Original Article

Physiotherapy and Occupational Therapy Journal
Volume 17 Number 2, April - June 2024
DOI: http://dx.doi.org/10.21088/potj.0974.5777.17224.3

To Analyze the Effect of Trunk forward Bending with and without Elbow Flexion on the Myoelectrical Activity of Serratus Anterior during Pushing

Mohammed Aslam

How to cite this article:

Mohammed Aslam. To Analyze the Effect of Trunk forward Bending with and without Elbow Flexion on the Myoelectrical Activity of Serratus Anterior during Pushing. Physio. and Occ. Therapy Jr. 2024;17(2):83-91.

Abstract

The convenience sample of forty-five male subjects including only adult were recruited in the study. All subjects were right side dominant. For group-A, the mean age was (29.933 ± 2.84) years and mean height was (177.46 ± 3.37) cm. For group-B, the mean age and height was (29.333 ± 2.82) years and (176.93 ± 3.97) cm respectively. For group-C, mean age was (28.933 ± 3.32) years and mean height was (178.40 ± 3.68) cm. All the subjects were taken from the population in and around the different hospitals of Dehradun. Each and every subject was informed about the procedure and demonstrated by the experimental therapist prior to the study. The study had received a written informed consent from the subjects with their willingness. From the above study, it was concluded that pushing activity performed, when the trunk is forward bend and elbow is extended, produce increased myoelectrical activity of Serratus anterior.

Keywords: Pushing activity; Myoelectric activity; Serratus anterior.

INTRODUCTION

Musculoskeletal injuries, or MSIs, are referred to by a variety of different names. They include repetitive strain injuries (RSIs), repetitive motion injuries, cumulative trauma disorders (CTDs), work-related upper limb disorders (WRULDs), and others. In each case, the name is used to describe injuries of the bones, joints, ligaments, tendons, muscles, and other soft tissues. Since there is much increase in the service jobs in many developed countries, there has been a move from heavy exertion at work to more postural stress. Approximately, one third of all industrial jobs in the united states involves some form of manual material handling such as lifting, pushing, pulling, carrying and these tasks results in 20-25% of all time lost due to industrial injuries.[1,7] Manual materials handling, or MMH, is the process of a human lifting, lowering, pushing, pulling, or conducting any similar task in which an object is moved through space solely by the power of that human. Manual handling tasks have become a major cause of work hazards to industrial workers.[1,3,4,5] Over the past few decades, there has been a substantial increase in the amount of pushing seen in the workplace. Pushing activities occurs in many types of work environment like departmental stores, agriculture, farming, nursing homes etc where workers adopt awkward postures while pushing heavy trolleys

Author Affiliation: [1]Professor, Department of Master in Physiotherapy in Neurology, Uttaranchal (PG) College of Bio-Medical Sciences and Hospital, Transport Nagar, Sewla Khurd 248002, Uttarakhand, India.

Corresponding Author: Mohammed Aslam, Professor, Department of Master in Physiotherapy in Neurology, Uttaranchal (PG) College of Bio-Medical Sciences and Hospital, Transport Nagar, Sewla Khurd 248002, Uttarakhand, India.

