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The degree of misjudgment between perceived and actual gait ability in older adults

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ABSTRACT

Successful execution of motor tasks requires an integration of the perception of one's physical abilities and the perception of the task itself. Physical and cognitive decline associated with ageing may lead to misjudgments of these perceived and actual abilities and possibly to errors that may lead to balance loss. We aimed to directly quantify the degree to which older adults misjudge their actual gait ability. Twenty-seven older adults participated and were instructed to walk on a narrow path projected on a treadmill. We tested two paradigms to estimate the participants' perceived gait ability: a path width manipulation, in which participants had to indicate the smallest path width that they could walk on without stepping outside or losing balance (at given speed), and a treadmill speed manipulation, in which they had to indicate the maximum speed that they could use at a given path width. We determined their actual ability as the probability of stepping inside the path over a range of path widths and speeds. The path width paradigm seemed suitable for evaluating self-perception of actual gait ability and revealed that participants appeared to show a range of misjudgment towards either over- or underestimating their actual abilities. Better abilities appeared not associated with better judgment. Direct quantification of the degree of misjudgment provides insight in the interplay between cognition and physical abilities and can be of added value towards prevention of falls and promotion of healthy ageing.

1. Introduction

For optimal motor performance, we need to predict the results of our motor actions in different circumstances. This predictive ability requires estimation of one's own physical abilities. Although this knowledge is not always perfect [15], in most cases we are nevertheless able to make an educated guess whether execution of a planned task can be performed successfully. Already at a young age, infants learn whether or not to move down a slope based on their locomotor abilities [1]. At the other side of the age spectrum, physical decline [28,24,21] requires accompanying adjustment of the perception of these abilities to select the appropriate motor strategy in view of the motor task requirements. This adjustment might even be all the more challenging due to the age-related brain changes such as reduced neural plasticity [25,16] and cognitive functioning [21]. Erroneous perception of one's own physical abilities or of the task requirements could lead to excessive risk-taking on the one hand [3], or needles avoidance of activities on the other hand [5].

Almost one-third of the older adults misjudged their physiological fall risk [4]. Age-related perceptual (mis)judgement of physical abilities has further been studied in gait related tasks. For example in aperture crossing, older adults rotate their shoulders more compared to young adults [8,9] and in stair climbing, older participants appear more likely to choose a step height which matches their maximum achievable step height than their younger peers [14], suggesting that estimates on physical capacities are adjusted with ageing. Nevertheless, 20% of the observed older persons overestimated their maximum step height, whereas 10% underestimated their maximum achievable step height [14]. Sakurai et al. [19] compared the estimated and actual height for stepping over a bar and found that 18% of the older adults overestimated the bar height that they could overstep. These studies mainly tested perception of abilities limited by physical dimensions, such as shoulder width or leg length.

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The relation between physical ability and perceived ability regarding balance control has been studied by Butler and co-workers [3] in plank crossing. They investigated the behavioural risk that older adults were willing to take by comparing individuals' selected plank width with the probability to make errors on this width measured during over ground walking. They found that persons whose behavioural risk matched their physical ability were less likely to experience a fall in the forthcoming year than their peers who took higher risks [3]. However, participants chose a plank to cross but were not actually allowed to cross it. The chosen plank width was compared with the stepping accuracy on an 18-cm wide path at ground level. Perceptual judgment may in this design be affected by plank height or length, and for actual ability ceiling effects may have occurred given the fixed path width.

We aimed to directly quantify the agreement of older adults' perceptual judgment and their actual ability in a daily life task (i.e., walking). We propose two paradigms of testing actual gait ability: a path width manipulation and a speed manipulation and asked participants to indicate the smallest path width (at given speed) and maximum speed (at given path width) at which they believed they could accurately perform, i.e., walk without stepping outside the path or losing balance. These manipulations were expected to affect step accuracy during gait. Narrowing the path width reduces the base of support and a more strict control of the centre of mass movement is needed to successfully complete the task [2,20]. Older adults have also been shown to decrease gait speed when walking on a narrow path [20,6], suggesting that more time is needed in narrow base walking for more strict control of foot placement. For both path width and speed manipulations, the perceived and actual abilities can be determined and compared to provide insight into the older adult's degree of misjudgment. Since one-third of older adults misjudges their fall risk [4], we expected no strong correlation between the perceived and actual gait ability. Furthermore, since sport experts are more accurate at judging their capabilities than their less expert peers [26,27], we hypothesised that older adults with better gait performance levels judge their actual abilities better than those performing less.

