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INTER-LABORATORY COMPARISON OF GAIT WAVEFORMS IN INDIVIDUALS WITH KNEE OSTEOARTHRITIS

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Purpose: Gait analysis is regularly used to test efficacy of interventions and to better understand knee function in individuals with knee osteoarthritis (OA). Assessment of gait is performed in many laboratories across the world utilizing custom setups and protocols. This creates the potential for large inter-lab variance when comparing results. Dalhousie University (DAL, Canada) and VU medical center (VUmc, the Netherlands) are striving to establish a collaborative initiative to combine resources in future gait studies in individuals with knee OA (this was supported by a scholarship from OARSI). The aim was to evaluate the inter-laboratory comparison of previous collected knee gait waveforms of individuals with knee OA.

Methods: Individuals with moderate knee OA were analyzed (DAL: n = 55, VUmc: n = 40). Population characteristics included anthropometrics, age, sex, walking velocity, muscle strength (DAL: isometric, VUmc: isokinetic), Western Ontario and McMaster Universities Arthritis Index scores (WOMAC), Kellgren & Lawrence grades and Numeric Pain Rating Scale (NRS) scores. Three-dimensional (Sagittal (SP), Frontal (FP) and Transverse Plane (TP)) kinematics and kinetics were measured in both labs with a R-mill dual belt instrumented treadmill (MotekForce link, Amsterdam, the Netherlands) and a motion capture system using their own marker protocol. Electromyography (EMG) of the Quadriceps (Q), Hamstrings (H) and Gastrocnemius (G) were acquired using a standardized protocol (SENIAM). The kinematics, kinetics and EMGs were processed in lab-specific programs to obtain the ensemble averaged gait waveforms of the knee. Principal Component Analysis (PCA) was used to analyze the knee gait waveforms on their amplitude and pattern characteristics. Additionally, common discrete values were calculated like peak, initial contact (IC) and impulse values. An inter-lab comparison was performed by analysis of variance models of the population characteristics, PCA Principal Pattern (*PP*) scores and discrete values. The scores and values were adjusted for walking velocity.

Results: The DAL population was shorter (0.04 m; $P = 0.02$), heavier (5.9 kg; $P = 0.04$), had higher knee flexion strength (20 Nm, $P < 0.01$) and lower WOMAC & NRS pain scores (6; $P < 0.01$ & 1; $P = 0.04$, respectively). A trend towards a higher walking velocity was observed in the VUmc population (0.05 m/s, $P = 0.09$). The knee gait waveforms of both labs are presented in Figure 1. The peak and IC values of the kinematic waveforms were different ($P < 0.01$), except for the TP ($P > 0.23$). PCA identified an amplitude offset in the SP and FP movement waveforms (*PP1-scores*: $P < 0.01$; $11.8 \pm 3.4^\circ$ & $4.1 \pm 1.5^\circ$, respectively). Only a difference in peak flexion during swing (4.4°, $P < 0.01$) remained after correction for these offsets. The peak and impulse values of the kinetic waveforms were similar in FP ($P > 0.08$), but different in SP and TP ($P < 0.01$). An amplitude offset of 0.16 ± 0.07Nm/kg was detected in the SP moment waveforms (*PP1-scores:* $P < 0.01$). Offset correction led to comparable peak extensor moments ($P = 0.33$), but a greater peak flexion moment remained in the VUmc waveforms (0.12 Nm/kg; $P = 0.01$). The IC values of the muscle activation waveforms were different in the Q and H ($P < 0.01$), but not in the G ($P = 0.45$). The area under the curve values were similar for H and G waveforms ($P > 0.24$), unlike the Q waveforms (9% difference; $P < 0.01$). PCA showed a phase shift in Q, H and G waveforms (*PP2* or *PP3-scores*: $P < 0.01$; 4%, 4% & 6% of gait cycle, respectively). Correcting this shift made the IC values of Q and H also corresponding ($P > 0.72$).