E-mail: aslamahmed5477@gmail.com

Recieved on 24.05.2024

Accepted on 29.06.2024

or carts and this is a potential environment for the development of musculoskeletal injuries. This is the reason that ergonomic interventions have become imperative in modern society.[25] Lifting activities are the significant risk factor for the occupationally related musculoskeletal disorders. Therefore, the lifting load is increasingly avoided by the industries. And thus, the industry has responded to this risk by modifying the workplace and replacing the lifting activities by pushing activities. It is therefore, not exaggerated, when it is stated that overall nearly half of the manual material handling consists of pushing activities.[4,5,16] Manual material handling tasks solely requires the human effort. Despite the attention that has been given to ergonomics in both industrialized and developing countries, the occurrence of the musculoskeletal complaints in the workplace are still a considerable problem. Pushing activities are the daily routine activities for a substantial number of workers. It was observed that pushing activities do not necessarily reduce the overall strain experienced by the workers completing the tasks. Rather these workers run a considerable risk of developing the musculoskeletal complaints.[1,5] Hoozeman (2002) and other researchers indicates a relation between pushing and shoulder complaints. For shoulder complaints, a dose–response relationship was observed for exposure to pushing or pulling tasks.[4] Musculoskeletal pain in shoulder region is common in working population of various industries. Van der beek (1993)[2,5] proposed that pushing led to an increase in the incidence of pain and stiffness in the shoulder region and not necessarily the low back complaints. It is recognized that such shoulder pain is generally associated with repetitive pushing activities. Furthermore, with the incidence of pushing in industry on the increase, it could be expected that the percentage of total musculoskeletal problems associated with manual work being caused by pushing will also become increasingly evident. It seems likely that shoulder pain is the result of many factors including the mismatch between the task demands and the workers capabilities and it is likely that the musculoskeletal system may become physically over exerted.[5] In recent past working, posture have also been attributed as an important etiology of these complaints. Less-than-optimal postures such as leaning forward from the waist for extended periods of time, can load muscles with ‘static work’. Static work involves muscles being tensed in fixed positions and over time, becoming tired, uncomfortable, and even painful. Body (awkward) posture greatly influence strength during pushing especially position of arm and trunk.[6] As a consequence, arm reach and trunk posture during force exertion should be defined precisely. There is a strong evidence that the combination of two or more risk factors, such as force and awkward working posture, cause excessive biomechanical stresses which may lead to degradation of performance, muscle fatigue, and musculoskeletal disorders thereby decreasing the efficiency of work. Shoulder muscle fatigue is a common sequel of repetitive arm use and this has been proposed as a possible link to explain the association between repetitive arm use and the development of shoulder pain.[19,26] Even with the increased prevalence of pushing as a form of normal work and the recent documentation of the high associated injury rate, pushing have received scant attention when compared to lifting tasks. While much attention in ergonomics has focused to the low back complaints, very little has been given to the shoulder complaints associated with the pushing activities. Therefore, the purpose of this research is to evaluate the effect of trunk and elbow position on the myoelectrical activity of the Serratus anterior during pushing.

METHODOLOGY

Sample

The convenience sample of forty-five male subjects including only adult were recruited in the study. All subjects were right side dominant. For group-A, the mean age was (29.933 ± 2.84) years and mean height was (177.46 ± 3.37) cm. For group-B, the mean age and height was (29.333 ± 2.82) years and (176.93 ± 3.97) cm respectively. For group-C, mean age was (28.933 ± 3.32) years and mean height was (178.40 ± 3.68) cm. All the subjects were taken from the population in and around the different hospital of Dehradun. Each and every subject was informed about the procedure and demonstrated by the experimental therapist prior to the study. The study had received a written informed consent from the subjects with their willingness.

Inclusion Criteria:

- Healthy male subjects
- Age: 20- 40 years
- Height: 160-196 cms

Exclusion Criteria:

- History of significant low back pain
- Weakness of serratus anterior muscle

- Any musculoskeletal injury of shoulder or neck
- Elbow pain or discomfort
- Weakness of upper trapezius
- History of any surgery of upper quadrant

Design:

This is an observational study

Instrumentation

Electromyography: An Nicoletviyasis EMG unit with silver-chloride electrode of 1cm diameter was used to record the amplitude of serratus anterior and upper trapezius electrical activity.

Goniometer: It is used to measure trunk flexion angle.

Measuring Tape: It is used to measure the mid height of the subjects.

Chalk: Chalk pieces were used to mark foot placement on the floor.

