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CONCURRENT CHANGE IN QUADRICEPS STRENGTH AND PHYSICAL FUNCTION OVER 5 YEARS IN THE MULTICENTER OSTEOARTHRITIS STUDY

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Objective: Quadriceps weakness, associated with functional limitations, is a target of treatment of knee osteoarthritis (OA). Limited data exist on modest strength increases and improvements in function. We evaluated concurrent change in strength and physical function over 5 years.

Methods: Using subjects from the Multicenter Osteoarthritis (MOST) study, we excluded those with knee replacement after baseline. A 3-category variable defined whether, at 5 years, knee extensor strength increased, decreased or remained within 15% of baseline, a clinically important cutoff.

Outcomes: Five-Times Sit-to-Stand-Test, 20-Meter Walk Test, WOMAC Physical Function Score, and 3 individual physical functions from WOMAC: arising from a chair, going up stairs and getting on/off toilet. Linear and logistic models, stratified by sex, evaluated associations between change in strength and change in physical function over 5 years. To compare weaker vs. stronger women, we stratified analyses at 56Nm baseline strength.

Results: Among 1534 participants (60.6% women), 22% of men and 30% of women increased strength by at least 15% at 5 years. Compared with women whose strength did not change, women whose strength increased had improved chair stand performance (OR=2.27, 95% CI 1.56, 3.30) but no improvements in other functions. In men, increase in strength was not associated with significant improvement in physical function. 20% or 30% change showed similar results.

Conclusion: Modest improvement in quadriceps strength was associated with improved chair stand performance in women, but not in men. Most functions did not improve with an increase in strength, and may require targeted interventions to improve functional status.

SIGNIFICANCE AND INNOVATIONS

- Unique in long follow-up of change in quadriceps strength and physical function, in a cohort of community-dwelling men and women with knee osteoarthrititis(OA) from the Multicenter Osteoarthritis Study (MOST).
- We present results of change over 5 years in minimal clinically important differences (MCID) in both performance-based and self-reported physical function measures.
- Among women, a 15% increase in measured quadriceps strength over 5 years was associated with improved chair stand performance, but not walk time or self-reported functional limitations. Among men**,** an increase in quadriceps strength over 5 years had no effect on these physical function measures.
- Although quadriceps strengthening can improve some physical function in very weak individuals, for many daily tasks more targeted task-based interventions may be needed to improve functional status.

Quadriceps weakness is associated with functional limitations and is a target in the treatment of knee osteoarthritis (OA)(1, 2). However, there are limited longitudinal data on the effect of modest increases in strength on improvements in physical function, particularly in individuals with OA.

A recent systematic review and meta-analysis of 15 longitudinal studies of knee extensor strength and function, in individuals with or at risk of knee OA, found low knee extensor strength was associated with increased risk of symptomatic and functional deterioration over periods from 1.5 to 8 years, but strengthening was not evaluated (3). In addition, although a number of trials have evaluated strength training with knee OA(4-6), performance-based outcomes(7, 8) have usually not been included. A meta-analysis of exercise therapy for knee OA (4) included 45 trials and found American College of Sports Medicine(ACSM)-based

interventions were significantly better with respect to knee extensor strength gain in comparison to non-ACSM interventions. They found no effect of strengthening on pain and disability, which were typically evaluated using WOMAC function and pain scores; these results led them to postulate that increases in knee extensor strength of 30-40% would likely be necessary for a concomitant beneficial effect on pain and/or disability. Most of the trials were short-term, often with 8 weeks of follow-up, and lacked performance-based outcomes (i.e. walking or chair stands). A longer study with 2 years of follow-up (6) found significant reductions in knee pain and improvements in self -reported function for exercise groups compared to the non-exercise control groups. Another study evaluating the effect of lower-extremity strength training on incidence and progression of knee OA, with 30 months of follow-up (5), found no differences between treatment groups for isotonic strength at 30 months followup, although the strength training group had a slower rate of decline. However, they did not experience an improvement in self reported function relative to those undergoing range of motion exercises. This study also included individuals without OA and half had no pain at baseline.

As rehabilitation focuses in large part on making a person stronger, we wanted to test whether increases in strength would improve physical function, and secondarily whether this effect was present across all levels of baseline strength, or only among persons who were relatively weak at baseline and whose functional limitations may be due, in part, to their weakness. In recent work (9) using cross sectional data, we have reported that the relation of quadriceps strength to function is different in weaker than stronger women (threshold of around 56 Newton-meters(Nm)). We found that the slope of the relationship was far steeper for weaker women, suggesting that any increases in strength could potentially improve their function. Our objective was to evaluate longitudinal changes in quadriceps strength and concurrent

changes in performance-based(7) and self reported physical function measures(10) over 5 years in a sample of men and women with or at risk of knee OA.

