DISTINGUISHING BETWEEN MECHANICAL PATHOLOGY AND COMPENSATION USING GAIT ANALYSIS IN PEOPLE WITH KNEE OSTEOARTHRITIS

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INTRODUCTION

The external knee adduction moment during gait has been implicated in the initiation of chronic knee pain [1] and radiographic progression of knee osteoarthritis (OA) [2]. Gait analysis yields thousands of data points beyond the knee adduction moment that likely contain information important to detecting and treating this disease. Principal components analysis (PCA) reduces the large gait data set to only important, uncorrelated variables and has proven useful in distinguishing between severities of knee OA [3]. However, this statistical approach may limit other interpretations. For example, PCA has not distinguished between characteristics that represent mechanical pathology, which lead to disease progression, versus those that represent compensation, which reduce or counteract pathological aspects of knee OA. Much interest has been invested in potential gait compensations, such as foot rotation and trunk lean. However, to-date no systematic approach has been used to identify gait compensations in people with knee OA. As preliminary step, correlates with structural disease markers such as mal-alignment likely identify pathological gait characteristics; while correlates of behavioural modification markers, such as self-efficacy can identify purposeful gait compensations. This study aims to distinguish between gait characteristics that represent mechanical pathology versus compensation among people with knee OA.

METHODS

An OA group of 54 adults with radiographic knee OA participated (age 68 ± 9, body mass index 29 ± 5 kg/m^2, 32 women). A control group (CON) of 52 symptom-free older adults with clear radiographs participated (age 64 ± 6, body mass index 26 ± 4 kg/m^2, 27 women).

Anatomical knee alignment was used as a marker of OA pathology using standardized coronal knee radiographs. Participants stood barefoot, positioned so that a transverse line through the femoral condyles was in the coronal plane. Anatomical angle was the angle between the tibial and femoral shafts and varus was designated positive.

Self-efficacy for physical tasks was assessed as a marker of OA compensations using the Arthritis Self-Efficacy Scale. Self-efficacy is the belief one has the capacity to execute actions required to satisfy specific demands [4]. Compromised self-efficacy coincides with the implementation of compensations in people with knee pain [5].

Gait data was collected using the Queen's Gait Analysis in Three Dimensions (QGAIT) system. Data was collected with an Optotrak optoelectronic system (Northern Digital, Waterloo, Canada) and a force plate (AMTI, Massachusetts, USA). Six infrared emitting diodes (IREDs) were used: Four IREDs were placed over anatomical landmarks (greater trochanter, lateral femoral condyle, fibular head, lateral malleolus) and two IREDs on anteriorly projecting probes attached to thigh and shank. Five walking trials were sampled at 100 Hz.

Three-dimensional positive and negative peaks, timings, ranges and stance averages for gait variables were averaged across 5 trials. Multivariate analysis of covariance (MANCOVA) compared the means for OA and CON with gait speed as a covariate. We entered data into the MANCOVA in 5 blocks: knee angles, knee forces, knee moments, hip forces, hip moments. Post hoc tests identified which variables were different between groups. Finally, gait characteristics unique to the OA group were correlated (Pearson) with each of alignment and self-efficacy scores.

RESULTS

After controlling for gait speed, 25 gait variables were unique to OA compared to CON. Of these 25, six were related to anatomical alignment and eight related to self-efficacy for physical tasks (Table 1).

Table 1: Relationships between unique knee OA gait characteristics and anatomical alignment and self-efficacy.