Push Apparatus: The push apparatus consisted of a 3-cm diameter aluminum bar handle attached to two vertical bars mounted on a wall. The horizontal handle can be raised or lowered to match the height requirement of each subject.[16]

Protocol

Forty-five subjects were recruited in the study based on inclusion and exclusion criteria, and randomly assigned into three groups. Fifteen subjects were participated in each group.

Group A: Pushing with trunk forward bending at 15 degrees.

Group B: Pushing with trunk forward bending at 25 degrees.

Group C: Pushing with trunk forward bending at 35 degrees.

Procedure: Forty-five selected subjects will be randomly assigned into three groups. The whole procedure was explained to each subject and then each subject signed a consent form before performing the procedure.

Subject preparation and instrumentation: Before placing the electrodes, the skin preparation was done in which the skin of each individual was wiped with the alcohol to reduce the skin impedance.[21,41] Two Ag/Agcl surface electrodes were filled with electrode paste and placed unilaterally. The inter electrode distance was 20 mm from center to center of the electrode and each electrode was of 1.0 cm diameter. Electrodes were oriented in the direction of the muscle fibers. First of all palpation of C-7 spinous process was done by moving the head in flexion and extension for the placement of ground electrode for electromyography (EMG).[14]

EMG Mechine

Push Appartus

Electrodes Placement for the Serratus Anterior: The inferior angle of the scapula is palpated by asking the subject to push the wall with both hands and marked. A line was drawn from the inferior angle laterally with the help of a marker. Then the electrodes are placed to the muscle fibres below the axilla, anterior to the latissimus, placed vertically over the ribs 4-6.[21]

Electrodes placement For the Upper Trapezius: The shoulder was positioned in 90° of abduction. Two electrodes were placed so that they ran parallel to the muscle fibers and positioned so that 1 electrode was superomedial and 1 inferolateral to a point 2 cm lateral to onehalf the distance between the C7 spinous process and the lateral tip of the acromion.[41] The electrodes were secured to the skin by means of adhesive tapes. Surface electrodes were chosen because they were simple to handle and they pick up signal from a comparatively large volume of muscle and do not discomfort the subject. It was necessary to have electrode attached for long period and at the same time retain comfort and relaxation. The parameters used in EMG data were sensitivity of ± 100 μV, bandwidth of 10 to 2000 Hz. The input impedance of the EMG amplifier was less than 10 Megaohms, common mode rejection ratio of 85 db and Gain of 1000.[21] Trunk flexion angle is measured with the metal goniometer. The subjects were instructed to stand erect with the staggering feet position (one foot forward of the other) facing towards the wall. The goniometer axis was placed at the junction of the superior iliac crest and the mid-axillary line. The stationary arm of the goniometer was positioned vertical to the floor; the movable arm was aligned with the midaxillary line. The subjects were then instructed to bend forward without bending the knees. The range of motion was then measured and recorded as 15, 25, 35 degrees with their respective groups.[17,18] Participants pushed on a stationary bar adjusted at height midway between the shoulder and waist height (mid height) The reference point for measuring the mid height is from anterior acromial process and along the midaxillary line to the tip of ASIS[16]. A measuring tape was used to measure the mid height from shoulder to ASIS. The push apparatus consisted of a 3 cm diameter aluminum bar handle attached to two vertical bars mounted on a wall. The handle can be raised or lowered to match the height requirement of each subject.[16] Recording the EMG activity of Serratus anterior and trapezius. Before the trials, participants were given practice trials and asked to find the most comfortable staggering feet position for the designated bar height and stance. After their preferred foot position was established, the locations of their feet were marked on the floor with the chalk piece so that participants could return to the same foot position between trials. The participants were required to maintain the same foot position for all the pushing exertions for a given bar height and stance. After the electrodes placement and the comfortable foot position attainment the trunk flexion angles were measured. Each subject in their respective groups were required to push the stationary bar first with elbow flexed and then with elbow extended maintaining the trunk flexion. The subjects were instructed to begin exerting there maximum voluntary isometric force and hold for 10 sec. While the subject exerted force, EMG signals were picked up by surface electrodes and recorded in EMG machine. There were three session of measuring EMG with rest interval of 30 seconds to avoid fatigue of muscle. Activities of the Serratus anterior and trapezius were displayed to the monitor and peak EMG amplitude was noted for each trial. Out of that the best reading of electrical

