# Group Versus Individual Physical Therapy for Veterans With Knee Osteoarthritis: Randomized Clinical Trial

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**Background.** Efficient approaches are needed for delivering nonpharmacological interventions for management of knee osteoarthritis (OA).

**Objective.** This trial compared group-based versus individual physical therapy interventions for management of knee OA.

**Design and Methods.** Three hundred twenty patients with knee OA at the VA Medical Center in Durham, North Carolina, (mean age=60 years, 88% male, 58% nonwhite) were randomly assigned to receive either the group intervention (group physical therapy; six 1-hour sessions, typically 8 participants per group) or the individual intervention (individual physical therapy; two 1-hour sessions). Both programs included instruction in home exercise, joint protection techniques, and individual physical therapist evaluation. The primary outcome measure was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC; range=0–96, higher scores indicate worse symptoms), measured at baseline, 12 weeks, and 24 weeks. The secondary outcome measure was the Short Physical Performance Battery (SPPB; range=0–12, higher scores indicate better performance), measured at baseline and 12 weeks. Linear mixed models assessed the difference in WOMAC scores between arms.

**Results.** At 12 weeks, WOMAC scores were 2.7 points lower in the group physical therapy arm compared with the individual physical therapy arm (95% confidence interval [CI]=−5.9, 0.5; $P$=.10), indicating no between-group difference. At 24 weeks, WOMAC scores were 1.3 points lower in the group physical therapy arm compared with the individual physical therapy arm (95% CI=−4.6, 2.0; $P$=.44), indicating no significant between-group difference. At 12 weeks, SPPB scores were 0.1 points lower in the group physical therapy arm compared with the individual physical therapy arm (95% CI=−0.5, 0.2; $P$=.53), indicating no difference between groups.

**Limitations.** This study was conducted in one VA medical center. Outcome assessors were blinded, but participants and physical therapists were not blinded.

**Conclusions.** Group physical therapy was not more effective than individual physical therapy for primary and secondary study outcomes. Either group physical therapy or individual physical therapy may be a reasonable delivery model for health care systems to consider.

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Knee osteoarthritis (OA) is one of the most common chronic health conditions and a leading cause of pain and disability among adults.[1–4] The lifetime risk of knee OA may be as high as 45%,[5] and the prevalence is rising.[6] This increased risk and prevalence will place an increasing burden on health care systems. Multiple studies have highlighted gaps in the use of nonpharmacological strategies for managing knee OA.[7–14] Physical therapy is one of the key components of knee OA management, consistently included in the treatment guidelines of major professional organizations.[15–19] There is evidence that physical therapy, particularly exercise-based physical therapy, reduces pain and improves function in patients with knee OA.[20–25] However, physical therapy includes diverse interventions, and the research base is limited for the spectrum of interventions provided by physical therapists for knee OA, as well as the effectiveness of different delivery models. Nonpharmacological interventions provided by physical therapists range from exercise to education in energy conservation and joint protection to use of assistive devices and braces.

Physical therapy of any sort is underutilized for knee OA in some clinical settings,[26] with one recent study showing that among patients who eventually underwent knee arthroplasty, only 10% had received any physical therapy for their OA during the prior 5 years.[27] Although factors underlying low use of physical therapy for knee OA are not clearly understood, delivery models that maximize patient benefits (eg, peer support) and clinical efficiency would be common-sense directions for improving use of physical therapy for this population. The American Physical Therapy Association projected that by 2020 there may be a shortage of physical therapists in the range of about 9,000 to 40,000 nationally.[28] This projection, coupled with the estimated increase in patients with knee OA, signals a need for evidence-based models for delivering physical therapy in an efficient manner.

Although physical therapy for knee OA can be provided in one-on-one sessions, a group-based approach also has promise as a model for delivering some commonly used physical therapy interventions for knee OA. This strategy mirrors that of cardiac rehabilitation programs and shared medical visits, both of which are effective in targeted illnesses.[29,30] Small studies have supported the efficacy of group-based physical therapy following joint replacement surgery,[31,32] but there is very limited evidence regarding a group-based model of physical therapy for patients with knee OA more generally.[23,33] There are several reasons that group-based physical therapy may be particularly appropriate and effective in the context of knee OA. First, delivering physical therapy in a group setting can be an efficient approach, potentially allowing more visits per patient than an individual physical therapy delivery model with similar staffing resources. The allowance of more visits per patient could be important for helping patients to adequately learn a home exercise program, address problems with specific exercises, and learn processes for appropriate exercise progression. Second, group visits are particularly useful in the context of chronic conditions, such as OA, that require education and support for a variety of self-care strategies.[34] Third, many components of physical therapy for knee OA, such as instruction in appropriate exercises, can feasibly be delivered in a group-based setting. Fourth, a group-based structure can provide peer social support, which is an important factor in promoting adherence to exercise-based interventions.[35,36]

The objective of this trial was to compare the effectiveness of physical therapist–led individual and group-based delivery of nonpharmacological interventions for patients with knee OA. Physical therapy interventions provided to patients in both study arms included instruction in an appropriate home exercise program, education regarding joint protection and activity pacing, and screening to ensure appropriate provision of other nonpharmacological interventions such as braces, assistive devices, and shoe lifts. Although the content was the same for both interventions, the group-based program was designed so that it could extend services to more patients, for a

greater number of sessions per patient, and with overall lower staffing resources, compared with the individual program. Because the group-based model provided more sessions per patient, it allowed more follow-up on educational components and exercise progression, more opportunities for participants to ask questions of therapists, and peer support. Therefore, we hypothesized that the group-based program would result in greater improvement in pain and functional outcomes compared with the individual intervention.

# Method

## Design Overview

This was a randomized controlled trial with equal allocation of patients to a group-based physical therapy intervention or an individual physical therapy program, both led by physical therapists. All study participants continued with their usual medical care for knee OA. A detailed description of study methods is published elsewhere.[37]

## Setting and Participants

All study participants were patients at the VA Medical Center in Durham, North Carolina. Study eligibility criteria were: (1) prior diagnosis of knee OA; (2) presence of pain, aching stiffness, or swelling in or around a knee with OA for most days of the previous month; and (3) no physical therapy for knee OA in the previous 6 months. Exclusion criteria are described in detail elsewhere[37]; in summary, these criteria included systemic rheumatic diseases, gout in knees, bilateral knee replacement, any hip or knee replacement in the preceding 6 months, planning arthroplasty within the next 3 months, knee ligament or meniscus injury in previous year, recent hospitalization for cardiovascular events or mental health conditions, and current participation in another OA-related or lifestyle interventional study.

