REVIEW ARTICLE

The use of various interventions to reduce falls and improve balance in knee osteoarthritis patients: a narrative review

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ABSTRACT

People with knee OA are more likely to fall, which is a major public health concern because it can lead to serious injuries and trips to the hospital. Despite the greater balance disorders, and fall prevalence among patients with knee OA, the field of study in this population has received less attention. This study aims to review articles using different interventions for balance improvement and fall prevention in individuals with knee OA. An extensive literature search was performed in the databases of Science Direct, Scopus, Google Scholar, PubMed, and ISI Web of Knowledge using OR, AND, and NOT operators and the selected keywords. Only studies written in English and published in journals from 2010 to May 2022 were used for this purpose. The studies that have examined the effect of various therapies on balance improvement and fall prevention in the individuals with knee OA were the ones that were selected for this study. Studies that examined balance and falls in the osteoarthritis of other joints, as well as those involving other disabilities that affect balance and stability were excluded from the study. Finally, 34 articles were selected from the final evaluation. Most of the studies showed that exercise and dance could be effective to improve balance and reducing falls in patients with knee OA. It can be concluded that these interventions can help individuals with knee OA enhance their balance and reduce their risk of falling. Therefore, they might be viewed as promoting this population's health. Although games and neuroscientific interventions can be effective, more studies are needed in this field. Moreover, there are contradictory results regarding the effect of orthotics.

Key words:
balance; falling; knee osteoarthritis; health

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INTRODUCTION

Knee OA is one of the most prevalent types of osteoarthritis in the world that occurs in the elderly, causing a significant loss of function and disability.[1] Over the coming years, it is anticipated that the occurrence of knee OA would dramatically increase as a result of population ageing and obesity.[2] Numerous studies showed that patients with knee OA have impaired balance, and suffer from loss of proprioceptive sensation, which can affect postural stability, and increase the risk of falls. Besides, the patients with knee OA have weakened muscles (especially the quadriceps), and altered muscle activation patterns, which can explain the imbalance and falls.[3] More than half of people with knee OA report falling every year.[4] Falls are a significant cause of hospitalization for patients with knee OA, and can lead to psychological problems, such as decreased self-esteem and independence as well as increased physical injury, functional decline, and death.[5] Many financial burdens are placed on individuals, their families, and communities.[6] Therefore, balance improvement and primary prevention of falls can be very significant. Finding an effective intervention to improve balance is considered one of the solutions to prevent falls in the elderly. Some studies indicated that interventions could improve balance and reduce fall rates in individuals with knee OA, [2, 7] while others show conflicting results.[8-10] In contrast to Takacs and colleagues, who showed no change in dynamic balance after balanced exercise, Anderson et al. and Jahanjoo et al. reported that balanced exercise might enhance balance and postural stability and decrease the incidence of falls in people with knee OA[3, 11] but Takacs and colleagues found no improvement in dynamic balance following balanced exercise.[9] Having more comprehensive information about different interventions, and fall prevention may lead to the selection of a more effective treatment to improve balance and prevent falls in patients with knee OA. This study aims to review articles that have used different interventions for enhancing balance and fall prevention among individuals suffering from knee OA.

MATERIALS AND METHODS

Design

This study is a narrative review.

Search Strategy

The Population Intervention Comparison Outcome (PICO) (Table1) served as the foundation for the search strategy, which contained all studies written in English published from 2010 to May 2022. The search was performed in Science Direct, Scopus, Google Scholar, PubMed, and ISI Web of Knowledge databases by using the following keywords: (knee Osteoarthritis *OR* Osteoarthritis of Knee *OR* Osteoarthritis of the Knee) *AND* (Exercise *OR* Exercise Training) *AND* (Dance Therapies *OR* Dance) *AND* (Telehealth *OR* eHealth) *AND* (Game Therapies) *AND* (tDCS) *AND* (Neurofeedback) *AND* (Biofeedback) *AND* (Foot Orthosis *OR* Foot Orthotic Device *OR* Orthotic Insole *OR* Orthosis *OR* Orthotic Devices *OR* Brace) *AND (*education) AND (pain management) AND (Reducing fear of falling) AND (enhancing fall efficacy) *AND* (*balance*) *AND (falls OR falls risk)*. We manually searched through the bibliographies of the reviewed publications, the references of additional studies that met our inclusion criteria, and performed citation searches of our qualified articles in Web of Science and Google Scholar. Following the completion of all database searches, the citations were collected and submitted into the Endnote 20 bibliography system, where duplicated citations were eliminated. The titles and abstracts of articles that might be relevant

were read and evaluated independently by two reviewers. In cases where the abstract did not provide enough information to assess eligibility for inclusion in the review, they eliminated irrelevant research and obtained the complete publication. According to inclusion criteria, two reviewers independently categorized these studies as "relevant", "irrelevant", or "possibly relevant". In the case of disagreements, they were resolved by referring to a third review author. The procedure of the study selection is shown in Fig. 1. Finally, 34 articles were selected from the final evaluation.