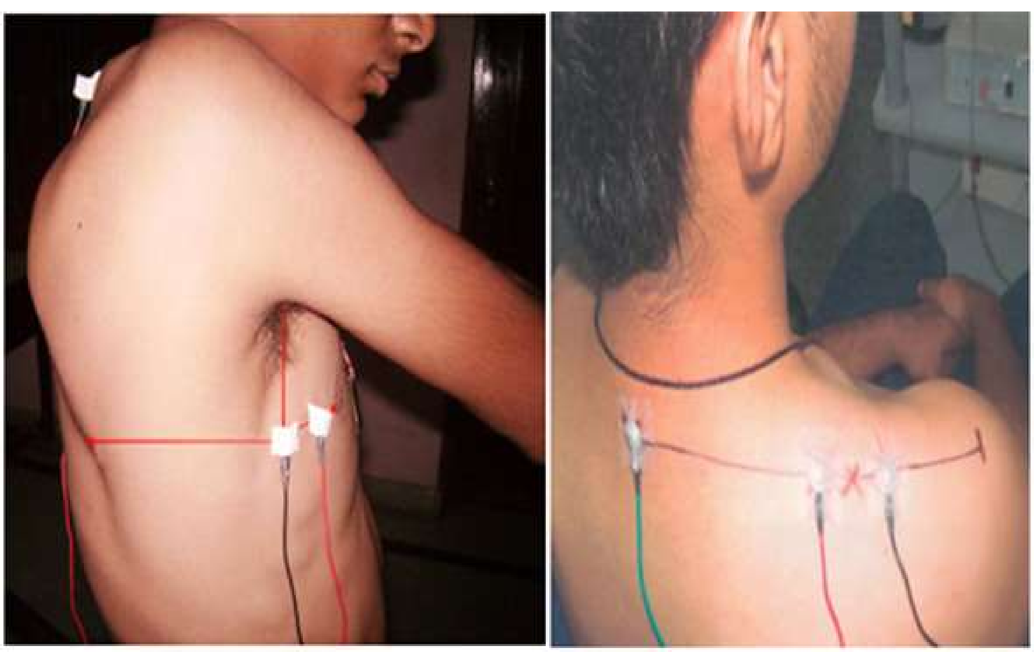

Fig. 1: Electrode Placement for Serratus Anterior Muscle Electrode placement for U/P Trapezius

Fig. 2: Pushing with Elbow Flexion in Group A Pushing with Elbow Extension in Group – A

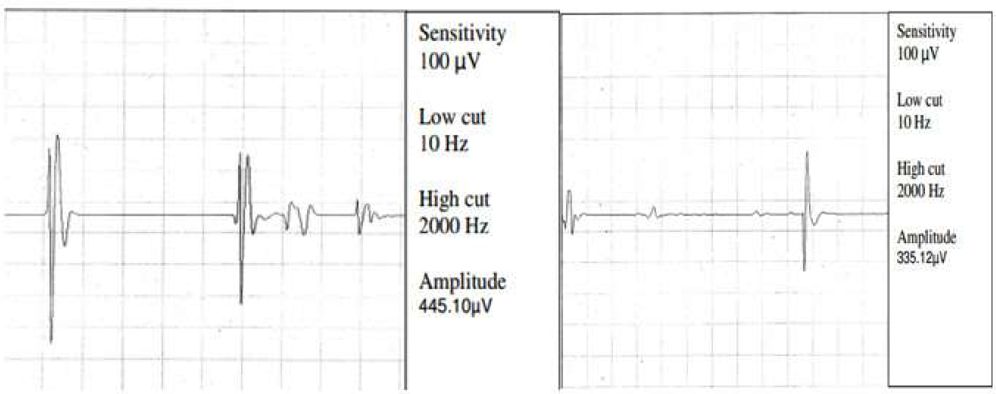

Fig. 3: EMG record sheet of Serratus anterior muscle EMG record sheet of Upper Trapezius muscle.

