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The Effect of Egoscue Corrective Exercises on Chronic Knee and Hip Pain

Zachary Vehrs

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of
Master of Science

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ABSTRACT

The Effect of Egoscue Corrective Exercises on Chronic Knee and Hip Pain

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Master of Science

INTRODUCTION: While strengthening and aerobic exercise have been shown to decrease chronic knee and hip pain, little is known about the effectiveness of Egoscue corrective exercises, which are intended to reduce musculoskeletal pain by bringing the body into postural alignment.

PURPOSE: An experimental study to determine the acute effect following one treatment and the short-term effect after a 2 week program of Egoscue corrective exercises on knee pain, hip pain, and whole-body postural alignment. **METHODS:** Forty participants with chronic knee and/or hip pain (defined as pain on most days of the week for at least the previous 12 weeks) were randomly assigned and equally divided between an exercise group ($n = 20$) and a control group ($n = 20$). The exercise group completed a corrective exercise routine, as per the Egoscue Method, at least 5 d/wk for two weeks. The control group simply maintained their current lifestyle for the 2-week duration of the study. All participants kept a daily log of their average pain levels at rest and during movement using a Visual Analog Scale (VAS). Standing posture was assessed using PostureScreen Mobile® and pain and function were recorded using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) at baseline and at the end of week 1 and 2.

RESULTS: The exercise group experienced a significant decrease in pain during everyday movement as reported in daily VAS logs ($p = 0.019$). After controlling for age, BMI, past surgeries, arthritis status, and location of pain, there was a significant group x time interaction in WOMAC scores ($p = 0.015$). At week 2, WOMAC scores were significantly lower in the exercise group ($p = 0.001$) but not the control group ($p > 0.05$). Pain was not significantly different after one treatment. No significant changes in posture were observed in this study.

CONCLUSION: Two weeks of corrective exercises significantly decreased knee and hip pain and improved function. Although an observable change in posture was not detected, further research is warranted to investigate the effects of Egoscue corrective exercises on posture over longer periods of time.

Keywords: therapeutic exercise, musculoskeletal pain, posture, function

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Introduction

Chronic musculoskeletal pain is a major cause of reduced quality of life,^{1,2} which can lead to distress, dependency, disability, anxiety, and depression.³ It is estimated that each year 25% of people over 55 y have a persistent episode of knee pain.⁴ Chronic hip and knee pain is a primary symptom of osteoarthritis. Approximately 9.5% of men and 11.2% of women have hip osteoarthritis,⁵ while about 9.3% of the U.S. population is diagnosed with symptomatic knee osteoarthritis by age 60.⁶

It has been suggested that posture plays a major role in the development of chronic pain.⁷ The misalignment of body segments as a result of improper posture leads to compensatory effort by other segments to maintain body balance, resulting in excess muscular strain⁸ and wear on the joints.⁹ Over time this can lead to musculoskeletal pain. Postural abnormalities are deviations from the ideal posture as defined by the Kendall and McCreary method (a plumb line passing through the ear lobe, vertebra prominens, acromion process, the greater trochanter, slightly anterior to the midline of the knee, and just anterior to the lateral malleolus).¹⁰ One group of researchers found that participants with more severe postural abnormalities had significantly greater incidence of pain in the thoraco-cervical-shoulder region.¹¹ Another study found that participants with ideal posture had significantly less lumbar back pain than participants with postural misalignments.¹²

Corrective exercise has been used to improve posture by properly activating skeletal muscles to bring body segments closer to an ideal alignment. For example, Lynch et al¹³ and Kluemper et al¹⁴ found that strengthening the posterior shoulder and cervical muscles decreased forward head angle and shoulder translation in swimmers. In addition, a Pilates-based exercise program demonstrated a decrease in kyphosis while standing and improved lumbar extension

while sitting.¹⁵ Similarly, Scannell et al¹⁶ found corrective exercise to be effective at improving lumbar posture. After 12 weeks of exercise training, participants with previous hyperlordosis or hypolordosis stood and walked with their lumbar spine in a more neutral position.

Although there is evidence to support the use of corrective exercise to improve posture, few studies have correlated an improvement in posture with a reduction in pain. Drescher et al¹⁷ found that corrective exercise interventions to improve neck posture significantly decreased pain in the treatment group compared to controls. Decreases in pain were still notable at 6-month and 3-year follow-ups. Similarly, Diab and Moustafa¹⁸ compared the effectiveness of postural corrective exercises, ultrasound, and infrared radiation to a traditional treatment of ultrasound and radiation alone. Following treatment there was a significant reduction in neck pain and forward head angle in the exercise group compared to the control group.

Exercise has been shown to be effective in decreasing chronic hip and knee pain. For example, a meta-analysis of eight randomized controlled studies investigated the effect of strengthening and/or aerobic exercise on chronic hip pain in participants with hip osteoarthritis.¹⁹ The pooled effect size of exercise on hip pain was 0.46 compared to a control group. Similarly, Fransen and McConnell²⁰ conducted a large meta-analysis of 32 studies which included data on 3616 patients with knee osteoarthritis. Their meta-analysis revealed a beneficial treatment effect for exercise with an effect size of 0.40 for knee pain.

While there are many types of corrective exercise used in chiropractic, physical therapy, and personal fitness training, the Egoscue Method of corrective exercise is the focus of this study. The Egoscue Method uses corrective exercises designed to improve whole-body postural alignment and reduce musculoskeletal pain by improving joint mobility and stability.⁷ The Egoscue Method involves evaluating a patient's posture, categorizing their posture into one of

three “conditions” according to their postural misalignments, and prescribing a personalized corrective exercise program (i.e., E-cise menu) based on their condition. The E-cise menu usually consists of 10 to 20 E-cises which may take 45 to 75 minutes to complete, preferably on a daily basis. Although the Egoscue Method is reported to be effective from an observational perspective in a clinical setting,²¹ it has not been objectively studied in a research setting.

