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Purpose: - To investigate the association between hip-contact force (HCF) during walking and cartilage defect severity in football players with hip and groin (hip/groin) pain - To investigate the relationship between HCF and size of cam morphology in football players with hip/groin pain

Methods: 121 football players (26 women) with hip/groin pain participated. Players were eligible if aged 18 to 50 years, undertaking ≥ 2 sessions of football per week (training/games) and > 6-month history of insidious onset hip/groin pain with a positive flexion-adduction-internal rotation test. Exclusion criteria included a history of significant hip/groin injury or surgery, presence of hip osteoarthritis (OA), or previous intra-articular injection in the past 3 months. All participants underwent a Dunn 45° radiograph, and 3 tesla MRI of each hip. The alpha angle was used to determine the size of cam morphology on the Dunn 45° radiographs using statistical shape modelling software. The Scoring Hip Osteoarthritis with MRI (SHOMRI) method was used to quantify the severity of cartilage damage. For each hip, specific cartilage scores (severity of damage) were calculated (0-20). Biomechanical data collection was conducted at the La Trobe Gait Laboratory. Participants completed walking trials while full-body motion analysis and ground force data were recorded. HCF for an entire stride cycle was calculated using a musculoskeletal modelling approach in OpenSim. We considered the HCF as its three components (posterior-anterior (PA)), inferior-superior (IS), lateral-medial (LM)). HCF was normalised to each participant's body weight. Our outcome measure for the primary aim was the HCF impulse, with time-normalised data used for the secondary aim. Cartilage defects and subsequent severity was characterised as: absent (SHOMRI=0), mild (SHOMRI= 1 to 3), or moderate/severe (SHOMRI&gt4). Differences in HCF based on cartilage deficit severity were assessed using linear models, controlling for sex, age and contralateral hip status (painful or not). Significant main effects of cartilage severity were followed up with pairwise comparisons via the estimate marginal means package in R. The relationship between alpha angle size and HCF was explored using linear models via statistical parametric mapping.

Results: Impulse magnitude of HCF in AP and SI directions decreased with more severe cartilage defects (Table 1).A significant negative relationship was observed between AP HCF and alpha angle size at toe-off (~58% to 60% of stride, P=0.040). In addition, significant negative relationships were also between alpha angle size and HCF in the SI direction (~77% to 83% of stride, P=0.009) and ML direction (~75% to 81% of stride, P=0.005) (Figure 1).

Conclusions: This study revealed that football players with hip/groin pain and greater cartilage defect severity display lower hip joint loads during walking. Optimal loading is integral to joint health, with hip OA progression thought to be related to increased joint loading. Our results challenge this paradigm. Whilst we cannot decipher cause and effect, it is possible that lower joint loading may play a role in the development and progression of OA features in young football players with hip/groin pain. Cam morphology is thought to influence joint forces during daily activities, with negative effects on articular cartilage and increasing hip OA risk. Football players with hip/groin pain and a larger cam walked with less HCF in the IS and LM direction at approximately 80% of stride, the time point corresponding to peak hip flexion during walking. Positions of hip flexion are often described as painful for people with hip/groin pain, and this reduction may be a compensatory mechanism to reduce discomfort and/or load in this position.

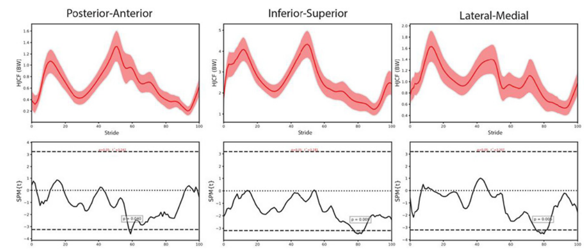

Figure 1: Results of Statistical Parametric Maps for linear models evaluating the relationship between cam morphology size (alpha angle) and hip joint contact force. "HJCF" hip joint contact force, "BW" body weights. Top panel represents time-normalised HJCF in its 3 componenets, bottom panel outlines the result of the linear models. Data reported in the femoral reference frame, positive values on the time-normalised HJCF plots represent the posterior, inferior, and lateral direction.

