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Original research

Serratus anterior muscle activation during knee push-up plus exercise performed on static stable, static unstable, and oscillating unstable surfaces in healthy subjects

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ABSTRACT

Objectives: To compare electromyographic (EMG) activity of the serratus anterior (SA) during knee push-up plus exercises according to various surfaces (static stable, static unstable, and oscillating unstable surfaces).
Study design: Comparative study by repeated measures.
Setting: Yonsei University laboratory.
Participants: In total, 15 healthy male subjects participated.
Main outcome measures: The subjects performed knee push-up plus exercises on three different surfaces: static stable, static unstable, and oscillating unstable surfaces. Surface EMG activity of the SA for the peak and average amplitudes were collected from the dominant arm and presented as a percentage of the maximal voluntary contraction. A one-way repeated-measures ANOVA with a Bonferroni *post hoc* test was performed to compare differences in SA EMG activity according to the surface.
Results: The peak and average amplitudes of SA activity were significantly greater during knee push-up plus on the oscillating unstable surface than on the static stable or static unstable surfaces ($p < 0.01$). Additionally, there was no significant difference between the stable and static unstable surfaces ($p > 0.05$).
Conclusions: Knee push-up plus exercise on an oscillating unstable surface activates the SA more than the same exercise on static stable and static unstable surfaces.

1. Introduction

The function and electromyographic (EMG) activity of the serratus anterior muscle (SA) has been highlighted for normal scapulothoracic position and motion (Decker, Hintermeister, Faber, & Hawkins, 1999; Ludewig & Cook, 2000; Ludewig, Hoff, Osowski, Meschke, & Rundquist, 2004; Marshall & Murphy, 2006; Park & Yoo, 2011; Thigpen et al., 2010). Weakness of the SA is associated with an altered scapular position, scapulothoracic motion, and muscle activity (Ludewig & Cook, 2000; Ludewig et al., 2004; Marshall & Murphy, 2006; Thigpen et al., 2010). Decreased SA motor recruitment induces altered scapular motion during shoulder elevation in the frontal and scapular planes, which causes shoulder impingement and pain in people involved in overhead activities, including baseball and tennis players (Ludewig & Cook, 2000; Page, 2011). Thus, SA recruitment is important in maintaining normal scapulothoracic rhythm and shoulder movement in rehabilitation programs (Decker et al., 1999; Kibler, Sciascia, Uhl, Tambay, & Cuningham, 2008).

Many studies have reported push-up plus exercises for strengthening the SA (Hardwick, Beebe, McDonnell, & Lang, 2006; Lehman, MacMillan, MacIntyre, Chivers, & Fluter, 2006; Ludewig et al., 2004; Sandhu, Mahajan, & Shenoy, 2008). Ludewig et al.

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