Strengthening and aerobic exercises can be beneficial for people suffering from chronic hip^{19,22,23} or knee pain.^{20,24,25} Nevertheless, most exercise prescriptions focus little on improving posture. To date, there are no published studies investigating the relationship between whole-body posture and chronic hip and/or knee pain. Furthermore, to the best of our knowledge, it has not been established that improving whole-body posture can reduce chronic hip and/or knee pain. The Egoscue Method, which employs corrective exercise, makes the claim to improve both posture and chronic pain. Because Egoscue E-cises are designed to be performed at home and do not require the use of expensive equipment, this type of therapy appears to be a cost effective treatment for people suffering from chronic knee and/or hip pain. The primary purpose of this experimental study was to determine the acute effect following one treatment and the short-term effect after a 2-week program of Egoscue corrective exercises on chronic knee and hip pain. A secondary purpose of this study was to determine the influence of Egoscue corrective exercises on whole-body postural alignment over the same time frame.

Methods

Participants

The participants for this study were recruited from university faculty and via email announcements and flyers posted on campus. Participants were adults (age range 18 to 71, mean 47.4 ± 15.5 y) with chronic knee and/or hip pain. Chronic pain was defined as pain on most days

of the week for at least 12 weeks.²⁴ Individuals were excluded from the study if they (a) had undergone a knee or hip surgery or had sustained a knee or hip injury in the past 12 months, (b) were currently receiving any form of pain treatment such as physical therapy, chiropractic, intra-articular injections, or prescription pain medications, (c) exhibited a severe lack of mobility, (d) reported an initial pain level < 3 cm on the VAS scale, (e) were pregnant, or (f) were unable to understand English. Individuals were not excluded from participation in this study if they were taking over-the-counter (OTC) pain medications such as nonsteroidal anti-inflammatory drugs, although they were required to refrain from taking any pain medication during the 12 hours preceding the first assessment. A power analysis using a power level of 80% and alpha set at 0.05 indicated a sample of 40 participants (20 in the control group and 20 in the exercise group). A large effect size (0.80) was assumed because this has been reported in the literature²⁶ for differences in Western Ontario and McMaster Universities Arthritis Index (WOMAC) scores following an at-home exercise program. Forty-two eligible participants were originally recruited.

Research design overview

This study was a randomized controlled experimental design. The primary outcomes were the visual analog scale (VAS) pain scores at rest and during movement, WOMAC pain and function subscores, and the following postural measurements taken from PostureScreen Mobile® (PSM): head shift and tilt, estimated head weight, shoulder shift and tilt, ribcage shift, hip shift and tilt, and knee shift. Participants were randomly assigned to either the exercise group which performed Egoscue corrective exercises for two weeks, or the control group which did not receive any treatment for two weeks. It should be noted that the relatively short study duration was chosen because the Egoscue Method suggests that significant reductions in pain can be made after a single exercise session.⁷ At the beginning of the study, pain and posture were measured

before and after a single bout of corrective exercises in the exercise group, while the control group was assessed before and after 45 minutes of rest. All participants recorded their level of pain daily, and their function and posture were measured both before and after the 2-week intervention as well as one week into the intervention. All study methods and procedures were approved by the university's Institutional Review Board for the use of Human Subjects prior to any data collection. All participants provided written informed consent prior to participation in this study.

Instrumentation

PostureScreen Mobile™

PostureScreen Mobile® (PSM) was used to quantify the measurement of posture. PSM is a postural screening tool that can be used in the field or clinical setting. The Apple iPad® app version was used for this study. Photographs from the anterior and lateral views of the participant in the standing position were used to measure deviations of the head, shoulders, trunk, hips, and knees. The PSM software calculates and reports deviations in postural alignment in degrees and inches. Although PSM is still in the initial stages of validity and reliability testing, the web based Posture Print™, on which PSM is based, has been shown to be both a valid and reliable clinical tool for measuring posture.²⁷⁻³⁰

Photographs of the anterior and right lateral sides of the participants were uploaded into the PSM software on an Apple iPad™. A single test administrator manually marked the photographs in the software at the following anatomical locations according to manufacturer directions: from the anterior view, the center of left and right eyes, center of upper lip, left and right acromioclavicular (AC) joints, sternal notch, left and right lateral rib at T8 level, left and right anterior superior iliac spine (ASIS), and center of left and right ankle; from the lateral view,

the external auditory meatus, AC joint, greater trochanter of the femur, the center of the knee, and the lateral malleolus. The software includes a user-friendly step-by-step sequence for identifying landmarks and a “zoom” feature to aid in landmark identification accuracy. From the anterior view, the software calculated and reported head shift and tilt, shoulder shift and tilt, ribcage shift, and hip shift and tilt. From the lateral view, the software calculated head shift, shoulder shift, hip shift, knee shift, and head weight. Shifts (lateral or forward/rearward translations) were calculated as deviations from the joint directly inferior and were reported in inches. Tilt was reported in degrees. The software also reported an anterior and lateral posture score for each participant, which represents a sum of the deviations in the anterior and lateral views, respectively. The software calculated head weight as a function of angle of head tilt (the greater the forward head shift, the greater the estimated head weight).

Western Ontario and McMaster Universities Arthritis Index

The Western Ontario and McMaster Universities Arthritis Index (WOMAC) is a self-administered, multidimensional questionnaire designed for osteoarthritis patients that assesses pain, stiffness, and physical function. Out of a total of 24 questions, 5 questions deal with pain at rest and during activity, 2 questions deal with stiffness, and 17 questions deal with the degree of function in common daily activities. Each question is answered using a five point Likert scale. Subscores are reported for pain (0 to 20), stiffness (0 to 8), and function (0 to 68). The WOMAC has been found to be both reliable and valid in patients with knee and hip osteoarthritis.^{31,32}

Visual Analog Scale for pain

The Visual Analog Scale (VAS) for pain is a continuous scale comprised of a horizontal line, 10 cm in length, anchored by two verbal descriptors, one for each symptom extreme (“no pain” and “worst imaginable pain”). The participant is asked to draw a line perpendicular to the

VAS line at the point that represents their pain intensity. Since there is no accepted criterion for pain measurement, the VAS pain scores have been correlated with a numerical rating scale with values ranging from 0.62 to 0.91.³³ Test-retest reliability has been shown to be very good ($r = 0.94$, $P < 0.001$).³⁴

ePete[®] software

The ePete[®] software is a computer program designed by Pete Egoscue for creating personalized corrective exercise programs. Postural misalignments (as noted in the posture assessment) and photos from the anterior, posterior and both lateral sides are entered into the software, which then compiles the corrective exercises that are designed to improve those misalignments into an E-cise menu. The E-cise menu can be edited by adding or removing specific exercises. The software has a database of approximately 600 corrective exercises, of which 60 to 70 are drawn from to create E-cise menus.

