COMPARING KNEE JOINT KINEMATICS, KINETICS AND CUMULATIVE LOAD BETWEEN HEALTHY-WEIGHT AND OBESE YOUNG ADULTS

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INTRODUCTION
Obesity has been identified as a worldwide epidemic [1]. While there are many co-morbidities associated with the condition, one of the most poorly understood is the pathway to musculoskeletal diseases, such as osteoarthritis of the knee [2]. To implement appropriate preventative strategies, it is important to explore how excess body weight is a causal factor for osteoarthritis. The present research compared the kinematics and kinetics of a group of young obese, but otherwise healthy, adults to a group of young, healthy-weight adults, in an attempt to identify mechanical abnormalities at the knee during walking that may predispose the obese to osteoarthritis of the knee.

METHODS
Sixteen participants recruited from the University of Waterloo population included 8 obese (age 23.5 (3.3) and BMI 35.5 (5.69)) and 8 age, height and sex-matched healthy-weight adults (age 23.5 (2.1) and BMI 23.2 (1.54)). Three-dimensional Optotruk motion capture data (NDI, Waterloo, ON) and a synchronized forceplate (AMTI, Watertown, MA) were used to collect and calculate ground reaction forces and knee joint kinematics and kinetics. Knee motions were tracked by fitting participants with 37 wireless skin markers, placed bilaterally on the lower limbs and posterior pelvis. Participants performed 5 successful trials at three walking speeds of self-selected, 15% faster and 15% slower. Healthy-weight participants walked at an additional “matched” speed condition that matched the self-selected speed of the obese participants. Following the lab procedures, participants wore an accelerometer for seven days to measure physical activity levels through steps per day. Average steps per day were combined with the measure of knee adduction moment impulse to calculate a cumulative knee adductor load (CKAL) [3]. Analyses were performed between groups on the speeds of fast, self-selected and slow. A separate analysis was conducted on the matched speed condition that compared participant groups walking at the same speed. Frontal, sagittal and transverse plane motions were analyzed. A series of dependent t-tests were performed to determine group differences in the maximum, minimum and range of ground reaction forces, knee angles and knee moments, as well as steps per day, knee adduction moment impulse and CKAL. Moments were not normalized to body mass, which allowed the observation of the absolute effect of excess body mass on knee joint kinetics. A multiple regression analysis was used to determine the effect of dynamic knee alignment on peak knee adduction moment and knee adduction moment impulse.

RESULTS AND DISCUSSION
Compared to the healthy weight group (1.55m/s (0.18)), the obese group walked at a slower self-selected speed (1.25m/s (0.15)) (p=0.013). The obese group also had a greater stance duration (0.68s (0.07)) compared to the healthy-weight group (0.59s (0.06)) (p<0.001). The three walking speeds of fast, self-selected and slow did not induce a significant difference in kinematic or kinetic variables. As such, the three walking speeds were used as replicates within each participant for the analysis. The obese group had greater mean peak ground reaction forces in all three planes (p<0.05). This difference was found despite a slower self-selected walking speed in the obese group, which would serve to reduce ground reaction forces. A greater maximum abduction angle and smaller minimum knee flexion angle at heel contact was found in the obese group (p<0.05). There were no
group differences in the frontal moment peaks or impulse (Figure 1). This was surprising, given that moments were not normalized to body mass.

![Frontal Knee Moment](image1)

**Figure 1:** Average frontal moment waveform for participant groups.

A greater transverse plane peak medial rotation moment was found in the obese group (p=0.003). Differences between groups in the ground reaction forces persisted in all three planes at the matched speed (p<0.05). However, all knee angle and moment group differences were neutralized at the matched speed condition. Non-significant results from the matched speed condition may have been due to reduced statistical power, being that there were no within participant replicates in this analysis. In some instances, such as the peak frontal and sagittal moments, a greater magnitude of difference between groups was observed at the matched walking speed, with the obese group having greater peak moments. Both participant groups had similar mean daily step counts, which fell well below the recommended 10,000 steps per day. Not only does this suggest comparable physical activity levels between groups, but also that neither group is obtaining daily physical activity levels that will adequately encourage weight-loss or prevent future weight-gain. No significant group differences were found in the CKAL, a consequence of no differences being found between groups in physical activity level and knee adduction moment impulse. Dynamic knee alignment was strongly related to peak knee adduction moment (r=0.497) and knee adduction impulse (r=0.361). Two obese participants presented with atypical frontal plane moments and were identified as statistical outliers (Figure 2). Both participants had knee alignments of 10° valgus. This alignment reduced the knee adduction moment magnitude in both obese participants by shifting load away from the medial compartment of the knee joint.

![Atypical Frontal Moments](image2)

**Figure 2:** Atypical frontal knee moment waveform found in two obese participants, S01 and S04.

Their data were removed and analyses were rerun as a reduced data set. With the reduced data set, the obese group had greater knee adduction moment impulse and CKAL (p<0.05). No group differences in the peak frontal moment magnitude were found for the reduced data set. Therefore, the greatest contributing factor to group differences in the knee adduction moment impulse (and resulting CKAL) was likely the increased stance duration in the obese group, which increased the time domain of the moment impulse.

**CONCLUSIONS**

Young adults with healthy knees who are obese may modify their gait in an effort to reduce medial knee joint compartment loading through greater knee abduction, medial knee rotation and a slower walking speed. While they are successful in doing this, the ramifications of gait modifications on long-term musculoskeletal health remain unknown. Furthermore, despite the employment of these gait alterations, obese young adults may still expose their knees to a greater daily cumulative load. These compensations and cumulative load may increase risk of osteoarthritis of the knee.

**REFERENCES**