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Review of safety and mobility issues among older pedestrians

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ABSTRACT

Although old people make up an extremely vulnerable road-user group, older pedestrians' difficulties have been studied less extensively than those of older drivers, and more knowledge of this issue is still required. The present paper reviews current knowledge of older-adult problems with the main components of pedestrian activity, i.e., walking and obstacle negotiation, wayfinding, and road crossing. Compared to younger ones, old pedestrians exhibit declining walking skills, with a walking speed decrease, less stable balance, less efficient wayfinding strategies, and a greater number of unsafe road crossing behaviors. These difficulties are linked to age-related changes in sensorial, cognitive, physical, and self-perception abilities. It is now known that visual impairment, physical frailty, and attention deficits have a major negative impact on older pedestrians' safety and mobility, whereas the roles of self-evaluation and self-regulation are still poorly understood. All these elements must be taken into consideration, not only in developing effective safety interventions targeting older pedestrians, but also in designing roads and cars. Recent initiatives are presented here and some recommendations are proposed.

1. Introduction

A common desire among older adults is to stay where they are as they age, while remaining mobile in their familiar environment (Lord and Luxembourg, 2006). The ability to stay connected to community services and to maintain social interactions is considered today to be crucial to well-being and successful aging (for a review, see Yen and Anderson, 2012). Beyond the need for mobility, walking is known to be the most common physical activity of older adults (McPhillips et al., 1989) and to have positive effects on health, cognition, and well-being (see e.g., Fox et al., 2007; for a review, see Kramer and Erickson, 2007). However, walking may be dangerous because it exposes the walker to accident risks and falling.

Within the last few decades, research has mostly focused on the safety of older drivers. The study of older pedestrians is more recent and more limited, even though a large portion of pedestrian accidents involve an older adult. For example, in Italy, Greece and France, more than half of all pedestrians killed on the road are over 65 years of age, whereas this age group represents a much smaller part (17–20%) of the population (ONISR, 2006; SafetyNet, 2009). The same pattern of over-implication of older adults in pedestrian casualties and injuries has also been observed in non-European countries such as New Zealand (Keall, 1995).

Being hit while crossing a street is not the only safety risk encountered by pedestrians: the risk of falls also increases dramatically with aging. About one third of adults age 65 or older have experienced a fall within the past year (for a review, see Lord et al., 2001). More than half of all falls in independent older community-dwelling people occur outside the home (Fothergill et al., 1995; Lord et al., 2001). Although the data are scarce, a study conducted on the US population reported that 77.5% of pedestrian's nonfatal injuries were linked to a fall; accidents while crossing the street (15%) and overexertion (5.8%) were the other main causes (Naumann et al., 2011; see also Abou-Raya and ElMeguid, 2009).

The aim of the present paper was to comprehensively portray older pedestrians' safety difficulties in carrying out three main tasks involved in travel on foot, i.e. walking and obstacle negotiation, navigation, and street crossing. To provide a more general understanding of these difficulties, we also report the underlying functional changes that occur with aging (sensorial, cognitive, and physical) and their consequences on pedestrian safety and mobility. Identifying risky situations and their main causes is a preliminary step toward developing efficient actions aiming at improving the safety and mobility of older pedestri-

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ans. Some of these programs are presented at the end of the paper.

2. Walking and obstacle negotiation

Directly linked to the risk of falling, walking and obstacle negotiation are two major components of pedestrian mobility that change during aging.

2.1. Walking and gait characteristics

A decrease in walking speed during aging is a typical observation, and older women are generally reported to walk more slowly than older men (see e.g., Asher et al., 2012; Knoblauch et al., 1996; Romero-Ortuno, 2010; Romero-Ortuno et al., 2010). Similarly, the acceleration capacity also reduces with aging (Buckley et al., 2009). When required to change from walking at one's preferred speed to walking quickly, the elderly fail to achieve the same increases in speed and stride length as those achieved by young adults (Shkuratova et al., 2004).

Several parameters other than walking speed also change with advancing age, where we find shorter stride lengths, greater standing widths and more time spent on the double support phase (i.e., both feet on the ground), a bent posture, and a less vigorous force development at push off time (Salzman, 2010; Winter et al., 1990). These changes are commonly noted as early as age 65, but become more marked and limit mobility to a greater extent after the age of 85. Cautious walking and standing behaviors may reflect adaptation to age-related changes affecting the sensory, motor, and cognitive systems (for reviews, see e.g., Al-Yahya et al., 2011; Salzman, 2010), and may also mainly express fear of falling (see e.g. Espy et al., 2010). Although such gait disturbances are frequent in older persons and are often an early manifestation of a subclinical disease, about 20% of older adults are found to retain normal gait patterns into very old age (i.e., over 85; see the review by Salzman, 2010).

