts (anterior, middle and posterior) of deltoid muscle (p=0,022, p=0,018, p=0,016) serratus anterior (p= 0,006), infraspinatus (p=0,000), subscapularis (p=0,002), and latissimus dorsi muscles (p=0,033) were found to be significantly different, no significant difference was found in all parts (upper, middle and lower) of trapezius muscle, supraspinatus, and pectoralis major-minor muscle (p>0,05). In some of the proprioception parameters, angular error in the dominant extremity was determined to be statistically significantly higher (p<0,05). While there was no significant difference in the vibration detection threshold on the acromion (p>0,05), a statistically significant difference was observed on the coracoid process (p=0,005). In this study, only female individuals were included to maintain homogeneity, and asymmetry was detected in the important muscles of the shoulder region, proprioception, and vibration senses. In future studies, more detailed evaluations should be made in a more heterogeneous group, and exercise and rehabilitation programs should be planned to reduce shoulder asymmetry and prevent overuse injuries in office workers.

KEYWORDS: Vibration, Joint Position Sense, Proprioception, Vibrometer, Shoulder.

INTRODUCTION

Shoulder-related disease complaints constitute a major health problem in the working population. In a general population, the prevalence of the musculoskeletal system formed in the shoulder region varies between 18.6%-31 for a month and 4.7-46.7% for a year. In individuals with a desk job, musculoskeletal problems may occur as a result of factors such as the working posture in which the shoulder is constantly in flexion and abduction, repetitive and challenging activities, and long-term static loads on the shoulder region.[1]

Proprioception disorder plays an important role in the pathogenesis and progression of musculoskeletal problems. If the quality of proprioceptive sensory input drops, it would be more difficult for the individual to perform the movements.[2] As a result of incorrect working posture at a desk, change in scapula position, change in strength as a result of shortness of the upper trapezius muscle, change in muscle activation in the middle and lower trapezius muscle, and change in muscle activation in the serratus anterior muscle, proprioceptive sense may be impaired and this situation creates a vicious circle.[3,4] Prolonged exposure to stress due to incorrect working posture may damage muscle spindles by impairing proprioception-related muscle functions.[5] It is important to examine the effect of muscle strength and proprioceptive sense in individuals working at a desk.

Although it has been stated in studies conducted in recent years that vibration sense is a component of proprioceptive sense as a receptor and a physiological process, there are various and contradictory results in studies evaluating this sense.[6-9] It has been determined that vibration sensitivity may be impaired due to the posture during work and especially keyboard use, leading to upper extremity problems in individuals working at a desk.[10] It is important to evaluate vibration sense, which is considered as a component of proprioception sense, in order to prevent musculoskeletal problems that may occur in desk workers.

Humans are characterized by bilateral symmetry, which is determined by the plane that stretches along the longitudinal axis of the body and divides the body into left and right parts. The functional preference of one of the upper extremities is to create directional asymmetry. Functionally, the right upper extremity is usually dominant and the frequency of left-handedness is estimated to be 10-13%.[11] Studies indicate that differences between extremities result in physical and sportive performance advantages and potential injury[11-13], while there is no study conducted on office workers. In line with this, this study was conducted for between the extremities comparison of the shoulder muscle strength, proprioception, and vibration sense of the individuals who work at a desk for a long time. The results of this study are important in regard to preventive exercise protocols and rehabilitation programs to be developed in these individuals.

MATERIALS AND METHODS

35 office workers who signed the consent form were included in the study. Individuals were evaluated at the Eastern Mediterranean University, Faculty of Health Sciences, Physiotherapy and Rehabilitation Department, Neuromuscular Laboratory. The ethics approval of the study was granted by the Eastern Mediterranean University Scientific Research and Publication Ethics Committee (ETK00-2019-0184). The dominant extremity of the individuals was determined by asking their writing hand, and they were included in the study according to the following criteria.

