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The influence of instruction on arm reactions in individuals with Parkinson's disease

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ABSTRACT

The purpose of this study was to examine whether explicit instruction would facilitate arm reactions in individuals with Parkinson's disease (PD). Individuals with ($n = 10$) and without ($n = 15$) PD responded to unexpected support-surface translations. To recover their balance, participants were required to either respond naturally (react natural) or to reach toward a nearby handrail (explicit instruction). Arm reactions were quantified from electromyographic (EMG) and arm kinematic recordings. Results showed that while explicit instruction led to earlier and larger arm reactions, the benefits were not different between individuals with and without PD. Specifically, when explicitly instructed to reach toward a handrail, shoulder EMG responses were 4% earlier ($p = .005$) and 32% larger ($p < .001$) compared to when instructed to react naturally. A 44% greater peak wrist medio-lateral velocity ($p < .001$) and a 29% greater peak shoulder abduction angular velocity ($p < .001$) were also observed when participants were instructed to direct their arms toward a handrail after an unexpected support-surface translation. Explicit instruction also led to a higher frequency of handrail contact and a 49 ms earlier time to handrail contact compared to the react natural condition ($p = .015$). These results suggest that providing instruction to promote arm movement may help reduce falls in older adults with and without PD.

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1. Introduction

The risk of falling for individuals with PD is approximately twice that of community dwelling older adults (Wood, Bilclough, Bowron, & Walker, 2002). This higher risk of falls may be due to delays in lower limb balance recovery responses (King, St George, Carlson-Kuhta, Nutt, & Horak, 2010), shorter reactive steps (Jacobs & Horak, 2006), or increased ankle stiffness (Bloem et al., 1996; Carpenter, Allum, Honegger, Adkin, & Bloem, 2004). Alterations in arm reactions occurring in response to a loss of balance may also contribute to falls. When individuals with PD lose their balance, they exhibit decreased velocity and peak displacement of the upper limbs (Carpenter et al., 2004) and consequently, their arm reactions may not aid in the grasping of a handrail or cushioning the force of a fall (Carpenter et al., 2004). This reduction in arm responses may explain why the rate of hip and not wrist fractures is greater in individuals with PD (Bloem, Munneke, Carpenter, & Allum, 2003; Grisso et al., 1991; Pressley et al., 2003).

Therefore, it is important to establish methods that may facilitate arm reactions in individuals with PD in order to reduce the risk of falls. One potential method may be to explicitly instruct individuals to reach toward a nearby support (e.g., handrail) when responding to a loss of balance. Providing instruction or a cue to an external target (i.e., external focus of attention) may be beneficial because it offers supplementary movement cues that allow individuals with PD to execute movements via pathways that involve an intact visual-sensorimotor set (Jacobs & Horak, 2006) or cerebellum, instead of the defective basal ganglia (Marsden & Obeso, 1994). Further, when an individual's attention is directed toward an external rather than internal source, this encourages a more automatic or reflexive control of movement (Wulf, Shea, & Park, 2001) and consequently, improves movement performance (Landers, Wulf, Wallmann, & Guadagnoli, 2005; Wulf, Landers, Lewthwaite, & Tollner, 2009; Wulf & Prinz, 2001).

Since individuals with PD tend to be more cautious and direct their attention to their own movements (i.e., internally) during activities of daily living (Landers et al., 2005; Masters, Pall, MacMahon, & Eves, 2007), it is likely that instruction to reach for a nearby handrail will also improve the timing and magnitude of arm reactions. This is based on previous studies that have examined the influence of instruction and cueing on lower limb postural responses. For example, when attentional, auditory and visual instructions (cues) are provided during gait or prior to a loss of balance, individuals with PD are able to improve their gait velocity, cadence and stride length, reduce the amount of time they spend in double-limb support (Morris, Iansek, Matyas, & Summers, 1996; Suteerawattananon, Morris, Etnyre, Jankovic, & Protas, 2004) as well as increase their reactive step length (Jacobs & Horak, 2006). If explicit instructions can facilitate the muscle onset latencies and amplitudes of the upper limbs, and provide functional benefits similar to external cue use during gait and reactive stepping, then instruction focusing on using a nearby handrail to aid in balance recovery may be useful for reducing falls and fall-related injuries in individuals with PD.

The purpose of this study was to determine whether explicit instruction to reach toward a handrail facilitates arm reactions, in response to a loss of balance, in individuals with PD. It was hypothesized that when explicit instruction to reach toward a handrail is provided, individuals with PD would demonstrate arm reactions that are earlier and larger in arm electromyographic (EMG) activity and with a greater arm velocity. To demonstrate the functional benefits of instruction, it was hypothesized that changes in arm reactions would result in a more frequent and earlier contact of the handrail for balance recovery.

2. Methods

2.1. Participants

Ten individuals with PD and 15 older adults without PD participated in this study. Participants were recruited from community PD support groups and exercise programs for older adults. The sample size is similar to many previous studies investigating balance control in older adults with and without PD (Carpenter et al., 2004; Horak, Dimitrova, & Nutt, 2005; Jacobs & Horak, 2006).