An Analysis of Discrete Biomechanical Loading Outcomes and Steps per Day in Knee Osteoarthritis Patients

Zurbuch E, Berkoff D, Bjornsen E, Blake K, Lisee C, Pietrosimone B

Department of Exercise and Sport Science, The University of North Carolina at Chapel Hill

BACKGROUND

- Symptomatic knee osteoarthritis (OA) affects 14 million individuals in the United States alone[1]
- Individuals with knee OA often exhibit irregular gait biomechanics and specifically display altered loading patterns[2]
- Vertical ground reaction force (vGRF) can be used as a measure of force exerted on the lower extremity in the vertical direction[3]
- External knee adduction moment (KAM) is a measure of compartmental loading, and individuals with knee OA often exhibit greater external KAM values indicating greater degree of medial compartment loading in comparison to healthy controls[4,5]
- Both excessive loading and underloading have been associated with cartilage breakdown[6] suggesting an optimal loading magnitude may exist.
- A 6000 step per day cut-off has been previously recognized as a preventative measure against functional limitation[7]
- It is unknown whether individuals with differing activity levels exhibit differences in biomechanical peak loading outcomes

PURPOSE

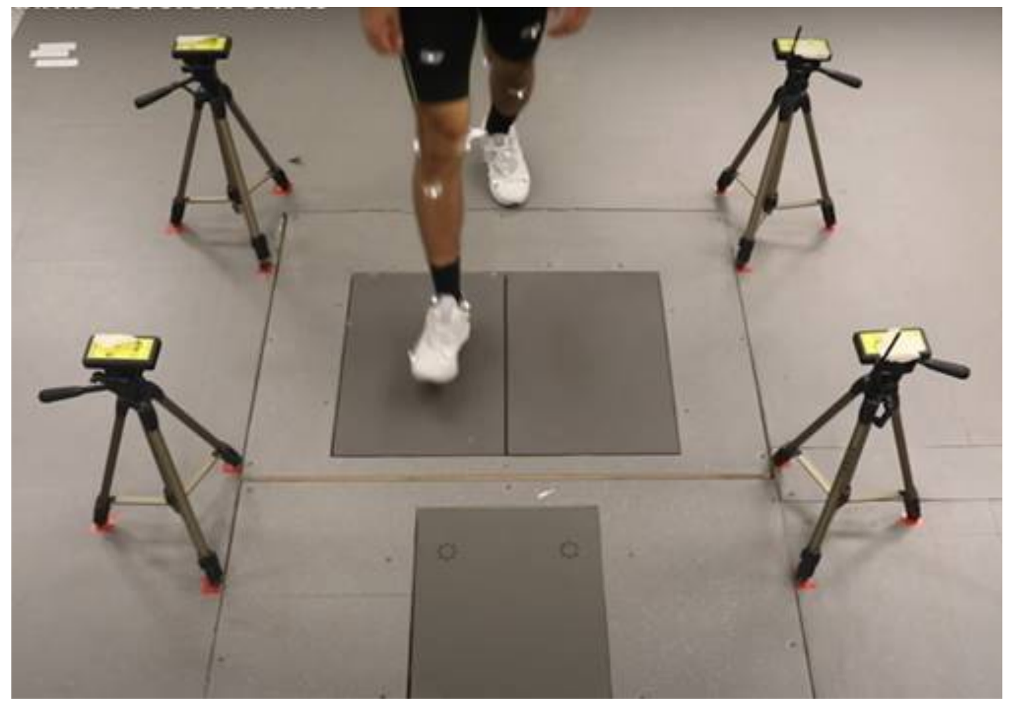
Purpose: To compare peak values of vertical ground reaction force and external knee adduction moment between individuals with knee OA who met or did not meet 6000 steps per day

Hypothesis 1: We hypothesized that both vGRF peak 1 and peak 2 will be higher in individuals who meet the 6000 steps per day in comparison to those who do not meet the step threshold

Hypothesis 2: We hypothesized that peak KAM values will be lower in individuals who meet the 6000 steps per day in comparison to those who do not meet the step threshold

METHODS

- Participants (40-75 yrs) with radiographic knee OA (≥1 on the Kellgran-Lawrence Scale) and BMI < 35 were included
- Subjects walked at a self-selected speed (TF100, TracTronix) across 3 embedded force plates (Bertec, Columbus, OH) for five trials
- Kinetic data was sampled at 960 Hz and lowpass filtered at 10 Hz (4^{th} order Butterworth)
- A 10-camera three-dimensional motion capture system (Vicon, Nexus, Denver, Colorado) utilized to collect gait biomechanics



- Peak vGRF was normalized to subject's body weight (% BW) and peak KAM was normalized to the product of body weight and height (BW X Ht), with positive values representing knee adduction

METHODS CONT.

