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Full Length Article

Attentional focusing instructions influence quadriceps activity characteristics but not force production during isokinetic knee extensions

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A B S T R A C T

The attentional focus emphasised in verbal instruction influences movement and muscle recruitment characteristics, with an external focus (onto movement effects) typically benefiting performance. However, contrasting findings suggest either a selective isolation or spreading activation effect on associated muscles as a result of internally focused instruction (movement characteristics). In the present experiment, participants completed maximal isokinetic concentric leg extension exercise using internally (muscle specific: vastus medialis oblique) or externally (outcome specific) focused instructions. Integrated Electromyography (iEMG) of the vastus lateralis, vastus medialis oblique and rectus femoris muscles was obtained in addition to knee extensor torque. There were no differences in torque production between conditions. Externally focused instruction produced significantly lower iEMG magnitude across muscles, whereas an internal focus produced the greatest activity but with no evidence of a selective isolation effect of the vastus medialis oblique. The muscle-specific internal focus of attention resulted in a spreading activation effect, such that activity is elevated in muscles not within the focus of attention. Whilst an external focus did not improve performance, force was produced with lower muscular activity reflecting increased efficiency. The resultant noise in the motor system associated with an internal focus inhibits movement economy and attempts at selective activation.

1. Introduction

Recent studies demonstrate that the attentional focus emphasised through verbal instruction differentially impacts upon force production (see Marchant, Greig, Bullough, & Hitchen, 2011; Wulf & Lewthwaite, 2016). For example, when compared to internally focused attention (onto aspects of the movements being executed) an external focus of attention (onto movement outcomes) has improved performance on standing long jumps (Porter, Anton, Wikoff, & Ostrowski, 2013), discus throwing (Zarghami, Saemi, & Fathi, 2012), bench press and squat exercise endurance (Marchant et al., 2011), and finally accuracy in an isometric force production task (Lohse, Sherwood, & Healy, 2011). To investigate these effects, researchers have identified muscular activation characteristics measured through electromyography (EMG) as a significant mechanism (See Lohse, Wulf, & Lewthwaite, 2012). In those studies, instructions to adopt an external focus of attention have typically

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resulted in more efficient activation (See Wulf, 2013) when compared to an internal focus of attention. An external focus of attention is manipulated through instructions directing attention to the intended outcome of the movement. However, inducing an internal focus of attention has been achieved through different approaches; with some directing attention to movement mechanics (e.g., Zachry, Wulf, Mercer, & Bezodis, 2005) whilst others focus attention onto the muscles themselves (e.g., Marchant, Greig, & Scott, 2009; Vance, Wulf, Töllner, McNevin, & Mercer, 2004). Further emphasising these differences in instructional approaches, research that does not incorporate electromyography typically does not emphasise muscular activation as part of the internal focus manipulations. Rather they focus attention onto the movement of the limbs involved in the action (e.g., Lohse, Sherwood, & Healy, 2010).

In research examining instructionally manipulated attentional focus, an external focus of attention has typically facilitated efficient muscular activation. On the other hand, the conscious control associated with internally focused attention results in inefficient muscular activity, or "noise" in the motor system, which is subsequently detrimental to performance. For example, during force production or exercise type movements reduced muscular activation has been observed with an external versus internal focus during biceps curls type exercise (Marchant et al., 2009; Vance et al., 2004: focus on the movement of the curl bar vs focus on the muscles involved), sit up exercises (Neumann & Brown, 2015: "make your movements smooth/flow" vs "focus on or feel your stomach muscles") and vertical jump and reach tasks (Wulf, Dufek, Lozano, & Pettigrew, 2010: reach for the target vs reaching with your fingers). Lohse et al. (2011) found less accurate isometric force production with the foot as well as a higher degree of co-contractions of agonist (soleus) and antagonist (tibialis anterior) muscles with an internal focus onto the calf muscles compared to externally focused instructions emphasising the force platform. Interestingly, although internal instruction purposefully directed attention to the agonist muscle, significantly greater muscle activity was only observed in the antagonist muscle.

