



Upper & Lower Knee Ab/Adduction Moment Sensing

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INTRODUCTION

Knee Osteoarthritis (KOA) is estimated to affect over 13% of the US population older than 45 years of age (Turciewicz, 2014). Indeed, the lifetime risk of developing symptomatic KOA for Americans has been estimated to be 44.7% (Murphy, 2008). Knee abduction/adduction moment (KAM) is recognized as a primary marker of KOA progression. A 1% increase in peak external KAM has been linked to a greater than 6-fold increase in the risk of KOA progression (Miyazaki, 2002).

Due to high costs, and limited measurement granularity, established KAM measurement techniques are an impractical means for tracking KOA progression. Measurement of KAM is currently limited to gait laboratories, which utilize motion capture systems to determine knee moments (van den Noort, 2013; Cappozzo, 1995). KOA often takes decades to develop. Identifying statistically significant changes in KAM on a year over year (or more frequent) basis therefore requires a higher degree of granularity than current techniques offer. Other attempts at measuring KAM during free ambulation have neither achieved complete independence from lab measurements, nor generated significantly greater granularity (van den Noort, 2012; van den Noort, 2013).

In this work, a novel means of measuring KAM during free ambulation is presented, offering determination of KAM with high measurement accuracy and measurement granularity. We have developed an orthotic leg brace containing pressure sensors located on the inner and outer shank and thigh regions that measure side forces. From these side forces, we have measured the forces generated by the knee that are balanced by the legbrace.

METHOD

Subjects: We performed a preliminary test on a 75-year old male **not** being treated for KOA with the legbrace set to its passive mode of operation. The subject walked on a treadmill at 2.2 miles per hour with an average step length 23.434 inches and average step period of 0.6052 seconds. Legbrace side force sensors were sampled at 4,608 samples per second. Sensor measures were created by adding 12 successive sensor samples and recording them on the legbrace's non-volatile memory. Additional Gait measures logged included: knee angle, shank tilt angle, shank lean angle, heel pressure, ball-of-foot pressure, foot angle and torso support force supplied by the legbrace. **Apparatus:** Sensor data were stored in Gait measurements of the subject were also taken using the lab-based motion capture system.

Procedures: The subject walked on a treadmill while data were collected by the brace and laboratory motion capture systems. After testing, data were processed using Wolfram's Mathematica. Motion capture data were analysed using commercially available software.

RESULTS

The novel approach used in this work generated KAM measurements that were lower than those generated by traditional techniques. Plots of data collected by laboratory and PUUMA KAM measurement systems are given in Figures 1 and 2.

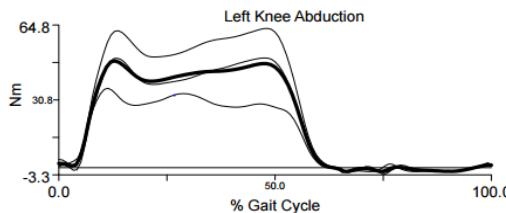
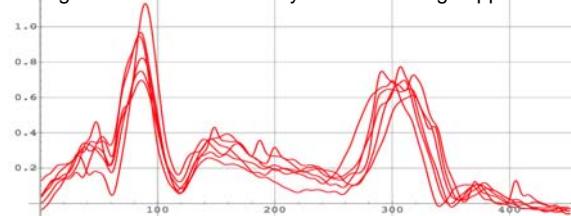


Figure 1: KAM measured by laboratory.

Figure 1 KAM measured by PUUMA during support



DISCUSSION

Our novel method for measuring KAM measures all discernable side forces exerted by the legbrace. These side forces began prior to heelstrike and peaked immediately following heelstrike and again prior to toeoff. Sensor calibration has not been completed preventing analysis of relative pressures between the brace and traditional methods.

CONCLUSION

The legbrace KAM measurements showed significant peaks not present in traditional KAM measurements. Further testing will be required to ascertain if these peaks are anomalous; peculiar to the brace/test; or are simply not detected by traditional methods. The potential for measuring KAM accurately and with the desired level of granularity is promising but unproven.

CLINICAL APPLICATIONS

The high accuracy and fine granularity side force measurements our method provides has the potential of creating a novel means of tracking/managing KOA.

REFERENCES

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Turciewicz A et al. Osteoarthritis and Cartilage 22, 1826-32, 2014.



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