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PREVENTION & REHABILITATION: ORIGINAL BIOMECHANICAL RESEARCH AND HYPOTHETICAL MODEL

Lumbopelvic muscle activation patterns in three stances under graded loading conditions: Proposing a tensegrity model for load transfer through the sacroiliac joints

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Summary *Purpose:* According to the conventional arch model of the pelvis, stability of the sacroiliac joints may require a predominance of form and force closure mechanisms: the greater the vertical shear force at the sacroiliac joints, the greater the reliance on self-bracing by horizontally or obliquely oriented muscles (such as the internal oblique). But what happens to the arch model when a person stands on one leg? In such cases, the pelvis no longer has imposts, leaving both the arch, and the arch model theory, without support. Do lumbopelvic muscle activation patterns in one-legged stances under load suggest compatibility with a different model? This study compares lumbopelvic muscle activation patterns in two-legged and one-legged stances in response to four levels of graded trunk loading in order to further

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our understanding the stabilization of the sacroiliac joints.
Methods: Thirty male subjects experienced four levels of trunk loading (0%, 5%, 10% and 15% of body weight) by holding a bucket at one side, at three conditions: 1) two-legged standing with the bucket in the dominant hand, 2) ipsilateral loading: one-legged standing with the bucket in the dominant hand while using the same-side leg, and 3) contralateral loading: one-legged standing using the same leg used in condition 2, but with the bucket in the non-dominant hand. During these tasks, EMG signals from eight lumbopelvic muscles were collected. ANOVA with repeated design was performed on normalized EMG's to test the main effect of load and condition, and interaction effects of load by condition.
Results: Latissimus dorsi and erector spinae muscles showed an antagonistic pattern of activity toward the direction of load which may suggest these muscles as lateral trunk stabilizers. Internal oblique muscles showed a co-activation pattern with increasing task demand, which may function to increase lumbopelvic stability ($P < 0.05$). No unilateral pattern of the internal obliques was observed during all trials..
Conclusions: Our results suggest that the lumbopelvic region uses a similar strategy for load transfer in both double and single leg support positions which is not compatible with the arch analogy. Our findings are more consistent with a suspensory system (wire-spoke wheel model). If our proposed model holds true, the pelvic ring can only be integrated by adjusting tension in the spokes and by preserving rim integrity or continuity. Thus, we propose that in order to restore tension integrity throughout the pelvic ring, efforts to unlock restrictions, muscular correction of positional faults and lumbopelvic or even respiratory exercises following sacroiliac joint dysfunctions must be taken into consideration. Our hypothetical model may initiate thinking and act as a guide to future work based on a biomechanical approach to the problem of sacroiliac joint dysfunction..

Introduction

The aim of this study was to compare the lumbopelvic muscle activation patterns between two-legged standing and one-legged standing positions in response to four levels of trunk loading in order to further our understanding of the stabilization of the sacroiliac (SI) joints.

Low back pain (LBP) affects a remarkable percentage of the human population every year. A systematic review of epidemiological studies on LBP found that the point prevalence of LBP was as high as 33%; one year prevalence was as high as 65% and lifetime prevalence was as high as 84% (Walker, 2000). These results indicate that LBP is widespread and deserves to be studied in depth.

The lumbopelvic region and especially the SI joints, in regard to their intermediary position, play an important role in transferring loads generated by upper body weight and gravity while sitting, standing and walking. It is suggested that SI dysfunction can contribute to LBP (Schwarzer et al., 1995). Therefore, understanding the stability mechanisms in the SI joints is important from both a diagnostic and a therapeutic standpoint.

According to the conventional arch model, the pelvis is structured as a Roman arch with the sacrum as the keystone, wedged between the two iliac bones (form closure). See Fig. 1

Two-legged standing supports the arch analogy. The legs can be seen as the imposts of an arch, allowing the sacrum to transfer forces to the articular surfaces of the SI joints through compression, which can prevent unnecessary muscle forces, and most studies on the stability of SI joints are in general agreement with the arch theory. In this model, the main source of loading is the sacrum, taking load from the spine and transferring it to the hips through

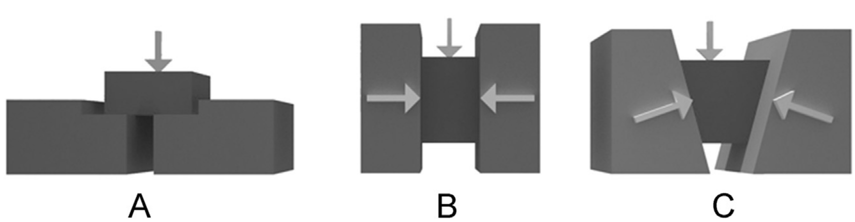

Figure 1 (A) Form closure: the object remains in place, independent of the exerted load. (B) Force closure: the object can only remain in place when continuous additional transversely oriented forces are applied to resist movement by friction. (C) Combination of form and force closures.
Adapted from Snijders et al. (1998).