Randomized Controlled Trial Investigating the Role of Exercise in the Workplace to Improve Work Ability, Performance, and Patient-Reported Symptoms Among Older Workers With Osteoarthritis

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Objective: The aim of this study was to evaluate the effectiveness of a 12-week workplace exercise program on work ability, performance, and patient-reported symptoms in older university employees with knee and/or hip osteoarthritis. **Methods:** Twenty-four participants with clinical hip and/or knee osteoarthritis were randomized to exercise or no exercise. At baseline and follow-up, several work (work ability, resilience), patient-reported (pain, physical function, depressive symptoms, self-efficacy), and performance outcomes (hip and knee strength, mobility performance) were measured. **Results:** Significant improvements in work ability ($P < 0.049$) and patient-reported outcomes (pain, function, depressive symptoms) existed in the exercise group. No improvements were demonstrated in the no exercise group. **Conclusions:** Exercise in the workplace improved work ability and patient-reported symptoms in older workers with osteoarthritis. The benefits of workplace exercise programs should be studied in a larger sample in which attention is given to improving exercise adherence.

The Canadian workforce is aging. Osteoarthritis (OA), a degenerative disease affecting all joint tissues, places a substantial burden on the aging worker.[1] OA affects the knee and hip most commonly.[2,3] Degradation of cartilage, bone, muscles, and other tissues in an OA joint causes pain and limits mobility. Importantly, 60% of Canadians suffering from arthritis are of working age (≤65 years).[4] Work loss due to illness or disability is significantly higher in OA (12.6%) than in non-OA (9.3%) individuals ($P < 0.01$).[5] Within a 5-year period, 76.5% workers required a workplace modification related to their arthritis.[6] The work-related cost associated with arthritis is profound. In fact, one in seven employees sought care for their arthritis or associated joint disorders; this resulted in considerably higher direct (health care, prescription drugs, short-term disability) and indirect (productivity loss) costs, exceeding $9000 per person.[7] These work impairments are not limited to occupations requiring high joint loading, such as lifting or carrying. Clerical employees reported significant arthritis-related work productivity losses, which were estimated to cost the employer $5.4 million per year.[8]

Obesity and muscle weakness are substantive risk factors for worsening knee OA. Obesity not only increases knee joint loading but may also worsen OA through pro-inflammatory processes, which result in cartilage degradation and osteophyte formation.[9] Muscle weakness is also a risk factor for OA development and progression. By reducing the load-bearing capabilities of the quadriceps and hamstring muscles, joint stability is compromised and the likelihood of overloading the joint is dramatically increased.[10]

Exercise aimed to reduce obesity and/or strengthen leg muscles is essential in managing pain and mobility deficits caused by OA. Exercise targets pain, strength, and flexibility.[11] A systematic review of exercise for knee OA[12] provided moderate to high-quality evidence that exercise improves pain and physical function.[12] In fact, exercise produced benefits to pain that were equivalent to analgesic medication.[12] Older women with knee OA who participated in 12 weeks of OA-specific exercise experienced significant improvements in pain, knee strength, physical function, and mobility.[13] It is important to note that, in order to obtain a complete picture of the effectiveness of exercise among older adults with lower limb OA, multiple constructs must be measured including self-reported and mobility performance outcomes. Self-reports of the ability to complete physical tasks predominantly reflect pain, whereas mobility performance appears influenced most by self-efficacy.[14,15] Although these studies are convincing that exercise should form the keystone in conservative management of hip and knee OA, adherence to exercise in OA is relatively poor.[16] Implementing exercise in a workplace setting may be an effective strategy in compelling adults to engage in regular exercise to manage OA. Few studies have investigated strategies to improve productivity among aging workers with arthritis.[17] Thus, identifying strategies to promote productivity and longevity among older workers with knee and/or hip OA will have an immense public health significance in the coming decades.

The purpose of this study was to investigate whether a 12-week, OA-specific leg strengthening program, delivered within the workplace, improved several outcomes related to work, OA symptoms, and physical performance in comparison to no exercise in older workers with knee and/or hip OA. Work-related outcomes included work resilience and work ability. Patient-reported outcomes included pain, physical function, depressive symptoms, and self-efficacy. Performance outcomes included hip and knee strength and mobility. It was hypothesized that all outcomes would be improved in the exercise group following 12 weeks of exercise and that these improvements would be significantly greater than the no exercise group. No changes in work, patient-reported, or performance outcomes were expected in the no exercise group.

