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Full Length Article

Applying an active lumbopelvic control strategy during lumbar extension exercises: Effect on muscle recruitment patterns of the lumbopelvic region

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ABSTRACT

Objective: Examine whether implementing an active lumbopelvic control strategy during high load prone lumbar extension exercises affects posterior extensor chain recruitment and lumbopelvic kinematics.

Methods: Thirteen healthy adults acquired an optimal active lumbopelvic control strategy during guided/home-based training sessions. During the experimental session electromyography was used to evaluate the activity of the posterior extensor chain muscles during high load trunk/bilateral leg extension exercises with/without application of the strategy. Video-analysis was used to evaluate thoracic/lumbar/hip angles.

Results: Implementing the active lumbopelvic control strategy decreased the lordotic angle during trunk ($p = 0.045$; $-3.2°$) and leg extension exercises ($p = 0.019$; $-10°$). The hip angle was solely affected during trunk extension ($p < 0.001$; $+9.2°$). The posterior extensor chain (i.e. mean of the relative activity of all muscles (%MVIC) was recruited to a higher extent ($p = 0.026$; $+9\%$) during trunk extension exercises performed with active lumbopelvic control. Applying the strategy during leg extension exercises lead to less activity of longissimus thoracic ($p = 0.015$; -10.2%) and latissimus dorsi ($p = 0.010$; -4.4%), and increased gluteus maximus activity ($p \leq 0.001$; $+16.8\%$).

Conclusions: When healthy people are taught/instructed to apply an active lumbopelvic control strategy, this will decrease the degree of lumbar (hyper)lordosis and this influences the recruitment patterns of trunk and hip extensors. Hence, the possible impact on predetermined training goals should be taken into account by trainers.

1. Introduction

Lumbar extension exercises are widely used in training regimens to enhance endurance, strength and functionality of the posterior extensor chain as this will enhance performance levels (Steele, Bruce-Low, & Smith, 2015; Verna et al., 2002). This chain consists of the extensor muscles located in the thoracic, lumbar and pelvic region of the posterior side of the body. More specifically, the

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posterior extensor chain consists of the Latissimus Dorsi (LD), the Thoracic Erector Spinae (TES) which is formed by the Longissimus thoracis pars Thoracic (LT) and Iliocostalis lumborum pars Thoracis (IT), the Lumbar Erector Spinae (LES) which is formed by the Longissimus thoracis pars Lumborum (LL) and Iliocostalis lumborum pars Lumborum (IL), the Lumbar Multifidus (LM), the Gluteus Maximus (GM) and the Biceps Femoris (BF), which are functionally coupled via the thoracolumbar fascia (Vleeming, Pool-Goudzwaard, Stoeckart, van Wingerden, & Snijders, 1995). Despite the fact that only some of these muscles directly attach on to the lumbar vertebrae, a contraction of one of the muscles will influence the lumbar region, even if this is not the muscle its primary function. Although many different modalities of lumbar extension exercises exist (Mayer et al., 1999; Mayer, Mooney, & Dagenais, 2008; Mayer, Verna, Manini, Mooney, & Graves, 2002; Plamondon, Serresse, Boyd, Ladouceur, & Desjardins, 2002) trainers often implement modalities performed from prone position into training programs (Mayer, Udermann, Graves, & Ploutz-Snyder, 2003; Verna et al., 2002). By extending either the trunk or the legs, lumbar extension and activation of the muscles generating this movement is induced. These exercises are 'high load' as they activate the muscles from the posterior extensor chain at high degrees, namely between 40 and 70% of their maximal voluntary isometric contraction (MVIC) (Clark, Manini, Mayer, Ploutz-Snyder, & Graves, 2002; Dickx et al., 2010; Mayer et al., 1999, 2002; Plamondon et al., 2002). Because these trunk and leg extension exercise modalities from prone position do not require expensive training devices they can be easily performed in the gym, at home, and during field training.

