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Speed dependant influence of attentional focusing instructions on force production and muscular activity during isokinetic elbow flexions

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ABSTRACT

This experiment assessed the influence of internal (movement) or external (outcome) attentional focusing instructions on force production and muscular activity at different movement speeds. Twenty five participants completed 10 reps of single arm elbow flexions on an isokinetic dynamometer at speeds of 60°, 180° and 300° s^{-1} under three conditions (control trial, followed by counterbalanced internal and external focus trials). EMG activity of the biceps brachii and net joint elbow flexor torque were measured. An external focus was associated with significantly lower EMG at all speeds when compared to an internal focus. However, an external focus resulted in greater torque production only at 60° s^{-1} when compared to an internal focus. These findings suggest that movement speed may influence the efficacy of different attentional focusing instructions, with implications for the instruction of movements in sport, exercise and rehabilitation settings.

1. Introduction

The use of verbal instruction and encouragement is generic to sports performance, exercise and rehabilitation. The specific emphasis of such instructions has been shown to have a significant impact on movement quality by influencing an individual's attentional focus (see Wulf, 2007). Instructions can direct attention either internally towards the actual bodily movements being produced during a

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movement (e.g. arms and hands during basketball free-throwing technique), or externally towards an outcome or the effects of the movement being produced (e.g. the hoop or backboard in basketball).

An external focus has been shown to benefit both the performance and learning of a wide variety of skills such as standing and dynamic balance (e.g., McNevin, Shea, & Wulf, 2003; Wulf, 2008), golf (Bell & Hardy, 2009; Wulf, Lauterbach, & Toole, 1999), volleyball and soccer kicks (Wulf, McConnel, Gartner, & Schwarz, 2002) and dart throwing (Marchant, Clough, & Crawshaw, 2007; Marchant, Clough, Crawshaw, & Levy, 2009; Radlo, Steinberg, Singer, Barba, & Melnikov, 2002). As a proposed explanation for these effects, the constrained action hypothesis (McNevin et al., 2003; Wulf, McNevin, & Shea, 2001) suggests that an internal focus induces conscious control of movement, increasing noise in the motor system (Zachry, Wulf, Mercer, & Bezodis, 2005) and disrupting automatic control processes. Supporting this, the data from studies to date suggest that such explicit attention to bodily movements results in less efficient movement outcomes (e.g., accuracy) and associated moment characteristics (e.g., muscular activation). An external focus is considered to enable unconscious or automatic processes to control the movement allowing more efficient movement execution. Evidence for this has been demonstrated in reduced attentional-capacity demands of tasks (e.g., Wulf et al., 2001) and recued muscular activation (e.g., Vance, Wulf, Töllner, McNevin, & Mercer, 2004) when an external rather than an internal focus is emphasized through verbal instruction.

A growing body of research has assessed the influence of attentional focusing instructions on force production tasks (for a review see Marchant, 2011). In a series of studies assessing force production using a vertical jump-and-reach test, Wulf and colleagues (Wulf & Dufek, 2009; Wulf, Dufek, Lozano, & Pettigrew, 2010; Wulf, Zachry, Granados, & Dufek, 2007) found that externally focused instructions resulted in greater jump-and-reach height when compared to internal instructions. Similarly, Porter, Nolan, Ostrowski, and Wulf (2010) demonstrated beneficial effects of externally focused instructions on standing long-jump performance. In a more constrained dynamometry task Marchant, Greig, and Scott (2009) reported that externally focused instructions resulted in significantly greater net joint torque during maximal isokinetic elbow flexions at $60^{\circ}\,s^{-1}$.

Not all tasks require the expression of maximal force, and efficient intra- and inter-muscular coordination has also been suggested to be sensitive to instruction (Sahaly, Vandewalle, Driss, & Monod, 2001). Attentional focusing instructions have also been shown to influence the ability to accurately generate targeted submaximal forces. Lohse, Sherwood, and Healy (2010) showed that participants were more accurate in producing 30% of their maximum force when instructed externally (focusing on pushing against the force platform during an isometric plantar flexion task) than when instructed internally (focusing on their calf muscles). Freedman, Maas, Caligiuri, Wulf, and Robin (2007) found that externally focused instructions benefitted accuracy during submaximal hand and tongue impulse force control tasks when compared to internal instructions.

The evidence suggests that attentional direction is a critical quality for instructing force production tasks. Ives and Shelley (2003) suggested that the manipulation of attentional focus is critical for effective strength and power training through its direct influence on movement quality and therefore subsequent adaptations. Furthermore, Marchant (2011) recommends research addresses how attentional focusing instructions interact with task and individual variables within force production settings. One such factor that has yet to be addressed is speed of movement execution. Ives and Shelley refer to both strength *and* power training efficacy, and speed of movement is a key variable to manipulate in distinguishing between the performance objective, i.e. strength *or* power. Although not directly addressed, an external attentional focus has been shown to produce faster movement across a range of tasks. For example, during walking rehabilitation in persons with Parkinson's disease (Canning, 2005), bicep curl exercises (Vance et al., 2004), an agility "L" run (Porter et al., 2010), when riding a foot-driven wheeled Pedalo (Totsika & Wulf, 2003), during functional reach tasks in persons after stroke (Fasoli, Trombly, Tickle-Degnen, & Verfaellie, 2002). Lohse (2012) also demonstrated reduced pre-movement times in an isometric plantar flexion submaximal force production task, representing more efficient motor planning.

Within exercise and health settings, movement velocity is a critical consideration given the force-velocity relationship of contractile muscle. Training-induced adaptations are specific to the velocity of training (Behm & Sale, 1993a; Behm & Sale, 1993b), and thus movements are often prescribed and executed at varying speeds depending upon the intended adaptation. For example, for developing