Participants were primarily recruited using Durham VA Medical Center electronic medical records to identify patients with knee OA. These patients were mailed introductory letters and then screened by telephone to further assess eligibility. A small number of enrolled participants were recruited via self-referral in response to posted advertisements (n=2) and provider referral (n=5). All participants who were eligible based on a screening telephone call were asked to meet a research assistant at the Durham VA Medical Center to complete the consent process, enrollment, and baseline assessments. Recruitment began in March 2011 and was completed in September 2013.

## Randomization, Blinding, and Interventions

**Randomization and blinding.** The randomization sequence was computer generated by the study statistician and stratified by sex and race (white versus nonwhite). Following baseline assessments, participants were notified by the study coordinator via telephone of their randomization assignment. The group assignment of each participant was not known to the study coordinator until the time that the participants were randomized. Outcome assessors who assessed the performance-based outcome measures were blinded to participants' randomization assignments. The randomization sequence was contained in the password-protected study database and concealed by restricting access only to those whose study roles did not require blinding. Because of the nature of this study, it was not possible to blind either participants or physical therapists to the group assignments after randomization.

**Overview of interventions.** Both interventions focused on initial management of knee OA and involved the same content, based on standard physical therapies for knee OA and guidelines for nonpharmacological management of knee OA within the scope of practice for physical therapists and physical therapist assistants with the North Carolina Board of Physical Therapy Examiners.[15–19,38,39] Both interventions emphasized exercise-based therapy because studies indicate that it is a key component of physical therapy for knee OA.[24,25,40] General components included: (1) instruction in an appropriate home exercise program; (2) advice on progression of home exercise; (3) instruction in strategies for pacing daily activities and protecting joints; (4) evaluation of specific areas of weakness or inflexibility and of mobility, stability, function, knee alignment, and possible limb-length inequalities; and (5) based on these evaluations, provision of appropriate mobility aids, knee braces, and shoe orthotic devices. If the physical therapist recommended any of these aids, they could be obtained by the participant directly from the Durham VA Medical Center. The intervention components were packaged differently to accommodate the structure of the group physical therapy and individual physical therapy arms; details of both programs have been described previously and are shown in Table 1.[37]

Multiple physical therapists (n=5) and physical therapist assistants (n=2) delivered the interventions to enhance generalizability. The same physical therapists were involved in both the group and individual physical therapy arms. Physical therapist assistants were involved only in the group physical therapy arm, as described below. All physical therapists were trained in the study interventions before leading any physical therapy sessions. Standard forms were used to ensure that physical therapists' evaluations were completed consistently across participants. The study principal investigator (K.D.A.) conducted periodic monitoring of group and individual physical therapy visits led by each physical therapist to ensure adherence to the study protocol.

Core exercises for the group and individual physical therapy programs included 4 stretching exercises (quadriceps muscle stretch, calf stretch, hamstring muscle stretch, and lower back and hip stretch) and 6 strengthening exercises (mini-squat, single-leg stand, chair stand, heel raises, hip abduction, and step-ups), based on an overall approach to enhancing lower extremity strength and flexibility.[38] If participants could not perform an exercise because of pain or functional limitations, they were instructed in appropriate modifications or substitutions. Participants were instructed to perform stretching exercises daily and strengthening exercises 3 times weekly. For each exercise, participants were instructed to start with a minimum of 5 repetitions and to increase the number of repetitions gradually until they could

**Table 1.**
Activities Occurring During Group and Individual Physical Therapy Sessions[a]

| Activity | Group Physical Therapy Arm Session No. | Individual Physical Therapy Arm Session No. |
|---|---|---|
| Instruction | | |
| Exercise program | 1 | 1 |
| Activity pacing | 3 | 2 |
| Joint protection | 5 | 2 |
| Physical therapist evaluation/consultation components | | |
| Evaluation for edema/instruction in use of heat, cold, etc | 1–2 | 1 |
| Discussion of individual health issues affecting exercise/develop exercise goals | 1–2 | 1 |
| Assessment of range of motion, alignment, etc | 4–6 | 2 |
| Review of progress toward exercise goals/recommend modifications | 4–6 | 2 |
| Recommendations for referrals for braces, orthotic devices, etc | 4–6 | 2 |
| Group exercise | 1–6 | N/A |
| Group discussion of exercise barriers/successes | 2, 4, 6 | N/A |

[a] N/A=not applicable.

perform 2 sets of 10 repetitions. Once participants could do 2 sets of 10 repetitions for a given exercise, they were given options to increase the difficulty as appropriate (eg, higher-tension therapy band). Although the physical therapy programs focused on strengthening and stretching exercises, participants also were encouraged to engage in appropriate aerobic exercise, such as walking, swimming, or water exercise. Participants were given written instructions and photographs to illustrate the exercises, logs to record their home exercise, and therapy bands. To help enhance attendance at physical therapy visits, participants in both groups were given reminder calls by the study coordinator prior to each session.

**Group-based physical therapy intervention.** The group physical therapy program involved six 1-hour sessions, every other week. We aimed for groups to include 8 participants per group, and they were jointly led by a physical therapist and physical therapist assistant. The physical therapist assistant taught and led group exercises. Participants also received 2 individual consultations/evaluations with the physical therapist, with the first evaluation occurring during session 1 or 2 and the second evaluation occurring during session 3, 4, 5, or 6. On average, the first evaluation took approximately 15 minutes, and the second evaluation took approximately 20 minutes. The physical therapy evaluations, described in detail previously,[37] included: (1) examination of the knee for edema (accompanied by appropriate recommendations for heat, cold, and elevation); (2) discussion of comorbidities that may affect exercise prescription and goals; (3) assessments of range of motion, knee alignment, limb-length equality, balance, and gait, accompanied by recommendations for appropriate assistive devices, braces, exercise modifications, or other therapies; and (4) review of patient's progress with home exercise and recommendations for appropriate modifications.

**Individual physical therapy intervention.** The individual physical therapy program involved two 1-hour sessions, approximately 2 weeks apart. The initial visit included: (1) examination of the knee for edema (accompanied by appropriate recommendations for heat, cold, and elevation); (2) discussion of comorbidities that may affect exercise prescription and goals; and (3) instruction in a home exercise program. The second visit included: (1) assessments of range of motion, knee alignment, limb-length equality, balance, and gait, accompanied by recommendations for appropriate assistive devices, braces, exercise modifications, or other therapies; (2) discussion of the participant's progress with the home exercise program and recommendations for appropriate modifications and progression; (3) observation of the participant performing prescribed home exercises to assess correct performance; and (4) instruction in activity pacing and joint protection.

## Outcomes and Follow-up

Assessments were completed in person at baseline and 12-week follow-up, with allowance for telephone-based assessments when participants could not come to the Durham VA Medical Center for follow-up assessment. Some outcomes (the primary study outcome and self-reported physical activity) also were assessed via telephone at 24-week follow-up to examine potential maintenance of intervention effects. Measures were administered by a trained research assistant blinded to intervention assignment.