Conclusions: This inter-laboratory comparison of treadmill gait in individuals with knee OA revealed systematic offsets (magnitude and phase) that may have implications for interpreting knee function in this population. Marker models, collection and processing decisions (i.e. filters and IC identification) may explain these results. Once offsets were corrected, few gait differences remained suggesting specific features may be stable across labs and warrant further investigation to foster future collaborations in gait research.

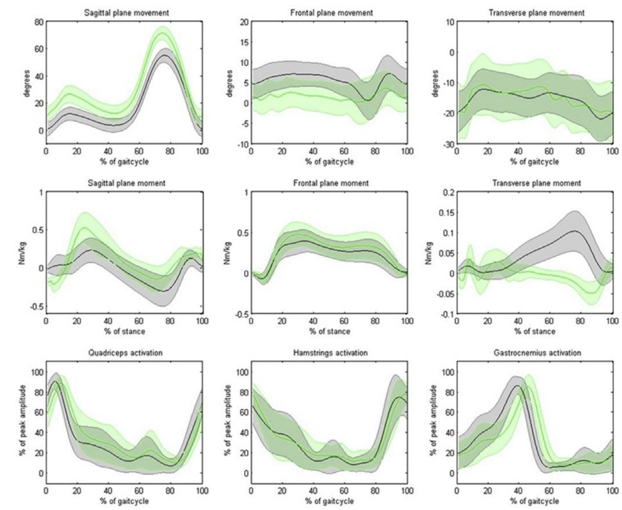

Figure 1: Knee gait waveforms of VUmc (green) and DAL (black), solid line represents the mean and shaded area is the standard deviation.

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QUADRICEPS WEAKNESS IS ASSOCIATED WITH LESSER PROTEOGLYCAN DENSITY IN THE MEDIAL FEMORAL CARTILAGE SIX-MONTHS FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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Purpose: Quadriceps weakness is a common clinical impairment that persists following anterior cruciate ligament reconstruction (ACLR). Patients with weaker quadriceps report greater disability and demonstrate aberrant knee biomechanics during walking gait, which may contribute to the development of posttraumatic knee osteoarthritis (PTOA). Specifically, the diminished capacity to eccentrically contract the quadriceps may result in increased compressive forces and suboptimal energy attenuation about the tibiofemoral joint. Weaker quadriceps is associated with greater radiographic tibiofemoral joint space narrowing four years following ACLR. Unfortunately, little is known regarding how quadriceps weakness associates with early deleterious tissue changes, including diminished proteoglycan density of the femoral cartilage, following ACLR. The purpose of our study was to determine if isometric quadriceps strength was associated with proteoglycan density of the articular cartilage, measured with T1ρ magnetic resonance imaging (MRI) relaxation times, in the medial and lateral femoral condyles of the ACLR and contralateral uninjured limbs 6 months following ACLR.

Methods: NTwenty-seven individuals with a unilateral ACLR participated in the study (12 males, 15 females; 21.7 ± 3.5 years old; 175.4 ± 11.24 cm tall; 73.31 ± 13.3 kg of mass). Bilateral isometric quadriceps strength was assessed using a HUMAC Norm dynamometer at 90° of knee flexion and normalized to body mass (Nm/kg). Bilateral MRI were assessed with either a Siemens Magnetom TIM Trio 3 Tesla scanner with a 4-channel Siemens large flex coil (n = 17) or a Siemens Magnetom Prisma 3T PowerPack scanner with a XR 80/200 gradient coil (n = 10, 60 cm × 213 cm). Strong inter-scanner reliability was found for T1ρ relaxation times in the medial ($ICC_{2,1} = 0.99$) and lateral ($ICC_{2,1} = 0.96$) femoral condyles. Greater mean T1ρ relaxation times correspond with lesser proteoglycan density. Medial and lateral weight bearing regions of the femoral condyles (MFC and LFC) were defined as the articular cartilage between the posterior edge of the posterior horn of the meniscus and the anterior edge of the anterior horn of the meniscus in the sagittal plane. We further sub-sectioned the weight