Procedures

First visit

Qualified participants came to the research lab having refrained from taking any pain medications within 12 h prior to the first visit. All participants provided written informed consent and completed a preparticipation questionnaire that included questions about age, gender, injuries, OTC pain medication use, and previous or planned total hip and/or knee arthroplasty. Participants completed two versions of the VAS for knee and/or hip pain: one for pain at rest and one for pain during movement. If participants had pain in multiple joints, they were told to record their overall level of pain. Participants were told to indicate their “usual pain” over the past seven days. Participants needed to have a VAS pain score of at least 3 cm (either at rest or during movement) in order to participate in the study.³⁵ Participants also completed one copy of

the WOMAC and the VAS for pain at the time of the visit. Female participants wore a swim suit and males wore spandex compression shorts and no shirt. Socks and shoes were removed for all testing. Participants' body mass was measured to the nearest 0.1 kg and height to the nearest 0.5 cm using a digital scale and a stadiometer, respectively. Participants were randomly assigned to either the exercise group or the control group by picking a piece of paper out of a hat (20 for the exercise group and 20 for the control group). After participants picked a piece of paper out of the hat, the paper was not replaced.

The test administrator marked the following anatomical locations of each participant with a total of seven reflective stickers: left and right AC joints, sternal notch, right and left ASIS, and right and left greater trochanter of the femur. Participants were told to stand in a normal relaxed position while they were photographed from the anterior, posterior, and both lateral views using the digital camera on an Apple iPad™. As the photos were taken, the test administrator trained in postural evaluation made notes about the participant's posture on an Egoscue "sticky" figure. The sticker placement and postural evaluations were all performed by the same researcher to reduce possible inter-rater error. The photographs and the observed misalignments were then entered into the ePete® software and an individualized exercise program (E-cise menu) was generated. To ensure that all participants were prescribed the same volume of exercise, the E-cise menus were adjusted by adding or removing exercises so the duration required to complete the exercises was approximately 45 minutes.

After being photographed, the participants in the exercise group were led through their complete E-cise menu. The test administrator explained each exercise then supervised the participants as they performed the exercises. The test administrator provided any necessary cues and verbal feedback to ensure that each exercise was done correctly. Participants in the control

group remained seated and did not perform any exercises for 45 minutes. Immediately following the exercise session or 45 minutes of rest, a test administrator checked all the reflective markers to ensure they were still in the correct locations. Participants were then photographed again in the same manner as before and filled out the VAS for their current knee and/or hip pain at rest and with movement.

All participants were given research logs (one for each day of the week) which they were to fill out every evening before retiring to bed. These logs contained questions about their compliance to the E-cise menu (for those in the exercise group), OTC pain medication use, and a VAS for pain at rest and during movement. Participants filled out the VAS for average pain experienced during that day. Participants in the control group were instructed to maintain their current lifestyle for the two week duration of the study and a return visit was scheduled one week later. Participants in the exercise group were scheduled for a return visit the following day.

Second visit (exercise group only)

Participants in the exercise group returned to the lab the next weekday following the first visit. They were given a copy of their E-cise menu, which contained pictures and descriptions of the E-cises, and then performed their entire E-cise menu under the supervision of a research administrator. Participants in the exercise group were instructed to complete their E-cise menu at home on at least five days of the week, but preferably every day, for the next two weeks.

Third visit

One week following the initial visit, all participants returned to the lab and were evaluated wearing clothing similar to what they wore at the initial visit. All participants again completed the WOMAC. The test administrator placed reflective markers on the same anatomical locations that were marked on the initial visit. All participants were photographed

from the anterior and right lateral side. The test administrator then supervised as the participants in the exercise group demonstrated each corrective exercise in their E-cise menu to ensure they were still performing the exercises correctly. Participants did not complete the total prescribed amount of repetitions and sets at this time, only enough for the test administrator to see that they knew how to perform the exercises correctly. All participants returned their completed pain logs from the previous week and received another seven logs to be completed during the next week.

Fourth visit

Two weeks following the initial visit, all participants returned to the lab and were evaluated wearing clothing similar to what they wore at the initial visit. Height and body mass were measured again using the same procedures as the initial visit. Participants also completed the WOMAC and a questionnaire that asked about their current OTC pain medication use and intent to receive a joint replacement. A complete postural evaluation, along with photographs, was performed as during previous visits. Participants in the control group were given a personalized E-cise menu, along with instructions, at this time. All participants who completed the study were given \$30 cash as compensation.

Statistical analysis

Statistical Analysis Software (SAS), version 9.3 (Cary, NC) was used for data analysis. VAS for pain, WOMAC, anterior and lateral posture scores, and postural deviations at each joint were analyzed using analysis of covariance. Age, gender, BMI, location of pain, history of joint surgery, arthritis, likelihood of future surgery, pain at baseline, and OTC pain medication use were all covariates used in analysis. The daily VAS pain data were analyzed using residual maximum likelihood. Participant demographics were analyzed to determine frequencies, means,

and standard deviations in order to describe the sample. Statistical significance was set at $p < 0.05$.

Results

Forty-two participants were originally recruited for this study. Contact was lost with one participant from the exercise group and a participant from the control group was excluded for receiving additional pain therapy during the study, leaving 40 participants for analysis (20 in exercise group, 20 in control group). All 20 of the participants in the exercise group reported performing their E-cise menu at least 5 d/wk for the duration of the study. At baseline, participants' age, BMI, likelihood of joint replacement surgery, VAS pain, WOMAC scores, and posture were not significantly different between groups (Table 1). At baseline, frequency of OTC pain medication use was greater in the control group compared to the exercise group ($p = 0.044$). Although there were differences between groups, OTC pain medication use was not a significant covariate in any of our statistical analyses. There were no significant changes in frequency of OTC pain medication use from baseline and after weeks 1 and 2 in either group ($p = 0.288$).

Seventy percent of participants were female (75% of exercise group, 65% of control group). Roughly 38% of participants had knee pain only (55% of exercise group, 20% of control group), 28% had hip pain only (25% of exercise group, 30% of control group), and 35% had both knee and hip pain (20% of exercise group, 50% of control group). Forty percent of participants had been previously diagnosed with arthritis in either the knee or hip (35% of exercise group, 45% of control group). Thirty percent of participants had undergone surgery in their knee and/or hip more than 12 months prior to participation in this study (20% of exercise group, 40% of control group). Forty-three percent of participants reported taking OTC pain medication during the study (30% of exercise group, 60% of control group).