**Primary outcome.** The primary outcome measure for this study was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a self-report measure of lower extremity pain (5 items), stiffness (2 items), and function (17 items) in the previous 2 weeks.[41–43] All items are rated on a 5-point Likert scale ranging from 0 ("none") to 4 ("severe"), with a possible range of scores of 0 to 96 and with higher scores indicating worse symptoms and functional limitations. In addition to the total WOMAC score, we separately examined the pain and function subscales.

**Secondary outcomes.** The main, specified secondary outcome selected for this clinical trial was the Short Physical Performance Battery (SPPB),[44,45] which includes tests of balance (3 assessments), gait speed (2.44-m [8-ft] walk), and chair stands (time to complete 5

chair stands). For each test grouping (balance, gait speed, chair stands), the score can range from 0 to 4, with a total possible score range of 0 to 12 for all tests; higher scores indicate better performance. Per scoring instructions, participants who were unable to do a specific test were given a score of 0.

We also report on several other outcomes of relevance for patients with OA. Participants completed a 6-minute walk, according to standard procedures[46]; the number of meters walked was recorded at baseline and follow-up assessments. For participants who declined or could not perform the walk, scores were coded as missing. We also assessed participants' satisfaction with physical function using a validated 5-item questionnaire that assesses individuals' satisfaction with their ability to complete basic functional tasks often affected by knee OA.[47] All items are rated on a 7-point Likert scale ranging from −3 ("very dissatisfied") to +3 ("very satisfied"); the total score is the average of the items. Self-reported physical activity was measured with the Community Health Activities Model Program for Seniors (CHAMPS),[48,49] which assesses the frequency and duration of light-to-vigorous activities during the previous 4 weeks; we examined weekly frequency and duration of all exercise, as well as moderate- or higher-intensity exercise.

**Participant characteristics.** We collected self-reported patient demographic and clinical characteristics, including: age, sex, race/ethnicity (reported as white versus nonwhite), household financial situation (with "inadequate income" defined as having just enough to meet basic expenses or not having enough to meet basic expenses), education level, marital status, work status (employed full time or part time versus other), general health (excellent, very good, or good versus fair or poor), duration of OA symptoms, and knees with OA (right, left, or both).

**Calculation of intervention staffing costs.** To estimate per-patient staffing costs of group and individual physical therapy, we collected salary data for study physical therapists and physical therapist assistants. We used the average of these salaries and calculated cost ranges based on minimum and maximum salaries for these positions. We added 30% for fringe benefits cost and 59% for indirect costs based on previous research.[50] The average physical therapist salary used in these calculations was $70,561; minimum and maximum salaries used to calculated ranges were $65,371 and $75,751, respectively. After accounting for fringe benefits and indirect costs, the average physical therapist hourly wage rate used for calculations was $64.12 (range=$59.40–$68.83). The average physical therapist assistant salary used in these calculations was $49,737; minimum and maximum salaries used to calculated ranges were $49,303 and $50,170, respectively. With fringe benefits and indirect costs added, the average hourly wage rate for physical therapist assistants was $45.19 (range=$44.80–$45.59).

We calculated intervention costs using 2 alternative methods. First, to be consistent with the intention-to-treat approach of our primary analyses, we calculated group and individual physical therapy intervention costs if patients attended all of their respective sessions. Second, we calculated the intervention costs taking into account participants' session attendance. Due to schedule logistics of participants, some groups in the group physical therapy program had 8 members, whereas other groups had 7 members; therefore, we calculated per-patient group physical therapy cost based on both of these group sizes.

## Data Analysis

The sample size target for the study was based on the primary hypothesis that the group physical therapy program would result in a significantly greater improvement in WOMAC scores compared with the individual physical therapy program. Our goal was to have a sufficient sample size to detect a medium effect size of approximately 0.27 for the primary hypothesis, with 80% power and a type I error rate of 0.05. This allowed detection of a between-group difference in WOMAC scores as small as 4 points (approximately 9% difference from baseline) at 12 weeks.[46] Sample size calculations were based on methods appropriate for analyses such as analysis of covariance (ANCOVA),[51] adjusted to reflect clustering within group physical therapy and assuming an intraclass correlation coefficient of .01.[52] A correlation of .64 between time points was estimated based on pilot data, and we accounted for a 25% attrition rate. Based on these assumptions, our original target sample size was N=376. However, we were unable to recruit participants for this target sample size after exhausting all possible recruitment strategies at Durham VA Medical Center. Therefore, a new sample size target was calculated using all of the same data and assumptions except for increasing the effect size difference that we could detect from 0.27 to 0.35. This calculation translated to a modified sample size target of 226 patients to detect a 5.2 point difference (approximately 12% difference from baseline) in WOMAC scores at 12 weeks between arms.[53] Therefore, the study still had adequate power to detect a clinically relevant change between study arms.[54]

Our primary hypothesis was that the 12-week group physical therapy program would result in a significantly greater improvement in WOMAC scores compared with the individual physical therapy program. Our secondary hypotheses examined differences between group physical therapy and individual physical therapy for the secondary outcomes. All analyses were performed using SAS software (SAS Institute, Cary, North Carolina). The primary analyses were conducted on an intention-to-treat basis, involving all randomly assigned participants using all data up to the 12-week or 24-week follow-up or last available measurement prior to exclusion or dropout.[55] No observations were deleted due to missing data.[56] The estimation procedure for our analytic technique (linear mixed models) implicitly accommodates missingness when related to prior outcome or to other baseline covariates included in the model (defined as missing at random).

For the primary and continuous secondary outcomes, hierarchical linear mixed models were used.[57] A random effect

was fit to account for the clustering in the group physical therapy arm and an unstructured covariance for the repeated measures over time. For CHAMPS outcomes, we fit a generalized linear mixed model using a negative binomial distribution with a log link function because the distribution of these variables followed a Poisson-type process.[58] The predictors in all models included dummy coded time effects and an indicator variable for group physical therapy interacting with the time effects.[59] This model assumes the study arms have equal baseline means, which is appropriate for a randomized controlled trial and is equivalent in efficiency to an ANCOVA model.[60] The final models also included stratification variables for race and sex. Our primary inference for all analyses was based on the group physical therapy × 12-week follow-up time indicator parameter, which is the estimated difference between group physical therapy and individual physical therapy at 12-week follow-up. The group physical therapy × 24-week follow-up time indicator examined for maintenance of effects.