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METHODS

This study was an assessor-blinded, parallel, two-arm randomized controlled trial (NCT02609672). Participants were randomly allocated to one of two study arms: exercise or no exercise. This study was approved by the Hamilton Integrated Research Ethics Board. All participants provided written informed consent.

Participants

Men and women employed at McMaster University in Hamilton were recruited to participate. Participants were recruited through electronic and paper flyers advertised throughout McMaster University campus, E-mail list serves, and advertisements on a webpage that is run by a McMaster University committee that promotes workplace wellness. Recruited participants were employed in a variety of occupations. All participants but three classified their job as sedentary, that is, requiring them to stand or walk for less than one-third of their work day. The three participants who did not classify their work as sedentary included an engineering technician, research assistant, and university services manager who were not primarily engaged in manual labor. All participants had symptomatic hip and/or knee OA, consistent with the clinical criteria of the American College of Rheumatology.[18,19] For the hip, these criteria included hip pain in addition to either reduced internal rotation ($\leq$15°) and hip flexion ($\leq$115°), or pain on internal rotation ($\geq$15°), hip stiffness 60 minutes or less, and more than 50 years of age.[19] For the knee, the clinical criteria included knee pain in addition to three of the six criteria: more than 50 years of age, knee stiffness less than 30 minutes, crepitus, bony tenderness, bony enlargement, and no palpable warmth.[18] Exclusion criteria were the following: other forms of arthritis, other nonarthritis hip or knee diseases, previous injuries and/or surgeries in the hip or knee, patellofemoral symptoms, use of a cane, unstable heart or neurological conditions, cancer treatment, physician restriction to physical activity, or pregnancy. If participants experienced symptoms bilaterally and/or in both the hip and knee, the side with the most symptomatic joint was studied.

Interventions

Recruited participants were randomized to one of two study arms: exercise or no exercise. Participants were stratified by Lower Extremity Functional Scale (LEFS) score and randomized using a custom Matlab program. Randomization was performed by a researcher not involved in the study interventions or the data analysis. Group allocation was concealed from the blinded assessor who conducted the data collection and analysis. Participants in the exercise group were asked to attend three of four supervised exercise classes offered weekly for 12 weeks at McMaster University, within the on-campus sport and recreation facility. The classes were offered between 7 and 8 AM, before the workday; thus, participation was not during paid time. This program was previously designed specifically for knee OA to avoid exposure to the knee adduction moment (KAM)[20] and improved symptoms, physical function, and mobility in women with knee OA.[13,21] A high KAM has been implicated in OA progression.[22,23] Specifically, the program consisted of static leg strengthening exercises (yoga poses) such as squats and lunges that elicited moderate activity from the lower limb musculature while requiring a lower peak KAM than that experienced during walking.[20] An instructor emphasized ideal alignment of the pelvis (level to the floor) and lower limb (hip, knee, and ankle joints positioned along the vertical as closely as possible) throughout the exercises. Exercises were progressed over the 12 weeks as described previously.[13] Participants were encouraged to maintain a rating of perceived exertion of 5 to 7 on a standard 0 to 10 category ratio scale[24] and a pain rating of 5 or less on a standard 0 to 10 numerical pain rating scale.

Participants in the no exercise group were asked to maintain their existing activity level for the 12-week intervention period. They were offered the same exercise program as the intervention group following follow-up data collection.

Strategies were implemented to boost adherence in the exercise and no exercise groups. Both groups were offered a monetary ($50) incentive to complete follow-up data collections. The exercise group was offered individualized feedback weekly on their progress through the exercises. The no exercise group was offered 3 months of exercise after study completion.

Outcome Measures

All outcome measures were captured at two time points: at baseline (before the intervention period) and at follow-up (12 weeks following the intervention period). Data collections took place at McMaster University.