Eligibility criteria

We included studies that met the following criteria: 1) were peer-reviewed articles published in English, and 2) examined balance and falls in patients with knee OA. Exclusion criteria were (1) participants whose primary diagnosis was other disabilities such as neuropathy and neurological disorders, vestibular and vision problems, or any other cause or disease that upsets the balance, (2) examined balance and falls in patients with osteoarthritis of other joints (3) examined other symptoms of people with knee OA.

Table 1. Selected keywords using the PICO method

P:Population	I: Intervention	C:Comparision	O:Outcome
knee Osteoarthritis Osteoarthritis of Knee Osteoarthritis of the Knee	Exercise Exercise Training Dance Therapies Dance Telehealth eHealth Game Therapies) tDCS Neurofeedbacks Biofeedback Foot Orthosis Orthotic Device Orthotic Insole Orthotic Devices Brace	-	Balance Fall Falls risk

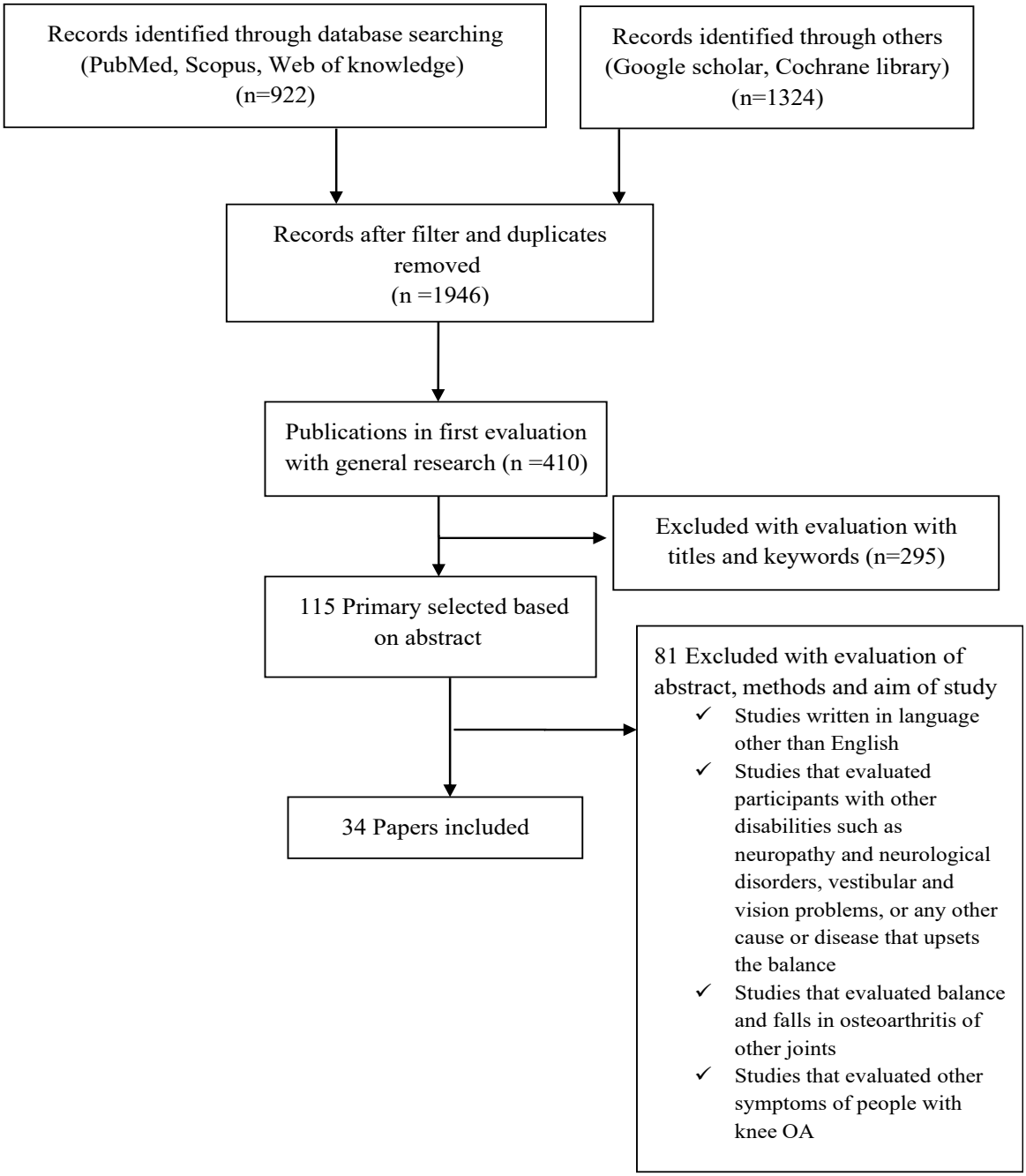

Figure1. The flow diagram of the study selection process

RESULTS

Considering the inclusion and exclusion criteria, 34 articles remained and were included in the review. The results of this review consist of 4 parts (details of sample population characteristics, study design, type of interventions, and type of instruments).

Table 2. This is a different intervention for improving balance and falls prevention in the people with knee OA

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
Ince et al./ 2022[1]	89	55.9	RCT[2]	Strengthening exercises plus balance and proprioception exercises	Ten-week exercise program	Overall stability index and the modified Clinical Test of Sensory Interaction and Balance	Patients with knee OA may noticeably improve in their balance after engaging in balance and proprioception training (P=0.002).
Dwarakanathan et al./2022[12]	66	49.7	Randomized Trial	An unloaded knee brace or full-length 6° lateral wedge insole	Six hours per day for six months	HUMAC® Balance and Tilt system	In comparison to lateral wedged insoles, the unloader knee orthosis significantly improved on all measures of balance (p 0.001).
Xiao and Li/ 2021[13]	284	70	RCT	Wuqinxi exercises	*24-weeks*	Static posture stability (SPS) tests, and dynamic fall index (DFI) tests	*Older female patients with knee osteoarthritis who performed wuqinxi exercises reported better balance (P < 0.05).*
Manlapaz et al/2021[14]	12	55.3	Pre-post design	Wii Fit	eight weeks	NeuRA FallScreen, Timed-up and go test (TUG)	Wii Fit helps seniors with knee osteoarthritis balance better and lowers the risk of falling (p =.035).