## Role of the Funding Source

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# Results

## Recruitment, Retention, and Participant Characteristics

Five licensed physical therapists (3 with doctor of physical therapy degrees, 1 with a master of physical therapy degree, and 1 with a bachelor's degree in physical therapy) and 2 licensed physical therapist assistants were involved in delivering the group and individual physical therapy programs. We identified 10,396 potentially eligible patients from VA electronic medical records, based on *International Classification of Diseases*, 9th revision (ICD-9) codes for OA (Fig. 1). The most common reason for ineligibility prior to screening was residence outside of the target geographic region of about 80 km (50 miles) from Durham VA Medical Center (n=5,252, 50.5%). Of 716 patients screened by telephone, 320 were eligible and randomized; 78% completed 12-week measures, and 81% completed 24-week measures. Some participants were not able to return to Durham VA Medical Center to complete 12-week follow-up measures. In these cases, we asked participants to complete self-report measures via telephone. Therefore, there is a greater amount of missing data for measures that required completion in person (SPPB and 6-minute walk). No serious study-related adverse events occurred. Participant characteristics are shown in Table 2.

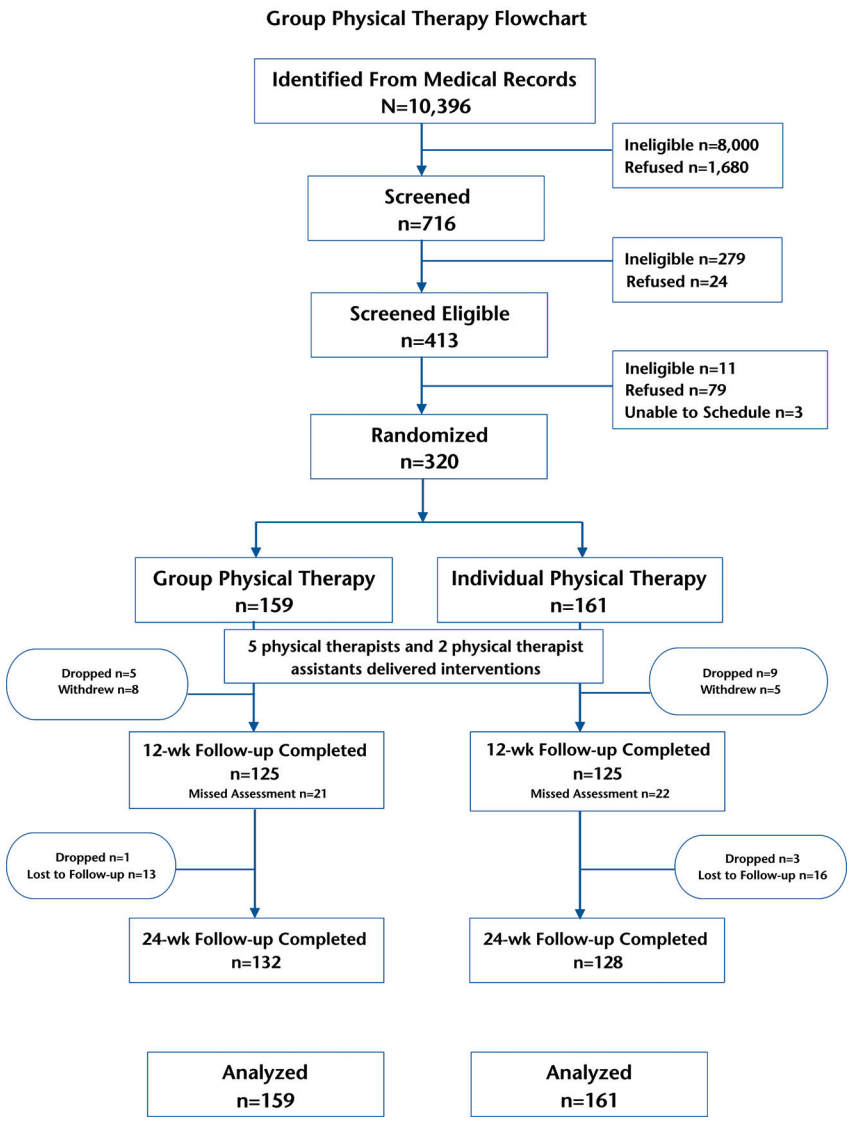


**Figure 1.**
Study participant flowchart.

There were 20 groups within the group physical therapy arm; 15 groups had 8 participants per group, and due to scheduling challenges with filling some groups in a timely manner, 5 groups had 7 participants per group. Among participants in the group physical therapy arm, the average number of sessions was 3.9 (range=0–6), and among those who attended at least one session, the average number of sessions was 4.4. About half of the group physical therapy participants attended 5 or 6 sessions; 28% attended all 6 sessions. Among participants in the individual physical therapy arm, 14 (8.7%) attended one visit, and 142 (88.2%) attended both visits.

**Table 2.**
Participant Characteristics at Baseline[a]

| Variable | Total Sample (N=320) | Group Physical Therapy (n=159) | Individual Physical Therapy (n=161) |
|---|---|---|---|
| Age (y), $\bar{X}$ (SD) | 60.0 (9.8) | 59.2 (9.6) | 60.8 (10.0) |
| Men (%) | 88.1 | 88.7 | 87.6 |
| Nonwhite race (%) | 58.4 | 57.9 | 59.0 |
| Married/living with partner (%) | 63.1 | 63.5 | 62.7 |
| High school education or less (%) | 24.7 | 22.0 | 27.3 |
| Inadequate income (%) | 23.4 | 27.0 | 19.9 |
| Employed (%) | 42.5 | 44.6 | 40.4 |
| Fair or poor health (%) | 29.7 | 32.1 | 27.3 |
| Body mass index (kg/m$^2$), $\bar{X}$ (SD) | 33.4 (6.9) | 33.1 (7.1) | 33.8 (6.7) |
| Duration of arthritis symptoms median (y), median (Q1, Q3) | 12 (5, 20) | 10 (5, 20) | 12 (6, 20) |
| Knees with osteoarthritis (%) | | | |
| Right | 10.3 | 11.3 | 9.3 |
| Left | 9.7 | 8.8 | 10.6 |
| Both | 80.0 | 79.9 | 80.1 |
| WOMAC total score | 43.7 (14.7) | 44.2 (14.9) | 43.2 (14.5) |
| Physical function (SPPB) | 9.1 (2.0) | 9.1 (1.9) | 9.1 (2.07) |

[a] Q1=first quartile, Q3=third quartile, WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index, SPPB=Short Physical Performance Battery.

## Primary Outcome

At 12-week follow-up, total WOMAC scores were 2.7 points lower in the group physical therapy arm versus the individual physical therapy arm (95% confidence interval [CI]=−5.9, 0.5; *P*=.10), indicating no meaningful difference in improvement between arms (Tab. 3, Fig. 2). At 24-week follow-up, WOMAC scores were 1.3 points lower in the group physical therapy arm versus the individual physical therapy arm (95% CI=−4.6, 2.0; *P*=.44), indicating no meaningful difference between groups. The ICC within the group physical therapy arm was .006, which represents the similarity of WOMAC scores among participants in the same group (eg, clustering effect).

