Changes in Medial Joint Contact Forces Following Gait Retraining in Individuals with Knee Osteoarthritis

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INTRODUCTION: Osteoarthritis is a chronic multifactorial joint disease that most frequently affects the knee, causing pain and functional disability.[1] High joint loading is a mechanism for knee osteoarthritis (KOA). Specifically, excessive knee contact forces contribute to the progression of KOA.[2] Real-time feedback to decrease peak tibial acceleration reduces loading in runners.[3,4,5] The purpose of this study was to examine whether a gait retraining program to reduce tibial acceleration during walking leads to a reduction in knee contact forces more than a standard walking program in adults with KOA.

METHODS: *Subjects:* Participants gave informed consent to participate in this IRB approved study. 20 participants with clinical defined KOA by using National Institute for Health and Care Excellence Guidelines, were randomly allocated to a Gait Retraining Program (n=11; 8 females; age 64±9 years) or Standard Walking Program (n=9; 5 females; age 57±9 years). *Data collection and processing:* Participants in both programs walked on a treadmill as time increased from 10 to 30 minutes over the 8 sessions. The Gait Retraining Program was provided with real-time feedback using an auditory signal to reduce axial tibial acceleration by 20% using an inertial measurement unit. The real-time feedback was faded over 8 sessions. The Standard Walking Program underwent the same treadmill walking program without feedback.[6] Participants completed overground gait assessments at a constant, self-selected speed before and after the intervention. Trajectory and force data from overground assessments were imported to OpenSim to generate a muscle-driven generic model. Medial and lateral tibiofemoral joint peak contact force during early stance phase, peak contact force loading rate during early stance phase, and contact force impulse were calculated and averaged across 5 steps in the more painful limb. Separate ANCOVA models for each outcome were used to compare the change in each joint contact force outcome between the two walking programs, adjusting for the baseline value of each outcome.

RESULTS: The mean and mean change of each joint contact force outcome before and after intervention are listed in Table 1 and 2. The mean change in peak medial contact force during early stance phase was significantly different between the two walking programs $F_{(1, 17)} = 7.20$, p=0.016. The mean change in peak lateral contact force was not significantly different between the two walking programs. The mean change in peak medial and lateral loading rates and contact force impulse were not significantly different between the two walking programs.

DISCUSSION: This study demonstrated that in adults with KOA, a gait retaining program aimed to reduce tibial acceleration decreased peak medial knee contact forces in comparison to a standard walking program. Increased loading of the medial compartment of the knee has been found in people with early stages of medial KOA.[2] Our results suggest that gait retraining with real-time feedback may be a viable treatment option to reduce medial knee contact forces, and further for reducing pain and slowing KOA progression. However, the mechanism of how the walking program reduced medial knee contact forces is unknown. Future work should examine the potential mechanisms of reducing medial knee contact forces (e.g., reduction of muscle co-contraction reduction, kinematic changes, etc.).

SIGNIFICANCE/CLINICAL RELEVANCE: Gait retraining may be superior to standard walking programs for reducing medial tibiofemoral joint contact force for those with KOA.

REFERENCES: (1) Heidari, 2011 (2) Meireles, et. Al, 2017 (3) Derie, et. Al, 2022 (4) Van den Berghe, et. Al, 2021 (5) Bowser, et. Al, 2018 (6) Corrigan, et. Al, 2020
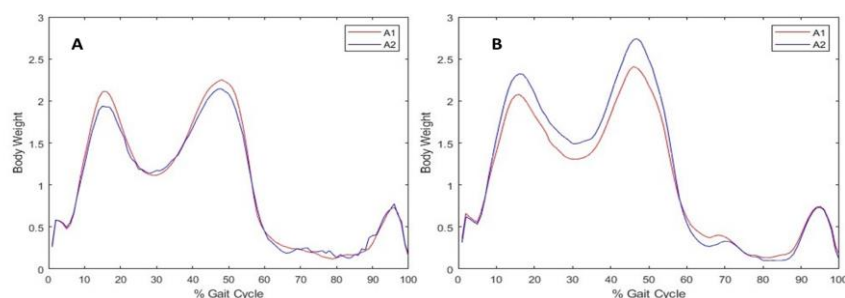
Figure 1: Gait Retraining (A) and Standard Walking (B) Program medial knee contact force plot. A1 indicates assessment before intervention; A2 indicates assessment after intervention. Note the reduction in the medial knee contact force following retraining.

Table 1: Mean (SD) of each joint contact force outcome before and after intervention.

	Retraining Group		Control Group	
	Medial	Lateral	Medial	Lateral
Baseline Peak Contact Force (BW)	2.16 (0.54)	1.05 (0.27)	2.29 (0.51)	1.15 (0.25)
A1 Loading Rate (BW/%gait cycle)	0.29 (0.08)	0.18 (0.04)	0.31 (0.10)	0.23 (0.16)
Baseline Contact Force Impulse (BW*%gait cycle)	87.47 (18.73)	45.05 (11.67)	94.01 (16.48)	48.11 (10.52)
Follow-up Peak Contact Force (BW)	2.04 (0.59)	1.02 (0.41)	2.55 (0.54)	1.17 (0.55)
Follow-up Loading Rate (BW/%gait cycle)	0.24 (0.12)	0.12 (0.06)	0.25 (0.11)	0.17 (0.10)
Follow-up Contact Force Impulse (BW*%gait cycle)	84.26 (27.09)	39.76 (13.78)	104.71 (19.10)	48.26 (15.24)

Table 2: Mean change (95% CI) of each joint contact force outcome.

	Retraining Group		Control Group	
	Medial Joint	Lateral Joint	Medial Joint	Lateral Joint
Mean Change in Peak Contact Force (BW)	-0.12 (-0.33,0.08)	-0.03 (-0.31, 0.24)	0.27 (0.04, 0.50)	0.03 (-0.28, 0.33)
Mean Change in Loading Rates (BW/%gait cycle)	-0.05 (-0.12, 0.02)	-0.07 (-0.13, -0.03)	-0.05 (-0.13, 0.02)	-0.04 (-0.10, 0.02)
Mean Change in Contact Force Impulse (BW*%gait cycle)	-4.10 (-17.57, 9.37)	-5.43 (-12.28, 1.42)	11.80 (-3.12, 26.71)	0.33 (-7.25, 7.91)