

CUMULATIVE KNEE LOADING RELATES TO PAIN INTENSITY AND KNEE EXTENSOR TORQUE IN PEOPLE WITH KNEE OSTEOARTHRITIS

¹Monica R. Maly and ²Shawn M. K. Robbins

¹School of Rehabilitation Science, McMaster University, Hamilton, ON, Canada, mmaly@mcmaster.ca

²School of Physical Therapy, The University of Western Ontario, London, ON, Canada, smrobbin@uwo.ca

INTRODUCTION

The peak knee adduction moment (KAM) has received much attention as a proxy for medial loading in knee osteoarthritis (OA). One limitation, however, is that the peak KAM represents exposure to loading during a single stride and therefore does not represent loading experienced throughout daily activity. The mechanical properties of articular cartilage in response to load vary in a time-dependent manner [1]. Furthermore, two individuals may have the same peak KAM but one could be twice as physically active as the other.

Representing the total exposure to knee loading, accounting for magnitude, abnormality and repetition may be useful in understanding clinical outcomes in knee OA. Cumulative loading represents a total exposure to loading, reflecting both the nature and repetition of loads [2]. It shares a dose-response relationship with osteoarthritic changes in the spine [3]. Although cumulative load is a recognized mechanism in low back injury [4], it has not been studied in knee OA. The purpose of this study was to compare relationships between the peak KAM and cumulative knee loading (CKL) with pain and knee extensor torque in knee OA.

METHODS

A convenience sample of 7 adults with radiographic knee OA was recruited through an orthopaedic clinic (age 53 ± 9 years, body mass index 29 ± 4 kg/m², 1 women).

Pain intensity was captured on the P4 questionnaire, which asks participants to rate pain intensity (0=no pain, 10="pain as bad as it can be") in the morning, afternoon, evening and with activity. Mean peak knee extensor torque of the OA knee was measured on the Biodex System 3 isokinetic dynamometer (Biodex Medical Systems, New York, USA). After submaximal practice, participants completed 5 concentric maximal knee extensor contractions at

60°/s. The mean peak values were normalized to body mass. Torque measurements were not collected on one participant due to drop-out.

Daily CKL was the product of the stance KAM impulse and mean number of steps per day. The KAM impulse was calculated using gait data from 8 cameras (Motion Analysis Corp., Santa Rosa, USA) with a sample rate of 60 Hz and a synchronized floor-mounted force plate (AMTI, Watertown, USA) with a sample rate of 1200 Hz. A Helen-Hayes marker configuration was used, with 21 reflective markers. Participants stood on the force plate to provide a reference frame. Participants actively flexed, extended, abducted and adducted the hip to calculate functional hip centres. The KAM waveform was extracted. The stance phase was integrated, using the trapezoidal rule in a custom Matlab program (Mathworks Inc., Natick, USA). The mean KAM impulse from 5 trials was calculated but was not normalized to mass or height to represent the absolute load borne through the medial compartment. The mean number of steps taken daily (steps/day) was measured with a uni-dimensional accelerometer (ActiGraph, Fort Walton Beach, USA) with an epoch of 60 seconds. The epoch represents the period for which a sum of the number of steps is written to memory. Participants wore the accelerometer for 7 consecutive days over the midline of the affected thigh.

Pearson correlation coefficients were calculated between P4 scores and mean peak extensor torque/mass with the peak KAM, CKL, impulse and steps/day.

RESULTS

A broad range of values was noted in pain, extensor torque, peak KAM and CKL, as well as the knee adduction moment impulse and steps/day. Pain and peak KAM values appeared typical for a sample with knee OA. Steps/day revealed very low levels of physical activity (Table 1).

Table 1: Descriptive statistics for pain, extensor torque, peak adduction moment and cumulative knee loading variables.

Variable	Mean (SD)	Range
P4 Pain Score (/40)	16.7 (5.2)	9 – 23
Peak Knee Extensor Torque (Nm)	140.2 (48.3)	61.4 – 180.7
Peak Knee Extensor Torque/Mass (Nm/kg)	1.22 (0.68)	0.83 – 1.98
Peak Knee Adduction Moment (Nm/kg)	0.55 (0.12)	0.45 – 0.79
Cumulative Knee Load (KNm*s)	77.5 (41.8)	30.0 – 132.9
Knee Adduction Impulse (Nm*s)	23.0 (9.9)	12.9 – 39.4
Steps/day	3382 (1488)	1920 – 6118

Correlates with Pain

Pain shared a weak relationship with the peak KAM ($r=0.18$). However, relationships between pain and the CKL ($r=-0.30$) or knee adduction impulse ($r=-0.31$) were moderate. Pain shared no relationship with the number of steps/day ($r=0.00$).

