Osteoarthritis and Cartilage 22 (2014) 1634–1638

Osteoarthritis and Cartilage

Brief Report

Thigh muscle cross-sectional areas and strength in knees with early vs knees without radiographic knee osteoarthritis: a between-knee, within-person comparison

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ARTICLE INFO

Article history:
Received 7 January 2014
Accepted 3 June 2014

Keywords:
Muscle
Knee osteoarthritis
Cross-sectional area
Strength
Magnetic resonance imaging

SUMMARY

Objective: To compare cross-sectional and longitudinal side-differences in thigh muscle anatomical cross-sectional areas (ACSAs), muscle strength, and specific strength (strength/ACSA), between knees with early radiographic change vs knees without radiographic knee osteoarthritis (RKOA), in the same person.

Design: 55 (of 4796) Osteoarthritis Initiative (OAI) participants fulfilled the inclusion criteria of early RKOA in one limb (definite tibiofemoral osteophytes; no radiographic joint space narrowing [JSN]) vs no RKOA (no osteophyte; no JSN) in the contralateral limb. ACSAs of the thigh muscles and quadriceps heads were determined using axial MRIs at 33%/30% femoral length (distal to proximal). Isometric extensor and flexor muscle strength were measured (Good Strength Chair). Baseline quadriceps ACSA and extensor (specific) strength represented the primary analytic focus, and 2-year changes of quadriceps ACSAs the secondary focus.

Results: No statistically significant side-differences in quadriceps (or other thigh muscle) ACSAs, muscle strength, or specific strength were observed between early RKOA vs contralateral limbs without RKOA ($P \geq 0.44$), neither in men nor in women. The 2-year reduction in quadriceps ACSA in limbs with early RKOA was $-0.9 \pm 6\%$ (mean ± standard deviation) vs $-0.5 \pm 6\%$ in limbs without RKOA (statistical difference $P = 0.85$).

Conclusion: Our results do not provide evidence that early unilateral radiographic changes, i.e., presence of osteophytes, are associated with cross-sectional or longitudinal differences in quadriceps muscle status compared with contralateral knees without RKOA. At the stage of early unilateral RKOA there thus appears to be no clinical need for countervailing a potential dys-balance in quadriceps ACSAs and strength between both knees.

Introduction

Quadriceps strength is an important determinant of physical disability, and quadriceps weakness is commonly observed in radiographic knee osteoarthritis (RKOA)[1]. In a recent between-knee, within-person comparison, we found smaller quadriceps anatomical cross-sectional areas (ACSAs) and isometric extensor muscle strength in limbs with frequent knee pain compared with contralateral limbs without pain with the same RKOA stage[2]. In contrast, baseline quadriceps ACSAs or strength did not differ between limbs with advanced RKOA (i.e., joint space narrowing [JSN]) vs contralateral ones without JSN, nor did longitudinal changes in

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http://dx.doi.org/10.1016/j.joca.2014.06.002
1063-4584/

ACSAs and strength[3]. These data have suggested that muscle status may be associated with knee pain, but not with advanced RKOA status.

Other work has proposed that a reduction in thigh muscle mass and strength may be primarily associated with the onset of the early stages of RKOA[4,5], and our study in JSN vs no-JSN limbs may have missed these, because the potential time window during which discordant muscle status was present had already passed. Whereas previous work studied whether reduction in muscle strength (as an independent exposure variable of risk) is associated with the onset or progression of RKOA as an outcome[4–6], the current study focuses on cross-sectional differences in thigh muscle status between knees with an early radiographic stage of knee OA vs contralateral knees without RKOA (within-person comparison), and on 2-year changes in muscle ACSAs (the dependent variable) of knees with and without early RKOA (the independent variable). We considered presence of an osteophyte and absence of JSN as an early stage of RKOA, because cartilage thickness is not yet reduced in these knees[7]. We tested the following hypotheses:

1) Quadriceps ACSAs, strength, and specific strength are lower in knees displaying early RKOA (i.e., definite osteophytes, no JSN) compared to contralateral knees without any radiographic change.
2) The 2-year decrease in muscle ACSAs is greater in early RKOA compared to contralateral no-RKOA knees.