We also examined parameters from the primary model that show the effect of each intervention on WOMAC scores compared with baseline. The WOMAC scores declined 4.5 points from baseline to 12 weeks in the individual physical therapy arm (95% CI=−6.8, −2.2; *P*=.0001) and 7.2 points in the group physical therapy arm (95% CI=−9.5, −4.9; *P*<.0001), indicating improvement for both groups. Similarly, mean WOMAC scores were 3.1 points lower at 24 weeks compared with baseline for the individual physical therapy arm (95% CI=−5.5, −0.7; *P*=.01) and 4.4 points lower for the group physical therapy arm (95% CI=−6.8, −2.0; *P*=.0003), indicating some sustained improvement in both groups.

## Secondary Outcomes

Similar to results for the total WOMAC scores, there were no differences between groups in WOMAC pain or function subscale scores at either time point (Tab. 3). Again considering overall change over time, there were improvements in the WOMAC pain subscale scores at 12 weeks for both individual physical therapy (−1.1; 95% CI=−1.6, −0.6; *P*<.001) and group physical therapy (−1.6; 95% CI=−2.0, −1.1; *P*<.001). The WOMAC pain subscale scores also remained improved at 24 weeks for individual physical therapy (−0.8; 95% CI=−1.4, −0.3; *P*=.002) and group physical therapy (−1.2; 95% CI=−1.8, −0.7; *P*<.0001). The WOMAC function subscale scores were improved at 12 weeks in both individual physical therapy (−3.1; 95% CI=−4.9, −1.3; *P*=.0009) and group physical therapy (−5.1; 95% CI=−6.9, −3.3; *P*<.0001), and there was some sustained improvement at 24 weeks for individual physical therapy (−1.8; 95% CI=−3.7, 0.07; *P*=.06) and group physical therapy (−2.7, 95% CI=−4.5, −0.8; *P*=.0051).

Physical performance, assessed with the SPPB, did not differ between groups at 12 weeks (−0.1; 95% CI=−0.5, 0.2; *P*=.53; Tab. 3). There also was no statistically significant difference between groups in self-reported satisfaction with physical function (0.2; −0.1, 0.6; *P*=.20) at 12 weeks (Tab. 3). Considering change over time in both groups, there was no substantial change in SPPB scores between baseline and 12 weeks (individual physical therapy: 0.2; 95% CI=−0.1, 0.5; *P*=.15; group physical therapy: 0.1; 95% CI=−0.2, 0.3; *P*=.54). Self-reported satisfaction with physical function improved by a mean of 0.5 points at 12 weeks in the individual physical therapy arm (95% CI=0.3, 0.8; *P*<.001) and by a mean of 0.8 points in the group physical therapy arm (95% CI=0.5, 1.0; *P*<.0001). There was a statistically significant difference between groups in the 6-minute walk distance (17.5 m; 95% CI=3.4, 31.6; *P*=.02); mean 6-minute walk distance decreased by 3.2 m for the individual physical therapy arm (95% CI=−13.0, 6.7; *P*=.53) and increased by 14.3 m in the group physical therapy arm (95% CI=4.2, 24.4; *P*=.006) at 12 weeks (Tab. 3).

The frequency and duration of all intensity types of physical activity from the CHAMPS did not differ between groups at either 12 or 24 weeks (Tab. 3). Similarly, there was no difference in estimated frequency or duration of moderate or greater intensity exercise between groups at either time point. However, across both groups, at 12 weeks the estimated frequency of all exercise increased 24% (incidence rate ratio [IRR]=1.24; 95% CI=1.12, 1.37; *P*<.0001), and moderate or greater intensity exercise increased 31% (IRR=1.31; 95% CI=1.14, 1.51; *P*=.0002). Duration of all exercise increased 16% across groups at

**Table 3.**
Estimated Mean and 95% CI Values for Study Outcomes: Results of Linear Mixed and Generalized Linear Mixed Models[a]

| Outcome | Time Point | Group Physical Therapy (n=151) | Individual Physical Therapy (n=149) | Treatment Difference (95% CI) | *P* |
|---|---|---|---|---|---|
| WOMAC total score | Baseline | 43.7 | | N/A | N/A |
| | 12 wk | 36.5 | 39.1 | –2.7 (–5.9, 0.5) | .10 |
| | 24 wk | 39.3 | 40.6 | –1.3 (–4.6, 2.0) | .44 |
| WOMAC pain subscale | Baseline | 9.3 | | N/A | |
| | 12 wk | 7.7 | 8.2 | –0.4 (–1.1, 0.2) | .20 |
| | 24 wk | 8.1 | 8.5 | –0.4 (–1.1, 0.3) | .26 |
| WOMAC function subscale | Baseline | 30.2 | | N/A | N/A |
| | 12 wk | 25.1 | 27.1 | –2.0 (–4.5, 0.5) | .12 |
| | 24 wk | 27.5 | 28.3 | –0.9 (–3.4, 1.7) | .52 |
| Physical function (SPPB) | Baseline | 9.1 | | N/A | N/A |
| | 12 wk | 9.1 | 9.3 | –0.1 (–0.5, 0.2) | .53 |
| 6-minute walk (m) | Baseline | 402.7 | | | |
| | 12 wk | 417.0 | 399.5 | 17.5 (3.4, 31.6) | .02 |
| Satisfaction with function | Baseline | –1.2 | | | |
| | 12 wk | –0.4 | –0.7 | 0.2 (–0.1, 0.6) | .20 |
| Frequency of all exercise (per week, CHAMPS) | Baseline | 16.7 | | N/A | N/A |
| | 12 wk | 21.6 | 20.7 | IRR: 1.0 (0.9, 1.2) | .48 |
| | 24 wk | 17.4 | 18.1 | IRR: 1.0 (0.8, 1.1) | .59 |
| Duration of all exercise (hours per week, CHAMPS) | Baseline | 13.8 | | N/A | N/A |
| | 12 wk | 18.0 | 16.0 | IRR: 1.1 (1.0, 1.3) | .14 |
| | 24 wk | 13.8 | 12.9 | IRR: 1.1 (0.9, 1.3) | .42 |
| Frequency of moderate-intensity or greater exercise (per week, CHAMPS) | Baseline | 6.3 | | N/A | N/A |
| | 12 wk | 8.0 | 8.3 | IRR: 1.0 (0.8, 1.2) | .72 |
| | 24 wk | 6.7 | 7.4 | IRR: 0.9 (0.7, 1.1) | .31 |
| Duration of moderate-intensity or greater exercise (hours per week, CHAMPS) | Baseline | 6.2 | | N/A | N/A |
| | 12 wk | 7.4 | 7.1 | IRR: 1.0 (0.8, 1.3) | .77 |
| | 24 wk | 5.8 | 5.3 | IRR: 1.1 (0.9, 1.4) | .50 |

[a] Seventy participants (34 group physical therapy, 36 individual physical therapy) and 60 participants (27 group physical therapy, 33 individual physical therapy) had no follow-up data for 12 and 24 wk, respectively. Additional data missing across time points: WOMAC scores (2 baseline; 1 group physical therapy, 1 individual physical therapy, 12 wk); SPPB scores (19 baseline; 15 group physical therapy, 20 individual physical therapy; 12 wk); 6-minute walk (23 baseline; 28 group physical therapy, 25 individual physical therapy; 12 wk); satisfaction score (6 baseline; 4 group physical therapy, 3 individual physical therapy; 12 wk). WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index, SPPB=Short Physical Performance Battery, CHAMPS=Community Health Activities Model Program for Seniors, IRR=incidence rate ratio, N/A=not applicable.