PATIENTS AND METHODS

Study Population

The Multicenter Osteoarthritis (MOST) study is a cohort study of 3026 men and women between 50-79 years of age at baseline, at risk of knee OA (i.e. overweight, obese, a history of knee injury, or with frequent knee pain) or with established knee OA. The study participants were from Birmingham, Alabama and Iowa City, Iowa in the U.S. (11). The study started in 2003 when study participants were interviewed by telephone and attended clinic visits. Further details of inclusion and exclusion criteria have been published (11, 12). The baseline visit included measurement of height, weight, knee extensor muscle strength, and performance based functions and surveys on self-reported physical function and pain, along with radiographic evaluation. These same measurements and surveys were repeated at the 5 year visit.

We included participants who had right knee extensor strength measured, at baseline and 5-year visits, using an isokinetic dynamometer (Cybex 350) set at 60 degrees/second and a chair back angle of 85°. After 3 practices, participants were asked to push maximally against a pad that moved isokinetically in a range of 0-90 degrees. This was repeated a total of 4 times and we used the maximal torque as the measure of strength. The MOST strength testing protocol had an intraclass correlation coefficient of 0.94(0.82-0.99), a coefficient of variation of 8%(6-12%) and a within-subject variation of 6.3 Nm(4.71-9.63)(13). The Standard Error of Measurement(SEM) was 10.2%, in line with other studies of isokinetic

strength (14-17). Based on a SD=41.94 for men and women together, the minimal detectable change (MDC)(18) in knee extensor torque in MOST was 24; for women alone (SD=26), MDC was 15.

We excluded participants missing data for the 5-year visit (n=147), those who had knee replacement after baseline (n=377), and those lacking strength data at baseline or 5 years (n=873). Finally, to eliminate values we felt were probably inaccurate assessments of the person's maximal strength, we excluded those with extreme values in the top or bottom 1% of strength at either baseline or 5 years, or those whose change in strength was in the top or bottom 1%, for their sex (n=108).

Exposure: Lower extremity muscular strength change

We used 15% change in a person's strength as a clinically important cutoff based on test-retest studies(19), and reasoning that the MOST strength SEM is approximately 10%, plus 5% probable decline in strength over 5 years due to aging (20). We created a 3-category exposure variable defined by whether, at 5 years, a participant's right quadriceps strength(Nm) had increased 15% or more from baseline, decreased 15% or more, or remained within 15% of baseline (no change). The right leg was used because of more complete data at the 5-year visit. Sensitivity analyses assessed 20% or 30% change in strength as the exposure. The MOST study initially included bilateral assessment of quadriceps strength but the symmetry in strength was substantial (r = 0.84 for correlation between limbs) and burden on subjects led us to limit measurement to right limb only.

Outcomes: Measures of physical function

20-Meter Walk Test: In the 20-Meter Walk Test, study participants were told to walk at their usual pace from the starting point to the end. The mean of two trials was used in the analyses. We calculated the difference in walk times from baseline to 5-years. Walk time was converted to meters/seconds to test for a minimal clinically important difference (MCID) change in walking pace, which was defined as 0.08m/sec based on testing in older adults(21, 22); the SEM in these studies ranged from 0.04m/sec (21) to 0.06 m/sec (22).

Five Times Sit-to-Stand Test: In the Five Times Sit-to-Stand Test, participants stood up from a standard chair five times as quickly as they could, keeping their arms folded across their chest. We recorded total time in seconds using a stopwatch. The mean of two trials was used in the analyses. We calculated the difference in chair stand times from baseline to 5-years. Based on a standard deviation (SD) at baseline=3.86 and estimated reliability coefficient for 5 chair stands=0.80(23), we calculated minimum detectable change(MDC)(18) and used this to estimate a MCID for chair stands of -1.56 seconds for improvement.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): We used the WOMAC physical function score (range: 0-68) and calculated the difference in scores from baseline to 5-years. MCID change was defined as change of 6.1(24). In addition we chose a priori items from the WOMAC survey which involve the human body acting against gravity: going up stairs, rising from a chair, and getting on or off the toilet. For each of these, respondents answered a question "How much difficulty have you had…" performing the task. For each question, possible responses were "none" (scored 0, best performance level),

"mild" (1), "moderate"(2), "severe"(3), or "extreme" (4 - worst performance level), yielding an ordinal value ranging 0-4 for each WOMAC item. For our purposes MCID in the individual WOMAC items was defined as a change of 1 or more points.