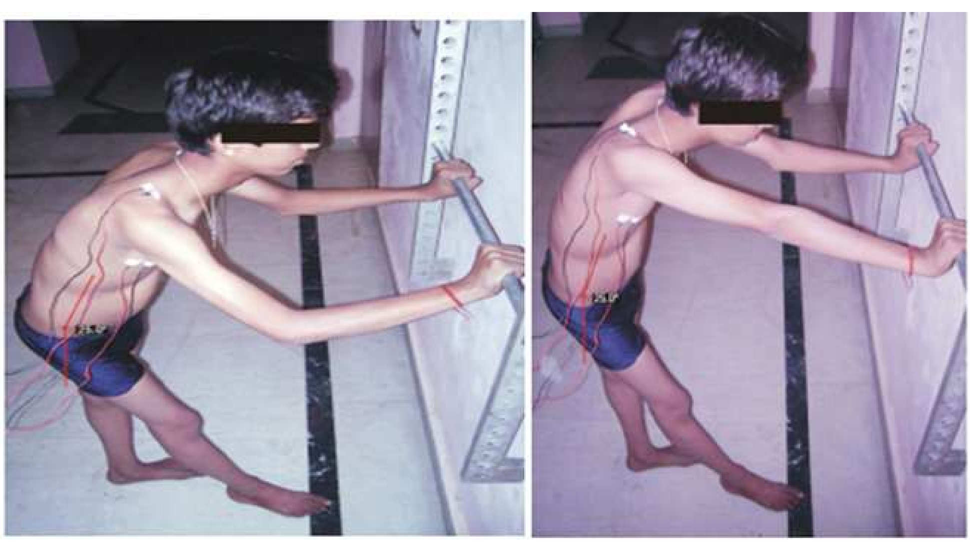

Fig. 4: Pushing with Elbow Flexion in Group B Pushing with Elbow Extension in Group - B

Fig. 5: Pushing with Elbow Flexion in Group C Pushing with Elbow Extension in Group – C

activity value is taken for data analysis. Same procedure will also be followed by the other two groups i.e. 25 and 35 degrees trunk flexion.