VAS measures of pain at rest and during movement

VAS pain scores before and after the first visit were analyzed to evaluate the effect of a single corrective exercise session on pain levels (Table 2). Although pain decreased slightly in the exercise group after a single bout of corrective exercises, after controlling for location of pain, past surgery, and age, there was no statistically significant group x time interaction for pain at rest ($p = 0.491$) or pain during movement ($p = 0.688$).

There was a significant decrease in pain during movement over the 2 weeks (Figure 1). Specifically, VAS pain scores decreased on average by 0.11 ± 0.03 cm/d in the exercise group ($p = 0.002$), while there was a nonsignificant decrease of 0.02 ± 0.03 cm/d in VAS pain scores in the control group ($p = 0.469$). The difference between the groups was statistically significant ($p = 0.019$) after controlling for significant covariates (initial pain level, location of pain, past surgery, arthritis). Compared to baseline, pain during movement at the end of the second week decreased by 3.77 ± 0.49 cm in the exercise group and 1.34 ± 0.46 cm in the control group ($p = 0.001$ for group x time interaction).

Compared to baseline, pain at rest at the end of the second week decreased by 1.40 ± 0.34 cm in the exercise group and 0.48 ± 0.32 cm in the control group (Figure 2), although the difference between groups did not reach statistical significance ($p = 0.058$). After controlling for initial pain level, location of pain, past surgery, and arthritis, there was no significant decrease over time for pain at rest as measured by daily VAS pain scores ($p = 0.522$).

Western Ontario and McMaster Universities Arthritis Index

There were no statistically significant differences in WOMAC scores between groups at baseline. Table 4 shows changes in WOMAC scores during the 2-week study. There was a trend for decreasing total WOMAC, function, and pain subscores in the exercise group over time,

while scores in the control group did not change significantly (Figures 3, 4, and 5). There were nonsignificant decreases in total WOMAC ($p = 0.106$), function ($p = 0.089$), and pain subscores ($p = 0.543$) in the exercise group after the first week. By the end of week 2, decreases in Total WOMAC ($p = 0.001$), function ($p = 0.002$), and pain ($p = 0.008$) subscores were significant in the exercise group. Total WOMAC, function, and pain subscores were significantly lower ($p = 0.017$, $p = 0.026$, $p = 0.011$, respectively) in the exercise group compared to the control group at the end of week 2. Compared to baseline, the exercise group showed a 60%, 67%, and 51% relative decrease in total WOMAC, function, and pain subscores, respectively at the end of week 2. Self-reported likelihood of undergoing joint replacement surgery in the future did not change significantly in either group (control group went down by 0.15 ± 0.59 and exercise group by 0.40 ± 1.60 $p = 0.516$).

Posture

Participants in the control group tended to have higher anterior view posture scores (i.e., greater deviations from “ideal posture”) at baseline, but these differences were not statistically significant ($p = 0.08$). There were no differences in any of the individual posture measurements or lateral view posture scores between groups. None of the individual posture measurements or scores changed significantly over time in either group.

Discussion

This study evaluated the effect of Egoscue corrective exercises on pain, function, and whole-body postural alignment in participants with chronic knee and/or hip pain after one treatment and after two weeks of performing Egoscue E-cises. The resulting data showed a significant decrease in pain over the two weeks, as well as a significant improvement in functional capacity in the exercise group compared to the control group. No significant changes

were noted in whole-body postural alignment over the course of the study. To date, this appears to be the first study to investigate the effectiveness of Egoscue corrective exercises.

Research on the effect of corrective exercise on pain and posture is limited. The studies that have examined corrective exercise have focused primarily on isolated locations of the spine or shoulders. For example, two studies^{17,18} have shown that corrective exercises can significantly reduce neck pain. Corrective exercises have also been shown to reduce forward head angle¹³ and forward shoulder angle.¹⁴ One study¹⁵ suggested that Pilates exercises may improve both standing and sitting sagittal plane posture. No studies were found which evaluated whole-body postural alignment following a corrective exercise program.

The Egoscue Method is based on the premise that in most instances musculoskeletal pain can be attributed to improper posture.⁷ Pete Egoscue, the founder of the Egoscue Method, joins others^{36,37} in the belief that misaligned posture is a result of underuse or overuse of skeletal muscles, which results in inadequate muscular control or muscle imbalances. These muscle imbalances can alter the alignment of the skeletal system, which puts excess stress on the joints and leads to chronic pain. Several cross-sectional studies support this hypothesis. Griegel-Morris et al¹¹ found that participants with more severe postural abnormalities had significantly increased incidence of pain in the thoraco-cervical-shoulder region. They also noted that postural abnormalities were quite common, with 66% of participants exhibiting forward head posture, 38% having kyphosis, and 73% and 66% of the participants showing right and left rounded shoulders, respectively. Guimond and Messrieh¹² also discovered that those with ideal posture (defined from the sagittal plane as a plumb line passing through the ear lobe, vertebra prominens, acromion process, the greater trochanter, slightly anterior to the midline of the knee and just anterior to the lateral malleolus¹⁰) had significantly less cervical, thoracic, and lumbar spine pain.

Another study found a positive correlation between neck pain and forward head and rounded shoulders.³⁸

The purpose of the Egoscue Method is to use corrective exercises to bring the whole body closer to “ideal” posture and thus reduce pain. A key characteristic of the Egoscue Method is the premise that postural misalignments of a given joint can lead to pain at the same or another joint, which is why the whole-body postural alignment should be considered when treating pain.³⁹ Others have suggested that misaligned posture can have negative effects on various locations on the body.⁴⁰ The E-cises are designed to influence all the major joints of the body. Data from our study show that Egoscue Method of corrective exercises can significantly reduce knee and hip pain, as well as improve physical function.

Our data show a significant decrease in pain in the exercise group, as reported in participants’ daily logs, over the course of this 2-week study. This suggests that the Egoscue corrective exercises have a relatively fast influence on decreasing knee and hip pain. Although it has been suggested that the Egoscue corrective exercises can provide immediate pain relief,³⁹ we did not note a significant reduction in pain at rest or pain during movement after the first exercise session (Table 2). There was large variation in reported pain using the VAS which, combined with the relatively small sample size, may have been the reason a statistically significant change was not detected. It is also possible that the corrective exercise prescription may not have been ideal for every participant in the study. It should be noted that in a clinical setting, an Egoscue exercise therapist would normally add or remove exercises from a patient’s E-cise menu based on effectiveness and feedback from the patient. In our study, participants were given an unmodified E-cise menu that was generated by the ePete[®] software.