Inclusion criteria

- Due to the homogeneity of the group, female individuals between the ages of 25-35
- Working at office for at least 1 year and more than 4 hours/daily
- The Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) score was 15 or less
- Pain in the neck and upper extremity was 2 cm or less on the visual analog scale (VAS) for the last 6 months

Exclusion criteria

- History of cervical spine and upper extremity surgery
- Musculoskeletal problems such as diabetes, rheumatoid arthritis, ankylosing spondylitis, osteoarthritis
- Those received a physiotherapy program for the neck and upper extremity in the last 3 months and are actively engaged in sports

Shoulder muscle strength was measured with a hand-held dynamometer (Lafayette Instrument Company, USA, Model 01163). Three repetitions were performed with 30 seconds interval between measurements, and the average score was recorded in kilograms (kg). The test position and procedure for each muscle are given in Table 1.[14-18]

Table 1: The test position and procedure for muscles.

Muscle	**Test Position**	**Test Procedure**
Upper Trapezius	Sitting	Dynamometer was placed on the superior part of the scapula and participants raised the shoulders to stand against resistance.
Middle Trapezius	Prone	At 90˚ abduction of the shoulder, full external rotation, and elbow at 90˚ flexion, resistance was given laterally with a dynamometer.
Lower Trapezius	Prone	Shoulder was positioned at 140°flexion and in full external rotation. The dynamometer was placed on the inferior line of the scapula and resisted laterally and upwards.
Anterior Deltoid	Sitting	Elbow was positioned at 90˚ flexion and the arm was slightly flexed. Resistance was given just above the elbow with a dynamometer.
Middle Deltoid	Sitting	The arm was positioned at 90˚ abduction and the elbow at 90˚ flexion, and resistance was given just above the elbow in the direction of adduction.
Posterior Deltoid	Sitting	The shoulder was positioned with extension, slight abduction and internal rotation. Resistance was applied against the posterolateral surface of the arm, above the elbow, in the direction of slight adduction and flexion.
Serratus Anterior	Supine	With the elbow in full extension and the shoulder at 90˚ flexion, resistance was given over the hand towards the humerus.
Supraspinatus	Sitting	With the arm at 90 flexion and 30˚ lift to the anterior of the frontal plane, and in full internal rotation (empty can test position), resistance was given just above the elbow.
Pektoralis Majör-Minor	Supine	The extremity was positioned with the elbow in extension and the shoulder at 90° flexion. By taking the upper extremity in horizontal adduction, resistance was given

		over the elbow in the direction of horizontal abduction.
İnfraspinatus	Sitting	The elbow was positioned at 90˚ flexion and the arm was in contact with the neutral body. The dynamometer was placed on the person's wrist and resistance was given outwardly (Belly press test)
Subscapularis	Sitting	The elbow was positioned at 90˚ flexion and the arm was in contact with the neutral body, and the dynamometer was placed on the wrist of the participant and resistance was given outwardly.
Latissimus Dorsi	Supine	With the elbow at 90˚ flexion and the shoulder at 30˚ extension, resistance was applied proximally and posteriorly to the elbow in an upward direction.

Reproduction of active positioning (RAP), reproduction of passive positioning (RPP), and threshold to detection of passive motion (TTDPM) were determined with an isokinetic (Cybex Humac Norm) dynamometer. During the measurement, the individual was positioned in supine position with the shoulder at 90˚ abduction and the elbow at 90˚ position. An eye patch and headphones were worn during all measurements. A pressure splint was placed on the extremity during passive measurements. During the evaluation of the shoulder joint RAP of external rotation (ER), the range of motion (ROM) of the shoulder was adjusted to 0-45˚ ER, passively moved to the 20˚ ER position and held there for 10 seconds, then participants actively took the dynamometer to the same position. The same method was repeated for RAP of internal rotation (IR) in the shoulder at 0-45˚ IR range. For RPP of ER measurement, the extremity was moved passively at a speed of 0.5°/s with a dynamometer kept in 20˚ ER for 10 seconds. When passive movement was initiated, the button was expected to be pressed as soon as the participant felt the shown angle. The same measurement was tested for RPP of IR in 20˚ IR angle. While evaluating the TTDPM of IR and ER, during the passive movement of the upper extremity at a speed of 0.5°/s, the button was expected to be pressed by the participants at the first time the movement was detected. Angular error was recorded in degrees.[19,20]