RESULTS

The mean for physical characteristics of all the subjects i.e. age and height were shown in demographic table. (Table 1) The p-value of the EMG of the Serratus anterior and trapezius within group-A (i.e. 15 degrees trunk flexion) were calculated using paired sample test with both elbow positions (i.e. elbow flexion versus extension). The EMG of Serratus anterior within group-A showed significant differences (p=0.001) with elbow flexion (SA.EF) compared with elbow extension (SA.EE). Also, the EMG of trapezius muscle within the same group showed significant differences (p=0.002) when the comparison was done between the two elbow positions (TP.EF versus TP.EE). (Table 2) Paired sample t-test was performed to see the EMG of both Serratus anterior and trapezius muscles within group-B (i.e. 25 degrees trunk flexion) with elbow flexion versus extension. The p-values showed significant differences for the Serratus anterior and trapezius muscles EMG within groupB with elbow flexion comparing with elbow extension (p=0.0001) and (p=0.0001) respectively. (Table 3) For group-C (35 degrees trunk flexion), the EMG of Serratus anterior and trapezius with both elbow positions comparison was calculated using paired sample t-test. The p-values for the electrical activity of Serratus anterior (p=0.001) and trapezius muscles (p=0.037) showed significant differences when compared with elbow flexion and elbow extension. (Table 4) Analysis of variances (ANOVA) was applied to analyse the EMG of Serratus anterior and trapezius with different elbow positions (i.e. SA.EF, SA.EE, TPEF, TP.EE) between the three groups. The p-values for Serratus anterior, electrical activity in the different elbow positions between all three groups revealed significant differences (p=0.0001) while the EMG of trapezius showed insignificant differences between the three groups with the position of elbow flexion (p=0.427). The p-value showed significant difference for the trapezius electrical activity with elbow extension between the three groups (p=0.056). (Table 5) Post Hoc analysis was used to analyze group wise comparison for the EMG of Serratus anterior and trapezius muscles with elbow flexion and elbow extension. The p-values for EMG of Serratus anterior showed significant differences for elbow flexion (SA.EF) on comparison between Group A-B (p=0.001), Group B-C (p=0.0001), Group C-A (p=0.0001). (Table 5) For Serratus anterior electrical activity, significant differences for elbow extension (SA.EE) were found, when comparison were made between all three groups. Group A-B (p=0.002), Group B-C (P=0.0001), Group C-A (p=0.0001). (Table 5) In EMG of trapezius, insignificant differences using elbow flexion position (TP.EF) were found when comparison between all three groups was done; Groups A-B (p=0.862), Group B-C (p=0.302), Group C-A (p=0.230). (Table 6) Insignificant differences were obtained for the EMG of trapezius elbow extension (TP.EE) when comparison between Groups A-B was done (p=0.698) but significant differences was found between Groups B-C (p=0.061) and Groups C-A (p=0.025). (Table 6)

Table 1: Demographic Data

	Age	Height
	Mean ± SD	**Mean ± SD**
Group-A	29.933 ± 2.84	177.46 ± 3.37
Group-B	29.333 2.82	176.93 ± 3.97
Group-C	28.933 ± 3.32	178.40 ± 3.68

Table 2: Paired t-test within the group–A

		t- Value	p-value
Serratus anterior	EF VS EE	4.051	0.001
Trapezius	EF VS EE	3.862	0.002

Table 3: Paired t-test within group-B

		t- Value	p-value
Serratus anterior	EF VS EE	4.576	0.0001
Trapezius	EF VS EE	5.707	0.0001

Table 4: Paired t-test within group- C

		t- Value	p value
Serratus anterior	EF VS EE	4.364	0.001
Trapezius	EF VS EE	2.304	0.037

Table 5: Anova between groups

		F Value	p value
Serratus anterior	Elbow flexion	54.142	0.0001
	Elbow extension	57.511	0.0001
Trapezius	Elbow flexion	0.869	0.427
	Elbow extension	3.082	0.056

Table 6: Multiple comparison between the groups

		Mean difference ± Standard error	p value
SA.EF	GR-A VS GR-B	70.24 ± 19.88	0.001
	GR-B VS GR-C	133.42 ± 19.88	0.0001
	GR-C VS GR-A	203.66 ± 19.88	0.0001
SA.EE	GR-A VS GR-B	68.30 ± 20.74	0.002
	GR-B VS GR-C	149.20 ± 20.74	0.0001
	GR-C VS GR-A	217.50 ± 20.74	0.0001
TP.EF	GR-A VS GR-B	3.14 ± 18.01	0.862
	GR-B VS GR-C	18.81 ± 18.01	0.302
	GR-C VS GR-A	21.96 ± 18.01	0.230
TP.EE	GR-A VS GR-B	8.44 ± 21.65	0.698
	GR-B VS GR-C	41.75 ± 21.65	0.061
	GR-C VS GR-A	50.20 ± 21.65	0.025

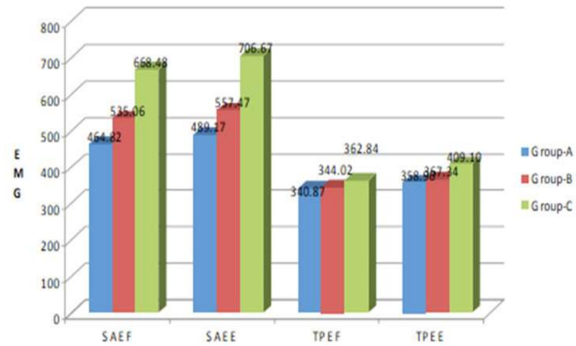

Fig. 1: Relationship between EMG of SA and TP Muscles between the three groups.