Resilience and Work Ability

Resilience was measured using the ''Resilience Scale 25 Survey.'' This questionnaire evaluates optimism, flexibility and ability to adapt to stress and adversity by addressing five main areas: perseverance, equanimity, meaningfulness, self-reliance, and existential aloneness.[25] Scores range from 25 to 175, with higher scores indicating higher resilience. It has produced data that are valid and reliable across a wide population range.[25]

Work ability was measured using the ''Work Ability Index'' (WAI). The WAI is a questionnaire used to assess self-reported work ability, considering both the physical and mental demands of work.[26] It is scored from 7 to 49, with work ability scored in four categories: ''poor'' (7 to 27), where the objective would be to restore work ability; ''moderate'' (28 to 36), where the objective would be to improve work ability; ''good'' (37 to 43), where the objective would be to support work ability; ''excellent'' (44 to 49), where the objective would be to maintain work ability.[26] Acceptable test–retest reliability has been demonstrated in older workers across various occupations.[27]

Pain and Self-reported Function

Pain and self-reported physical function were measured using the ''Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP)'' tool, the ''Knee Injury and Osteoarthritis Outcome Score (KOOS),'' and the ''Hip Disability and Osteoarthritis Outcome Score (HOOS).'' The ICOAP addresses both constant and intermittent pain related to intensity and frequency and its impact on sleep and quality of life.[28] The questionnaire is scored out of 100, ranging from 0 (no pain) to 100 (extreme pain) and has produced reliable and valid data in samples with OA.[28] Both the KOOS and HOOS address pain and physical function of the knee and hip, respectively, on five subscales: pain, other symptoms, function in daily living, function in sport and recreation, and quality of life. Each subscale on these questionnaires is scored out of 100, ranging from 0 (extreme problems) to 100 (no problems).[29,30] Both the KOOS and HOOS produce reliable, valid, and responsive data among older adults with OA.[29,30] Regardless of whether participants were experiencing symptoms of hip pain or knee pain, all completed each of the three questionnaires.

Depressive Symptoms

Depressive symptoms were measured using the ''Center for Epidemiologic Studies Depression Scale (CES-D).'' This 20-item scale addresses items including depressive mood, feelings of guilt, worthlessness, helplessness, and hopelessness, among others.[31] Scores range from 0 to 60, with higher scores reflecting more symptoms of depression. The scale has produced high internal consistency, acceptable test–retest stability, excellent concurrent validity, and evidence of construct validity in adults.[31]

Self-efficacy

Self-efficacy measures a person's belief that they can achieve a specific behavior or perform a particular task.[32] The Arthritis Self-efficacy scale (ASES) measures self-efficacy for behavior including controlling pain and disability. The scale is a 20-item questionnaire divided into three subscales, which address the self-efficacy for physical function, controlling other arthritis symptoms and pain management.[32] Scores for each subscale and the total score are calculated. The scale has produced adequate construct and concurrent validity and test–retest reliability in samples with OA.[32]

Hip and Knee Strength

Peak flexor and extensor torque of the hip and knee were measured using a fixed dynamometer (Biodex System 2, Shirley, NY). To measure hip strength, participants were supine with their hip joint center aligned with the axis of rotation of the dynamometer. Straps were placed across their waist and their untested thigh. Following a submaximal familiarization and warm-up period, participants performed five maximal isometric contractions with the hip flexed to 45°.[33] Exertions were performed for both flexion and extension using visual feedback and verbal encouragement. To measure knee strength, participants were seated with their knee joint center aligned with the axis of rotation of the dynamometer. Straps were placed firmly across their chest, waist, thigh, and shank of their tested limb. Following a submaximal familiarization and warm-up, participants performed five maximal isometric contractions with the knee angle set to 60°.[34] Exertions were performed for both flexion and extension using visual feedback and verbal encouragement. At both the hip and knee, the peak extension and flexion torque acquired from each of the five repetitions was determined and normalized to body mass (Nm/kg).

