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# Asymptomatic radiographic hip osteoarthritis is associated with gait differences, especially in women: A population-based study

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ABSTRACT

*Background:* Hip and knee osteoarthritis (OA) are debilitating diseases that impair gait at severe stages. Although associations between OA and gait are established for normal walking, little is known about its relation with turning and tandem (heel-to-toe) walking. Furthermore, it is unknown how asymptomatic OA associates with gait, and whether associations differ by sex. We investigated how symptomatic and asymptomatic hip and knee OA associate with gait in community-dwelling individuals.
*Methods:* In 2706 participants of a population-based cohort study, gait was assessed by electronic walkway and summarised into seven gait domains. Hip and knee radiographs were graded for radiographic OA (ROA) using the Kellgren and Lawrence (K&L) score. Linear regression was used to investigate associations between ROA and gait. Analyses were repeated including only participants with asymptomatic ROA, defined as a K&L-score of 2 without pain.
*Results:* In total, 177 participants (6.5%) had hip ROA and 441 (16.3%) knee ROA. We found no associations of knee ROA with gait. Hip ROA associated with Rhythm, Tandem, and Turning. Furthermore, unilateral hip ROA associated with larger gait asymmetry and gait differences in osteoarthritic and non-osteoarthritic leg, when compared to people without hip ROA. Associations between hip ROA and gait were generally stronger for women than men. Associations for hip ROA remained after restricting to asymptomatic ROA.
*Conclusion:* Hip ROA, but not knee ROA, associates with gait differences in normal walking, turning, and tandem walking in community-dwelling individuals. These associations differ between the sexes, and are already present for asymptomatic ROA.



## 1. Introduction

Osteoarthritis (OA) is a debilitating disease that limits people in daily functioning, eventually leading to loss of independence [1,2]. Hip and knee OA are common in the elderly (7–30% aged ≥ 65 years) and characterised by joint pain and stiffness, which may severely impair gait [2–10].

Gait is an important health indicator and poor gait associates with higher fall risk and mortality [11–15]. Gait is a complex concept that is assessable using many parameters. These parameters, as assessed by electronic walkways, can be summarised into seven gait domains comprehensively describing gait [16,17].

Of domains, previous studies found hip and knee OA to associate with Base of Support (larger step width), Pace (slower gait velocity), Phases (shorter support on both legs), Rhythm

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(higher cadence), and Variability (larger gait variability) [5–10]. Additionally, unilateral OA associated with gait asymmetry [6–8].

Yet, previous studies on gait included clinical patients with severe and symptomatic OA [5–10,18]. Little is known on associations of OA with gait in a community-dwelling population. Moreover, it remains unclear how subclinical asymptomatic OA associates with gait, with the only study finding no differences for asymptomatic knee OA [18]. However, gait differences in asymptomatic OA may indicate early clinical impact, through increased fall risk and mortality [12–14]. Although sex-differences in knee OA have been reported, it is unknown whether sex influences associations of hip OA with gait [9]. Furthermore, previous studies focused on gait in normal walking, while it is unknown how OA relates to gait in other walking conditions [5–10].

We hypothesized that hip and knee OA associate with gait differences in the general population, even at an asymptomatic stage. Furthermore, we hypothesized that these associations would differ by sex. Hence, we investigated associations of radiographic hip and knee OA with gait in normal walking, turning, and tandem walking, in community-dwelling individuals. Additionally, we investigated sex differences and associations for asymptomatic OA.

## 2. Materials and methods

### 2.1. Setting

This study was embedded in a prospective population-based cohort study initiated in 1990, aimed to investigate causes and determinants of chronic diseases in middle-aged and elderly [34]. The cohort was extended in 2000 and 2005, including people aged ≥45 years. At baseline and every 3–4 years of follow-up, participants undergo home interviews and extensive examinations at the research centre. From March 2009 onwards, gait assessment was included in the core study protocol. Gait assessment was primarily introduced to investigate effects of brain pathology on physical functioning. The current study includes all participants that completed gait assessment between March 2009 and March 2012. The study was approved by the medical ethics committee. Written informed consent was obtained from all participants prior to study inclusion.