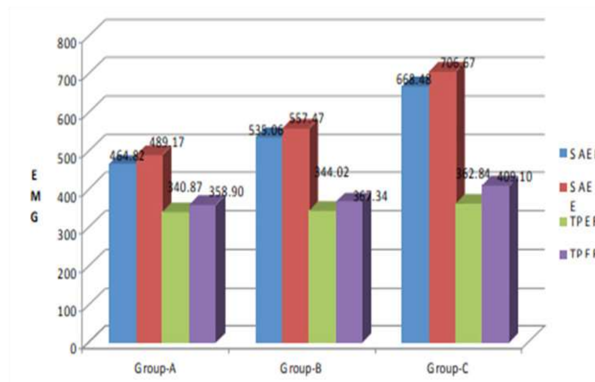

Fig. 2: Relationship between EMG of SA and TP Muscles within the groups

Future Research

1. In this study, there is just isometric pushing. In future studies, the participants may be asked to perform the dynamic pushing so that the exact recording of the muscle activity of the muscles can be done.
2. The similar study can be done with the simultaneously recording of the muscle activity of trunk muscles so that the effect of pushing on the back can also be measured along with shoulder.
3. In future study, the further experiments detailing kinematics of the scapula should be conducted.
4. The impact of pushing tasks on the biomechanical loading of the body under dynamic condition is a current area of interest stress the need for detailed investigation.

Relevance to Clinical Study

The result of the present study shows that Serratus anterior muscle activity increases as the trunk flexion increases and the elbow is flexed while pushing. This will stress the shoulder joint and leads to the musculoskeletal disorder of shoulder.

1. The data gathered using EMG may easily be used to establish the risk evaluation guidelines to minimize the risk of musculoskeletal disorders of shoulder.
2. The data collected should be used as a proactive tool in assessing maximal isometric pushing values and establishing optimal working posture requirements for workers in the workplace. Thus, this have practical relevance in the workplace, in the way that, the industry workers should be encouraged to push the trolleys or carts in upright posture with elbow flexed in order to reduce the potential hazards associated with musculoskeletal disorders of shoulder.

Limitation of the Study

1. In this study, less number of subjects were taken.
2. Second limitation of the present study was the maintenance of the trunk flexion angle, which might get change during the pushing.
3. Third limitation was the application of the maximum voluntary contraction. No method has been used in the study to check out whether the subject is exerting maximal voluntary contraction or not.

CONCLUSION

From the above study, it was concluded that pushing activity performed, when the trunk is forward bend and elbow is extended, produce increased myoelectrical activity of Serratus anterior.

Source of Funding: Self

Ethical Clerence: It is abonified work done by me and I have not taken any part of thesis from anywhere.