12 weeks (IRR=1.16; 95% CI=1.02, 1.32; *P*=.02), but there was no increase in moderate or greater intensity duration (*P*=.09).

## Staffing Costs

Per-patient costs differed for the 7- and 8-person groups in the group physical therapy arm due to the relative difference in maximal potential size for each group. With our primary, intention-to-treat approach, in an 8-person group, the per-patient cost of group physical therapy was $82 (range=$78–$86) based on salary ranges. With a 7-person group, the per-patient cost of group physical therapy was $94 (range=$89–$98). The per-patient cost of individual physical therapy was $128 (range=$119–$138). Using the actual attendance approach, the per-patient cost of group physical therapy was $126 (range=$120–$132) for a group with a maximum of 8 attendees and using the attendance figures for our group physical therapy arm; for a group with a maximum of 7 attendees, the per-patient cost of group physical therapy was $144 (range=$137–$151). The per-patient cost of individual physical therapy was $118 (range=$110–$127).

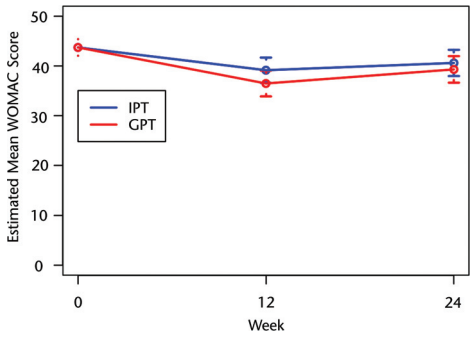


**Figure 2.**
Estimated mean Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores. IPT=individual physical therapy, GPT=group physical therapy.

## Discussion

This study is one of the first clinical trials to evaluate a group-based approach to provision of a multifactorial physical therapy intervention for knee OA.[23] We found that there were no statistically significant or clinically meaningful differences in specified primary or secondary study outcomes for the group physical therapy arm compared with a more traditional individual approach. However, there was a statistically significant difference between arms in 6-minute walk distance in favor of group physical therapy. We expected that the group physical therapy arm would be favorable across outcomes because it allowed a greater number of contacts per participant and provided group support, which can facilitate participation in exercise programs. However, the results suggest that there may have been different advantages of each approach that ultimately resulted in similar changes for most outcomes. Although the group physical therapy approach allowed more contact and group support, the individual physical therapy visits allowed greater one-on-one time with a physical therapist. In agreement with a prior study of patients with knee OA in Australia,[23] these results indicate that group physical therapy was not more effective than individual physical therapy for improving all outcomes among patients with knee OA. Both may be reasonable delivery models for health care systems to consider. Prior studies have shown that group-based physical therapy is effective for other health conditions.[61,62]

Based on an intention-to-treat approach, the per-patient cost of group physical therapy was lower than that of individual physical therapy. Even though group physical therapy had more sessions per patient and included the effort of a physical therapist assistant, these additional costs were outweighed by the fact that 7 or 8 patients could be treated at a time. We acknowledge that not all group physical therapy sessions were attended by 7 or 8 participants. However, the costs of the staff time are fixed, regardless of the number of participants who attend each session. It would be useful to identify strategies to maximize attendance at these types of group physical therapy sessions. Study physical therapists and physical therapist assistants received approximately 2 hours of training to implement the group physical therapy intervention. Given that allocating all of the training cost to only the study participants would overestimate training cost over time, we excluded training cost from the analysis. However, planning and training to implement a group physical therapy intervention will vary among institutions and can be a cost issue that needs to be considered.

Because both the group and individual physical therapy interventions focused on initial nonpharmacological management of knee OA, the numbers of sessions were limited to 6 and 2, respectively. We acknowledge that this study compared group and individual physical therapy interventions in the context of relatively limited duration interventions; therefore, these results may be most applicable to scenarios where per-patient physical therapy visits are limited, either due to personnel resources (eg, medically underserved areas) or due to issues related to patient costs and insurance coverage. The study results may not be applicable to patients or settings where a course of outpatient physical therapy for knee OA typically would include more than 2 individual visits. It would be valuable to compare group and individual physical therapy approaches that each include more visits.

For the main outcome of total WOMAC score at 12 weeks, the group and individual physical therapy arms in this study improved 16% and 11% from baseline, respectively; these changes are similar to the minimal clinically important difference for the WOMAC in the context of rehabilitation interventions (12%).[53] It is possible that changes in both groups could have been due to factors other than the physical therapy interventions, such as a placebo or Hawthorne effect. It also is possible that intervention effects could have been larger in either the group or individual physical therapy arm if more in-person visits had been provided or if the strengthening regimen had been more intensive, and indeed some prior studies of more intensive physical therapy interventions for OA have shown somewhat greater reductions in pain and improvements in functional outcomes.[21–23,33] Unfortunately, although some patients may receive multiple physical therapy visits for knee OA, many patients with knee OA do not receive physical therapy at all, and those who do get physical therapy may receive few visits due to caps on therapy coverage.[27,63,64] Therefore, although both group and individual physical therapy interventions in this study were limited in duration, both arms provided nonpharmacological treatment of knee OA that is within the range of—and indeed better than—that which is provided to many patients with knee OA.[53]

There are several limitations to this study. First, this study was conducted in one VA Medical Center, which may limit generalizability. Second, both group and individual physical therapy interventions were standardized across patients in

terms of the number of visits provided and thus may not mimic true clinical reality. At the Durham VA Medical Center and other clinical settings, patients may receive additional physical therapy visits, following initial therapy, based on their treatment response, OA severity, or other clinical factors. It would be valuable for future research to incorporate this type of real-world heterogeneity in treatment intensity. Third, we did not obtain de novo radiographs for participants. However, all participants had a clinical diagnosis of knee OA from a health care provider. Fourth, it was not possible to blind the physical therapists or participants to treatment assignment. The physical therapists were not involved in outcome assessment. It is possible that because most outcomes were patient-reported, participants' knowledge of their own treatment assignment may have influenced their responses. If one physical therapy intervention was viewed more favorably by participants, this could have biased responses. Fifth, although we assessed adherence in terms of attendance at physical therapy sessions, we did not measure participants' completion of home exercises. Sixth, we also did not directly measure strength or range of motion in study participants. Finally, participants were encouraged to participate in aerobic exercise, particularly as appropriate for individuals with OA, but specific prescriptions for intensity and duration were not individualized for each participant.