- Subjects were instructed to wear a GT9X Link Actigraph activity monitor for 7 days, where daily step values were averaged across the wear period
- We utilized cutpoints from The National Health and Nutrition Examination Survey (vigorous activity ≥ 5999, moderate activity = 2020-5998, light activity = 100-2019 counts/minute)
- We defined individuals having a functional limitation as those accumulating less than 6000 steps per day
- Between group comparisons were conducted using t-tests for vGRF peak 1, vGRF peak 2, and peak KAM. Hedge's g effect sizes were calculated (.20 = small, .50 = medium, .80= large)[8]

RESULTS

Table 1. Demographic Characteristics of Participants N=19 (Mean ± SD)

	Steps Met n=8	**Steps Not Met** n=11
Gender	4 males, 4 females	8 males, 3 females
Age (yrs)	64.82 ± 8.83	59.63 ± 8.62
BMI	28.93 ± 4.15	29.02 ± 2.75
Average Gait Speed (m/s)	1.24 ± 0.18	1.34 ± 0.23
Womac Pain	7.09 ± 3.14	7.38 ± 1.51
Womac Stiffness	3.73 ± 1.10	4.13 ± 1.36
Womac Function	27.36 ± 9.55	27.88 ± 7.74
Average Daily Steps	7736.17 ± 1543.70	4055.54 ± 902.77

SD: Standard Deviation; *p<.05

Table 2. Between Group Differences for Peak Biomechanical Outcomes

	Steps Met	**Steps Not Met**	***p***	**Hedge's g**
vGRF Peak 1	1.0466±.0909	1.0958±.0839	0.2462	0.558551
vGRF Peak 2	1.0041 ± .0821	1.0347± .1001	0.4735	0.340193
Peak KAM	.0287 ± .0155	.0290 ± .00814	0.9692	0.023104

8 individuals were classified as meeting the step goal and 11 did not (Table 1). Individuals who met the 6000 daily step goal (1.0466±.0909) exhibited lesser peak 1 vGRF in comparison to those who did not (1.0958±.0839), although the differences were not statistically significant (p>.05; Table 2). No statistically significant differences for peak 2 vGRF were observed between groups (1.0041 ± .0821, 1.0347± .1001; p>.05; Table 2). Additionally, no differences were observed for peak KAM between individuals who did (.0287 ± .0155) and did not meet the step goal (.0290 ± .00814; p>.05; Table 2). Effect sizes ranged from small to moderate (Table 2).

DISCUSSION

- Contrary to our hypothesis, vGRF peak 1, vGRF peak 2, and peak KAM did not differ between groups
- Individuals who took less steps per day also displayed faster walking speeds, which may be unique to this cohort
- Previous research has estimated that every 1000 step increase reflects a 16-18% risk deduction in developing functional limitations.[7] Activity monitoring is limited in the type of activities it can capture, and older adults may pursue activities that are not captured in this analysis, such as swimming or water aerobics. Other factors in addition to step count should be considered when assessing activity levels and when designing clinical interventions
- Only discrete peak variables were analyzed in this study. Possible between-group differences may be observed at other time points across stance phase
- The sample size for this study was small (n=19), and we did not examine possible influence of OA severity which may have contributed to the findings
- Future research should examine biomechanical loading outcomes in a larger sample size, other aspects of activity, and assess loading across the entirety of stance phase

REFERENCES

1. Arthritis Foundation. 2019; v3; 4100.17.10445
2. Childs, J., Sparto, P., Fitzgerald, G.K., Bizzini, M., Irrgang, J. *Clinical Biomechanics*, 19(1), 44-49
3. Wiik, A. V. et al. (2017). *World Journal of Orthopedics*, *8*(4), 322-328.
4. Kumar, D., Manal, K.T., Rudolph, K.S. (2012). *Osteoarthritis and Cartilage*, *21*(2), 298-305.
5. Nie, Y., Wang, H., Xu, B., Zhou, Z., Shen, B., Pei, F. *BioMed Research International*, vol. 2019, 1-8
6. Andriacchi, T. et al. (2004). *Annals of Biomedical Engineering*, *32*(3), 447-457
7. White, D. K. et al. (2014). *Arthritis care & research*, *66*(9), 1328-1336
8. Ellis PD. Cambridge University Press; 2010

FUNDING SOURCES

Flexion Therapeutics

Contact Information:
Erica Zurbuch
ericaz@live.unc.edu

Our Mission is to Explore, Educate & Engage in MUSCULOSKELETAL INJURY PREVENTION