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MUSCLE FORCES DURING WEIGHTBEARING EXERCISES IN MEDIAL KNEE OSTEOARTHRITIS AND VARUS MALALIGNMENT: A CROSS-SECTIONAL STUDY

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Purpose: Clinical guidelines strongly recommend strengthening exercises for people with knee osteoarthritis (OA). While the best type of strengthening exercise for clinical benefits in knee OA is unclear, weightbearing exercises are often prescribed with the intention to increase the force generating capacity of muscles in the context of functional movements. Weightbearing exercises have the additional

Linear models and follow up comparisons for the differences in HCF between cartilage defect severity

Linear Model Result		Follow Up Comparisons			
Component	F Statistic, P-value	Comparison	Adjusted MD	95% CI	P-value
Posterior-Anterior	F = 4.88, P=0.01*	Absent vs Mild	0.04BW	0.01 to 0.07BW	0.02†
		Absent vs Mod/severe	0.07BW	0.02 to 0.12BW	0.01†
Inferior-Superior	F = 4.83, P=0.01*	Mild vs Mod/severe	0.03BW	-0.02 to 0.07BW	0.31
	.	Absent vs Mild	0.10BW	<-0.01 to 0.21BW	0.06
		Absent vs Mod/severe	0.23BW	0.08 to 0.38BW	<0.01†
		Mild vs Mod/severe	0.13BW	-0.03 to 0.28BW	0.10
Lateral-Medial	F = 4.83, P=0.01*	Absent vs Mild	-	-	-
		Absent vs Mod/severe	-	-	-
		Mild vs Mod/severe	-	-	-

* significant cartilage main effect (<0.05);
† significant follow-up comparison; "BW" bodyweight, "MD" mean difference, "CI" confidence interval, "Mod" moderate, "-"not calculated.

advantage of using body weight to apply resistance, eliminating the need for exercise equipment or resistance machines. However, little is known about the muscle forces experienced during common weight-bearing exercises and how these compare to everyday movements such as walking. Furthermore, there is a common misconception for patients with knee OA that weightbearing exercise will aggravate their symptoms or hasten structural decline. Accordingly, kineseophobia and pain catastrophising towards exercise is common in knee OA. Conceivably, these fears may be accentuated in high-risk subgroups such as those with varus malalignment, who have greater functional and structural decline than neutrally aligned OA knees. The stigma surrounding weightbearing exercise also extends to clinicians, who can be reluctant to prescribe weightbearing exercises due to a fear of aggravating patient symptoms. The uncertainty towards weightbearing exercise may arise because medial knee OA pathogenesis is likely due, at least in part, to increased medial tibiofemoral compartment loading. The medial tibiofemoral contact forces (MTCF) during walking in people with knee OA and varus malalignment is on average ~2 times bodyweight, yet limited research has evaluated articular knee loads during different weightbearing exercises in people with knee OA. The aim of this cross-sectional study was to use EMG-informed neuromusculoskeletal modelling to test the hypothesis that common weightbearing exercises will generate larger lower-limb muscles forces than walking in people with medial knee osteoarthritis and varus malalignment. A secondary aim was to test the hypothesis that peak MTCF was no higher during these exercises compared to walking.

Methods: Twenty-eight participants aged ≥50 years with medial knee OA (Kellgren & Lawrence grade ≥2) and varus malalignment were recruited from the community. Three-dimensional lower-body motion, ground reaction forces and surface electromyograms from 12 lower-limb muscles were acquired during five squat, forward lunge, single-leg heel raise and walking trials, performed at self-selected speeds. These exercises were selected to reflect a different range of weightbearing exercises and positions often used within knee OA programs. The exercises were divided into three phases: (i) ascent/descent from starting pose to end of self-selected range; (ii) a three-second isometric hold; and (iii) ascent/descent back to the initial starting pose. An electromyogram-informed neuromusculoskeletal model with magnetic resonance imaging informed bone geometry and tibiofemoral contact points was used to estimate muscle forces (N) and bodyweight (BW) normalised MTCF. The peak forces for muscle groups (knee extensors, knee flexors, ankle plantar flexors and hip abductors) and peak MTCF during each exercise were compared to walking using a multivariate analysis of variance model. We were primarily interested in the main effect of each exercise condition (squat, lunge, heel raise) compared to walking. In the event of a significant main or interaction effect, post-hoc pairwise comparison (mean difference [95% confidence interval (95% CI)]) with a Bonferroni correction was performed to explore significant effects.