Covariates

Age: Age in years was used as a continuous variable.

Mass: Body mass in kilograms at baseline was used as a continuous variable. We also calculated the different from baseline to 5-years.

Height: Height in millimeters was measured at the baseline visit.

Kellgren-Lawrence Score: We used the Kellgren-Lawrence Score (range: 0-4) from the baseline MOST visit to create a dichotomous variable indicating whether the participant had at least one knee with score greater than or equal to 2.

Physical Activity Survey for the Elderly PASE (25): Scores are summary values calculated from weights and frequencies for each of the 12 types of activities described in the questionnaire. Q1 on page 1 (sitting activities over the past 7 days) and Q4 on page 2 (climbed flight of stairs over the past 7 days) were administered as part of the PASE questionnaire, but did not contribute to the overall PASE score. Q8-Q11 have been given an option "Don't know/Refused" – all such responses were converted into missing values before calculation. If all PASE components were missing, the score is set to missing. There are no substitutions made for missing or skipped questions. If at least one component of the score is non-missing, then the score is calculated.

WOMAC Pain Score: WOMAC Pain Scores were calculated for each knee (range, 0-20) at the baseline and 5-year visits. We also calculated the difference between the 5-year and baseline scores for each knee.

Statistical Methods

This is a prospective longitudinal analysis using subjects from the Multicenter Osteoarthritis (MOST) study from the baseline and 5-year visits. Due to differences in strength in men and women, all analyses were stratified by sex.

We summarized participant characteristics with frequencies and means. Physical function was measured with the Five-Times Sit-to-Stand-Test, 20-Meter Walk Test, and WOMAC physical function scores. For each physical function outcome, "change" was calculated as the difference between the baseline and the 5-year value. Generalized linear models were used to evaluate associations between 15% change in strength and mean change in each physical function outcome over 5 years. Logistic regression models were used to calculate the odds of MCID change for each functional outcome, based on 15% change in strength. In addition to stratifying by sex, we adjusted for baseline age, baseline body mass and change over 5 years, WOMAC pain at baseline in right leg, and change in WOMAC pain over 5 years for each leg (26). Based on cross-sectional analyses in MOST (9) which suggested a threshold of strength for function in women but not men, we stratified analyses at 56 Nm at baseline to determine whether associations differed in weaker vs. stronger women. In analyses of WOMAC outcomes, we further restricted the data for each measure to include participants with scores greater than 0 at the baseline visit, i.e. those who could show improvement on that measure over 5 years.

To test the robustness of our analyses, we carried out sensitivity analyses using 20% and 30% change in strength for the exposure, and restricting the analysis sample to subjects with OA in the right knee at baseline (Kellgren and Lawrence grade greater or equal to 2). For outcomes of mean change in function, we additionally tested restricting the exposure reference group to ±10% of change in strength; adjustment for the baseline Kellgren and Lawrence grade of the worse knee; and adjustment for baseline physical activity (PASE).

Analyses were performed using SAS software version 9.4 and alpha level for significance set at <0.05.

RESULTS

Participant characteristics at baseline are summarized in Table 1. The 1534 study participants (60.6% women) were on average 62 years of age, with a mean BMI of 30 kg/m^2. Mean quadriceps strength in men (124±38 Nm) was higher than in women (68±23 Nm) and over 5 years increased by 15% or more in 22% of men and 30% of women, while 31% of men and 23% of women saw decreases in strength of at least 15%. Less than half of the participants had Kellgren-Lawrence grades ≥2 (44% of men ; 43% of women), and 89% of participants had a walking speed of ≥1 m/s. The experience of pain differed across the sample, with men, and stronger women being similar (59% of men, and 52% of stronger women reported no pain), compared to weaker women (only 37% reported no pain at baseline; 32% reported pain at both baseline and 5 years).

In men (Table 2), a 15% or greater increase of strength had minimal effect on walking pace or chair stands performance, compared with those whose strength did not change. A 15% or greater decrease in strength was not associated with MCID changes in function, but was

associated with 0.7 second (95% CI= 0.2, 1.3) slower chair stands time (supplementary Table 3).

