Gait & Posture 41 (2015) 119–124

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Gait shows a sex-specific pattern of associations with daily functioning in a community-dwelling population of older people

Vincentius J.A. Verlinden [a,b], Jos N. van der Geest [c], Jan Heeringa [a], Albert Hofman [a], M. Arfan Ikram [a,b,d,*]

[a] Department of Epidemiology, Erasmus MC University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands
[b] Department of Radiology, Erasmus MC University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands
[c] Department of Neuroscience, Erasmus MC University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands
[d] Department of Neurology, Erasmus MC University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands

ARTICLE INFO

Article history:
Received 22 May 2014
Received in revised form 13 August 2014
Accepted 13 September 2014

Keywords:
Activities of daily living
Aging
Gait
Sex
Walking

ABSTRACT

Background: Gait is increasingly considered an important indicator of health. Yet, little is known on the relation of gait with established health indicators, e.g. daily functioning. Although gait differs by sex, it is unknown whether different gait domains provide different health indicators in men or women. We investigated how gait associates with basic and instrumental activities of daily living (BADL and IADL) in community-dwelling persons.

Methods: In 2500 participants of the population-based Rotterdam Study (aged ≥50yrs), gait was assessed by electronic walkway and summarized into seven independent gait domains: Pace, Rhythm, Phases, Tandem, Turning, Variability, Base of Support, which were averaged into Global Gait. We assessed BADL with the disability index of the Stanford Health Assessment Questionnaire and IADL with the Instrumental Activities of Daily Living scale. BADL and IADL were analyzed as continuous scores, and dichotomised: with impairment defined as moderate to very severe disability.

Results: In men, Global Gait, Pace, and Rhythm associated with BADL in linear analyses. In contrast, all domains except Base of Support associated with BADL or IADL in women. Associations of Global Gait and Phases with BADL were significantly stronger in women (p-interaction < 0.05). Similarly, associations of Global Gait, Rhythm, and Phases with IADL were stronger in women (p-interaction < 0.05). For dichotomised analyses, higher Global Gait, Pace, and Rhythm associated with less BADL-impairment in men, while Global Gait associated with less BADL and IADL-impairment in women.

Conclusions: In men, Pace and Rhythm may suffice as health indicators, while women may require comprehensive gait assessment to better estimate their health status.

1. Introduction

Daily functioning is an important indicator of health that requires integration of many abilities [1,2]. With aging, people deteriorate in daily functioning, leading to loss of independence and institutionalization [1,3]. Daily functioning is generally assessed using activities of daily living (ADL), including physical basic ADL (BADL), e.g. dressing, and cognitive instrumental ADL (IADL), e.g. finance management [4]. Proper functioning across this whole spectrum is an indicator of health and essential to function independently in society.

Similarly, the walking pattern, or gait, is increasingly considered an important indicator of health [5,6]. Poor gait is a strong risk factor of both falls and death [6–10]. Additionally, gait relates to many abilities, such as cognition, and may even be a risk factor of dementia [11–15]. Hence, studies have increasingly suggested that gait may be a valid outcome measure of health in both clinical and research settings [5,6]. Little is known on the relation of gait with established health indicators, such as BADL and IADL that are commonly studied as outcome measures. More importantly, although gait differs strongly between the sexes, sex-differences in associations of gait with BADL and IADL have not been investigated [16].

* Corresponding author at: Department of Epidemiology, Erasmus MC University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands. Tel.: +31 107043930; fax: +31 107043489.

E-mail addresses: v.verlinden@erasmusmc.nl (Vincentius J.A. Verlinden), j.vandergeest@erasmusmc.nl (J.N. van der Geest), j.heeringa@erasmusmc.nl (J. Heeringa), a.hofman@erasmusmc.nl (A. Hofman), m.a.ikram@erasmusmc.nl (M.A. Ikram).