### 2.2. Hip and knee OA assessment

Radiographic assessment of hips and knees was performed on participants as part of the population-based study, without specific indication. Weight-bearing anteroposterior hip and knee radiographs were obtained as previously described [35]. Hip and knee OA were scored using the Kellgren and Lawrence (K&L) grading system. Radiographic OA (ROA) was defined as a K&L-score ≥ 2 [19].

In a sub-population, joint pain was identified with pain homunculi, showing pictures of the front and back of the human body. Participants were asked: "Did you have pain anywhere in your body, for at least half of the days, during the last six weeks?" If answered positively, participants marked painful areas. A template was used to assign these areas to 14 different joint regions. For the current study, only pain in hip or knee was considered.

Joints were considered to have asymptomatic ROA when having a K&L-score of 2 without pain.

### 2.3. Gait assessment

Details on gait assessment have been described elsewhere [36]. Gait assessment was performed regardless of radiographic parameters or pain scores. Gait was assessed using a 5.79m. electronic walkway (4.88m. active area; GAITRite Platinum; CIR systems, Sparta, NJ, USA). Participants walked in three conditions: normal walk, turn, and tandem walk. In normal walk, participants walked at usual pace. This process was performed eight times. The first was considered a practice walk and excluded from analyses. In turn, participants walked at usual pace over the walkway, turned halfway, and returned. In tandem walk, participants walked heel-to-toe over a straight line.

Principal components analysis was used to summarise 30 gait parameters (means of both legs) into seven independent domains (z-scores), as described previously: Base of Support, reflecting step width and step width variability; Pace, reflecting step length and velocity; Phases, reflecting double support time and single support phase (single support as a percentage of the gait cycle); Rhythm, reflecting cadence and single support time; Tandem, reflecting errors in tandem walking; Turning, reflecting turning step count and time; and Variability, reflecting step variability in length and time [36]. To evaluate single leg walking behaviour, we used the highest correlating gait parameter from each domain that could be calculated for a single leg: step width variability for Base of Support, step length for Pace, single support phase for Phases, single support time for Rhythm, and step length variability for Variability [36]. Walking behaviour of single legs was not assessed for Tandem and Turning. Gait asymmetry was calculated as gait parameter values for the left minus values for the right leg.

### 2.4. Study population

Between March 2009 and March 2012, 3651 persons were invited for gait assessment.

Of these, 119 persons did not undergo gait assessment for following reasons: perceived physical inability (n = 61), technical reasons (n = 44), refusal (n = 12), and other reasons (n = 2).

Of remaining participants, we excluded 35 for performing less than 16 steps in normal walks [20], 13 for use of walking aids, and one for not following instructions.

Of 3483 participants with valid gait assessments, 2852 had radiographs of both hips and/or both knees. Of these, 146 participants were excluded for total hip or knee replacements. Of 2706 included participants, 2611 had gradable radiographs of both hips and 2680 of both knees.

Numbers of participants slightly varied among analyses for missing turn or tandem walk (in analyses on gait domains) or bilateral ROA (in analyses on unilateral ROA). Exact numbers of participants included for analyses are provided in legends of the respective tables.

### 2.5. Statistical analysis

We performed four distinct analyses to separately investigate associations of hip and knee ROA with gait.

First, we used linear regression to investigate differences in gait domains between people with ROA (bi-/unilateral) and without ROA.

Second, we used linear regression to investigate differences in gait asymmetry in unilateral ROA compared to no ROA. To ensure results inform on differences in gait asymmetry between unilateral ROA cases and people without ROA, we recoded the ROA variable. Difference in asymmetry of left-sided ROA compared with no ROA is expected to be similar to that of right-sided ROA compared with no ROA, but in the opposite direction. Hence, in asymmetry analyses, we recoded ROA of hip and knee as 1 if present in the left leg, 0 for no ROA, and −1 if present in the right leg. In this way the opposite direction is taken into account and left and right-sided ROA may be investigated in the same analysis. Since the difference