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Full Length Article

Head flexion and different walking speeds do not affect gait stability in older females

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ABSTRACT

Head flexion is destabilizing in older individuals during quiet stance, yet the effect head flexion has on gait is not known. The study examined whether head flexion and gait parameters were altered when walking freely and fixed to a visual target, at different walking speeds. 15 young (23 ± 4 years) and 16 older (76 ± 6 years) healthy females walked at three different walking speeds (slow, comfortable, and fast) under two visual conditions (natural and fixed [focusing on a visual target set at eye level]). Head flexion was assessed using 2D video analysis, whilst gait parameters (step length, double support time, step time, and gait stability ratio) were recorded during a 9 m flat walkway. A mixed design ANOVA was performed for each variable, with age as the between-subject factor and, visual condition and walking speed as within-subject factors. When walking freely, older displayed a greater need for head flexion between walking speeds ($P < 0.05$) when compared to young. Walking under fixed condition reduced head flexion at all walking speeds in the older ($P < 0.05$), but had no effect on the young ($P > 0.05$). Walking at different speeds showed no difference in head flexion when walking under either visual condition and had no effect on gait stability for both groups. Despite older displaying differences in head flexion between visual conditions, there was no effect on gait parameters. Walking speed presented trivial difference in head flexion in older females, whilst overall gait stability was unaffected by different walking speeds.

1. Introduction

Walking is a habitual activity, requiring transition from a stable to an unstable position, i.e. from double to single leg support. Such movement results in a continuous perturbation in the balance equilibrium, as the centre of mass (COM) alters in relation to the also changing base of support (BOS) (Woollacott & Tang, 1997). This can prove challenging for older individuals (Ihlen et al., 2012; Prince, Corriveau, Hébert, & Winter, 1997), reflected by the fact that the majority of falls occur during walking in older individuals (Rubenstein, 2006).

Given the challenge gait poses to older individuals, head flexion is typically implemented to identify lower limb trajectory and enable better footfall vision (Marigold & Patla, 2008) and to gather more information when walking towards an obstacle (Muir, Haddad, Heijnen, & Rietdyk, 2015). This increased head flexion, whilst enabling better lower visual vision, may however have a negative impact on postural control, and subsequently, on fall risk (De Groot et al., 2014). During walking, at heel strike, the pelvis moves posteriorly due to ground reaction forces, which consequently causes the upper body to rotate forward over the feet, altering the COM towards the limits of the BOS, thus challenging balance (Winter, 1995). A flexed head, weighing ~7% of overall body mass

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(de Leva, 1996), may exacerbate this forward shifting of the COM, further threatening stability or making recovering from an unexpected perturbation difficult (De Groot et al., 2014). During quiet standing in older individuals Buckley, Anand, Scally, and Elliott (2005) reported a destabilising effect of head flexion. Although this destabilising effect has been seen in static conditions, it has not been examined in dynamic conditions and given the previously mentioned problems with falls during walking, it is important to examine the effect head flexion could have to either consider it in future studies and interventions or reject it as a contributor to gait instability.

Head flexion has also been shown to be influenced by gait speed in young individuals. Hirasaki, Moore, Raphan, and Cohen (1999) reported that at speeds $> 1.2\ m{\cdot}s^{-1}$, there was an increased magnitude of head pitch displacement, such that a greater amount of head flexion was observed. Although gait speed is commonly assessed as an outcome measure of functional capacity and gait ability in the older population (Bongers et al., 2015; Montero-Odasso et al., 2004; Toots et al., 2013; Verghese, Holtzer, Lipton, & Wang, 2009), it has rarely been considered the subject of investigation. In other words the effect of different walking speeds on head flexion has rarely been examined in older adults. During day to day life, however, walking at different speeds is required, for example, when walking faster due to being late for an appointment, or in contrast, walking slower to negotiate a busy shopping centre. If the findings by Hirasaki et al. (1999) in young also hold true for older adults, it is feasible that as walking speed increases, concurrently increasing head flexion, postural control may also be increasingly challenged.

In addition to the postural control issue that head flexion could cause during heel strike, it also raises an important methodological question. Gait studies typically instruct participants to focus on a visual target fixed at eye level to standardise head position during walking (Cromwell, Newton, & Forrest, 2002; Hirasaki et al., 1999). Such instructions, which constrain head movement, may mask a true effect, as they would reduce the naturally occurring head flexion. In turn, this could impact on gait stability and postural control, most likely underestimating the true challenge walking poses on older individuals and potentially reaching to erroneous results and less specific intervention advice. Therefore, understanding differences between a natural head position and a typical standardised head position, at different walking speeds, is warranted.

The aim of the study was twofold; to examine A) if head flexion and gait parameters were altered when walking without and with a visual target, and B) how the effect of using a visual target may change at different walking speeds. It was hypothesised that the implementation of a visual target would restrict head flexion, which in turn, would alter gait pattern. Females were the focus of the study as it has been reported that females dynamic stability declines to a greater extent than males (Wolfson, Whipple, Derby, Amerman, & Nashner, 1994) and tend to fall more often (Schultz, Ashton-Miller, & Alexander, 1997).

2. Methods

2.1. Participants

Sixteen healthy older females (age 75.5 ± 6.2 years, height 1.62 ± 0.04 m, body mass 74 ± 6.8 kg) and 15 healthy young females (age 23 ± 3.5 years, height 1.67 ± 0.04 m, body mass 63.3 ± 6.0 kg) participated in the study. Older females were recruited from local community groups while young were students at the Institution. All participants had no known neuromuscular disorders, impaired postural alignment such as kyphosis, osteoarthritis or neck related pain, while older participants were community residing, functionally independent, considered medically stable (Greig et al., 1994). All participants were able to perform all conditions without the use of bifocal or multifocal spectacles and had an uncorrected visual acuity ≥20/100 measured on the day of testing. Ethical approval was obtained from the Institutional Ethics Committee and written informed consent was obtained prior to testing.

2.2. Protocol

Walking trials were performed on an unobstructed 9 m flat walkway under two visual conditions; walking with no visual target and walking with a visual target. In the no visual target condition, no instructions were given to participants as to where to orient their gaze whereas in the visual target condition, participants were instructed to focus on a stationary target located at eye level, 3 m directly ahead of the end of the walkway. The visual target consisted of a black circle (15 cm diameter) on a white background. The position, size and distance of the visual target were decided following pilot testing, which allowed us to design a target which could be comfortably seen by the participants without excessive eye focusing effort. All participants underwent familiarisation with each visual condition and speed, and confirmed they were able to clearly see the target from the beginning of the walkway without the use of glasses.

Three trials were completed at three walking speeds (slow, comfortable, and fast). Instructions for walking speeds were given by associating the walking speeds to everyday activities (Thomas, De Vito, & Macaluso, 2007). Slow walking speed was described as 'the way you would walk during relaxed window shopping'; comfortable as 'how you would normally walk in a relaxed mood' and fast walking as 'how you would walk when late for an appointment'. Participants completed 18 trials in total (three trials per walking speed in both no visual target and visual target condition). The order of visual condition and walking speed was randomised and the mean of three trials was used for analysis.

2.3. Head flexion

To measure head flexion, a marker was placed on the apex of the skull (attached to a headband secured around the participant's