2. Methods

2.1. Subjects

Twenty-seven older adults (74.4 SD 5.6 years, 16 females) participated. Persons who had a mini mental state examination (MMSE) score of 24 or lower, were not able to walk continuously and without walking aid for 10 min, reported any musculoskeletal or neurological impairments or major trauma in the last year, or took medication which could have affected their gait stability, were excluded from participation. All participants signed an informed consent, which was approved by the local research ethics committee (#2015-50).

2.2. Protocol

Before the gait ability test, we assessed participants' self-efficacy [13], using the Dutch version of the Falls Efficacy Scale International (FES-I, [29]) and their physical capacities by measuring grip strength (A5401-Digital Hand Grip Strength Dynamometer, Take, Niigata, Japan) and knee extension strength (MicroFET 2, Hoggan Health Industries, Draper, UT).

Participants were familiarised with walking on a large, motor-driven treadmill at a speed of 1.11 m/s (S-Mill, Forcelink, Culemborg, The Netherlands; length × width: 4 × 3 m) for at least 3 min or longer if considered necessary by the participant or experimenter. A projector (CP-X5022WN, Hitachi, Tokyo, Japan) projected in the walking direction on the treadmill a visual path; a yellow rectangle of which the width could be varied while the virtual path length was always 20 m, irrespective of speed. Participants wore a safety harness, attached by ropes to the ceiling. First, the self-perceived path width performance ($Width_{perc}$) was determined by instructing the participants to indicate the narrowest path width they perceived they could walk on without stepping outside the path's boundaries, at the speed they experienced during the familiarisation period. This procedure was done on a stationary treadmill, by scrolling the scroll-wheel of a handheld computer mouse to adjust the width of the projected path, and repeated four times and randomised in two directions, by broadening a path starting at 0.05 m and narrowing a path starting at 0.50 m. Secondly, the actual path width was determined by subjecting the participants to 3 repetitions of 5 randomised paths widths (0.120, 0.144, 0.160, 0.178, 0.200 m) while walking at a speed of 1.11 m/s. There was at least 10 m without projection before a new path was presented. Thirdly, the participants walked at 1.11 m/s, and a 0.16 × 0.16 m square was projected 1.50 m in front of them for 10 seconds. Then the projection disappeared and the treadmill simultaneously switched to a self-paced mode. This mode allowed participants to control their own gait speed by speeding up or slowing down. The algorithm the treadmill obeyed was conform Eq. (1) ([23] for details). This equation is based on a standard PD-controller and controls the belt using participant's position (x) and gait speed ($\dot{x}$). The parameters K_x and $K_{\dot{x}}$ are respectively a position-gain and a speed-gain, and were set at 0.6 and 1.2.

$$\ddot{x} = K_x \cdot \Delta x - K_{\dot{x}} \cdot \dot{x} \cdot \Delta x \quad (1)$$

Participants were instructed to adjust their speed as soon as the square disappeared and indicate the fastest speed they believed they could walk without stepping outside the path at the previously indicated path width. Prior to this speed manipulation, participants were given the opportunity to familiarise again for at least 3 min with the self-paced mode of the treadmill. The mean speed of four repetitions was used to determine the self-perceived speed (v_{perc}). Finally, we determined the actual speed (v_{act}) by asking the participants to walk on paths of a fixed width of 0.16 m for 3 repetitions at 5 different speeds (0.83, 0.97, 1.11, 1.25, 1.39 m/s). The order of speeds was randomised over subjects and for each speed, the participants performed 3 paths before the speed changed. In all experimental testing participants walked without any assistive walking device.

2.3. Data acquisition and analysis

Feet and pelvis kinematics were measured using an OptoTrak motion capture system (Northern Digital Inc., Ontario, Canada). Three rigid clusters with three infrared light emitting diodes each, were placed on the participant's heels and lower back and were captured by a 2 × 3 camera array. The feet were considered as rigid segments and a pointer was used to indicate the outer boundaries of the shoe (Fig. 1) as well as the position of the projected path in space. Separate pointer recordings were combined to express the projected path and foot markers in global coordinates [30]. Gait events (toe-offs and heel strikes) were automatically detected from the kinematic data [12], and visually checked. From these boundaries (Fig. 1), the positions of the middle of the foot at mid-stance were determined. A Gaussian probability curve was fitted to the mediolateral mid-stance foot position data. This enabled the computation of the probability of successfully stepping with the entire foot inside the projected path ($P(path)$, Fig. 1) according to Butler et al. [3]. Following this calculation, $P(path)$ depended on the combination of step width, step width variability, and the mean