Methods

Participants

Participants were drawn from the Osteoarthritis Initiative (OAI) participants (n = 4796 http://www.oai-ucsf.edu/datarelease/)[7,8]. The inclusion criteria were early RKOA of the tibiofemoral joint (i.e., definite tibial or femoral marginal osteophytes according to the Osteoarthritis Research Society International atlas) in one knee, no signs of RKOA in the contralateral knee, and no JSN in either knee at baseline. Radiographic readings were taken from the OAI data base, identifying 84 subjects fulfilling the above criteria; these were confirmed by an experienced musculoskeletal radiologist (FR) in 61 cases[7]. Pain was not an inclusion criterion, but WOMAC pain scores (3.1 Likert scale; 0–20; 20 being the worst) and Physical Activity Scale for the Elderly (PASE) scores were exported from the OAI data base. Further, participants needed to have baseline T1-weighted axial spin-echo MR images of the thigh available (imaging data set 0.E.1), which was the case for 55 participants. Of these 38 also had 2-year follow-up MRI (3.E.2) available.

Evaluation of ACSAs and strength

ACSAs of the quadriceps, hamstrings, and adductors were manually segmented at anatomically consistent locations (33% femoral length; distal to proximal), and individual quadriceps heads at 30%[2,3] (Fig. 1). Isometric knee extensor and flexor strength was measured using the "Good Strength Chair" (Metitur Oy, Jyvaskyla, Finland) at 60° knee flexion[2,3]. Strength data was available for 49 of the 55 participants; specific strength was calculated as strength per unit ACSA (N/cm^2).

Statistical analyses

The cross-sectional between-knee within-person comparison of quadriceps ACSAs, strength, and specific strength (early RKOA vs no-RKOA) was considered the primary analytic focus; the 2-year changes in quadriceps ACSAs within limbs and between early RKOA vs no-RKOA limbs were the secondary analytic focus; differences between knees were tested using paired t-tests and statistical significance was considered as $P < 0.05$. Other tests were considered exploratory. Given reports on the reduction of muscle strength to be associated with knee OA in women, but not in men[5,9], sensitivity analyses were performed between both sexes. Pearson's correlation coefficients were calculated for quadriceps ACSAs vs extensor strength, hamstring ACSAs vs flexor strength, and for 2-year change in quadriceps ACSAs vs 2-year change in PASE scores.

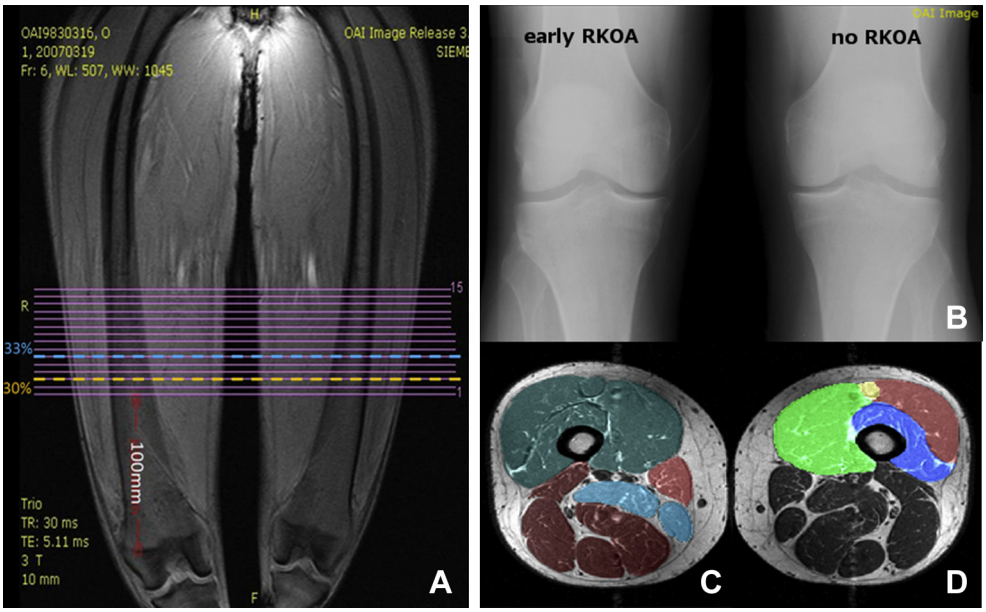

Fig. 1. A. Coronal localizer image: 15 continuous axial slices of the thigh have been acquired. **B**. Participants (right top). For the current study we selected participants with early RKOA in one knee and no RKOA in the contralateral knee on fixed-flexion X-rays (right top). **C**–**D**. Axial cross-sectional MRIs with segmented muscles. ACSAs of the quadriceps (pink), hamstrings (red), and adductors (yellow) have been segmented at 33% of femoral length (from distal to proximal) (C). ACSAs of the individual quadriceps heads vastus medialis (brown), vastus intermedius (turquoise), vastus lateralis (yellow), and rectus femoris (purple) have been segmented at 30% of femoral length (from proximal to distal) (D).