Racial differences in gait mechanics associated with knee osteoarthritis

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ABSTRACT. Background and aims: This study examines racial differences in gait mechanics in persons with knee osteoarthritis and the influence of anthropometrics, educational level, radiographic disease severity (rOA), and self-report measures of pain and disability on racial differences in gait. Methods: One hundred seventy five (64 black and 111 white) adults with radiographic knee OA were tested. 3-D kinematic and kinetic data were collected while subjects walked at two self-selected speeds (normal and fast). Anthropometric data, radiographic level of OA, and self-report measures of pain and disability were also collected. Gait patterns were compared across groups and within groups. Results: Black and white subjects did not differ significantly in radiographic OA. However, blacks walked significantly more slowly when asked to walk fast. At the normal speed, blacks had a smaller knee range of motion and loading rate than whites. Blacks also took longer to reach their peak maximum ground reaction force than whites. Within black subjects variations in gait mechanics were primarily explained by BMI, rOA, self-reported psychological disability, and pain self-efficacy. In white subjects, variations in gait mechanics were primarily explained by weight, age, velocity, psychological disability, and self-efficacy. Conclusions: Blacks in this study had a pattern of gait mechanics generally associated with high levels of osteoarthritis, though they did not differ significantly in rOA from whites. The variability in gait patterns exhibited by blacks was most strongly related to variance in walking speed, anthropometrics, and perceived physical ability. Taken together, these results suggest that race is an important factor that must be considered in the treatment and study of osteoarthritis.

INTRODUCTION

Osteoarthritis (OA) is one of the most prevalent musculoskeletal conditions, affecting more than 4.3 million adults over age 60 (1). Previous studies have examined the many factors, including obesity (2), age (2, 3), gender (4), lower extremity injury (5), and disease severity (6, 7), as well as self-report measures of pain, disability, and arthritis self-efficacy (6, 7), that might explain variations in locomotor disability in persons with knee OA. As a result, it is known that age, body composition, radiographic disease severity, and self reports of pain and disability, as well as attitude and one's confidence about their ability to control arthritis, all strongly influence mobility and gait disability of knee OA patients through kinematic adaptations such as reduced walking speed and limb range of motion (2, 3, 8-14).

Another important factor that is likely to influence gait variations in patients with OA is race. Yet the relationship between gait disability associated with OA and race has been largely under-investigated. This is surprising considering emerging evidence of racial disparities in disability in other persistent pain conditions (15) and racial disparities in other substantial health issues in the United States, including heart disease, obesity, and diabetes. Moreover, blacks with knee OA have greater radiographic severity and more mobility impairment than whites with OA (16-18). Previous studies have explored racial variation in self reported OA symptoms (19), as well as the relationship between race and spatiotemporal gait variables such as speed and support time (20). They found that white participants walked faster, had longer stride lengths and spent more time in double support (20).

The primary goal of this study was to follow up on the intriguing results of Golightly and Dominick (19) and Sowers et al. (20) by examining if differences in gait
mechanics exist between blacks and whites with knee OA in parallel with the psychosocial and spatio-temporal variables described in these previous studies. The secondary goal was to examine the degree to which these differences, if found, are influenced by anthropometric (age, body mass index, height, and weight), radiographic disease severity, education level, and self-report measures of pain, disability, and self-efficacy.

METHODS

Patients

The sample consisted of 175 patients (64 black, 111 white; 42 men, 133 women) with knee osteoarthritis. All data presented were collected as part of a baseline evaluation of a subset of the participants enrolled in an ongoing study (OA Life) evaluating the separate and combined effects of lifestyle behavioral weight management and pain coping skills training interventions for knee OA. Study entry required that patients meet the American College of Rheumatology criteria for symptomatic knee OA (21), along with the following inclusion criteria: body mass index greater than 25 kg/m² and less than 42 kg/m², chronic knee pain, and no other weight bearing joint affected by OA as assessed by clinical examination. Exclusion criteria included: a significant medical conditions that would increase risk of an adverse experience (e.g. myocardial infarction), already involved in regular exercise, an abnormal cardiac response to exercise, a non-OA inflammatory arthropathy, and regular use of corticosteroids. The study was approved by the Duke University Medical Center Institutional Review Board and all participants provided informed consent. Weight in kilograms and height in meters were recorded for each patient. Height and weight data were used to calculate body mass index (BMI).

Disease severity

Weight-bearing, fixed-flexion (30 degrees) posterior-anterior radiographs of both knees were taken with the SynaFlexer™ X-ray positioning frame (Synarc, San Francisco, CA) (22). Disease severity was assessed using the Kellgren and Lawrence (K/L) radiographic grading system (23). This system rates the level of disease on a scale of 0-4, with a score of 0 representing no disease, 1 representing mild disease, 2 representing moderate disease, 3 representing moderate to severe disease, and 4 representing severe disease. For subjects with bilateral knee OA, the limb with the highest K/L grade, was recorded as the most affected limb. If both limbs had the same K/L grade, the right limb was used as the most affected limb. This most affected limb was the limb used in all data analyses. The breakdown of participants with unilateral versus bilateral knee OA was as follows: 148 bilateral (52 black, 96 white) and 27 unilateral (12 black, 15 white).

Gait parameters

Three-dimensional kinematic data were collected using a motion analysis system (Motion Analysis Inc, Santa Rosa, CA). Following the practice trials, kinematic data were collected at 60 Hz, as subjects walked along a 30-meter walkway at two speeds; the speed at which they normally perform their daily walking activities (normal) and the maximum speed they felt comfortable achieving (fast). These two speeds were chosen in order to get a sense of the speed at which the participants are most comfortable and to see how their gait mechanics change when they were presented with a challenge. Reflective markers were placed bilaterally at the following landmarks: anterior superior iliac spine, thigh, lateral knee (at the joint line), shank, lateral malleolus, calcaneus, and foot (2nd webspace). A marker was also placed at the superior aspect of the L5-sacral interface to aid in defining the pelvis. Patients performed five walking trials along the walkway at each of the self-selected speeds. Time synchronized ground reaction force data were collected at 1200 Hz using AMTI force plates (Advanced Medical Technologies Inc., Watertown, MA). Variability in walking velocity for each speed was restricted to ±5%; trials outside of this range or trials during which the subject did not contact at least one of the force plates cleanly were repeated. The range of ±5% was maintained using wireless infrared photocell timing devices (Brower Timing Systems, Draper Utah). EvaRT (Motion Analysis Inc, Santa Rosa CA) software was used to track the reflective markers and condition the data. The raw data were smoothed using a 4th order, recursive Butterworth filter with a 6 Hz cut-off frequency. Three trials at each speed in which all markers were identified and the subject had clean contact with the force plate were reduced using OrthoTrak 6.3 (Motion Analysis Inc, Santa Rosa CA), and averaged to yield kinetic and kinematic data. Kinetic data were normalized to subject height and weight.

Pain, disability and arthritis self-efficacy measures

Pain and disability were assessed by means of two widely used, self-report measures: the Arthritis Impact Measurement Scales (AIMS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Version VA3.1. The AIMS is a 66 item, standardized instrument that provides three summary measures: pain, physical disability, and psychological disability. Research has supported the reliability of the AIMS and it is valid when used for different types of arthritis as well as within a range of social and demographic groupings and in different clinical settings (24). The WOMAC OA index used in this study was a visual analog scale that consisted of three subscales that assessed pain (5 questions), stiffness (2 questions), and physical function activities (17 questions). The reliability and validity of this index has been supported by previous research (25). The range of scores