Mobility Performance

Five performance-based tests were used to capture mobility, as recommended by Osteoarthritis Research Society International (OARSI): 30-second chair stand test, timed up-and-go (TUG) test, 40-meter walk test (40mWT), 6-minute walk test (6MWT), and stair climb test.[35] The 30-second chair stand test measures the number of times participants can rise and lower from a standard height chair, without using arm rests, in a 30-second period. The TUG test measures the time (s) taken to rise from a standard chair with arm rests, walk 3 m, and return to a seated position. The 40mWT measures the time taken (s) to complete a fast-paced 40-m walk, while the 6MWT measures the maximum distance covered (m) during a 6-minute fast-paced walk. The stair climb test measures the time taken (s) to ascend and descend nine stairs.[35] These tests have been previously used to measure improvements in mobility following exercise interventions in older women with knee OA.[13,21]

Statistical Analysis

Shapiro–Wilk tests were used to evaluate the normality of each outcome measure. A one-way analysis of variance (ANOVA) was used to evaluate between-group effects on change scores. Specifically, the effect of intervention (exercise, no exercise) on the change scores (follow-up – baseline) of all work-related outcomes (resilience, work ability), patient-reported outcomes (pain, physical function, depressive symptoms, self-efficacy), and performance outcomes (hip and knee strength, mobility) was examined. Pairwise comparisons were evaluated with a Sidak correction to reduce the risk of type I error. Kruskal–Wallis tests were performed for nonparametric outcomes. A corrected P value ($P = 0.025$) to account for type I error was used to determine significance. Further, two-tailed paired t tests were used to evaluate within-group effects. Specifically, the effect of the time (baseline, follow-up) on all work-related, patient-reported, and performance outcomes for both the exercise and no exercise interventions was examined. A P value of 0.05 was used to determine significance. Effect sizes (Cohen d) were calculated for all within-group and between-group comparisons, with 0.2, 0.5, and 0.8 representing small, medium and large effect sizes, respectively.[36] Statistical analyses were performed in Stata/IC 13.0 (StataCorp LP, College Station, TX).

RESULTS

Participants

Twenty-four participants (19 women, 5 men) were randomly allocated to either the exercise or no exercise group. There were no statistically significant differences between groups with regard to sex ($P = 0.63$), affected limb ($P = 1.0$), age ($P = 0.45$), body mass index ($P = 0.17$), or LEFS score ($P = 0.96$) (Table 1). Further, there was no significant difference in baseline fitness level ($P = 0.795$) between groups as measured by the Ebbeling Single Stage Treadmill Test.[37] Participants in the exercise group attended an average of 1.2 classes per week over the 12 weeks (median, 0.5 classes per week; maximum, 3.9 classes per week; minimum, 0 classes per week). Four participants were lost at follow-up: three from the exercise group and one from the no exercise group.

Work-related Outcomes

No significant between-group effects were demonstrated for WAI ($P = 0.16$, $d = 0.66$) or resilience ($P = 0.849$, $d = 0.25$); however, a medium-large effect size was present for WAI. Significant within-group effects were present. Specifically, paired t tests demonstrated a significant improvement in WAI following the intervention ($P = 0.049$) (Fig. 1) in the exercise group. This improvement, which was an average of 1.5 points on the WAI scale, was a small-medium effect ($d = 0.30$) with both baseline and follow-up scores falling in the "good" work ability classification. There was no significant difference in resilience following exercise ($P = 0.292$); however, the improvement in resilience yielded a medium effect size ($d = 0.56$). No within-group differences in either WAI ($P = 0.509$, $d = 0.22$) or resilience ($P = 0.391$, $d = 0.18$) were evident in the no exercise group. WAI scores in the no exercise group also fell into the "good" work ability classification at baseline and follow-up, despite showing a mean reduction of 1 point following the 12 weeks.

Patient-reported Outcomes

Significant between-group effects with corresponding large effect sizes were present for ICOAP constant ($P = 0.034$, $d = 1.03$), intermittent ($P = 0.004$, $d = 1.48$), and total ($P = 0.004$, $d = 1.48$; Fig. 2) pain scores, as well as KOOS pain ($P = 0.015$, $d = 1.92$) and

TABLE 1. Summary of Participant Information at Baseline, Including Number of Participants (n), Ratio of Number of Men to Women [n (Men: Women)], and Hip to Knee [n (Hip: Knee)], as Well as the Mean (Standard Deviation) age, Body Mass Index (BMI), and Lower Extremity Functional Scale (LEFS) Score