Distinctive Knee OA Gait Characteristics	Anatomical Alignment	Self-Efficacy
Knee Kinematic Variables		
Peak Knee Adduction Angle (°)	0.57*	0.14
Peak Knee Abduction Angle (°)	0.55*	0.07
Average Stance Knee Adduction-Abduction Angle (°)	0.75*	0.18
Peak Knee Extension Angle (°)	0.09	-0.58*
Range Knee Flexion-Extension Angle (°)	-0.34	0.49*
Average Stance Knee Flexion-Extension Angle (°)	0.04	-0.48*
Peak Knee External Rotation Angle (°)	-0.07	-0.33
Range Knee Internal-External Rotation Angle (°)	0.12	0.16
Knee Kinetic Variables		
Peak Knee Posterior Force (N/kg)	0.22	-0.35*
Time to Peak Knee Posterior Force (%)	0.12	-0.05
Time to Peak Knee Anterior Force (%)	-0.13	0.30
Peak Knee Distal Force (N/kg)	0.17	-0.48*
Range Knee Proximal-Distal Force (N/kg)	-0.21	0.49*
Average Stance Knee Proximal-Distal Force (N/kg)	0.32	-0.35
Time to Peak Knee Flexion Moment (%)	0.12	-0.30
Peak Knee Extension Moment (Nm/kg)	0.10	-0.32
Time to Peak Knee Extension Moment (%)	-0.09	-0.03
Range Knee Flexion-Extension Moment (Nm/kg)	-0.09	0.40*
Hip Kinetic Variables		
Peak Hip Anterior Force (N/kg)	-0.45*	0.32
Range Hip Anterior-Posterior Force (N/kg)	-0.28	0.47*
Peak Hip Medial Force (N/kg)	0.58*	0.25
Average Stance Hip Medial-Lateral Force (N/kg)	0.75*	-0.10
Peak Hip Proximal Force (N/kg)	-0.02	-0.03
Time to Peak Hip Proximal Force (%)	-0.17	-0.17
Peak Hip Adduction Moment (Nm/kg)	-0.28	0.23

*p<0.001(Bonferroni correction for multiple comparisons)

In general, anatomical knee alignment related to gait measures reflecting dynamic frontal plane knee alignment and forces acting at the hip (Figure 1A). By comparison, self-efficacy scores related to sagittal plane knee angles (Figure 1B), forces acting at the knee, the range knee flexion-extension moment and the range hip anterior-posterior force.

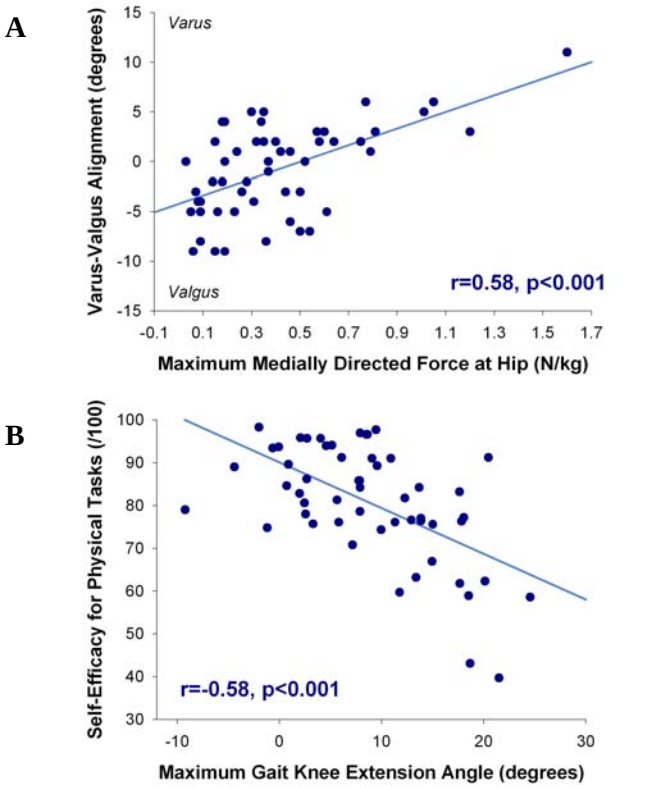

Figure 1: Anatomical knee alignment related to characteristics that reflected knee OA pathology, such as hip joint forces (A) while self-efficacy related to characteristics that reflect compensations, such as reduced knee range of motion (B).

DISCUSSION AND CONCLUSIONS

Of the gait characteristics unique to knee OA, this technique completely segregated pathological from compensatory characteristics through correlates of mal-alignment versus self-efficacy. Pathological factors extended beyond the knee, emphasizing the need to consider the lower extremity kinetic chain. Self-efficacy, which reflects the ability to mobilize motivation and cognitive resources to complete specific tasks, proved useful in identifying potential compensatory strategies. These compensatory characteristics, in general, appeared to represent a "careful" approach to walking performance.

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