The results of this study agree with the majority of research on the effect of therapeutic exercise on chronic knee and hip pain. A meta-analysis of eight randomized control studies showed favorable results on hip pain for the exercise group over the control group (effect size = 0.46; 95% CI = 0.64-0.28).¹⁹ Similarly, a meta-analysis of 32 studies on exercise and knee pain produced an effect size of 0.40 (95% CI = 0.30-0.50) for pain and 0.37 (95% CI = 0.25-0.49) for function.²⁰ In our study, the exercise group showed reduced WOMAC scores with effect sizes of 0.93 (95% CI = 1.58-0.28) for pain and 0.80 (95% CI = 1.48-0.19) for function. These changes were statistically significant after controlling for potential confounding variables such as age, gender, BMI, past joint surgery, arthritis, and location of pain.

There are several important differences between this study and previous studies. The average follow-up time in the studies included in the meta-analyses^{19,20} was 8 weeks, while our study lasted only 2 weeks. We employed a 2-week study to specifically evaluate the immediate and short-term effects of Egoscue corrective exercises. The type of exercise therapy employed in previous studies was also different than the Egoscue Method used in this study. All the studies included in the meta-analyses^{19,20} used strengthening exercises on the muscles surrounding the painful joint and some included range of motion, aquatic, and aerobic exercises as well. There are currently no published studies which use corrective exercises (e.g., Egoscue E-cises) that focus on improving whole-body postural alignment to reduce knee and/or hip pain.

Although we found the Egoscue corrective exercises to be effective at reducing pain and improving function, we saw no significant changes in postural alignment in either the exercise or control group. It is possible that a noticeable change in postural alignment requires a longer treatment period than was used in our study. Despite the fact that this study lasted only two weeks, the volume of corrective exercises performed was relatively high (a minimum of ten

exercise sessions, each lasting roughly 45 minutes, over the course of 2 weeks). While this may have been enough to reduce pain and increase function, it may not have been of sufficient duration to significantly improve posture.

Any potential changes in posture may have also been masked by error in the postural assessment process. It is important to consistently mark anatomical locations on the participants' bodies in order to ensure validity and test-retest reliability. In this study, the same researcher performed all postural assessments to eliminate any potential inter-rater error and participants wore minimal, tight fitting clothing to make the identification of key landmarks easier. Even so, with the majority (63%) of participants being overweight or obese ($\text{BMI} \geq 25 \text{ kg/m}^2$), it was difficult to reliably identify the correct anatomical landmarks for postural assessment, especially the ASIS and greater trochanter. Using a normal body weight ($\text{BMI} < 25 \text{ kg/m}^2$) sample could decrease this potential error in future studies.

Finally, the way PSM reports postural alignment may influence the ability to detect changes in posture. The software reports postural deviations relative to the load-bearing joint directly inferior. For example, if the hips do not directly line up vertically over the knees in the sagittal plane, the software reports that the hips are shifted either forward or backward. Ideal posture in the sagittal plane is typically defined as a plumb line passing through the ear lobe, vertebra prominens, acromion process, the greater trochanter, slightly anterior to the midline of the knee, and just anterior to the lateral malleolus.¹⁰ By this definition, the closer these landmarks are to the vertical plumb line, the closer the body is to ideal posture. Thus, it is possible that study participants' postural alignment relative to a plumb line improved, but this improvement was not recognized because of the way the software measures posture. In addition, PSM cannot measure certain postural angles which may influence knee and/or hip pain and which may have

changed during the course of this study (e.g., ankle pronation and supination, knee valgus and varus, and pelvic tilt). We used PSM because it is a readily available and easy-to-use tool that measures posture. Although it is based on similar software which has been shown to be a reliable and valid measure of posture,²⁷⁻³⁰ the validity and reliability of PSM has not yet been established. Until the validity and reliability of using the device is reported, it may not be the ideal tool for assessing improvements in posture in a research setting. Until such data are available, the PSM app is most applicable as a screening tool. Other methods should be considered in future research designed to evaluate the effectiveness of Egoscue E-cises or other forms of corrective exercises on posture and pain.

There were notable strengths to this study, including the study design. This was a randomized control trial, which allows the possible establishment of a causal relationship. The results of this study may be inferred to a similar population of that used in the study. Several potential covariates (age, BMI, gender, location of pain, history of joint surgery, arthritis, likelihood of future surgery, pain at baseline, and OTC pain medication use) were controlled for in the analysis of the data. A single test administrator performed all of the posture evaluations, which eliminated potential inter-rater measurement error.

There were also limitations to this study. The short duration of this study, while sufficient to assess the short-term effect of Egoscue corrective exercises on pain and function, may not have been long enough to observe changes in posture. The limitations of PSM may have inhibited our ability to detect potential changes in posture. Participants reported the frequency of OTC pain medication use but not the amount in milligrams. It is possible that, although the frequency of OTC pain medication use didn't change during the study, the dosage changed. In addition, participants completed most of the corrective exercise sessions unsupervised under

free-living conditions; therefore, the researchers had very little – if any – control over other potential confounding variables which may have influenced the outcome of the study.

Conclusion

This study found that 2 weeks of Egoscue corrective exercises significantly reduced knee and hip pain and improved functional capacity. These improvements were observed after adjusting for age, BMI, location of pain, history of joint surgery, and the presence of arthritis. Pain did not decrease significantly after a single corrective exercise session. The reduction in pain and improvement in function were noted despite no measureable changes in posture. The Egoscue Method appears to be a safe and effective treatment for chronic knee and hip pain. Future research is warranted to investigate the effects of Egoscue corrective exercises on posture and pain in other locations of the body (e.g., back, neck, and shoulders). Studies that employ follow-up should be also be used to determine whether beneficial effects are sustained over time.