	Exercise Group	Control Group
N	12	12
n [Men:Women]	2:10	3:9
n [Hip:Knee]	5:7	5:7
Age, years [mean (SD)]	52.8 (6.4)	54.9 (6.7)
BMI, kg/m^2 [mean (SD)]	30.7 (6.8)	27.6 (3.4)
LEFS (/80) [mean (SD)]	60.1 (13.8)	59.8 (7.8)

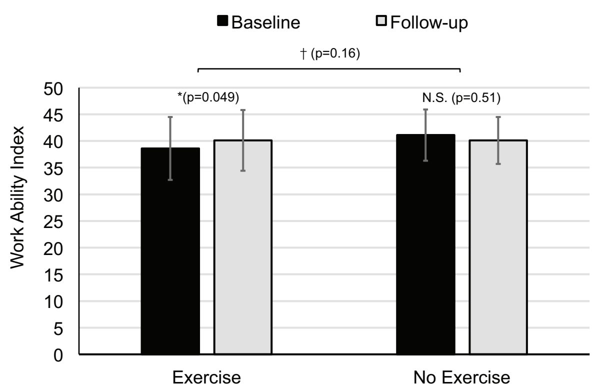

FIGURE 1. Mean (standard deviation) ''Work Ability Index'' questionnaire scores at baseline and follow-up for the exercise and no exercise groups. Statistically significant between-group differences denoted by†. Statistically significant within-group differences denoted by*. *P* values are provided for significant ($P < 0.05$) and nonsignificant (N.S.) differences.

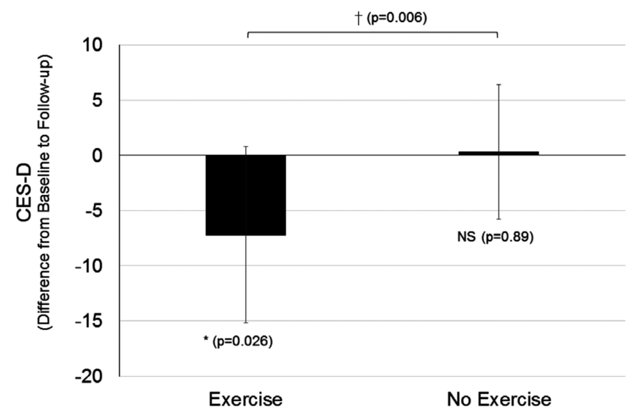

FIGURE 3. Mean (standard deviation) difference scores (follow-up – baseline) for the ''Center for Epidemiologic Studies Depression Scale (CES-D)'' questionnaire for the exercise and no exercise group. Statistically significant between-group differences denoted by†. Statistically significant within-group differences denoted by*. *P* values are provided for significant ($P < 0.05$) and nonsignificant (N.S.) differences.

depressive symptoms ($P = 0.006$, $d = 1.07$; Fig. 3), with larger reductions in pain and depressive symptoms present in the exercise group. Significant within-group effects were present for several patient-reported outcomes in the exercise group. In particular, following the intervention, there was a significant reduction in constant ($P = 0.028$, $d = 0.90$), intermittent ($P = 0.002$, $d = 1.80$), and total pain ($P = 0.005$, $d = 1.47$; Fig. 2), as measured by the ICOAP tool, and a 50% reduction in depressive symptoms ($P = 0.026$, $d = 0.82$; Fig. 3), each yielding a large effect. There were also significant improvements in the functions of daily living subscale of the KOOS ($P = 0.046$, $d = 0.53$) and HOOS ($P = 0.027$, $d = 0.33$) with small-medium effect sizes. Despite not being significant, certain outcomes yielded medium-large effect sizes, including the symptom ($d = 0.54$), and quality-of-life subscales of the KOOS ($d = 0.72$), as well as all subscales of the arthritis self-efficacy scale (range, $d = 0.76$ to 1.11).