In women (Table 2), a 15% increase in strength was associated with significantly improved chair stands performance (MCID improvement OR=2.27, 95% CI= 1.56, 3.30; mean change in time= 0.7 seconds 95% CI= -1.2, -0.3). Walking performance and WOMAC function scores were not associated with increase in strength. A 15% decrease in strength was associated with slower walking time by approximately 0.7 seconds (95% CI= 0.3, 1.2), and slower chair stand time by 0.6 seconds (95% CI= 0.1, 1.2) (supplementary Table 3).

Results from analyses among women stratified by baseline strength are shown in Table 3 and Supplementary Table 4. Compared with women whose strength did not change, among weaker women of baseline strength ≤56 Nm , a 15% increase in strength had little or no effect on 20-meter walk time or WOMAC scores, or chair stands. Among stronger women with baseline strength >56 Nm, a 15% increase in strength was associated with a signicant improvement in chair stands performance (OR=2.27, 95%CI= 1.33 , 3.88; mean change = -0.6 seconds, 95% CI= -1.3, 0.0) , and in "going up stairs" (OR=2.01, 95%CI= 1.01 , 3.99).

Sensitivity analyses of 20% and 30% change in strength showed similar results in models of mean change (see Supplementary Tables 1-2). Restricting the sample to those with baseline radiographic knee OA (K&L grade >=2) in the right knee gave similar trends in results, although the smaller sample resulted in wider CIs and no significant associations. In models with mean change outcomes, neither the baseline PASE score, nor the baseline K&L grade were significant predictors when added to the analytic model.

DISCUSSION

In this community-dwelling population with or at risk of knee OA, an increase in measured quadriceps strength over 5 years was not associated with improved walking or chair stands time, or self-reported physical function in men. An increase in strength was associated with improved chair stand performance and "going up stairs" in women, but not improved walk time or other self-reported functional limitations on the WOMAC index. For both men and women, decreases in strength were associated with worsening function.

These results are expected for timed chair stands, since increases in strength, particularly in weaker individuals, would be most likely to affect objective performance; whereas usual walking time is less likely to be associated with increases in strength. In addition, our results are consistent with other studies which show decreases in muscle strength are associated with worsening physical performance (3).

Most other studies which evaluated increases in strength did so in the context of a trial with a strength training intervention. In a small 8-week strengthening trial(27, 28), 10 elderly men and women experienced an average strength gain of 174% ± 31%. Assuming that increases in strength at least partially mediate improved functional outcomes(28), we note that in this trial "habitual gait" speed was not significantly improved (in line with our results), but a few participants saw an improved ability to do a chair stand (27). In our sample from the MOST cohort, we observed changes in strength over 5 years, and note that some 22% of men and 30% of women increased their baseline strength by 15% or more. We also observed slight improvements in some performance-based measures with even a modest 15% increase in strength, in contrast to studies which concluded that increases of 30-40% would be necessary for functional improvements (4). In our sample, 12% of men, and 18% of women showed

improvements of 30% or more in strength over 5-years. In sensitivity analyses using exposures of 30% change in strength in women, results were similar to our primary analyses of 15% or greater changes in strength (see supplementary tables1 and 2). Among men, a 30% increase in strength was associated with significantly increased odds of MCID change in "getting on or off toilet" (OR=2.95, 95%CI=1.09 , 7.98) and 30% decrease in strength was associated with significant worsening in "rising from a chair" (OR=2.51, 95% CI=1.01 , 6.21).

Although our results indicate that improvement in quadriceps strength may be associated with improvements in some functional performance measures, the lack of associations likely indicate achieving improvements in functional status requires more than simply addressing strength impairments. Task-specific training in rehabilitation(29) focuses on goal-directed practice and repetition of specific task(s), and may yield improvements in pain and function for some individuals who have not benefited from more traditional approaches. Older adults with knee OA who participated in walking training have improved their walking speed and activity level, but not other functional limitations, such as chair stands or stair ascent, or impairments such as pain or weakness(30). In a study of adults over age 70, comparing power training to a walking program, walk time and physical performance did not improve, but power training improved muscle power(31). These example validate the importance of specificity of training and demonstrate the need for function-specific interventions to effectively improve functional limitations.

The MOST study has several key strengths for this type of analysis. Our study is unique in its long duration of follow-up and in its inclusion of performance measures that included those likely dependent on quadriceps strength (chair stand) and those not so dependent (walk time) and on selected self reported function measures that depend on quadriceps strength.