Vibration sense evaluation was performed with a Vibrometer-VPT (Diabetic Foot Care, India) device which demonstrated high reproducibility and reliability.[21] The probe of the device was placed on the acromion and coracoid process of the shoulder region while the person was in supine position.[22] The vibration amplitude was slowly increased by 1 V per second, the volt was recorded as vibration perception threshold (VPT) when the participant felt the vibration for the first time. To determine the vibration disappearance threshold (VDT), vibration was reduced in the same procedure and it was asked for the participant to declare when no longer felt. Vibration threshold (VE) was calculated in volts using the formula [(VPT1 + VPT2 + VPT3)/3] +[(VDT 1 + VDT2 + VDT3)/3]/ 2) by repeating VPT and VDT measurement three times.[23]

Statistical Analysis

SPSS Statistics 26.0 software was used for statistical analysis. Scale data such as age, height, weight and body mass index (BMI) were given as arithmetic mean and standard deviation (X ± SD), and categorical data such as working years and durations were given as percentage (%). The normal distribution of the data was examined visually with histograms and plots, and with analytical methods using the Shapiro-Wilk Normality Test. The normally distributed muscle strength data between the dominant and non-dominant extremities were analyzed using the Paired-T test, and for proprioception parameters that were not normally distributed, Wilcoxon test was used. The fact that the p value was less than 0,05 in the data results was considered to be statistically significant.

RESULTS

35 female participants were included in this study. Age, height, weight, and body mass index were determined as 28 ± 3 years, 1,62 ± 0,06 m, 58 ± 8 kg, and 21,11 ± 2,28 kg/m^2, respectively. While it was determined that 28,6 % of the participants worked for 4-8 hours/daily and 71,4 % of them worked for more than 8 hours/daily, the working years are given in Figure 1. It was determined that the dominant upper extremity of 31 (88,6 %) people was right and of 4 (11,4 %) people was left.

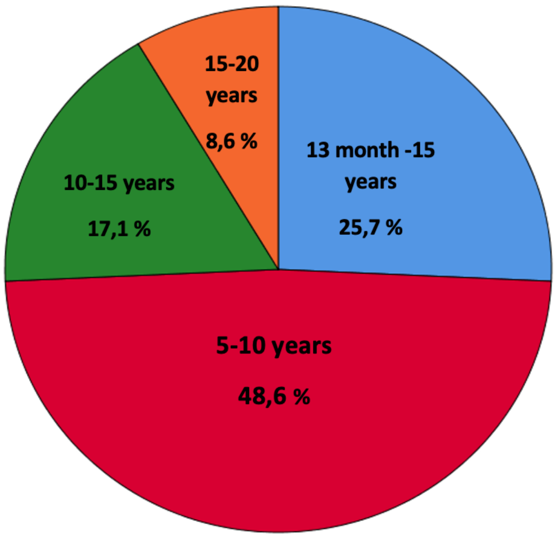

Figure 1. Working years of the participants at office.

Table 2: Comparison of the muscle strength of dominant vs non-dominant extremities.

Muscle	Dominant X ± SD (kg)	Non-dominant X ± SD (kg)	p value
Upper Trapezius	9,58 ± 2,45	9,42 ± 2,61	0,430
Middle Trapezius	8,85 ± 1,95	8,51 ± 1,77	0,160
Lower Trapezius	8,61 ± 1,34	8,98 ± 1,70	0,098
Anterior Deltoid	9,28 ± 2,14	8,81 ± 1,70	**0,022***
Middle Deltoid	9,16 ± 1,95	8,69 ± 1,99	**0,018***
Posterior Deltoid	9,64 ± 2,14	9,26 ± 1,94	**0,016***
Serratus Anterior	9,33 ± 1,98	8,89 ± 1,84	**0,006***
Supraspinatus	8,49 ± 1,90	8,37 ± 1,87	0,455
Pektoralis Majör-Minor	11,26 ± 2,03	11,07 ± 2,19	0,463
İnfraspinatus	6,46 ± 1,33	5,5 ±1,04	**0,000****
Subscapularis	8,31 ± 1,54	7,61 ± 1,69	**0,002***
Latissimus Dorsi	9,19 ± 2,23	8,76 ± 2,25	**0,033***

Paired-T test; X: mean; SD: Standart Deviation; kg: kilogram; *:p<0,05, **:*:p<0,001

In the comparison of muscle strength between the extremities, it was determined that all muscles were stronger in the dominant extremity except the lower trapezius muscle. While all parts (anterior, middle and posterior) of deltoid muscle (p=0,022, p=0,018, p=0,016) serratus anterior (p=0,006), infraspinatus (p=0,000), subscapularis (p=0,002), and latissimus dorsi muscles (p=0,033) were found to be significantly different, no significant difference was found in all parts (upper, middle and lower) of trapezius muscle, supraspinatus, and pectoralis major-minor muscle (p>0,05) (Table 2).