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Table 1: Participant characteristics at baseline

Variable	Exercise (n = 20)	Control (n = 20)	<i>p</i> value
Age (y)	43.2 ± 3.7	51.6 ± 3.2	0.091
BMI (kg/m ²)	29.0 ± 1.5	27.4 ± 1.4	0.446
Surgery likelihood (Likert 1-7)	3.7 ± 0.5	3.2 ± 0.4	0.439
OTC Pain medication (days/week)	0.6 ± 0.3	2.2 ± 0.6	0.044*
VAS pain during movement (cm)	5.5 ± 1.8	5.9 ± 1.6	0.559
VAS pain at rest (cm)	2.4 ± 1.9	2.7 ± 1.7	0.737
Total WOMAC score	26.8 ± 3.6	24.2 ± 3.8	0.521
WOMAC function score	15.5 ± 2.4	13.9 ± 2.5	0.586
WOMAC pain score	6.6 ± 0.8	6.4 ± 0.8	0.842
Posture score (anterior)	4.5 ± 0.7	6.3 ± 0.7	0.082
Posture score (lateral)	4.7 ± 0.4	5.4 ± 0.4	0.244
Estimated head weight (lbs)	31.0 ± 3.5	32.3 ± 3.5	0.791

Results are described as mean ± standard error

*Significant at the 0.05 level

Table 2: VAS pain (cm) during the first visit

	Pain at rest		Pain during movement	
	Before	After	Before	After
Exercise group	1.2 ± 0.49	1.0 ± 0.49	4.1 ± 0.55	3.1 ± 0.55
Control group	1.5 ± 0.52	1.8 ± 0.52	4.6 ± 0.51	4.0 ± 0.51

Results are described as mean ± standard error

No significant change ($p < 0.05$) in VAS pain scores at rest or with movement in either group

Table 3: Changes in WOMAC scores from baseline

		Week 1	Week 2
WOMAC total	Exercise group	-10.19 ± 3.92	-16.15 ± 3.92*
		(<i>p</i> = 0.106)	(<i>p</i> = 0.001)
	Control group	-0.83 ± 3.92	0.11 ± 3.92
		(<i>p</i> = 0.999)	(<i>p</i> = 1.000)
WOMAC function	Exercise group	-7.10 ± 2.65	-10.35 ± 2.65*
		(<i>p</i> = 0.089)	(<i>p</i> = 0.002)
	Control group	0.10 ± 2.65	-0.10 ± 2.65
		(<i>p</i> = 1.000)	(<i>p</i> = 1.000)
WOMAC pain	Exercise group	-1.65 ± 0.95	-3.35 ± 0.95*
		(<i>p</i> = 0.543)	(<i>p</i> = 0.008)
	Control group	0.50 ± 0.95	0.20 ± 0.95
		(<i>p</i> = 0.995)	(<i>p</i> = 0.999)

Results are described as mean ± standard error

*Significant at the 0.05 level after controlling for age, gender, BMI, past surgery, arthritis, and location of pain

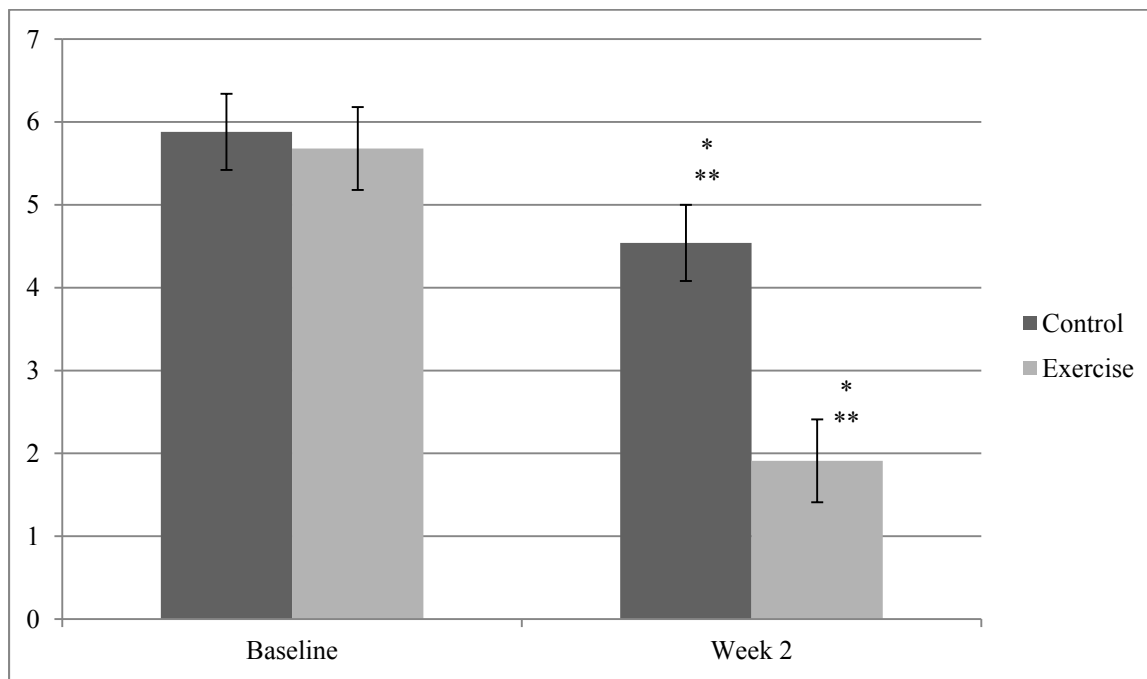


Figure 1: VAS pain (cm) during movement, by group

Data are presented as means \pm standard error bars.

* Statistically significant difference from baseline at the 0.05 level after controlling for age, past surgery, and location of pain.

** Statistically significant difference between groups at the 0.05 level after controlling for age, past surgery, and location of pain.