Correlates with Knee Extensor Torque/Mass

Knee extensor torque normalized to body mass had no relationship with the peak KAM ($r=0.04$, Figure 1) and a weak relationship with CKL ($r=0.18$). However, knee extensor torque normalized to body mass related to the knee adduction impulse ($r=0.32$, Figure 2). No relationship was found between extensor torque/mass and the number of steps/day ($r=-0.13$).

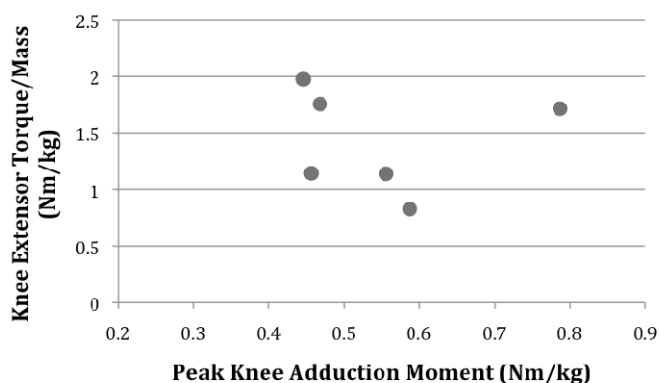


Figure 1: No relationship ($r=0.04$) between the peak knee adduction moment and extensor torque normalized to mass.

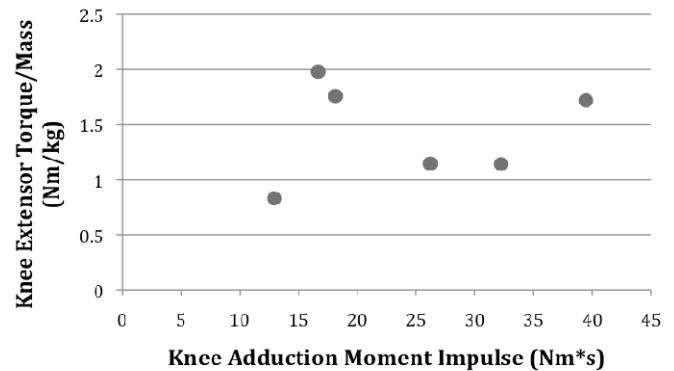


Figure 2: Knee adduction impulse related to extensor torque normalized to mass ($r=0.32$).

DISCUSSION AND CONCLUSIONS

Pain intensity and knee extensor torque showed stronger relationships with exposure to medial loading (CKL and impulse) than peak loading. Previous work [5] has also shown stronger relationships between pain and impulse versus peak. This study adds by relating knee extensor torque to loading characteristics. Thus, exposure to loading variables show promise in understanding the mechanical pathology underlying knee OA.

This sample had very limited exposure to walking, well below recommendations for physical activity and normative values for healthy adults [6]. The effectiveness of walking programs in knee OA may simply reflect physical re-activation. Because the number of steps/day did not relate to pain intensity or knee extensor torque, it appears that pain and weakness may not contribute to physical inactivity. However, the small sample and limitations of accelerometry to capture modes of physical activity other than walking and running are limitations. Nevertheless, the factors that limit walking activity in people with knee OA deserve attention.

REFERENCES

1. Flachsman et al. *J Orthop Res* **19**, 1131-1139, 2001.
2. Kumar. *Spine* **15**, 1311-1316, 1990.
3. Seidler et al. *Occup Environ Med* **58**, 735-746, 2001.
4. Norman et al. *Clin Biomech* **13**, 561-573, 1998.
5. Thorp et al. *Arthritis Rheum* **57**, 1254-1260, 2007.
6. Bohannon et al *Phys Ther* **87**, 1642-1650, 2007.

ACKNOWLEDGEMENTS

Fowler Kennedy Sports Medicine Clinic Internal Funding Competition and the Natural Sciences & Engineering Council of Canada #353715-2008.