In many of the force production studies an internal focus of attention is induced through emphasising specific muscular activation. However, this is typically not an approach adopted in studies assessing skilled movements. For example, in a basketball free throw task Zachry et al. (2005) found that instructions to focus externally (the target hoop) compared to internally (movement of the wrist) resulted in greater accuracy and reduced EMG activity of the biceps and triceps brachii. Supporting this in a dart throwing task, Lohse et al. (2010) found that externally focused instructions (the flight of the dart) improved accuracy in addition to lowering EMG activity of the triceps muscle when compared to an internal focus (onto their arm). Such inconsistencies suggest potential differences in the conceptualisation of an internal focus and how it should be instructed depending upon the task being assessed.

One interesting observation is a "spreading" of influence where an internal focus of attention has a broader influence of movement efficiency and muscular activation. Specifically, an internal focus influences the activity of muscle groups that participants were focusing on, in addition to those that they were not specifically directed to focus on (e.g., Lohse et al., 2011; Vance et al., 2004; Wulf et al., 2010; Zachry et al., 2005). This spreading effect appears to be observed regardless of whether specific muscles or movement characteristics are emphasised in the internally focused instructions provided. This observation and the muscular activation findings to-date are in line with the constrained action hypothesis (McNevin, Shea, & Wulf, 2003; Wulf, McNevin, & Shea, 2001). When an external focus is adopted there is greater utilisation of the motor system's self-organising capabilities (e.g., Lohse, Jones, Healy, & Sherwood, 2014) and automatic control processes. This supports effective neuromuscular coordination and activation of agonist and antagonist muscle groups. An internal focus on the other hand promotes conscious control of movements through self-related processing (Wulf & Lewthwaite, 2010) which constrains the motor system resulting in unnecessary muscular activation and co-contractions. This "noise" in the motor system evidences reduced automatic control processes and increased conscious attempts to control movement. Although motor unit recruitment is not under conscious control (Lohse et al., 2012), these observations highlight that the attentional focus adopted influences the efficiency of the motor system, which in turn significantly impacts on neuromuscular coordination. Consequentially, the alterations in neuromuscular activity coincide with changes in outcome measures.

Contrasting this spreading effect, researchers have demonstrated that instructional approaches can selectively recruit muscles during exercise and rehabilitative movements. Muscle specific verbal instruction have resulted in selective activation of oblique and rectus abdominis muscles during trunk curl exercises (Karst & Willett, 2004), the latissimus dorsi during low-intensity lat pull-down exercise (Snyder & Leech, 2009), and pectoralis major and triceps brachii activity during bench press exercise and 50% of trained participants 1-repetition max (1RM), but not at 80% of 1RM (Snyder & Fry, 2012). Using a single legged dynamic landing movement Palmerud, Sporrong, Herberts, and Kadefors (1998) found selective reductions in upper trapezius activity during isometric shoulder abduction exercise (with corresponding increases in rhomboids major and minor and the transverse trapezius muscles) only when verbal cues were supported with EMG biofeedback. However, Cowling, Steele, and McNair (2003) found that instructions to specifically recruit the hamstring muscles during jump landing were unsuccessful. The instructions resulted in inefficient co-contraction of associated muscles such that landings posed a greater risk of injury. The internally focused nature of the instruction provided may have resulted in a spreading influence across associated muscles rather than the intended selective effect.

Given the evidence reviewed, it is clear that verbal instruction provided by coaches, physical therapists, and personal trainers has a measurable effect on muscle activation and force production during exercise movements. Attempts to isolate or promote muscular activation through verbal guidance may well be hindered by the "spreading" effect (e.g., Lohse et al., 2011) where the influence of internally focused instructions "spreads" to other muscle groups that participants were not specifically instructed to focus on. The present study aims to assess the influence of internally focused instructions emphasising specific muscular activity when compared to externally focused instructions that emphasise the movement outcome.