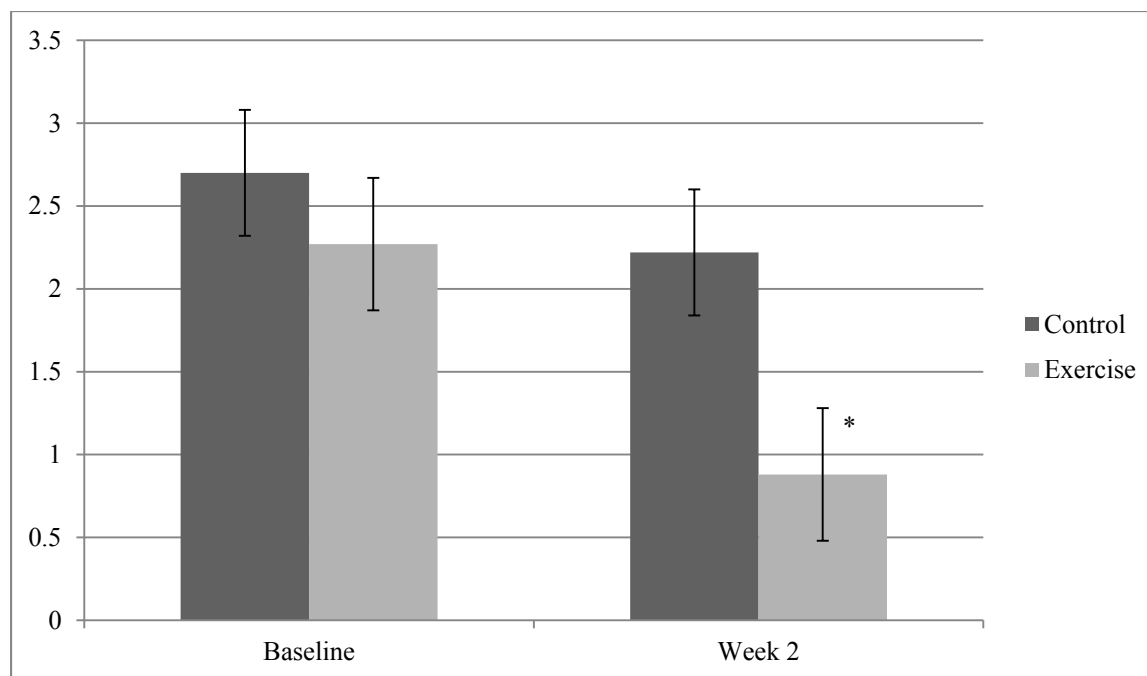


Figure 2: VAS pain (cm) at rest, by group

Data are presented as means \pm standard error bars.

* Statistically significant difference from baseline at the 0.05 level after controlling for age, past surgery, and location of pain.

No significant differences between groups at the 0.05 level after controlling for age, past surgery, and location of pain.

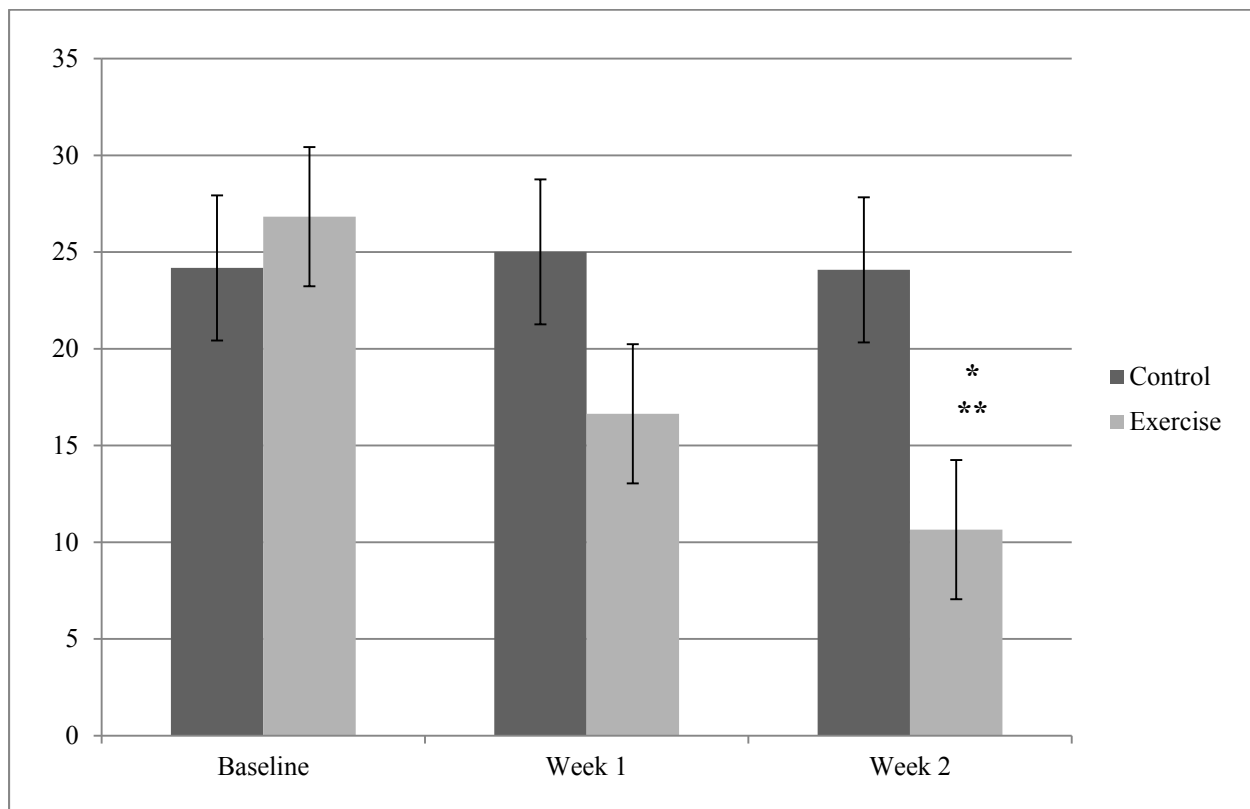


Figure 3: Total WOMAC scores over time, by group

Note: Total WOMAC scores are standardized to range from 0 to 100 with higher scores indicating greater functional impairment.

Data are presented as means \pm standard error bars.

* Statistically significant difference from baseline at the 0.05 level after controlling for age, BMI, past surgery, arthritis, and location of pain.

** Statistically significant difference between groups at the 0.05 level after controlling for age, BMI, past surgery, arthritis, and location of pain.