Among the various phases involved in walking, gait initiation and cessation are the most risky periods due to the complex postural adjustments they require (Uemura et al., 2012). Both walking initiation and cessation slow down with aging (e.g., Cao et al., 1998; Halliday et al., 1998; Winter et al., 1990). This slowing seems to be partly explained by the more cautious strategy of older adults, who need to be careful of their gait (Muir et al., 2014; Tirosh and Sparrow, 2004). It seems that older adults prefer stability over speed (Buckley et al., 2009) and placing priority on this sensorimotor performance may even be detrimental to other kinds of performance (see e.g., Shumway-Cook et al., 1997). With aging, gait cannot be conceived of as the outcome of a series of identical, automatic steps. Instead, gait performance becomes a complex task that places demands on the sensory and cognitive systems (Sheridan and Hausdorff, 2007). Given their fear of falling (e.g., Scheffer et al., 2008) and their need to keep their balance when walking (Woollacott and Tang, 1997), older pedestrians seem to allocate more attention to watching their steps as they cross, causing them to at least partly disregard approaching traffic (Avineri et al., 2012). The presence of curbs at the beginning and end of a street-crossing task may add supplementary cognitive and motor demands that very few studies have examined in a detailed manner (see e.g., Naveteur et al., 2013).

The use of canes or a walker is an effective adaptive means of reducing the risk of falling (for a review, see Alexander, 1996). Logically, older pedestrians using canes or walkers walk more slowly than older pedestrians who are not using such devices, and again, in the case of the use of canes, older women appear to walk more slowly than older men (Thompson and Medley, 1995), although this gender effect is not always observed (Arango and Montufar, 2008).

2.2. Obstacle negotiation

Walking is also challenged by the presence of obstacles such as uneven surfaces (e.g., cobblestone, stones, cracks), but also obstacles to be avoided (e.g., other pedestrians, benches) or to step over. Tripping over an obstacle is actually one of the most common causes of falls among older adults (Blake et al., 1988; Campbell et al., 1989). Avoiding an obstacle is risky too: having to change one's direction while walking is associated with more gait variability and a risk of falling among older people (Meinhart-Shibata et al., 2005).

Several adaptive strategies are used by older pedestrians who are confronted with obstacles. Older adults tend to adopt a slower, more conservative obstacle-negotiation strategy that gives them more time to adjust their foot trajectory (for a review, see Galna et al., 2009). In the presence of uneven surfaces, for example, they have been shown to decrease their walking speed and their step length more than younger adults do (Marigold and Patla, 2008). Moreover, older adults have been found to spend more time looking at the ground during obstacle avoidance, whereas younger adults spend more time gazing straight ahead (Paquette and Vallis, 2010). Finally, the maintenance of a large personal space between themselves and other pedestrians is another strategy used by older adults to reduce the risk of bumping into someone and falling (Gérin-Lajoie et al., 2006).

One of the main obstacle-negotiation situations encountered by city-dwelling pedestrians is handling sidewalks. Despite efforts from local authorities to provide lowered sidewalks at pedestrian crossings, moving from a sidewalk into the street is frequently associated with gutters and level or surface changes that challenge older pedestrians. While specific studies on sidewalk negotiation during street crossing by older pedestrians are scarce, some insights have been provided by studies about climbing stairs and stepping over obstacles with aging. Indeed, going up and down stairs is rated by older adults to be among the most difficult tasks in their daily life (Williamson and Fried, 1996). Falls are three times more frequent during descent than ascent (Svanström, 1974; Tinetti et al., 1988), which seems often to be explained by a decline in the ability to regulate body sway during the stair-to-floor transition when descending (Lee and Chou, 2007). In response to these changes, older adults adopt cautionary behaviors in stair cases, such as lowering their speed, watching their feet while walking, and using the handrails (Hamel and Cavanagh, 2004).

3. Wayfinding

Wayfinding is another important pedestrian activity. It can be divided into preparing for the journey (i.e., planning) and navigating while walking (i.e., moving and orientation).

3.1. Planning the journey

Efficient navigation requires making decisions about how to reach a given destination while satisfying various constraints such as avoiding having to walk overly long distances or avoiding barriers (Salthouse and Siedlecki, 2007). This ability is typically tested with laboratory tasks such as the multiple errand test (Shallice and Burgess, 1991) or the zoo map task (Wilson et al., 1996), which require using a map provided to carry out certain activities (e.g., shopping, visiting people). Older adults are generally found to be less efficient than young ones at determining the complex course of actions needed to reach the predefined goal; they make more mistakes and take more time to prepare the journey (Allain et al., 2005; Sander and Schmitter-Edgecombe, 2012). These findings are problematic, because before navigating to an unfamiliar place, older pedestrians often plan their journey on a map in order to reduce