As seen in Table 3, angular error in the dominant extremity was determined to be statistically significantly higher at RAP of ER (p=0,003), RPP of IR (0=0,002), and TTDPM of IR (p=0,001). Although the error angle was higher in the dominant extremity, RAP of IR, RPP of ER, TTDPM of ER was not found to be statistically significantly different (p>0,05). While there was no significant difference in the vibration detection threshold on the acromion (p>0,05) , a statistically significant difference was observed in the vibration detection threshold on the coracoid process (p=0,005).

Table 3. Comparison of the proprioception and vibratory sensation parameters of dominant vs nondominant extremities.

	Dominant X ± SD	Non-dominant X ± SD	P value
RAP- IR(°)	4,34 ± 1,61	3,80 ± 1,55	0,134
RAP- ER(°)	4,74 ± 1,88	3,64 ± 1,63	**0,003***
RPP- IR (°)	5,34 ± 2,65	4,12 ± 2,28	**0,002***
RPP- ER (°)	4,22 ± 2,12	4,02 ± 1,84	0,614
TTDPM -IR (°)	3,60 ± 1,62	2,79 ± 1,45	**0,001***
TTDPM -ER (°)	2,90 ± 1,56	2,55 ± 1,23	0,067
Acromion VT (V)	3,23 ± 1,27	2,93 ± 1,34	0,124
Coracoid Process VT (V)	3,32 ± 1,05	2,77 ± 1,12	**0,005***

Wilcoxon Test; ; X: mean; SD: Standart Deviation; RAP: Reproduction of active positioning; RPP: Reproduction of passive positioning; TTDPM: Threshold to detection of passive motion; VT: Vibration threshold; IR: Internal rotation; ER: External Rotation;˚: degree; V:Volt; *:p<0,05.

DISCUSSION

Asymmetry in upper extremity motor behavior is more evident during daily life activities such as eating, drinking, dressing, or during activities at work, and approximately 90% of the individuals use their right extremity dominantly.[24] It was seen that the individuals included in our study were similar in this regard and 88.6% of them used their right extremity, while 11.4% used their left one dominantly. In the literature, studies investigating the difference between extremities have generally been conducted on sports activities such as volleyball and handball,[11,12] thus it is important that our study is the first to examine extremity asymmetry in office workers. In line with this, the aim of our study was to examine between the extremities difference of the upper extremity muscle strength, proprioception, and vibration sense of people who work at a desk for a long time.

It has been determined that musculoskeletal system problems are more common in the shoulder region of female office workers.[25] Due to the homogeneity of the participants and the fact that female office workers face more shoulder musculoskeletal problems, only female individuals were included in this study.

