Changes in Sit To Stand Biomechanics after a Muscle Strengthening Program

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Introduction

Sit to stand (STS) is an important functional task that depends on lower extremity (LE) strength and balance to perform safely. The upper extremities (UE) are often substituted to compensate for LE weakness. These subjects can present with UE musculoskeletal overuse symptoms including pain, tenderness and weakness. We studied (1) the efficacy of a tailored strengthening program to reduce shoulder symptoms and (2) relationships between changes in strength, symptoms, and biomechanical factors of STS.

Statement of Clinical Significance

A strengthening program can be a main or adjunct treatment recommendation in patients presenting with musculoskeletal symptoms. Understanding how strengthening affects the biomechanics of task performance in the presence of pathology can clarify the role of strength changes in improving function. Generalizing information about neuromuscular compensation strategies can better enable the rehabilitation professional to design optimal interventions.

Methodology

Performance of STS was evaluated before and after a six month, home-based muscle strengthening program. A relaxation group (i.e. breathing exercises) was the control. Instructions regarding intensity, duration, and frequency for exercise were standardized. Subjects performed 4-8 exercises for up to 60 minutes, three to four days per week. Each exercise program was designed to provide a challenge to the functional capacity of the individual without causing excessive fatigue and/or muscle soreness. Pre- and post-treatment data on level of impairment, functional ability, quality of life, and strength were collected for each subject. Full body motion, bilateral upper extremity EMG, arm force and ground reaction force were measured while the subject performed STS in the gait lab. An index to gauge co-contraction was proposed using normalized EMG measured during STS. The normalization factor was the EMG measured from each muscle during a 30% maximum voluntary contraction during each test session.

Results

Data revealed a significant decrease in shoulder pain ($p = 0.004$, <u>all</u> subjects, SPADI scores) and a significant increase in overall leg extensor strength for the exercise groups ($p = 0.014$, 4 of 5 subjects in the strengthening group). None of the subjects in the relaxation therapy program showed a significant change in overall LE or UE strength (n=2). Peak ground reaction force magnitudes were generally unchanged. Arm rest A/P pushoff forces were generally increased. Changes in peak forward trunk displacement during STS was mixed; several subjects showed increases while the remainder showed minor decreases. Many of the subjects with increased LE strength showed increased forward and/or upward velocity. There was no consistent pattern for change in timing of arm release. Co-contraction was bilaterally decreased for the biceps-triceps pair. Other muscle pairs showed mixed changes in co-contraction with no clear trend evident.

Discussion

There was a correlation between increased LE strength and reduction in shoulder symptoms. Increased LE strength was predicted to shift load bearing towards the legs and away from the arms during STS. This could be the mechanism for decreased UE symptoms. However, the two relaxation subjects also showed decreased shoulder symptoms suggesting that another mechanism was present for this group or that LE strengthening was not the causative factor in the strengthened group. The subject sample size was not sufficient to confidently assess the significance of this result. Testing continues.

Increased LE strength did not correlate with increased foot-floor forces, but there was a weak correlation with increased arm A/P forces. It was predicted increased LE strength would result in the LE carrying more of the load to propel the body during STS. This would result in increased ground reaction forces and decreased UE forces. This mechanism was not supported. There was a trend towards decreased ground reaction forces and increased arm A/P forces in subjects with increased LE strength. Subjects may have produced a larger push-off force from the chair as the result of the decrease in symptoms.

Increased LE strength did not correlate with less forwards trunk lean. Trunk lean may be used to assist propulsion. Increased leg muscle propulsion may allow subjects to reduce forward lean. The expected correlation between increased leg strength and decreased trunk velocity also did not hold. Three out of four subjects who had an increase in LE strength also showed an increase in forward and/or upward velocity. Previous studies have indicated that weaker subjects tend to use momentum to assist muscles. With more stability from the legs, less forward velocity for the trunk was expected. There were no clear trends between forward lean and timing of arm release. With more stability from the legs, earlier release of armrests was expected. The mechanism of increased forward trunk velocity may be that subjects generated this through increased arm pushoff forces.

Increased UE strength was associated with decreased co-contraction for the biceps-triceps muscle group combination. Decreased UE symptoms were predicted to show increased agonist EMG in the UE. Decreased coactivation may be related to symptom improvement as the subjects' can "let go" more. A decrease in shoulder symptoms was associated with a decrease in the co-contraction index for the biceps-triceps muscle combinations in both arms for the majority of subjects. Three of these subjects also showed an increase in EMG activity in either the triceps or post-deltoid muscle group. EMG data were found to be sensitive to the intervention and were supportive of the a-priori hypotheses about mechanism of change. The co-contraction index helped to partially quantifying changes in muscle utilization strategies. Further analysis is underway to assess changes in trunk acceleration and to determine its role in the changes in functional performance due to the treatment program. Intersegmental dynamics or induced acceleration analysis will be used to assess the changes in contribution of LE and UE joint moments to trunk kinematics during the propulsion and momentum transfer phases of STS. Collection of more data will allow study of group effects and generalization about compensation and adaptation strategies.

Acknowledgments

This work was supported by NIDRR #H133A000101. Thanks also to Barbara Hirai and Oliver Woods for their help in data collection and analyses.