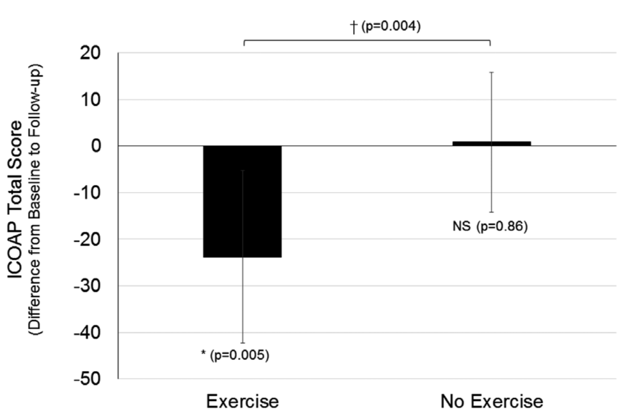

FIGURE 2. Mean (standard deviation) difference scores (follow-up – baseline) for the ''Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP)'' tool for the exercise and no exercise group. Statistically significant between-group differences denoted by†. Statistically significant within-group differences denoted by*. *P* values are provided for significant ($P < 0.05$) and nonsignificant (N.S.) differences.

In the no exercise group, no significant within-group differences were observed among patient-reported measures from baseline to follow-up.

Performance Outcomes

There were no significant between-group or within-group effects present for any of the strength or mobility measures (Table 2).

DISCUSSION

The results from this small randomized controlled trial support exercise in the workplace for improving OA symptoms among workers with clinical hip and knee OA. Improvements in work ability and patient-reported outcomes, including pain, physical function, and depressive symptoms, were present following 12 weeks of exercise. Exercise-induced improvements in strength and mobility performance were not significant, likely as a result of the limited sample size. Further, the demonstrated changes across all outcomes for the exercise group are smaller than anticipated based on previous findings from research studying static strengthening exercise interventions for knee OA.[13,21] We expect this to be a result of the poor adherence to exercise over the 12 weeks. Lastly, as expected, there were no significant changes in any outcome in the no exercise group.

Exercise in the Workplace for Older Adults with OA

A primary focus of this randomized controlled trial was to study the effect of exercise on work ability and work resilience. Given the high prevalence of OA among those of working age, it is of particular importance to determine whether exercise can be implemented in the work environment to improve work ability among older workers with painful knees and hips. Researchers have demonstrated the benefits of on-site workplace exercise programs for musculoskeletal health and work ability.[38–41] In a 10-week randomized controlled trial comparing workplace versus home-based exercise programs, exercise at work was more effective in preventing reductions in work ability than home-based exercise ($P = 0.03$).[38] In this previous study, WAI scores at baseline and follow-up ranged from approximately 42 to 43.25, indicating that

TABLE 2. Mean (Standard Deviation) at Baseline and Follow-up and Difference Scores (from Baseline to Follow-up) for Hip and Knee Strength and Mobility Performance Measures for the Exercise and No Exercise Groups

		Baseline	Follow-up	P^*	Difference Score	$P^\dagger$
Strength						
Hip extensor, Nm/kg	Exercise	1.3 (0.5)	1.4 (0.5)	0.174	0.1 (0.3)	0.764
	No exercise	1.3 (0.7)	1.4 (0.7)	0.367	0.1 (0.3)	
Hip flexor, Nm/kg	Exercise	1.0 (0.3)	0.9 (0.3)	0.501	0.0 (0.1)	0.899
	No exercise	1.0 (0.2)	1.0 (0.3)	0.538	0.0 (0.1)	
Knee extensor, Nm/kg	Exercise	1.9 (0.5)	1.9 (0.5)	0.315	0.1 (0.2)	0.212
	No exercise	1.7 (0.4)	1.6 (0.5)	0.437	−0.1 (0.3)	
Knee flexor, Nm/kg	Exercise	0.7 (0.3)	0.7 (0.3)	0.160	0.0 (0.1)	0.215
	No exercise	0.9 (0.2)	0.9 (0.3)	0.690	0.0 (0.1)	
Mobility performance						
30-second Chair Stand (*n*)	Exercise	14.1 (2.1)	14.2 (2.1)	0.787	0.2 (2.4)	0.551
	No exercise	14.1 (3.4)	13.6 (3.4)	0.567	−0.5 (2.5)	
Timed up-and-go, s	Exercise	7.2 (1.5)	6.8 (0.9)	0.198	−0.5 (1.0)	0.165
	No exercise	7.1 (0.8)	7.3 (0.9)	0.571	0.2 (1.0)	
40m walk, s	Exercise	25.1 (5.2)	24.4 (4.1)	0.443	−0.7 (2.7)	0.584
	No exercise	24.5 (2.5)	24.4 (3.0)	0.902	−0.1 (2.4)	
6-minute walk, m	Exercise	540.0 (81.2)	552.6 (72.8)	0.370	12.5 (39.6)	0.612
	No exercise	526.7 (60.5)	550.4 (61.0)	0.177	23.7 (54.1)	
Stair ascent, s	Exercise	4.5 (0.8)	4.1 (0.3)	0.096	−0.4 (0.6)	0.147
	No exercise	4.2 (0.3)	4.2 (0.6)	0.837	0.0 (0.6)	
Stair descent, s	Exercise	3.6 (0.5)	3.5 (0.5)	0.387	−0.1 (0.4)	0.683
	No exercise	4.0 (0.6)	4.0 (0.5)	0.868	0.0 (0.6)	