The tendency of the shoulders to be protracted while working in the office environment leads to forward flexion of the head and upper back region and to general flexion posture. This working posture increases muscle activation in the shoulder muscles and may cause muscle imbalances due to overuse of some muscles and underuse of others.[26] Park et al. found in their study that especially the infraspinatus muscle shows excessive activation during activities that require manual use (such as using a keyboard), and it creates an imbalance on the subscapularis muscle, thus changing the position of the humeral head and causing secondary joint injuries such as articular cartilage degeneration, injury of the rotator cuff muscle and the long head of the biceps muscle.[27] In our study, the asymmetry of the infraspinatus muscle strength between the extremities shows that this muscle must be evaluated in order to prevent shoulder injuries during office work that causes the activation of this muscle, and that it is important to provide symmetrical balance by strengthening the muscle. Another study conducted on office workers showed that the anterior deltoid muscle showed dynamic contraction during work in the flexion posture, while the upper and lower trapezius muscles were active at a static level.[28] In our study, while there was no difference in the statically loaded trapezius muscle strength between the extremities, the fact that the dominant anterior deltoid muscle was stronger indicates the result of dynamic activation. The serratus anterior plays an important role in stabilizing the scapula, providing thoracic alignment compatible with the lower trapezius and dynamically stabilizing the scapula motion. Serratus anterior muscle fibers and lower trapezius muscle have high synergistic muscle activation compared to upper trapezius muscle, and if the activation of these muscles is not balanced, other muscles of the shoulder complex tend to provide scapula movement.[29] In our study, although the serratus anterior muscle strength was stronger in the dominant extremity, there was no difference in the trapezius muscle, suggesting that the scapular movement is provided by the activation of other muscles. Ding et al. stated that after about 40-50 minutes of sedentary work at a desk, fatigue manifests in the trapezius and latissimus dorsi muscles.[30] Fatigue may be associated with a temporary decrease in the strength and strength capacity of the skeletal muscle, and may adversely affect the daily lives of workers.[31] Although fatigue was not evaluated in our study, we think that latissimus dorsi muscle strength asymmetry may disrupt muscle activation symmetry in the shoulder and back region and cause symptoms such as fatigue and pain. In our study, the muscles around the scapula and shoulder were evaluated and asymmetry was found in many muscles. Since the lack of balance between the extremities may lead to symptoms such as pain, fatigue, and posture disorder in the future, exercise programs should definitely be designed for muscle groups with asymmetry.

Proprioceptive sense plays an important role for the individual to perform physical activities efficiently. A strong sense of sensorimotor control is required to prevent injuries of the glenohumeral joint due to its wide mobility ability in the shoulder structure. Thus, proprioception, which is among many somatosensory senses, contributes to the active stabilization of the shoulder and healthy movement patterns.[32] Given that the sense of proprioception is associated with injuries and physical limitations,[33,34] it would be advantageous to objectively evaluate the disease in a clinical setting before injuries occur. Due to the fact that the proprioception measurement protocol performed with an isokinetic dynamometer at 90° shoulder abduction is considered as the most reliable method,[35] in our study, using the same method, the error angle difference of the active position sense (RAP) in the dominant extremity ER direction, of passive position sense in the IR direction (RPP) and of motion detection threshold in the IR direction (TTDPM) were found to be high. Previous studies have shown that the non-dominant extremity has a lower error difference due to its nature while matching proprioceptive sensory targets, and the dominant extremity is successful during target matching with the presence of visual input.[24.36] In the evaluation in which visual input was blocked by an eye patch, similar results were obtained, with the error difference being higher in the dominant extremity. In office workers who have to work in a static posture for a long time due to the job's nature, they may damage peripheral afferent receptors by creating microtrauma in the shoulder region or may lead to decreased stimulation of mechanoreceptors by stretching the capsuloligamentous complex.[4.19] Especially the large error angle difference in IR direction suggests that it may be caused by the anterior capsular tension in the dominant extremity and the pectoral muscle in the anterior part of the shoulder, which is expected to shorten during the flexion working posture. Therefore, in future studies, the sense of proprioception and muscle shortness should definitely be evaluated together. In another study, it was stated that the vibration perception threshold and the risk of injury increased when office workers were compared with the group with repetitive strain injuries.[37]Also, in the results of our study, the detection of a significant increase in the vibration perception threshold at the coracoid process point, which is the insertion part of the pectoralis minor muscle of the dominant extremity which is used more actively in daily life, draws attention to the tension of the capsuoligamentous complex, similar to the results of the proprioception sense. Vibration and proprioception sense should be evaluated in order to prevent musculoskeletal diseases that may occur in office workers who are at risk of sensory changes. In addition, for sensory asymmetry in office workers, ergonomic training in the workplace and shoulder stabilization exercises for the development of proprioception and vibration sense should be aimed.

CONCLUSIONS

Evaluating and determining shoulder asymmetry in office workers is important to prevent and treat possible shoulder injuries. In our study, only female individuals were included to maintain homogeneity, and asymmetry was detected in the important muscles of the shoulder region, proprioception, and vibration senses. In future studies, more detailed evaluations should be made in a more heterogeneous group, and exercise and rehabilitation programs should be planned to reduce shoulder asymmetry and prevent overuse injuries in office workers.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

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