We were able to follow participants for 5 years, and to include both men and women. They represent a community-dwelling sample that is neither severely disabled, nor extremely healthy, but rather spans a range of performance. The sample size is also large compared to many strength trials in older adults. Knee extensor strength was measured using an isokinetic dynamometer, measuring knee strength while the leg is in motion, rather than pressing against a static instrument and therefore represents a more functionally relevant and better tolerated measure than isometric strength. We were able to include both performance-based measures of function and self-reported WOMAC measures, and to adjust for pain at both baseline and 5-years.

There were a number of limitations to our study. As in any observational study, residual confounding may exist. We also lacked strength data for a number of MOST participants at 5-years, causing them to be eliminated from this sample, although we still had a large sample. The walk test was self-selected at "usual" gait speed, which is less likely to be driven by muscle strength, and chair stand performance is better related to quadriceps muscle power than it is to strength. Self-reported physical function frequently represents what individuals perceive they can do, rather than what they can actually do.

In summary, in this study of adults age 50–79 years, with or at risk of knee OA, we found an increase in quadriceps strength was associated with improved chair stand performance in women, but not improved walk time or self-reported functional limitations. An increase in strength was not associated with change in performance-based physical function in men. Modest strength improvements may have limited effects on common functions. Targeted interventions may be required to improve functional status.

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Table 1. Participant Characteristics at baseline and changes in strength and function

	Men n=609 (mean, sd)	Women(all) n=925 (mean, sd)	Women, weaker n=295 (mean, sd)	Women, stronger n=630 (mean, sd)
Age (years)	61.5(7.9)	61.8(7.6)	64.2(7.9)	60.7(7.3)
Body mass (kgs)	95.7(16.1)	79.7(15.4)	78.0(15.2)	80.5(15.4)
BMI : Body mass index (Kg/m^2)	30.2(4.7)	29.8(5.7)	29.7(5.6)	29.8(5.8)
Race (%white)	87%	85%	80%	88%
PASE Score (baseline)	211.6(95.7)	162.4(74.7)	155.8(74.3)	165.4(74.7)
Kellgren and Lawrence (KL), Grade 2 or greater (%)	44%	43%	52%	39%
WOMAC Pain : Left knee				
Score (baseline, range:0-20)	2.3(3.1)	2.9(3.5)	3.7(3.9)	2.5(3.2)
Score difference at 5 years (+) =increased pain	0.1(2.9)	0.3(3.3)	0.4(0.4)	0.2(3.0)
WOMAC Pain : Right knee				
Score (baseline, range:0-20)	2.2(2.8)	3.1(3.4)	4.5(3.8)	2.4(2.9)
Score difference at 5 years (+) =increased pain	0.0(2.5)	0.0(3.2)	- 0.4(3.6)	0.2(3.1)
Knee extensor muscle strength (Nm, baseline, right leg)	124.0(37.7)	68.7(23.1	42.7(10.0)	80.9(16.5)
[Min, Max]	[36.0, 226.0]	[13.0, 126.0]	[13.0, 56.0]	[57.0, 126.0]
Strength change (Nm, baseline to 5 years, right leg)	-5.4(27.3)	+0.6(17.4)	+9.7(15.1)	-3.6(16.7)
Strength change %, right leg				
Increase in strength >=15%	22%	30%	58%	17%
No Change (change <15%)	47%	47%	27%	56%
Decrease strength >=15%	31%	24%	15%	28%
Strength change %, right leg				
Increase in strength >=30%	12%(n=71)	18%(n=166)	40%(n=119)	7%(n=47)
No Change (change <30%)	79%(n=480)	73%(n=679)	55%(n=161)	82%(n=518)
Decrease strength >=30%	10%(n=58)	9%(n=80)	5%(n=15)	10%(n=65)
Chair stands (five; seconds)	10.2(2.9)	11.4(3.1)	12.8(3.5)	10.7(2.7)
Walking time (20m; seconds)	15.9(2.4)	16.8(2.9)	18.0(3.3)	16.2(2.5)
Walking Pace (meters/sec)	1.3(0.2)	1.2(0.2)	1.1(0.2)	1.3(0.2)

WOMAC physical function score (Total score, knee. Range: 0-60.)	10.0(10.8)	12.8(11.6)	17.3(12.3)	10.8(10.6)

Table 2. Association of change in strength with physical function, stratified by sex