http://dx.doi.org/10.1016/j.gaitpost.2014.09.003
0966-6362/

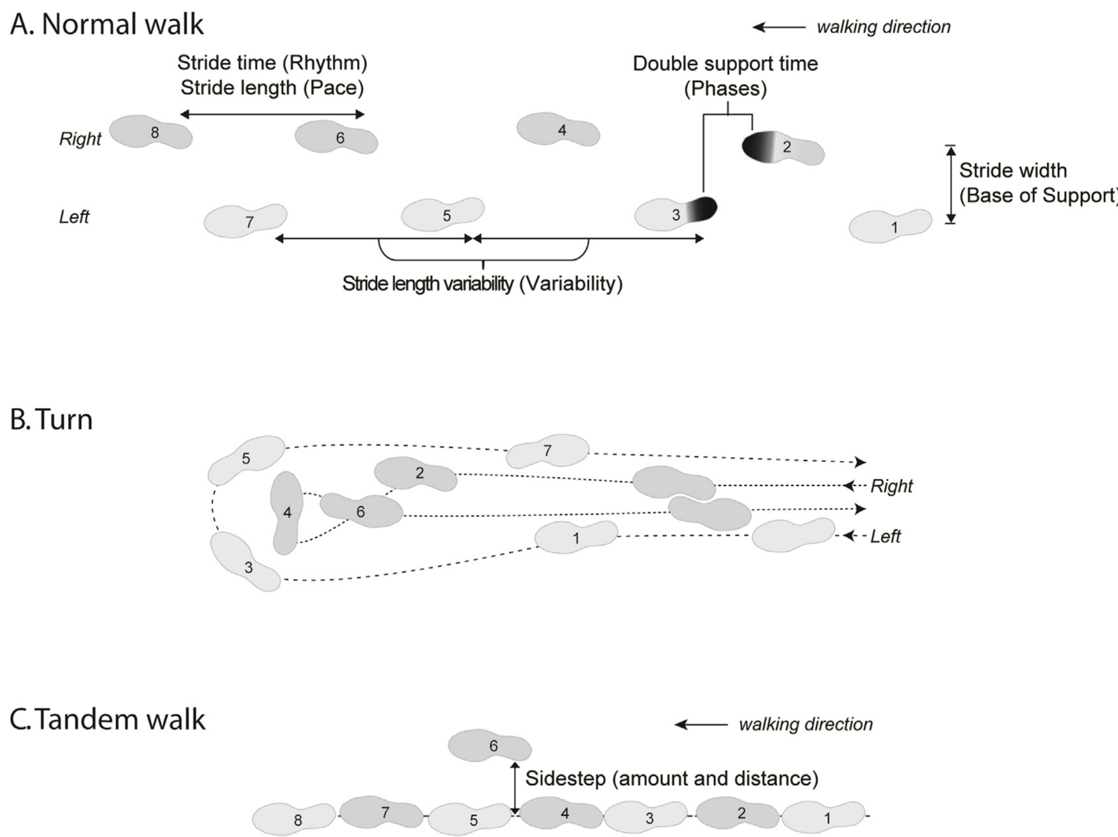

Fig. 1. The three walking conditions. (A) Normal walk, including five gait parameters that constitute different gait domains. (B) Turn. Only feet that were taken into account for the turning time or turning step count calculation were numbered. In this case, turning step count was 5 (number of feet minus 2). Turning time was calculated from last contact of foot 1 until first contact of foot 7. (C) Tandem walk. Sidesteps were quantified as the distance from the line on the walkway and the surface of the sidestep foot on the walkway, relative to the average normal foot. Additionally, double steps with the same foot on the line were considered errors.

Gait is a complex concept, assessed using many different parameters. Recently, for ease of interpretation and use in research, studies have summarized these parameters into seven independent gait domains that together comprehensively describe gait (Fig. 1) [16,17]. Pace, which captures gait velocity, has been investigated as a health indicator and associates with BADL and IADL, but sex-differences have not been investigated [2,18–20]. Also, relations of other domains with BADL and IADL have not been studied intensively. Different gait domains reflect different abilities, such as physical strength, cognition, and balance, and each may provide unique information in relation to BADL and IADL [11–13,15].

In a population-based study of community-dwelling older people, we investigated sex-specific associations of various gait domains with BADL and IADL.

2. Methods

2.1. Setting

The study was embedded in the Rotterdam Study [21]. The current study includes participants aged 50 years and older. At baseline and every 3–4 years of follow-up, participants undergo home interviews, including questionnaires on BADL and IADL, and medical examinations at the research center. During examinations, height, weight, Center for Epidemiologic Studies Depression Scale (CES-D) [22], and Mini-Mental State Examination score (MMSE, cognition) [23] are assessed. Gait assessment was implemented from March 2009 onwards, and until December 2011 3242 participants were invited for gait assessment. All participants gave written informed-consent. The study was approved by the medical ethics committee.

2.2. Gait assessment

Details on the gait assessment protocol are described elsewhere [16]. Gait was assessed with a 5.79 m long electronic walkway (4.88 m active area; GAITRite Platinum; CIR systems, Sparta, NJ, USA), in three conditions: normal walk, turn, and tandem walk (Fig. 1). In normal walks, participants walked over the walkway at their usual pace. This was performed eight times. In turn, participants walked at their usual pace over the walkway, turned halfway, and returned to the starting position. In tandem walk, participants walked tandem (heel-to-toe) over a line visible on the walkway. The first normal walk was considered a practice walk and excluded from analyses. The other seven normal walks were combined for calculation of gait parameters in normal walking. Turning time and turning step count were calculated from the turning condition after removing feet that did not belong to the turn (see Fig. 1). Sidesteps in tandem walking were quantified by the distance from the line, and the surface of the sidestep on the walkway as a percentage of the average normal foot. Additionally, double steps on the line with the same foot were considered errors in tandem walking.

Principal components analysis (PCA) was used to reduce the number of gait parameters into fewer gait domains, while capturing the largest amount of variance. Gait domains should explain at least as much variance as a single parameter. The 30 gait parameters included in the PCA were summarized into seven independent gait z-scores, or domains, as described previously: