

Research article

Efficacy of home-based kinesthesia, balance & agility exercise training among persons with symptomatic knee osteoarthritis

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Abstract

The purpose of this study was to determine the efficacy of a home-based kinesthesia, balance and agility (KBA) exercise program to improve symptoms among persons age ≥ 50 years with knee osteoarthritis (OA). Forty-four persons were randomly assigned to 8-weeks, 3 times per week KBA, resistance training (RT), KBA + RT, or Control. KBA utilized walking agility exercises and single-leg static and dynamic balancing. RT used elastic resistance bands for open chain lower extremity exercises. KBA + RT performed selected exercises from each technique. Control applied inert lotion daily. Outcomes included the OA specific WOMAC Index of Pain, Stiffness, and Physical Function (PF), community activity level, exercise self-efficacy, self-report knee stability, and 15m get up & go walk (GUG). Thirty-three participants [70.7 (SD 8.5) years] completed the trial. Analysis of variance comparing baseline, mid-point, and follow-up measures revealed significant ($p < 0.05$) improvements in WOMAC scores among KBA, RT, KBA + RT, and Control, with no differences between groups. However, Control WOMAC improvements peaked at mid-point, whereas improvement in the exercise conditions continued at 8-weeks. There were no significant changes in community activity level. Only Control improved exercise self-efficacy. Knee stability was improved in RT and Control. GUG improved in RT and KBA+RT. These results indicate that KBA, RT, or a combination of the two administered as home exercise programs are effective in improving symptoms and quality of life among persons with knee OA. Control results indicate a strong placebo effect in the short term. A combination of KBA and RT should be considered as part of the rehabilitation program, but KBA or RT alone may be appropriate for some patients. Studies with more statistical power are needed to confirm or refute these results. Patient presentation, preferences, costs, and convenience should be considered when choosing an exercise rehabilitation approach for persons with knee OA.

Key words: Exercise therapy, rehabilitation, postural balance, resistance training.

Introduction

It has been estimated that over 27 million persons in the United States have osteoarthritis (OA) in one or more joints (Lawrence et al., 2008). Symptomatic knee OA alone affects 12% of American adults, making it one of the most frequent causes of physical disability and pain among older persons (Dillon et al., 2006). Indeed, nearly half of all Americans will develop symptomatic knee OA by age 85 (Murphy et al., 2008). Such persons often report difficulty with daily activities such as walking,

climbing stairs, stooping, and standing up from a seated position due to knee pain, weakness or instability (Dillon et al., 2006). The Osteoarthritis Research Society International (OARSI) recommendations for hip and knee OA management (Zhang et al., 2007; 2008; 2010) note a number of interventions have been universally recommended by the published treatment guidelines, though the efficacy of many of these treatments (e.g., massage, ultrasound, heat/ice therapy) has not been confirmed. However, OARSI reports there is a growing body of evidence for the efficacy of exercise interventions for treating knee OA symptoms (Zhang et al., 2010). A number of therapeutic exercise programs have been reported to be effective in this regard (e.g., Bennell and Hindman, 2005; Bennell et al., 2010; Diracoglu et al., 2005; Fitzgerald et al., 2002; Hicks et al., 2001; Lange et al., 2008; Mikesky et al., 2006; Sekir and Gur, 2005). A variety of isotonic, isometric, and isokinetic lower extremity resistance training programs have been commonly employed in intervention programs, given the recognition of a nearly universal presence of quadriceps femoris muscle weakness among persons with knee OA (Bennell and Hindman, 2005; Mikesky et al., 2006).

Some promising evidence suggests that programs incorporating knee-stabilizing kinesthesia, balance and agility (KBA) techniques with traditional therapeutic resistance training exercise (RT) may improve knee OA symptoms and function more rapidly than RT alone (Diracoglu et al., 2005; Fitzgerald et al., 2002). KBA is widely used among sports participants to rehabilitate and prevent knee ligament ruptures (Hurd et al., 2006; Liu-Ambrose et al., 2003; Mandelbaum et al., 2005; Risberg et al., 2001) and ankle sprains (Eils and Rosenbaum, 2001; McGuine and Keen, 2001; Verhagen et al., 2000). It has been established that proprioceptive acuity, i.e. the awareness of joint position, joint movement (kinesthesia), and sense of resistance (Lephart et al., 2000), declines both with age and as a result of knee OA (Swanik et al., 2000). These proprioceptive deficits may contribute to reduced dynamic knee stability. KBA exercise programs are designed to decrease proprioceptive impairment by using agility and balance movements to activate, challenge, and adapt the nervous system's proprioceptors. Decreasing proprioceptive deficit would thereby increase dynamic knee stability and improve activities of daily living function. In addition, joint instability and frontal plane joint laxity has been cited as a probable causative factor in both the development of knee OA and the further

erosion of articular cartilage among persons with knee OA (Lewek et al., 2004; 2005; Rudolph et al., 2007). Improved joint stability, therefore, has the potential to both improve symptoms and slow the disease's progression. KBA rehabilitation training differs from sport performance agility training, with the latter designed primarily to improve the ability to more rapidly change body or limb positions. In the rehabilitation sense, KBA requires efficient changes in body positioning, utilizing balance, coordination and speed. Speed in this definition is relative to the function required for normal daily activities, and therefore agility training is generally conducted at a walking pace.

A case study reporting the successful rehabilitation of a 73 year old woman with bilateral symptomatic knee OA using KBA and RT (Fitzgerald et al., 2002) prompted further study, but to date only five clinical trials are known to have been published in this area (Chaipinyo and Karoonsupcharoen, 2009; Diracoglu et al., 2005; Fitzgerald et al., 2011; Rogers et al., 2011a; Sekir and Gur, 2005) as detailed in Table 1. Only two of these studies have examined the efficacy of KBA without the addition of RT (Rogers et al., 2011a; Sekir and Gur, 2005). Sekir and Gur (2005) used a simple 6-week, two times per week multi-station KBA exercise program to improve postural control, functional capacity, and knee pain among 22 persons with bilateral knee OA. Although the study group was small, it was the first to suggest that KBA exercises in the absence of a specific resistance training program may be beneficial for persons with symptomatic knee OA. Similarly, the authors' 8-week, three times per week pilot study with 15 participants found that KBA and RT independently improved knee OA symptoms in a group exercise setting (Rogers et al., 2011a). Further evidence suggests KBA programs are effective in both clinical and home-based settings among persons with symptomatic knee OA (Rogers et al., 2011b).

The purpose of this study was to determine the efficacy of a home-based KBA exercise program to improve symptoms and quality of life among persons with symptomatic knee OA.

Methods

A single-blind, block randomized placebo controlled clinical trial with four interventions was conducted between February 2009 and July 2011. The study was approved by the Ethics Committee of the Faculty of Science and Agriculture of The University of Zululand and registered at Clinicaltrials.gov (NCT00735098). A dynamic entry cohort was utilized wherein participants began the study as soon as they were qualified and ready to start. Written informed consent was obtained from each participant before testing began.

Participants

Forty-four participants were recruited from the Tampa Bay, Florida, USA community via newspaper announcements and advertisements, posted fliers, word of mouth, and internet postings. Inclusion criteria included: age 50 or older; self-reported knee pain on most days of the pre-

vious month; met American College of Rheumatology diagnostic criteria for unilateral or bilateral symptomatic knee osteoarthritis (Altman et al., 1986) as confirmed by participant's physician; not engaged in a lower extremity exercise program for a minimum of six months prior to enrollment; minimum disability score of 17 points (25% of scale maximum) on the Physical Function sub-scale of the Western Ontario & McMaster Universities Osteoarthritis Scale (WOMAC) (Bellamy et al., 1988). Exclusion criteria included: rheumatic disease other than osteoarthritis; high risk health status for exercise; inability to obtain physician release for exercise; unresolved balance or neurological disorder; history of major knee surgery, major knee trauma, hip or knee arthroplasty; hip or ankle instability or excessive weakness; and intra-articular joint injection within 4 weeks of beginning the study.

Testing protocol

The primary investigator performed the home-based testing protocols. Height, weight, blood pressure, resting heart rate and medical history were completed at baseline. Outcome measures included the WOMAC, the Human Activity Profile (HAP) (Fix and Daughton, 1988), the Self-efficacy for Exercise Scale (SEE) (Resnick and Jenkins, 2000), a subjective knee stability rating (details specified below), and a 15 meter get up and go (GUG) walk. WOMAC, knee stability and GUG were conducted at baseline, the 4-week mid-point, and the 8-week follow-up while the HAP and SEE were conducted only at baseline and follow-up.

WOMAC is an OA specific survey consisting of sub-scales of Pain, Stiffness, and Physical Function (PF) and a total score additive of the sub-scales. HAP estimated participants' usual community physical activity levels. HAP subscales are Maximum Activity Score (MAS), defined as "the highest oxygen-demanding activity that the respondent still performs", and Adjusted Activity Score (AAS), defined as "a measure of usual daily activities" (Fix and Daughton, 1988). The SEE Outcome Expectancy for Exercise Positive (POEE) and Negative (NOEE) subscales determined participants' beliefs about the benefits of exercise. SEE uses a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Higher mean POEE scores indicate a more positive view of exercise benefits, while higher NOEE scores indicate a more negative view of exercise consequences. To assess subjective knee stability, participants responded to the following question from the Knee Outcome Survey - Activities of Daily Living Scale (KOS-ADLS) (Irrgang et al., 1998) at baseline and follow-up: *To what degree does giving way, buckling, or shifting of the knee affect your level of daily activity?* 0 – *The symptom prevents me from all daily activity;* 1 – *The symptom affects my activity severely;* 2 – *The symptom affects my activity moderately;* 3 – *The symptom affects my activity slightly;* 4 – *I have the symptom but it does not affect my activity;* 5 – *I do not have giving way, buckling, or shifting of the knee.* The KOS-ADLS has been validated for a variety of knee pathologies, including OA (Irrgang et al., 1998). The 15 meter GUG walk was conducted to measure objective physical function related to activities of daily living. Following

Table 1. Kinesthesia, balance & agility (KBA) knee OA studies summary

STUDY	STUDY TYPE	ENTERED/COMPLETED	AGE (SD)	ENTRY CRITERIA	STUDY TIME	INTERVENTION	OUTCOME MEASURES	OUTCOME SUMMARY
Diracoglu et al (2005)	Two group trial	66/60	Range 35-65 (mean not reported)	ACR	8 weeks (3x/wk)	KBA + RT vs RT	Proprioceptive acuity; WOMAC; SF-36; 10 stairs climbing; 10-m walk; isokinetic muscle strength	Both groups improved all measures; WOMAC function better in KBA; SF-36: physical function, role limitations (physical) and vitality (energy or fatigue) higher in KBA; KBA > RT on stair climb, walk; no between group difference on proprioceptive acuity
Fitzgerald et al (2011)	RCT	183/ITT analysis	64.6 (8.4); 63.3 (8.9)	ACR, KL 2+	12 supervised sessions over 6-8 wks, then HEP through 6 months	RT vs RT + KBA (2x/wk + walking 30 min 3x/wk)	WOMAC; subjective knee stability; knee pain; global rating of change in symptoms; get up & go walk	Both improved self-reported function and global rating of change at 2-, 6-, and 12-month, no differences between groups. No change knee pain or up & go. No additive effect of agility and perturbation training with RT.
Sekir & Gur (2005)	RCT	22/22	59 (8.9); 62 (8.1)	ACR, radiographs; bilateral knee OA	6 weeks	Proprioceptive exercise vs Control	Pain; get up & go walk; stair ascent/descent; joint position sense; balance; isometric & isokinetic strength	Exercise improved postural control, functional capacity, and knee pain in patients with bilateral knee OA.
Chaipinyo & Karoonsupcharoen (2009)	Two Group trial	48/42	62 (6) 70 (6)	ACR	4 weeks (5x/wk)	Balance training (stepping forward/back/side ways, mini-squats) vs Isometric quads RT, multi position	Pain; knee symptoms; isokinetic knee strength; 15m walk; 15m up & go walk; stair ascent, descent	Both equally effective in improving pain and most symptoms, strength, walks, stair climb (RT > balance on stair descent)
Rogers et al (2011a)	Two Group trial	20/15	69.3 (11.4)	Physician Dx knee OA	8 weeks (3x/wk)	RT vs KBA	WOMAC; community physical activity; exercise self-efficacy; knee stability self report; 15m up & go walk; stair ascent/descent	Both improved WOMAC Physical Function (KBA 59%, RT 40%), and subjective knee stability. Community physical activity level improved only in KBA; There were no between-group differences. Both appear to improve function and knee stability.

OA: osteoarthritis; RCT: Randomised clinical trial; RT: resistance training; ACR: American College of Rheumatology OA diagnostic criteria; Dx: diagnosis; KL: Kellgren & Lawrence radiographic OA grading scale; SF-36: Short Form 36 quality of life survey; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index, pain, stiffness, physical function; ITT: intention to treat; HEP: Home Exercise Program

instruction and demonstration by the investigator, a participant began by sitting in an armless folding chair with his or her arms folded across the chest. At the command “go” the investigator started a stopwatch and the participant rose from the chair, unfolded the arms, and walked as quickly as possible past another chair placed 15 meters

away. The investigator stopped the stopwatch when the participant crossed the 15 meter mark. The test was repeated in the opposite direction, then back again, with the fastest of the three trials recorded.

Interventions

Participants were assigned using an online randomization generator (<http://www.randomization.com>) which utilized randomly permuted blocks. The lead investigator entered the number of blocks (groups) and the desired number of subjects per group. As participants entered the study, they were assigned to the next group that had been chosen by the generator. This approach was used to provide equal numerical representation in each of four conditions: kinesthesia, balance and agility exercise training (KBA); resistance exercise training (RT); a combination of KBA and RT (KBA+RT); or control treatment (Control). All instructional sessions were conducted by the primary investigator. Participants were blinded as to which condition was considered experimental, but it was not possible for the investigator to be blinded. During the 8-week interventions, all exercise participants trained three times per week for 30 - 40 minutes and Control participants applied an inert skin lotion to the knee or knees once daily. Exercise participants in all three groups received an initial three sessions of one-to-one instruction, written/pictorial instructions, telephone or e-mail follow-up and in-person refresher sessions at weeks 4 and 6. Control participants received an in person instructional session after baseline testing, telephone or e-mail follow-up every two weeks and in person visits for testing at 4 and 8 weeks. All participants were advised to continue usual care as prescribed by their physicians, including any use of pain medication, but not to take up any lower extremity exercise program other than the prescribed intervention.

KBA utilized walking agility exercises plus single-leg static and dynamic balancing, as summarized in Table 2. Agility exercises preceded the balance exercises and were progressed by adding repetitions, i.e. taking more steps during a given exercise. Participants began with 15 steps and progressed to a maximum of 75 steps per agility exercise. Balance exercises were conducted on either the floor or on Thera-Band® stability trainer pads (The Hygenic Corporation, Akron, OH, USA) of two difficulty levels, depending on ability. Green and blue stability trainer pads were used, with the softer blue providing the more difficult balance challenge. Participants progressed by moving to a softer pad if possible and by adding time and repetitions to the balance exercises, completing up to three sets of up to 30 seconds per set. Both legs were trained. For static balance, participants were instructed to stand steady as long as possible (up to the 30 second limit), while dynamic balance required the addition of small, rapid bouncing movements. The foot remained in contact with the surface at all times, i.e. there was no jumping. Participants were taught to flex and extend the knee about 5 to 10 degrees maximum during dynamic balance.

RT participants were trained to use Thera-Band® non-latex elastic resistance bands (The Hygenic Corporation, Akron, OH, USA) to perform a single 15-repetition set of lower extremity exercises with each leg as detailed in Table 3. The program utilized primarily seated, open-chain exercises to train the major muscle groups without challenging balance or agility. For participants that could not perform 15 repetitions with the lightest resistance

band for a given exercise at baseline, the maximum number that could be completed with good form was prescribed with an initial goal of progressing to a 15 repetition maximum. Otherwise, RT exercises were progressed by adding greater stretch to the prescribed band to give greater resistance or by moving up to the next strength of resistance band.

Table 2. KBA agility and balance exercises.

Exercise	Description
Wedding march*	Step forward and slightly to one side with leading foot, bring trailing foot together with leading foot, alternate leading foot to continue forward walk
Backward wedding march*	As above, stepping backward
High knees march	Walk forward while flexing hip about 90 degrees
Side stepping	Stand with feet together, step to side with leading foot, bring trailing foot back to leading foot; repeat for prescribed number of steps; repeat in opposite direction
Semi-tandem walk	Walk forward heel-to-toe with heel of leading foot landing just in front of and medial to great toe of opposite foot
Tandem walk	Advanced version of above; leading heel lands directly in front of opposite foot
Cross-over walk*	Walk forward bringing each foot across midline of body
Modified grapevine*	Step to side with leading foot, bring trailing foot behind leading, step to side with leading, bring trailing in front; repeat for prescribed number of steps; change leading foot and repeat in opposite direction
Toe walking	Walk forward on toes
Heel walking	Walk forward on heels
Static balance*	Stand on one foot
Dynamic balance*	Stand on one foot while making small, rapid bounces

*Also used in KBA+RT intervention

KBA+RT participants performed selected exercises from each technique, as noted on Tables 2 and 3, to ensure the total exercise exposure of the three conditions remained as equal as possible. These participants completed the same balance training as KBA participants, described above. KBA+RT participants completed agility, balance, and resistance exercises in that order.

Table 3. RT resistance band exercises.

Seated: Ankle extension*, ankle flexion, knee extension*, knee flexion*, hip abduction, hip adduction, hip internal rotation, hip external rotation, leg press* (hip and knee extension)
Standing: Hip hyper-extension*

*Also used in KBA+RT intervention

At the conclusion of each exercise session, participants in all three programs completed one set of 30-second static stretches of the calves, quadriceps, and hamstrings.

Table 4. Baseline participant characteristics, by group*

Group	Age (Yrs)	Height (m)	Weight (kg)	BMI (kg·m ⁻²)	% Female
KBA	70.7 (10.7)	1.67 (.11)	80.3 (19.1)	28.9	69
RT	70.8 (6.5)	1.67 (.10)	78.2 (24.9)	28.2	70
KBA+RT	68.8 (10.1)	1.68 (.09)	82.0 (31.1)	29.2	75
Sham	71.2 (10.9)	1.68 (.11)	87.1 (26.0)	30.8	67

Age, height, weight: mean (standard deviation); BMI: Body Mass Index (weight/height²); * no differences between groups ($p > 0.05$) on any characteristics

Control participants were instructed to apply a “dime sized” amount of the lotion, provided in a plain white plastic jar, to the knee or knees in a gentle manner that avoided self-massage. The lotion was simply described as a “topical cream” and Control participants were debriefed as to its true nature at the end of participation. All Control participants were offered the opportunity to participate in an exercise program at the end of the control period.

All participants recorded each intervention session in a provided log to track compliance, pain medication usage and, for the exercise participants, progress with repetitions, resistance (band color), and balance time and difficulty level (balance pad color) as applicable.

Results

Participants' baseline characteristics are presented in Table 4. Thirty-three participants (20 women, 13 men) completed the 8 week trial (KBA, $n = 8$; RT, $n = 8$; KBA+RT, $n = 9$, and Control, $n = 8$). Three participants in each group had been diagnosed with unilateral knee OA, and the remainder with bilateral knee OA. Reasons for loss to follow up include: injury/illness unrelated to study ($n = 4$); no-show for follow-up testing ($n = 1$); joined an exercise program ($n = 1$); caring for ill family member ($n = 1$); out of state emergency ($n = 1$); and other rheumatic disease diagnosed during study ($n = 1$). In addition, two participants cited increased knee pain as their reason to discontinue the study. One of these participants was in the KBA condition and greatly exceeded the exercise prescription, logging 90 steps per exercise in the first two weeks. The other participant was in the RT intervention and completed only one session. This partici-

pant considered having been on her feet for 6 hours the day before her first session to be responsible for the pain flair up. Compliance with the interventions among program completers is as follows (mean and standard deviation): KBA 95.3 (6.5)%; RT 96.4 (8.8)%; KBA+RT 98.6 (2.95)%; and Control 97.0 (5.5)%. There were no changes in the usage of pain medication.

Results for the WOMAC survey are presented in Table 5. Analysis of variance utilizing SPSS Version 18 statistical software comparing baseline, mid-point, and follow-up measures revealed significant ($p < 0.05$) improvements in WOMAC Pain, Stiffness, PF, and Total scores among KBA, RT, KBA+RT, and Control conditions, with no differences between groups. The exercise participants continued to improve WOMAC scores between the mid-point and 8-week follow-up while the Control participants did not. The RT group demonstrated significant improvement ($p = 0.02$) on the GUG, decreasing time by 8%, while the KBA+RT group had a near significant 11% improvement ($p = 0.053$). GUG improvement for KBA (6.8%; $p = 0.09$) and Control (6.6%; $p = 0.06$) did not reach statistical significance. Results for other ancillary outcome measure are presented in Table 6. There were no significant changes in HAP community activity levels. Only Control improved exercise self-efficacy, with participants stating a more positive belief about the benefits of exercise (POEE scale) after the study period. Subjective knee stability was significantly improved ($p < 0.05$) in the RT and Control conditions.

Discussion

All three home-based exercise programs appeared to be relatively equal in their ability to reduce the symptoms of

Table 5. WOMAC Osteoarthritis Index results.

Group	Variable	Baseline*	Week 4*	Δ (%)	p-value	Week 8*	Δ (%)	p-value	Week 4 to 8 Δ (%)
KBA	Pain	6.87 (2.75)	5.21 (2.98)	24	.01	4.87 (3.6)	29	.01	6.5
	Stiffness	3.75 (1.91)	3.00 (1.60)	20	.32	2.5 (1.69)	33	.05	17
	PF	27.50 (8.25)	21.72 (11.57)	21	.14	20.0 (9.2)	27	.00	7.9
	Total	38.12 (11.72)	29.94 (15.71)	21	.01	27.37 (13.83)	28	.01	8.5
RT	Pain	8.00 (2.20)	4.50 (2.62)	44	.00	4.25 (3.45)	47	.01	5.5
	Stiffness	5.00 (1.60)	2.87 (1.36)	43	.03	2.25 (1.28)	55	.01	22
	PF	29.75 (6.82)	20.38 (13.13)	32	.09	16.25 (12.53)	45	.02	20
	Total	42.75 (8.55)	27.75 (16.42)	35	.03	22.75 (16.95)	47	.01	18
KBA+RT	Pain	8.33 (2.18)	5.47 (3.39)	34	.02	5.0 (3.35)	40	.01	8.6
	Stiffness	4.11 (1.69)	2.22 (1.09)	24	.01	3.11 (1.27)	46	.25	29
	PF	30.11 (7.67)	19.49 (11.43)	35	.04	13.89 (9.44)	54	.00	29
	Total	45.00 (12.03)	28.07 (15.22)	38	.02	21.11 (13.11)	53	.00	25
Control	Pain	10.25 (3.41)	6.75 (2.43)	34	.05	8.00 (1.60)	22	.09	-18.5
	Stiffness	4.12 (0.64)	3.00 (0.92)	27	.02	2.50 (1.19)	39	.00	1.66
	PF	35.50 (6.48)	25.75 (6.69)	23	.03	25.87 (5.28)	23	.00	-.04
	Total	48.87 (8.10)	36.00 (9.80)	26	.02	36.37 (7.17)	26	.00	-.03

*Mean (standard deviation); WOMAC: Western Ontario and McMaster University Osteoarthritis Index, Total scale maximum = 96, Sub-scale maximums are Pain = 20; Stiffness = 8; Physical Function (PF) = 68; lower scores indicate lesser symptoms

Table 6. Ancillary results.

Group	Variable	n	Baseline	Week 8	p-value
KBA	HAP MAS	7	76.4 (14.9)	77.7 (10.7)	.77
	HAP AAS	7	65.6 (18.4)	66.1 (13.5)	.75
	SEE POEE	7	4.2 (.5)	3.9 (.5)	.18
	SEE NOEE	7	2.5 (.5)	2.9 (.6)	.17
	Stability (0 – 5)	5	1.8 (.8)	2.4 (.6)	.21
RT	HAP MAS	8	69.0 (10.2)	67.5 (9.4)	.64
	HAP AAS	8	51.9 (9.2)	59.8 (11.6)	.12
	SEE POEE	8	3.8 (.7)	4.0 (.6)	.26
	SEE NOEE	8	2.6 (.9)	2.4 (.3)	.44
	Stability (0 – 5)	8	2.1 (1.0)	3.9 (.8)	.01
KBA+RT	HAP MAS	8	73.2 (14.5)	74.6 (10.1)	.64
	HAP AAS	8	56.8 (11.8)	62.0 (11.8)	.19
	SEE POEE	8	4.5 (.6)	4.5 (.6)	.70
	SEE NOEE	8	2.5 (1.1)	2.4 (1.0)	.64
	Stability (0 – 5)	7	3.3 (1.4)	3.7 (1.0)	.35
Control	HAP MAS	8	67.8 (11.7)	66.1 (12.6)	.69
	HAP AAS	8	50.9 (9.6)	52.5 (7.5)	.50
	SEE POEE	8	4.0 (.8)	4.3 (.7)	.02
	SEE NOEE	8	2.4 (1.0)	2.3 (.9)	.35
	Stability (0 – 5)	8	1.8 (.7)	2.8 (1.3)	.03

HAP: Human Activity Profile, MAS: Maximum Activity Score, AAS: Adjusted Activity Score (both scales' maximum = 94); SEE: Self-efficacy for Exercise, POEE: Positive Outcome Expectancy for Exercise (1-5 scale), NOEE: Negative Outcome Expectancy for Exercise (1-5 scale)

knee OA, based on the WOMAC Index. This study is among the first to provide evidence that KBA as a sole intervention can be effective for this purpose. While this is an encouraging finding, the research hypothesis regarding *greater* efficacy with KBA must be rejected.

An improvement on the WOMAC of about 20% has been considered a minimal clinically important change for persons with OA (Barr et al., 1994). In absolute terms, as reported in Table 5, the percent change in WOMAC was greater for the RT and KBA+RT groups than for KBA for each variable at each time point. It is not known if this difference would have reached statistical significance with more participants. In addition, RT and KBA+RT appear modestly superior for improving objective physical function as measured by the 15 meter GUG walk. This finding could reflect improved lower extremity strength. While a limitation is that strength was not directly measured, the GUG is a functional test requiring both leg strength (chair rise element) and gait speed. As noted previously, reduced quadriceps femoris strength is common in persons with knee OA prior to rehabilitation (Bennell and Hindman, 2005; Mikesky et al., 2006). While in this investigation KBA alone appears effective for reducing knee OA symptoms, the overall effectiveness may be less than that of programs that include resistance training.

Interestingly, only the Control participants in the present study showed improvement in positive perceptions of exercise. This outcome could be a statistical anomaly or, speculatively, could indicate anticipation of entering the exercise program at the end of the knee cream intervention. The Control condition in the present study also lead to significant improvements in WOMAC scores, as well as perception of knee stability, indicating a strong a placebo effect for the “topical cream” intervention. Given the number of commercially available topical creams in the United States advertised to treat arthritis

and other joint pain, an expectation effect is not unusual. Indeed, the authors chose to use a topical cream placebo for this reason. However, the improvement in symptoms for control treatment leveled off after the 4-week mid-point, with no further improvement and even a regression towards baseline in the case of Pain, whereas in all cases the WOMAC improvement in the exercise conditions continued at the 8-week follow-up. Given the measured improvement with a control intervention, the authors suggest other investigators utilize similar methodology in future exercise rehabilitation studies to better control for placebo and expectation effects.

These results are similar to our previous study (Rogers et al., 2011a) in which KBA and RT interventions were both found to be effective for reducing knee OA symptoms in a group exercise setting. In contrast, Diracoglu et al. (2005) found superior results with the addition of KBA to a RT program compared to RT alone. However, it appears that the total volume of exercise was greater for the combination condition than for the RT group. A study by Fitzgerald et al. (2011) found no additional benefit with the addition of KBA to RT, but this study used only half the exercise volume of the aforementioned study by Diracoglu et al. (2005). Likewise, Chaipinyo and Karoonsupcharoen (2009) compared a KBA and RT program to isometric RT alone and found the programs to be essentially equivalent. Clearly, more study is needed in this area. Given the challenge in recruiting participants for the current study, statistical power is a limitation. While within groups changes were clinically and statistically significant, it is possible that low power masked a difference between KBA and the two groups utilizing RT. Given the encouraging but preliminary results of this and other small studies, future studies of similar design with greater statistical power are needed. The authors further suggest direct measurements of lower extremity strength be utilized, since it is not known if

KBA alone improves this factor. Other functional measures such as stair climbing and biomechanical measures of gait quality, not available for this study, should also be considered. Such measures could help determine the factors affecting symptomatic changes and any differences between groups.

Conclusion

Our results indicate that KBA, RT, or a combination of the two administered as home exercise programs appear effective in reducing symptoms and improving the quality of life among persons with knee OA. However, given the limited statistical power and the initial benefit seen with a placebo treatment, these findings must be interpreted with caution. The current evidence suggests clinicians should continue to prescribe RT as part of the rehabilitation program, but further research on the effects of KBA is warranted. Patient presentation and preferences, costs, and convenience remain important factors in choosing an exercise rehabilitation approach for patients with symptomatic knee OA.

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Key points

- Kinesthesia, balance and agility programs, as well as lower extremity resistance training programs, or a combination of the two appeared equally effective in reducing symptoms of knee osteoarthritis.
- A placebo control intervention also appeared effective, but improvements reached a plateau at mid-point (4 weeks), unlike exercise program improvement which continued between mid-point and follow-up (8 weeks).
- Our results, along with two previous small studies, provide preliminary evidence that kinesthesia, balance, and agility programs without additional resistance training could be effective in treating knee osteoarthritis symptoms.
- Some evidence was found to suggest programs that include resistance training may be more effective for improving function, but more research is needed to confirm or refute this finding.

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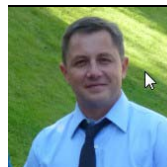
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