

Thigh Muscle Volume is Predictive of Total Knee Replacement: Longitudinal Analysis of Data from the Osteoarthritis Initiative

PURPOSE

To evaluate whether higher thigh muscle volume is associated with lower odds of total knee replacement (cases) compared to participants who do not undergo knee replacement (controls).

METHODS AND MATERIALS

A total of 134 participants (70 female, age 62.1 [45.0, 79.0] years, BMI 29.9 [22.2, 41.8] kg/m) from the Osteoarthritis Initiative (OAI) cohort who underwent total knee replacement (TKR) of a single knee, excluding bilateral cases, were selected (n=67). Participants who did not undergo TKR were propensity-score matched on age, sex, BMI, Kellgren-Lawrence (KL) grades, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Physical Activity Scale for the Elderly (PASE) as controls (n=67). 3T MRI of the thigh obtained at the time of surgery, 2 years and 4 years before the surgery (if available) were evaluated. A previously trained, accurate (dice score > 0.90 for all muscle groups) deep-learning model for 3D muscle segmentation was used to segment and compute volumes of: extensors, hamstrings, adductors, gracilis, sartorius, and subcutaneous fat. Additional markers such as total muscle volume, normalized volumes (muscle volume / total muscle volume), and extensor-hamstring ratio (extensors volume / hamstrings volume) were derived based on these measurements. Association between thigh muscle volume markers and TKR was assessed using a longitudinal mixed effects logistic regression model; odds ratio (OR) along with 95% confidence intervals for each muscle group (representing overall effect across the 3 timepoints) were computed; a $p < 0.05$ was considered statistically significant.

RESULTS

Normalized thigh muscle volumes were overall associated with TKR (F-statistic=6.36, $p < 0.001$). A higher extensor-hamstring ratio was significantly associated with lower odds of TKR (OR: 0.18 [0.04, 0.58], $p = 0.005$). Higher normalized volumes of hamstrings (OR: 0.93 [0.89, 0.97], $p = 0.002$) and gracilis (OR: 0.92 [0.87, 0.96], $p = 0.01$) were also associated with lower odds of TKR. Adductors (OR: 1.0 [0.99, 1.10]), extensors (OR: 1.02 [0.99, 1.12]), sartorius (OR: 1.05 [0.89, 1.32]), and subcutaneous fat (OR: 0.99 [0.98, 1.01]) as well as absolute muscle volumes did not show significant association with TKR.

CONCLUSIONS

A lower odds ratio of TKR for the extensor-hamstring ratio was found indicating that a stronger extensors group, relative to hamstrings, may lower the risk of TKR. Strong hamstrings, in general, may also lower the risk of TKR.

CLINICAL RELEVANCE/APPLICATIONS

These results can potentially inform clinical management; namely, strengthening extensors relative to hamstrings may lower the risk of eventual total knee replacement.