However, it has been shown that lumbar extension exercises from prone position can cause high spinal compressive loads (up to 6000 N) due to excessive anterior pelvic tilt and hyperlordosis of the lumbar spine, which could diminish the positive training effects (Callaghan, Gunning, & McGill, 1998; Granata, Lee, & Franklin, 2005; McGill, 2002). It has been advocated that these disadvantages can be limited by applying active lumbopelvic control techniques during exercise (Oh, Cynn, Won, Kwon, & Yi, 2007). In normal trunk function co-contraction of the deep lumbopelvic muscles, i.e. LM, transversus abdominis (TA), and the pelvic floor muscles, precedes the activation of prime movers during movements which jeopardize the trunk stability, providing mechanical stability for spinal loads exceeding 1500 N (Demoulin, Distree, Tomasella, Crielaard, & Vanderthommen, 2007; Panjabi, 2003). As contraction of this lumbopelvic muscle corset contributes significantly to lumbar segmental control, the use of these deep muscles should be optimized using training and implemented during lumbar extension exercises (Jull & Richardson, 1994). The lumbopelvic control training focuses on teaching subjects to actively co-contract the deep lumbopelvic muscles and to maintain this co-contraction while performing activities such as prone lumbar extension exercises (Cameron & Monroe, 2011; Oh et al., 2007). The continuous tonic low level activation of the deep lumbopelvic muscles will form a cylinder around the lumbar spine providing functional control during these activities and exercises (Cholewicki & VanVliet, 2002; Hodges, 1999, 2003).

Currently, little is known on how active involvement of this lumbopelvic muscle corset during lumbar extension exercises influences the recruitment of the posterior extensor chain in healthy people. Several studies have demonstrated that contracting the lumbopelvic muscle corset alters the muscle recruitment patterns when performing low load exercises or daily activities (Oh et al., 2007; Stevens et al., 2007; Watanabe, Eguchi, Kobara, & Ishida, 2007). For instance, it has been demonstrated that an abdominal drawing-in maneuver, used to facilitate activation of the TA, during prone unilateral leg extension reduces the LES activity but increases the activity of the hip extensors (Oh et al., 2007). On the other hand, it has been shown that contraction of the lumbopelvic muscle corset during active sitting enhances the activity of the LES and LM (Watanabe et al., 2007). As these studies have examined the recruitment patterns during different activities or positions, are limited to low load activities or exercises, and have not examined the activity of the thoracic extensors, it is difficult to compare findings and to conclude how recruitment of the posterior extensor chain is exactly influenced when an active lumbopelvic control strategy is implemented to high load lumbar extension exercises. In the same context, it is relevant to note that most studies investigating muscle recruitment patterns during lumbar extension exercises have overlooked the contribution of the hip extensors. A trunk extension consists of a combined extension movement of the thoracic and lumbar spine as well as anterior rotation of the pelvis and hips (Graves et al., 1994; Pollock et al., 1989), whereas a leg extension is composed of an extension of the lumbar spine and a rotation of the hips and pelvis (Oh et al., 2007). From this biomechanical perspective it is clear that lumbar extension exercises do not only require activation of the trunk extensor muscles but also of the hip extensor muscles (Arokoski et al., 1999; Kankaanpaa et al., 1998; Plamondon et al., 2002; Sparto & Parnianpour, 1998). Furthermore, it has been shown that the active lumbopelvic control strategy is able to reduce the degree of lumbar lordosis during sitting (Watanabe et al., 2007) and unilateral leg extension exercise (Oh et al., 2007), but no studies have examined whether this is also the case during high load lumbar extension exercises from prone position such as trunk and bilateral leg extension exercises.

To examine whether the implementation of an active lumbopelvic control strategy during high load prone lumbar extension exercises affects the lumbopelvic recruitment patterns and kinematics, the activation levels of the posterior extensor chain during prone trunk and leg extension exercises were studied with and without the implementation of an active lumbopelvic control strategy. Since the LES and (the deep fibers of) the LM contribute to lumbar spine control (Cholewicki & VanVliet, 2002; MacDonald, Moseley, & Hodges, 2006; Wilke, Wolf, Claes, Arand, & Wiesend, 1995), we hypothesized an increased recruitment of these muscles and a reduced degree of lumbar lordosis when the lumbopelvic muscle corset is contracted during prone lumbar extension exercises.

2. Materials and methods

2.1. Subjects

A convenience sample consisting of 13 healthy subjects (9 females, 4 males) of 22.6 ± 2.1 years participated in this study. Subjects their mean height and weight were 172 ± 7.3 cm and 61.3 ± 9.5 kg respectively. Subjects were excluded from participation if they; 1) reported previous back surgery or established spinal deformities, 2) had consulted a physician regarding

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