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The impact of symptomatic knee osteoarthritis on overall gait pattern deviations and its association with performance-based measures and patient-reported outcomes

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ABSTRACT

Background: Limited knowledge exists regarding the impact of symptomatic knee osteoarthritis (OA) on the overall gait pattern; and whether gait deviations are associated with performance-based measures (PBMs) and patient-reported outcomes (PROs). This cross-sectional study evaluated overall gait patterns in patients with knee OA using the Gait Deviation Index for kinematics (GDI) and kinetics (GDI-kinetic), and explored associations between gait deviations, PBMs, and PROs.

Methods: Forty patients with knee OA and 25 age and gender-matched controls underwent three-dimensional gait analysis. Participants performed the Timed Up and Go (TUG), Five Times Sit-to-Stand (5STS), and Single Limb Mini Squat (SLMS) tests and completed a disease-specific PRO. Associations between gait deviations, PBMs, and PROs were assessed by Pearson's correlation and multiple linear regression.

Results: Patients with OA demonstrated significantly lower GDI and GDI-kinetic scores of the OA and contralateral limbs compared to controls; with GDI-kinetic scores on the contralateral limb more impacted than the OA limb. On the contralateral limb, GDI-kinetic score significantly correlated with TUG ($r = -0.42$) and 5STS ($r = -0.33$), while on the OA limb with TUG ($r = -0.68$), 5STS ($r = -0.38$), SLMS ($r = -0.38$), activities of daily living ($r = 0.35$) and Knee-related Quality of Life ($r = 0.35$). No significant associations existed between kinematic GDI scores, PBMs and PROs.

Conclusion: The overall gait pattern, as represented by GDI and GDI-kinetic scores, in patients with symptomatic knee OA is affected both on the painful OA limb and the contralateral limb. The GDI and GDI-kinetic scores provide different information regarding function that is not revealed by PBMs or PROs.

Abbreviations: GDI, Gait Deviation Index kinematics; GDI-kinetic, Gait Deviation Index-kinetics; 5STS, Five Times Sit to Stand; TUG, Timed Up and Go; SLMS, Single Limb Mini Squat test.

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1. Introduction

Knowledge concerning altered gait patterns in patients with knee osteoarthritis (OA) has grown over the last decades and focuses primarily on specific alterations to gait. Data suggest decreased amplitude of the knee flexion moment, diminished range of knee motion [1], and increased magnitude of the knee adduction moment during stance [2] are evident in adults with OA pathology. These gait deviations appear to increase with disease severity [3]. Additionally, increased magnitude of overall knee adduction moment, together with altered sagittal plane movements is indicative of future total knee replacement (TKR) [4]. In patients with knee OA, studies report that the kinematics and kinetics of the contralateral knee, and joints other than the knee are also affected [1,5], and involvement of more than one joint will likely influence the patients' compensation strategies during walking. The altered kinetics of the contralateral limb may exacerbate progression of OA [6].

By examining gait using three-dimensional (3D) motion analysis, we can obtain unique and detailed information regarding separate joint angles (kinematics) and joint loadings (kinetics). Despite the fact most studies examine discrete variables, measured at specific time-points of the gait cycle, methods to evaluate the overall gait pattern throughout the entire gait cycle exist. The Gait Deviation Index (GDI) and GDI-kinetic summarize gait patterns captured by 3D gait analysis and provide a score describing the degree to which an individual's gait pattern deviates from normal gait pattern [7,8]. The GDI summarizes the gait pattern of each limb, including all major lower extremity joints, and taking the entire gait cycle into account. In doing so, the GDI provides an index score of overall gait pattern deviations, without the limitation of merely choosing a few specific gait variables, and may therefore be useful in the clinic to guide and evaluate treatment [7,8]. Additionally, it may be more convenient for a clinician, patient or non-expert to work with a comprehensive measure such as an index score describing the overall gait pattern expressed as the degree of deviation from normal gait. The GDI has previously been used in studies evaluating patients with different neurological diseases [9,10], patients with rheumatoid arthritis [11], and patients with hip OA [12,13]. In patients with severe hip OA, higher physical function and quality of life scores were associated with a better (closer to normal) overall gait pattern [13]. The GDI-kinetic was developed in 2011 [8], and has been used to quantify the impact of medical treatment in patients with rheumatoid arthritis [14], and in patients with knee OA post-TKR [15].

In patients with OA, function is often evaluated using questionnaires, even though patient-reported outcomes (PROs) of function have been shown to be independent of measured capacity [16–18]. The Osteoarthritis Research Society International and the Outcome Measures in Rheumatology and Clinical Trials organizations encourage the use of clinical outcomes, including performance-based measures (PBMs) and PROs in trials involving individuals with OA [19], but currently no gold standard assessment exists [20]. Since PROs of function reflect patients' perceptions and are highly influenced by pain [16], and PBMs lack the ability to capture subtle, but possibly important aspects of movement patterns, it is necessary to integrate other methods to accurately quantify function. Gait is a fundamentally important and complex activity that can be affected by pathology. Therefore, it is important to evaluate gait patterns, providing overall measures of how it deviates from normal but also with explanations in detail on the underlying specific joint dyscoordination, and how these are influenced by the pathology of knee OA. Thus, a combination of measurements that includes quantitative 3D gait analysis may provide a more comprehensive description of joint function, enhance the understanding of associated impairments, and inform rehabilitation. To our knowledge, the GDI and GDI-kinetics have not been validated against other clinical outcome measures in patients with knee OA.

This study examined the impact of symptomatic knee OA on overall gait pattern in patients scheduled for a TKR. The GDI for kinematics and GDI-kinetics were used to quantify gait deviations in patients with knee OA and compared to age and gender matched controls. Further, we explored associations between overall gait pattern, PBMs and PROs of function and pain.

2. Methods

2.1. Participants

Forty patients with knee OA were recruited from two orthopedic clinics in Stockholm, Sweden (Ortho Center, Löwenströmska hospital, Karolinska University Hospital). Patients were included if they: had physician diagnosed primary knee OA, were scheduled for TKR within one month, were able to walk 10 m repeatedly without the use of a walking aid, and could understand verbal and written information in Swedish. Exclusion criteria were: total joint replacement in hip or knee within the last 12 months, rheumatoid arthritis, diabetes mellitus, neurologic disease and/or other condition affecting walking ability. Stockholm's regional ethical review board approved the study and participants provided written informed consent in accordance with the Declaration of Helsinki. We included all patients with knee OA who met the inclusion and exclusion criteria and agreed to participate (Table 1). A sample of 25 healthy controls without any known musculoskeletal disease or neurological disorder was recruited through acquaintances during 2013–2015. Controls were matched to patients with knee OA by gender and age strata (40–49, 50–59, 60–69, 70–79, 80–89 years of age). The control group performed the entire test protocol as the OA group did (including gait analysis, performance-based tests and PROs), and was used for all comparisons between OA vs controls.

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