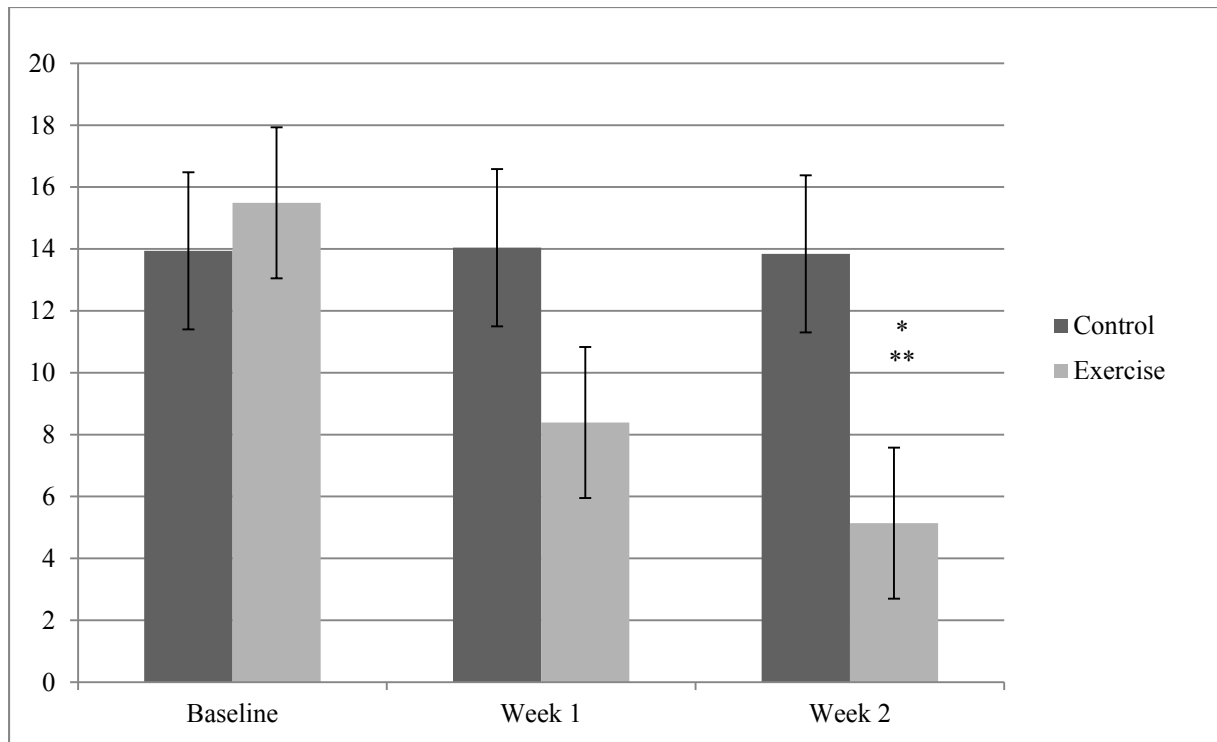


Figure 4: WOMAC function subscores over time, by group

Note: WOMAC function subscores range from 0 to 68 with a higher score indicating greater functional limitation.

Data are presented as means \pm standard error bars.

* Statistically significant difference from baseline at the 0.05 level after controlling for age, BMI, past surgery, arthritis, and location of pain.

** Statistically significant difference between groups at the 0.05 level after controlling for age, BMI, past surgery, arthritis, and location of pain.

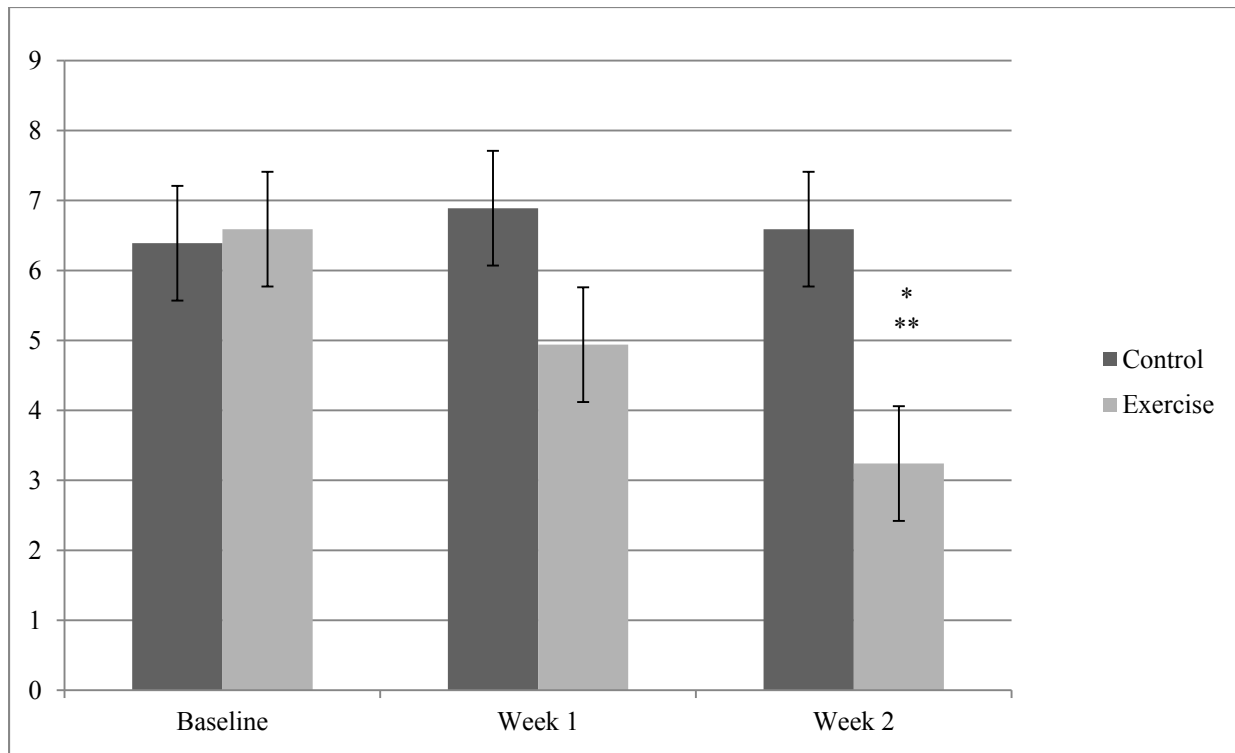


Figure 5: WOMAC pain subscores over time, by group

Note: WOMAC pain subscores range from 0 to 20 with a higher score indicating greater pain.

Data are presented as means \pm standard error bars.

* Statistically significant difference from baseline at the 0.05 level after controlling for age, BMI, past surgery, arthritis, and location of pain.

** Statistically significant difference between groups at the 0.05 level after controlling for age, BMI, past surgery, arthritis, and location of pain.