P values for within-group (*) and between-group (†) differences are provided.

work ability fell within the ''good'' classification, similar to the current sample. Further, an 8-year longitudinal study was conducted relating physical activity to subjective work ability and return to work in rehabilitation patients with a variety musculoskeletal diseases.[40] At least 40 minutes of physical activity per week during the first 6 months after rehabilitation was positively related to subjective work ability and lead to 3.28 times lower odds of being on sick leave after 1 year, compared with those who were inactive.[40] It is possible, though, that strength training alone is not sufficient to improve work ability. A 10-week randomized controlled trial compared strength training versus ergonomic training on work ability in those with chronic upper extremity pain. The WAI score at baseline and follow-up was classified as ''good'' in both groups. A significant between-group difference ($P = 0.012$; $d = 0.52$) was elicited, with the ergonomic training group demonstrating a reduction in the WAI of 2.2 points ($P < 0.01$), with no statistical improvement in the strength training group.[41] Despite some inconsistencies across various studies, overall, a critical review of the impact of worksite physical activity programs on activity, fitness, and health reported strong evidence that these programs are effective in reducing the impact of musculoskeletal disorders.[39]

In the current study, although small, there was a significant improvement in work ability in the exercise group; at the same time, a nonsignificant reduction was present in the no exercise group (Fig. 1). Further, there was no change in work resilience for either intervention; however, the improvement demonstrated in the exercise group yielded a medium effect size ($d = 0.56$). There are several possible explanations for the lack of change in resilience and small increase in work ability in the exercise group following the 12-week intervention. The most likely causes are the small sample size and poor adherence to the exercise intervention. Of the included participants in the exercise group ($n = 12$), median attendance was less than one class per week, and three of the four participants lost to follow-up were randomized to the exercise group. Thus, the improvements in work ability and patient-reported outcomes would likely be larger if all participants adhered to the intervention. As well, previous researchers have reported that a reduction in work ability may be attributed to the seasonal variations that patients may experience in their level of pain, sickness absence, and overall health.[38] It is possible that this may have masked greater improvements in work ability. The WAI considers aspects of physical and mental demand as well as several diagnosed disease possibilities, which may fluctuate over the 12 weeks, particularly across the winter months during which time this study was conducted. Thus, this tool may not be optimal to assess work ability in the context of OA-related symptoms.

Effect of Exercise on Patient-Reported and Performance Outcomes in OA

Exercise had a positive effect on patient-reported symptoms. Although not statistically significant, strength and mobility outcomes also demonstrated trends supporting improvement. These findings are comparable to previous research, which has reported exercise to be beneficial for OA. High-quality evidence exists that exercise improves pain and quality of life in knee OA, and moderate-quality evidence that exercise improves physical function.[12] Interestingly, exercise programs that target quadriceps strengthening have the largest effect sizes for physical function improvements, compared with programs that included general lower limb strengthening or strengthening combined with aerobic activity.[12] In a recent cohort study of older women with knee OA, improvements in pain ($P < 0.001$), self-reported function ($P < 0.001$), knee extension ($P = 0.004$), and flexion ($P = 0.001$) strength, and two measures of mobility performance (30-second chair stand test, $P = 0.006$; 6MWT, $P < 0.001$), were present following 12 weeks of static quadriceps strengthening exercises (yoga).[13] This study reported an adherence rate to the exercise classes of 87.1% (2.6 classes per week).[13]