Results: The cohort had a mean age of 64, slightly more males than females and was overweight on average. Muscle force and MTCF outcomes for each exercise condition and walking are presented in Table 1. There was a significant main effect ($p<0.001$). Post-hoc tests (mean difference [95%CI]) showed that compared to walking, participants generated higher peak knee extensor and flexor forces during squatting (extensor: 902 N [576, 1227], flexor: 192 N [9.39, 375]) and lunging (extensor: 917 N [604, 1231], flexor: 496 N [198, 794]), and lower peak hip abductor force during squatting (-1975 N [-2841, -1108]) and heel raises (-1217 N [-2131, -303]). Compared to walking, MTCF was lower during squatting (-0.79 BW [-1.04, -0.53]) and heel raises (-0.27 BW [-0.50, -0.04]). No other significant differences were observed.

Conclusions: Despite clinical practice guidelines advocating exercise as a core treatment for all people with knee OA based on strong research evidence, there is uncertainty amongst physiotherapists and patients about whether exercise is effective and/or safe for all people with knee OA. Compared to walking, peak knee extensor force was ~3 times higher during squatting and lunging, and peak knee flexor forces were 1.6 and 2.5 times higher, respectively. These are important observations given these muscles stabilise the knee during the loading response of walking, which is where the peak MTCF occurs. Surprisingly, peak ankle plantar flexor and hip abductor force did not exceed the peak forces during walking for any of the exercises. This may highlight a need for alternative and/or more demanding exercises to target these muscle groups. Furthermore, the MTCF was lower during the heel raises and squatting relative to walking, but similar between lunging and walking. Collectively, these novel findings can give clinicians and their patients confidence that squatting and lunging will generate peak knee extensor and knee flexor forces larger than normal walking but do not increase forces within the osteoarthritic joint compartment.

	Mean (SD)				Mean difference (95% confidence interval)		
	Squat (n=28)	Lunge (n=28)	Heel raise (n=28)	Walking (n=28)	Squat minus walking	Lunge minus walking	Heel raise minus walking
Peak muscle force (N)							
Knee extensors	1409 (529)	1420 (521)	437 (367)	487 (253)	902 (576,1227)	917 (604, 1231)	-46.1 (-274, 182)
Knee flexors	531 (316)	836 (521)	417 (372)	342 (149)	192 (9.39, 375)	496 (198, 794)	90.0 (-119, 298)
Ankle plantar flexors	762 (619)	1002 (641)	1073 (546)	1219 (829)	-399 (-913, 114)	-156 (-648, 336)	-85.8 (-533, 362)
Hip abductors	842 (376)	2536 (1114)	1600 (902)	2817 (1610)	-1975 (-2841, -1108)	-281 (-1178, 616)	-1217 (-2131, -303)
Tibiofemoral contact force (BW)							
Peak medial	1.32 (0.41)	2.12 (0.45)	1.83 (0.43)	2.09 (0.42)	-0.79 (-1.04, -0.53)	-0.01 (-0.25, 0.24)	-0.27 (-0.50, -0.04)

Table 1

Osteoarthritis and Cartilage

Peak muscle and medial tibiofemoral contact force for exercise conditions and walking

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PREDICTING CHANGE IN KNEE CARTILAGE FROM INTERACTIONS OF CUMULATIVE LOADING WITH CARTILAGE TURNOVER BIOMARKERS: DATA FROM THE OSTEOARTHRITIS INITIATIVE

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Purpose: In people with established knee OA, exposure to high dynamic loading is associated with worsening knee cartilage morphology. Yet, habitual runners, who experience high loading rates do not show an increased risk of developing OA. This apparent contradiction likely requires that we identify factors that modify the relationship between loading and knee joint health. The purpose of our work was to evaluate potential factors that influence the relationship between cumulative loading to affect cartilage knee outcomes. Our primary objective was to investigate the relationship between cumulative load and two-year changes in cartilage thickness and mean transverse relaxation time (T2). A secondary objective was to examine whether baseline cartilage turnover biomarker concentration predicted changes in cartilage outcomes.

Methods: Data from the FNIH OA Biomarkers Consortium Project of the longitudinal Osteoarthritis Initiative (OAI) study was used for this