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Both age and physical activity level impact on eye-hand coordination

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ABSTRACT

Aging impacts on our ability to perform goal-directed aiming movements. Older adults generally make slower and shorter initial impulses towards the end target, and therefore require more time for corrections in the final movement stage. Recent studies however suggest that a physically active lifestyle may attenuate these age-related changes. Also, it remains unclear whether eye-movement control exhibits a similar pattern of adaptation in older adults. Therefore, the first aim of this study was to describe how age and physical activity level impact eye–hand coordination during discrete manual aiming. Young and older participants were divided into physically active and sedentary subgroups, and performed discrete aiming movements while hand and eye movements were recorded. Secondly, to determine whether older adults depend more on vision during aiming, the task was repeated without visual feedback. The results revealed that the typical age-related hand movement adaptations were not only observed in older, but also in sedentary young participants. Older and sedentary young participants also spent more hand movement time after the eyes fixated the end target. This finding does not necessarily reflect an augmented reliance on vision, as all groups showed similar aiming errors when visual feedback was removed. In conclusion, both age and physical activity level clearly impacted eye–hand coordination during discrete manual aiming. This adapted coordination pattern seems to be caused by other factors than an increased reliance on vision.

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1. Introduction

According to the *multiple-process model of limb control* (Elliott et al., 2010) manual aiming movements such as pressing a light button or picking up a glass of wine consist of two consecutive phases: a primary submovement and a homing-in phase. The primary submovement corresponds to the initial pulse towards the vicinity of target. Although this pre-programmed movement phase is traditionally associated with open-loop control (Woodworth, 1899), recent work has shown that subtle movement trajectory corrections can already occur during the primary submovement (i.e., impulse control; see also Khan et al., 2006 and Saunders & Knill, 2003). Still, the main body of closed-loop control occurs during the homing-in phase: here, proprioceptive and visual feedback is used to correct for any spatial discrepancy between hand and target positions (i.e., limb-target control). Previous research has shown that primary submovements generally undershoot the target to allow corrections in the same direction as the initial pulse (Elliott, Helsen, & Chua, 2001; Engelbrecht, Berthier, & O'Sullivan, 2003; Heath, 2005; Helsen, Elliott, Starkes, & Ricker, 1998). This type of correction entails lower energy-costs than correcting for target overshoots, as reversals involve overcoming the inertia of a zero-velocity situation and the limb traveling a greater total distance (Elliott, Hansen, Mendoza, & Tremblay, 2004; Elliott et al., 2010; Welsh, Higgins, & Elliott, 2007).

Interestingly, by slowing down their primary submovement, older adults tend to undershoot the target to an even greater extent than young controls (Ketcham, Seidler, Van Gemmert, & Stelmach, 2002; Poston, Van Gemmert, Barduson, & Stelmach, 2009; Pratt, Chasteen, & Abrams, 1994). As a result, they travel a larger distance in the homing-in phase and consequently need more time to complete feedback-based adjustments (Boisseau, Scherzer, & Cohen, 2002; Ketcham et al., 2002; Lyons, Elliott, Swanson, & Chua, 1996). This results in overall greater movement times. Older adults thus spend relatively more time on the homing-in phase, suggesting an increased reliance on limb-target control (Coats & Wann, 2011; Seidler-Dobrin & Stelmach, 1998).

Though the majority of studies consistently found the abovementioned age-related changes, there are some exceptions. For instance, Lyons et al. (1996) reported no differences between young and older adults' movement times, accuracy levels, and primary submovement trajectories. To explain these unexpected results, the possible influence of a physically active lifestyle was raised. Recently, our lab found support for this statement: When comparing manual aiming kinematics of physically active and sedentary older adults, the typical age-related movement adaptations were observed only in sedentary older adults, but not in physically active ones (Van Halewyck, Lavrysen, Levin, Elliott, & Helsen, in press). Though this study focused mainly on cyclical aiming, its outcome suggests that a physically active lifestyle might counteract the mechanism(s) underlying the age-related alterations of aiming movements. More specifically, high levels of physical activity have already shown to attenuate age effects playing a key role in manual aiming such as sarcopenia (DiPietro, 2001) and the gradual decline in proprioceptive acuity (Wright, Adamo, & Brown, 2011). The level of physical activity should therefore be considered as a possible mediating factor when studying manual aiming in older participants.

Given the role visual feedback plays in limb regulation, it is surprising that most investigators have neglected to examine eye movements. Ocular motor literature has shown that the neuromuscular system underlying eye movements is only slightly affected or even spared by the aging process (Kadota & Gomi, 2010; Pratt, Dodd, & Welsh, 2006; Yang & Kapoula, 2006), as evidenced by equal movement times, movement speeds and saccadic amplitudes during volitional saccades among young and older adults (Pratt et al., 2006). However, recent work suggests older adults' eye-movement control might be compromised during manual aiming: Similar to the hand, older adults tend to make hypometric primary saccades followed by more corrective eye movements during two-segment aiming movements (Rand & Stelmach, 2011b; Rand & Stelmach, 2012). Remarkably, whether older adults' eye-movement control is also modified during one-segment aiming movements has not been studied to date.

Taken together, it remains unclear how both age and physical activity level impact on eye–hand coordination during discrete (one-segment) aiming movements. To address this question, young and older participants were divided in an active and sedentary subsample. Participants were asked to hit a small target as quickly and accurately as possible with a cursor controlled by wrist movements