The current research showed that following exercise, there was a reduction in intermittent, constant and total pain, improvements in physical function in daily living at the hip and knee, and a reduction in depressive symptoms among workers. Although not reaching statistical significance, there was a large effect size for the improvements in self-efficacy (range, $d = 0.76$ to 1.11) and for the quality-of-life subscale of the KOOS ($d = 0.72$). These large effect sizes likely reflect the small sample. Exercise has been previously shown to improve performance-related self-efficacy in knee OA.[42] Further, differences in each of these outcome measures can also be considered clinically meaningful. The minimum clinically important difference (MCID) or minimal important difference (MID) is the change in outcome score that can be perceived as meaningful for the patient.[43] The MCID for ICOAP overall, constant, and intermittent pain is 18.4 to 18.7, with moderate improvements denoted by 26.7, 29.6, and 24.3, respectively.[44] In the current study, improvements in overall, constant, and intermittent pain in the exercise group all exceeded the MCID (23.8, 20.6, 26.4, respectively), with intermittent pain exceeding the moderate improvement threshold. The MID for the KOOS questionnaire varies on the basis of analytical methods employed.[43] In the current research, despite not being statistically significant, the mean improvement in quality of life (17.9 points) exceeded the highest mean MID reported for this subscale.[43] On the contrary, performance measures were not significantly improved in the exercise group. It would be interesting to note whether the poor adherence demonstrated by participants in this study limited the change demonstrated in performance-based measures of lower extremity function.

Adherence to Exercise in the Workplace

Adherence to the exercise classes in the exercise group was poor, despite the use of typical incentives. Also, drop-out was high relative to the small sample size. In our previous exercise trials for knee OA, where we asked participants to attend three of four available exercise classes each week, adherence rates were 87.1% and 95.4%.[13,21] Further, we anticipated that the convenience of delivering the intervention at the participants' place of employment would support adherence. However, researchers have previously reported that low adherence and high drop-out rates are common among workplace interventions.[38] Adherence to exercise in OA populations has also been reportedly low. This trend is problematic given that the effectiveness of an intervention is related to adherence.[45] Potential factors that could affect adherence include level of satisfaction with the activity, emotional involvement or attitude toward physical activity, fear of the activity or fear of the activity causing pain, physical fitness level, and change in medication use.[16] In the current study, the lack of adherence may have been attributed to any or all of the following features: exercise classes were scheduled before the beginning of the workday, conflicts or busy work schedule, unexpected personal conflicts, poor understanding of the study commitment, lack of belief that exercise will improve their symptoms, or disinterest in the exercise program itself. However, a review of strategies to improve adherence to exercise in those with chronic pain indicated that there is evidence that the delivery rather than the type of exercise may improve adherence.[46] Despite the poor adherence, it is interesting to note that a relatively small investment in exercise each week produced meaningful improvements in work and patient-reported measures in the exercise group. Future research should investigate strategies to improve adherence and reduce drop-out rates in workplace interventions. From a practical perspective, it may be that adherence requires that an exercise workplace intervention must be conducted during paid time. Future work must explore the management and social structures in the workplace that may act as barriers or supports to successfully implementing exercise in the workplace.

Limitations

There were three key limitations of this research. First, the sample size in this trial was limited. Twelve participants were randomized to each intervention, with fewer men recruited overall than women. This lack of balance between participants recruited from each sex may reflect the greater prevalence of OA among women of this age.[17] Despite the imbalance of sex, participant randomization was stratified by their LEFS score, to ensure that physical function deficits were matched between groups. Second, adding further to these issues as a result of the small sample, several outcome measures were included in this study, increasing the likelihood of identifying a significant finding by chance. Also, due to the limited sample size, a significant dose–response relationship between exercise adherence and improvements in work-related, patient-reported, and performance outcomes was not present. Finally, this study is limited in generalizability to the university environment.

CONCLUSIONS

A 12-week exercise program implemented in the workplace for older workers with knee and/or hip OA was effective in improving work ability, self-reported pain, physical function, and depressive symptoms. As the limited sample size likely precluded finding statistically significant improvements in performance outcomes, a larger-scale randomized controlled trial should be conducted, with particular attention given to exercise intervention adherence strategies.

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