REFERENCES

1. M.J.M Hoozeman et.al. Low-back and shoulder complaints among workers with pushing and pulling tasks. Scand J Work Environ Health 2002; 28(5):293–30.
2. P. Paul F.M.Kuijer et.al. A different approach for the ergonomic evaluation of pushing and pulling in practice, International Journal of Industrial Ergonomics, Vol 37, Issue 11-12, dec 2007, p 855-862.
3. Van der Windt et.al. : Occupational risk factors for shoulder pain: a systematic review, Occup Environ Med. 2000 July; 57(7): 433–442.
4. M.J.M Hoozemenn et.al. Pushing and pulling in association with low back and shoulder complaints . Occupational and Environmental Medicine 2002;59:696-702.
5. Andrew I Todd: Current Trends In Research Focused On Pushing And Pulling. Journal of Ergonomics Society of South Africa, 2005, No 2, p 42-5.
6. Biman Das and Y.Wang: Isometric Pull-push Strength in workspace: 2.Analysis of spatial factors. International Journal of Occupational Safety and Ergonomics (JOSE) Volume 10, No.1, p 59-64.
7. Hoozemans MJM et. al, Pushing and pulling in relation to musculoskeletal disorders: a review of risk factors. Ergonomics 1998;41:757–81.
8. Brian A.Garner and Joe Shim: Isometric Shoulder Girdle Strength Of Healthy Young Adults. Clinical Biomechanics Vol 23, Issue 1, Jan 2008,P 30-37.
9. Gray’s Anatomy: The Anatomical basis of medicine and surgery. Late. Peter L. Williams, Churchill Livingstone 38th edition, 1995. 85.
10. C.K Huang et.al. Scapular activities during pushing tasks. Journal of biomechanics, 40, 2007, page 396.
11. Susan B.O’Sullivan, Physical Rehabilitation: Assessment and Treatment. Jeypee Brothers, 4th Edition, 213-255, 2001.
12. B.D.Charasia, Human Anatomy: Regional and Applied, CBS Publishers, 3rd Edition, Vol-1,131-134,2001.
13. WilfridT.Dempster, Mechanims of shoulder movement, Archives of Physical Med. and Rehab, Jan, 49-70,1965.
14. Richard A. Ekstrom et.al. Comparing the Function of the Upper and Lower Parts of the Serratus Anterior Muscle Using Surface Electromyography. JOSPT.35, (5), May 2004, 235-243.
15. ChristopherI.M.Price, Paul Franklin et.al. Active and passive scapulohumeral movement in healthy persons: A comparison, Arch.phys. Med.Rehab., 81,28-31,2000.
16. Kevin P. Granata and Bradford C. Bennett: Low-Back Biomechanics and Static Stability During Isometric Pushing. Human Factors. 2005; 47(3): 536–549.
17. D.O Odebiyi et.al. Relationship between Spinal Mobility, Physical Performance, Pain Intensity And Functional Disability In Patients With

Chronic Low Back Pain. Nigerian Journal of Medical Rehabilitation (NJMR); Vol. 11, No. 2, (Issue No. 20) Dec. 2006 49-54.

18. Roger M. Enoka and Jacques Duchateau, Muscle fatigue: what, why and how it influences muscle function. Journal of Physiology.
19. D. David Ebaugh et.al,: Effects of shoulder muscle fatigue caused by repetitive overhead activities on scapulothoracic and glenohumeral 86 kinematics. Journal of Electromyography and Kinesiology, 16 (2006) 224–235.
20. Richard S.Snell, clinical anatomy for medical students, Lippincott Williams and Wilkins, 6th Edition, 408-410, 2000.
21. Michael J. Decker et.al. Serratus Anterior Muscle Activity During Selected rehabilitation Exercises. The American Journal of Sports Medicine, volume 27 No. 6, P 784-91.
22. Baril-Gingras and Lortie M. The handling of objects other than boxes: univariate analysis of handling techniques in a large transport company. Ergonomics, 38: 1995,905 – 925.
23. Davinder Gaur et.al. Effect of aging on activation of shoulder muscles during dynamic activities: An electromyographic analysis. International journal of shoulder surgery, volume 1, Issue 2 2007, P 51- 57.
24. Travell J.Simmons D: Myofacial pain and dysfunction: The trigger point manual. Williams and Wilkins, 2nd Edition, 183-202, 1999.
25. R. H. Westgaard: Work-related musculoskeletal complaints: some ergonomics challenges upon the start of a new century. Applied Ergonomics, Volume 31, Issue 6, December 2000, Page 569-580.
26. D. David Ebaugh et al, Scapulothoracic and glenohumeral kinematics following an external rotation fatigue protocol, Journal of Electromyography and Kinesiology, 36(8), 557-571.2006.