	Strength change over 5 years		
	Increase >=15%	**No change (<15% change)**	**Decrease >=15%**
Odds Ratio for MCID Change in Physical Function over 5 years	**OR for MCID Change in Function (OR, 95% CI)**		**OR for MCID Change in Function (OR, 95% CI)**
Men	**n=132**	**n=289**	**n=188**
Walking pace over 20-meters(m/sec)	0.97(0.62-1.52)	1.0 (REF)	0.76(0.50-1.16)
Chair stands time	0.84(0.49-1.43)		0.56(0.33-0.97)
WOMAC Physical Function Score	0.98(0.49-1.95)		0.76(0.39-1.49)
WOMAC Item "going up stairs"	0.75(0.38-1.48)		1.13(0.59-2.14)
"rising from chair"	1.46(0.77-2.79)		1.21(0.65-2.27)
"getting on or off toilet"	1.22(0.54-2.76)		1.24(0.57-2.70)
Women	n=276	n=430	n=218
Walking pace over 20-meters (m/sec)	0.94(0.68-1.31)	1.0 (REF)	0.65(0.44-0.94)
Chair stands time	2.27(1.56-3.30)		1.01(0.63-1.61)
WOMAC Physical Function Score	1.29(0.82-2.04)		0.67(0.38-1.19)
WOMAC Item "going up stairs"	1.26(0.81-1.96)		0.90(0.53-1.52)
"rising from chair"	1.12(0.73-1.72)		0.73(0.44-1.23)
"getting on or off toilet"	0.84(0.50-1.40)		0.56(0.31-1.00)

All analyses stratified by sex and adjusted for baseline age; baseline body mass and change in body mass over 5 years; WOMAC pain at baseline (right leg), and change in WOMAC pain for each leg (baseline to 5 years).WOMAC analyses are restricted to individuals with scores >0 at baseline. Maximum likelihood parameter estimates are odds of MCID change over 5 years for each outcome by categories of change in strength (over 5 years): MCID change in m/sec walking pace (.08m/sec); MCID change in execution time for 5 chair-stands in seconds (-1.56sec); MCID change in WOMAC physical function score (absolute change -6.1 of 68) ; for individual WOMAC items, improvement of at least one point on the ordinal scale.

Table 3. Association of change in strength with physical function, stratified by strength, in women

	Strength change over 5 years		
	Increase >=15%	**No change (<15% change)**	**Decrease >=15%**
Odds Ratio for MCID Change in Physical Function over 5 years	**OR for MCID Change in Function (OR, 95% CI)**		**OR for MCID Change in Function (OR, 95% CI)**
Weaker women: Baseline strength<= 56Nm (n=295)	**n=171**	**n=80**	**n=44**
Walking pace over 20-meters(m/sec)	0.86(0.48-1.57)	1.0 (REF)	0.46(0.18-1.12)
Chair stands time	1.56(0.82-2.97)		0.78(0.29-2.13)
WOMAC Physical Function Score	0.98(0.46-2.09)		1.06(0.34-3.27)
WOMAC Item "going up stairs"	0.80(0.38-1.69)		0.52(0.16-1.66)
"rising from chair"	1.11(0.52-2.36)		0.42(0.13-1.42)
"getting on or off toilet"	0.79(0.33-1.88)		0.65(0.17-2.56)
Stronger women: Baseline strength > 56Nm (n=630)	**n=105**	**n=350**	**n=174**
Walking pace over 20-meters(m/sec)	0.82(0.51-1.32)	1.0 (REF)	0.70(0.46-1.07)
Chair stands time	2.27(1.33-3.88)		1.09(0.64-1.86)
WOMAC Physical Function Score	1.34(0.67-2.71)		0.54(0.27-1.09)
WOMAC Item "going up stairs"	2.01(1.01-3.99)		1.02(0.55-1.88)
"rising from chair"	1.52(0.79-2.90)		0.81(0.46-1.44)
"getting on or off toilet"	0.95(0.39-2.31)		0.46(0.24-0.90)

All analyses stratified by sex and adjusted for baseline age; baseline body mass and change in body mass over 5 years; WOMAC pain at baseline (right leg), and change in WOMAC pain for each leg (baseline to 5 years).WOMAC analyses are restricted to individuals with scores >0 at baseline. Maximum likelihood parameter estimates are odds of MCID change over 5 years for each outcome by categories of change in strength (over 5 years): MCID change in m/sec walking pace (.08m/sec); MCID change in execution time for 5 chair-stands in seconds (-1.56sec); MCID change in WOMAC physical function score (absolute change -6.1 of 68) ; for individual WOMAC items, improvement of at least one point on the ordinal scale.