In summary, this study provides important information about an alternative model for delivering outpatient physical therapy for patients with knee OA. The group physical therapy program in this study was not more effective than the individual physical therapy program for most outcomes but did have an advantage for 6-minute walk distance. A group-based approach has potential to enhance efficiency of care, particularly if attendance and group size are optimized. Given the expected rise in prevalence of knee OA[65,66] and the general need to provide efficient health care, a physical therapist–led, group-based approach to delivering nonpharmacological treatment of knee OA could be a useful approach in many health care settings.

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## References

1 Johnson VL, Hunter DJ. The epidemiology of osteoarthritis. *Best Pract Res Clin Rheumatol.* 2014;28:5–15.

2 Hootman JM, Helmick CG, Brady TJ. A public health approach to addressing arthritis in older adults: the most common cause of disability. *Am J Public Health.* 2012;102:426–433.

3 Verbrugge LM, Juarez L. Arthritis disability and heart disease disability. *Arthritis Care Res.* 2008;59:1445–1457.

4 Hawker GA. The challenge of pain for patients with OA. *HSS J.* 2012;8:42–44.

5 Murphy L, Schwartz TA, Helmick CG, et al. Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Rheum.* 2008;59:1207–1213.

6 Lawrence RC, Felson DT, Helmick CG, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States: part II. *Arthritis Rheum.* 2008;58:26–35.

7 Maserejian NN, Fischer MA, Trachtenberg FL, et al. Variations among primary care physicians in exercise advice, imaging, and analgesics for musculoskeletal pain: results from a factorial experiment. *Arthritis Care Res.* 2014;66:147–156.

8 Hunter DJ, Neogi T, Hochberg MC. Quality of osteoarthritis management and the need for reform in the US. *Arthritis Care Res.* 2011;63:31–38.

9 Centers for Disease Control and Prevention. State-specific prevalence of walking among adults with arthritis—United States, 2011. *MMWR Morb Mortal Weekly Rep.* 2013;62:331–334.

10 Brand CA, Ackerman IN, Bohensky MA, Bennell KL. Chronic disease management: a review of current performance across quality of care domains and opportunities for improving osteoarthritis care. *Rheum Dis Clin North Am.* 2013;39:123–143.

11 Song J, Hochberg MC, Chang RW, et al. Racial and ethnic differences in physical activity guidelines attainment among people at high risk of or having knee osteoarthritis. *Arthritis Care Res.* 2013;65:195–202.

12 Do BT, Hootman JM, Helmick CG, Brady TJ. Monitoring Healthy People 2010 arthritis management objectives: education and clinician counseling for weight loss and exercise. *Ann Fam Med.* 2011;9:136–141.

13 Li LC, Sayre EC, Kopec JA, et al. Quality of nonpharmacological care in the community for people with knee and hip osteoarthritis. *J Rheumatol.* 2011;38:2230–2237.

14 Hinman RS, Nicolson PJA, Dobson FL, Bennell KL. Use of nondrug, nonoperative interventions by community-dwelling people with hip and knee osteoarthritis. *Arthritis Care Res.* 2015;67:305–309.

15 Richmond J, Hunter DH, Irrgang JJ, et al; American Academy of Orthopaedic Surgeons. American Academy of Orthopaedic Surgeons clinical practice guideline on the treatment of osteoarthritis (OA) of the knee. *J Bone Joint Surg Am.* 2010;92:990–993.

16 Nelson AE, Allen KD, Golightly YM, et al. A systematic review of recommendations and guidelines for the management of osteoarthritis: the Chronic Osteoarthritis Management Initiative of the US Bone and Joint Initiative. *Semin Arthritis Rheum.* 2014;434:701–712.

17 Hochberg MC, Altman RD, April KT, et al. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip and knee. *Arthritis Care Res.* 2012;64:465–474.

18 McAlindon TE, Bannuru RR, Sullivan MC, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. *Osteoarthritis Cartilage.* 2014;22:363–388.

19 Fernandes L, Hagen KB, Bijlsma JW, et al. EULAR recommendations for the non-pharmacological core management of hip and knee osteoarthritis. *Ann Rheum Dis.* 2013;72:1125–1135.

20 Bennell KL, Hinman RS, Metcalf BR, et al. Efficacy of physiotherapy management of knee joint osteoarthritis: a randomised, double blind, placebo controlled trial. *Ann Rheum Dis.* 2005;64:906–912.

21 Deyle GD, Allison SC, Matekel RL, et al. Physical therapy treatment effectiveness for osteoarthritis of the knee: a randomized comparison of supervised clinical exercise and manual therapy procedures versus a home exercise program. *Phys Ther.* 2005;85:1301–1317.

22 Deyle GD, Henderson NE, Matekel RL, et al. Effectiveness of manual physical therapy and exercise in osteoarthritis of the knee: a randomized, controlled trial. *Ann Intern Med.* 2000;132:173–181.

23 Fransen M, Crosbie J, Edmonds J. Physical therapy is effective for patients with osteoarthritis of the knee: a randomized controlled clinical trial. *J Rheumatol.* 2001; 28:156–164.

24 Jamtvedt G, Dahm KT, Christie A, et al. Physical therapy interventions for patients with osteoarthritis of the knee: an overview of systematic reviews. *Phys Ther.* 2008;88:123–136.

25 Wang SY, Olson-Kellogg B, Shamliyan TA, et al. Physical therapy interventions for knee pain secondary to osteoarthritis: a systematic review. *Ann Intern Med.* 2012; 157:632–644.

26 Allen KD, Bosworth HB, Chatterjee R, et al. Clinic variation in recruitment metrics, patient characteristics and treatment use in a randomized clinical trial of osteoarthritis management. *BMC Musculoskelet Disord.* 2014;15:413.

27 Dhawan A, Mather RC III, Karas V, et al. An epidemiologic analysis of clinical practice guidelines for non-arthroplasty treatment of osteoarthritis of the knee. *Arthroscopy.* 2014;30:65–71.

28 American Physical Therapy Association Workforce Task Force. A Model to Project the Supply and Demand of Physical Therapists, 2010–2020. 2012. Available at: http://www.apta.org/workforcedata/. Accessed December 18, 2012.

29 Edelman D, Gierisch JM, McDuffie JR, et al. Shared medical appointments for patients with diabetes mellitus: a systematic review. *J Gen Intern Med.* 2015;30: 99–106.

30 Wenger NK. Current status of cardiac rehabilitation. *J Am Coll Cardiol.* 2008;51: 1619–1631.

31 Coulter CL, Weber JM, Scarvell JM. Group physiotherapy provides similar outcomes for participants after joint replacement surgery as 1-to-1 physiotherapy: a sequential cohort study. *Arch Phys Med Rehabil.* 2009;90:1727–1733.

32 Aprile I, Rizzo RS, Romanini E, et al. Group rehabilitation versus individual rehabilitation following knee and hip replacement: a pilot study with randomized, single-blind, cross-over design. *Eur J Phys Rehabil Med.* 2011;47:551–559.

33 da Silva FS, de Melo FES, do Amaral MMG, et al. Efficacy of a simple integrated group rehabiliation program for patients with knee osteoarthritis: single-blind randomized controlled trial. *J Rehabil Res Dev.* 2015;52:309–322.

34 Jaber R, Braksmajer A, Trilling JS. Group visits: a qualitative review of current research. *J Am Board Fam Pract.* 2006; 19:276–290.

35 Fraser SN, Spink KS. Examining the role of social support and group cohesion in exercise compliance. *J Behav Med.* 2002;25: 233–249.

36 Estabrooks PA. Sustaining exercise participation through group cohesion. *Exerc Sport Sci Rev.* 2000;28:63–67.

37 Allen KD, Bongiorni D, Walker TA, et al. Group physical therapy for veterans with knee osteoarthritis: study design and methodology. *Contemp Clin Trials.* 2013; 34:296–304.

38 Kisner C, Colby LA. *Therapeutic Exercise: Foundations and Techniques.* Philadelphia, PA: FA Davis Co; 1996.

39 North Carolina Board of Physical Therapy Examiners. Available at: http://www.ncptboard.org/index.html. Accessed March 19, 2015.

40 Bennell KL, Buchbinder R, Hinman RS. Physical therapies in the management of osteoarthritis: current state of the evidence. *Curr Opin Rheumatol.* 2015;27: 304–311.

41 Bellamy N, Buchanan WW. A preliminary evaluation of the dimensionality and clinical importance of pain and disability in osteoarthrits of the hip and knee. *Clin Rheumatol.* 1986;5:231–241.

42 Bellamy N, Buchanan WW, Goldsmith CH, et al. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol.* 1988;15:1833–1840.

43 Bellamy N. WOMAC: a 20-year experiential review of a patient-centered self-reported health status questionnaire. *J Rheumatol.* 2002;29:2473–2476.

44 Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol.* 1994;49:M85–M94.

45 Studenski S, Perera S, Wallace D, et al. Physical performance measures in the clinical setting. *J Am Geriatr Soc.* 2003;51: 314–322.

46 ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med.* 2002;166:111–117.

47 Katula JA, Rejeski WJ, Wickley KL, Berry MJ. Perceived difficulty, importance, and satisfaction with physical function in COPD patients. *Health Qual Life Outcomes.* 2004;2:18.

48 Stewart AL, Mills KM, King AC, et al. CHAMPS physical activity questionnaire for older adults: outcomes for interventions. *Med Sci Sports Exerc.* 2001;33: 1126–1141.

49 Harada ND, Chiu V, Stewart AL. An evaluation of three self-report physical activity instruments for older adults. *Med Sci Sports Exerc.* 2001;33:962–970.

50 Allen KD, Oddone EZ, Coffman CJ, et al. Telephone-based self-management of osteoarthritis: a randomized, controlled trial. *Ann Intern Med.* 2010;153:570–579.

51 Borm GF, Fransen J, Lemmens W. A simple sample size formula for analysis of covariance in randomized clinical trials. *J Clin Epidemiol.* 2007;60:1234–1238.

52 Donner A, Klar N. *Design and Analysis of Cluster Randomized Trials in Health Research.* New York, NY: Oxford University Press; 2000.

53 Angst F, Aeschlimann A, Stucki G. Smallest detectable and minimal clinically important differences of rehabilitation intervention with their implications for required sample sizes using WOMAC and SF-36 quality of life measurement instruments in patients with osteoarthritis of the lower extremities. *Arthritis Rheum.* 2001;45: 384–391.

54 Angst F, Aeschlimann A, Michel BA, Stucki G. Minimal clinically important rehabilitation effects in patients with osteoarthritis of the lower extremity. *J Rheumatol.* 2002;29:131–138.

55 International Conference on Harmonization E9 Expert Working Group. ICH Harmonised Tripartite Guideline: statistical principles for clinical trials. *Stat Med.* 1999;18:1905–1942.

56 Little RJA, Rubin DB. *Statistical Analysis With Missing Data.* Hoboken, NJ: John Wiley & Sons Inc; 2002.

57 Hedeker D, Gibbons RD. *Longitudinal Data Analysis.* Hoboken, NJ: John Wiley & Sons Inc; 2006.

58 Diggle PJ, Heagerty P, Liang KY, Zeger SL. *Analysis of Longitudinal Data.* 2nd ed. New York, NY: Oxford University Press; 2002.

**59** Liu GF, Mogg KLR, Mallick M, Mehrota DV. Should baseline be a covariate or depenent variable in analyses of change from baseline in clinical trials. *Stat Med.* 2009; 28:2509–2540.

**60** Fitzmaurice GM, Laird NM, Ware JH. *Applied Longitudinal Analysis.* Hoboken, NJ: Wiley-Interscience; 2004.

**61** Robertson B, Harding KE. Outcomes with individual versus group physical therapy for treating urinary incontinence and low back pain: a systematic review and meta-analysis of randomized controlled trials. *Arch Phys Med Rehabil.* 2014;95:2187–2198.

**62** Pereira VS, Correia GN, Driusso P. Individual and group pelvic floor muscle training versus no treatment in female stress urinary incontinence: a randomized controlled pilot study. *Eur J Obstet Gynecol Reprod Biol.* 2011;159:465–471.

**63** Centers for Medicare & Medicaid Services. Medicare Limits on Therapy Services. Available at: https://www.medicare.gov/Pubs/pdf/10988.pdf.

**64** Centers for Medicare & Medicaid Services. Medicaid Benefits. Available at: http://www.medicaid.gov/medicaid-chip-program-information/by-topics/benefits/medicaid-benefits.html. Accessed March 18, 2015.

**65** Holt HL, Katz JN, Reichmann WM, et al. Forecasting the burden of advanced knee osteoarthritis over a 10-year period in a cohort of 60–64 year-old US adults. *Osteoarthritis Cartilage.* 2011;19:44–50.

**66** Centers for Disease Control and Prevention. Projected state-specific increases in self-reported doctor-diagnosed arthritis and arthritis-attributable activity limitations—United States, 2005–2030. *MMWR Morb Mortal Wkly Rep.* 2007;56:423–425.