Yang et al/ 2021[15]	8	62.8	Pilot study	Tai chi	three sessions were	Vicon	Compared to a control group, tai

[2] Randomized controlled trial

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
					conducted weekly		chi resulted in a greater improvement in dynamic stability (p = 0.021).
Yang et al/ 2021[16]	10	65.1	Pilot study	Tai chi	two weeks (three sessions weekly)	Motion analysis	The results showed that Tai chi enhanced dynamic stability in those with OA of the knee (P< 0.05).
Jamebozorgy1 et al / 2020[17]	8	67.5	Post/test-pre a with study experiment-quasi	Neurofeedback	8 sessions (three days a week, in eight 30-min sessions)	Biodex balance system	After neurofeedback, an improvement in dynamic stability was seen (P=0.004).
Anderson et al/ 2019[11]	350	65.2	RCT	Balance exercises	8 one-hour sessions	Timed Up and Go Test (TUG)	This study reported that balance training improved balance and prevented falls (P< 0.05)..
Jahanjoo et al/2019[3]	60	56.55	RCT	Balance exercises and physical therapy	10 sessions of one-hour treatment	Timed Up and Go (TUG), Biodex balance system	Patients with knee osteoarthritis who received both balance training and physical therapy saw a significant improvement in their ability to balance and function (P=0.003). For the fall risk score, similar outcomes were seen (P 0.001).
Gezginaslan et al/2018[18]	39	61.7	Pre- and post	Strengthening exercises	three times a week for six weeks	Berg Balance Scale (BBS)	The findings demonstrated that patients with knee osteoarthritis who

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
							engaged in isokinetic quadriceps and hamstring strengthening activities had improved balance and a lower risk of falling. (p=0.036).
Sumaiyah et al/ 2018[19]	41	73.3	RCT	Otago exercises	3 times per week (approximately 30 minutes each time) for 6 months.	Timed Up and Go (TUG)	The results showed increased postural control and a decreased risk of falling after Otago exercises (p=0.03).
Braghin et al/2018[20]	42	61.53	RCT	Exercises	50–60 min twice a week for 8 weeks.	Balance Master System® (Neurocom Inc, Oregon, USA)	Exercise has been shown to provide improved function, especially when emphasizing muscle strengthening (P< 0.05).
Tavares et al/2018[2]	10	60 years and older	RCT	TDCS	15 sessions of 2 mA active or sham tDCS for 20 minutes	TUG	Participants demonstrated better balance after TDCS(P< 0.05).
Deepeshwar et al/ 2018[21]	66	60.2	RCT	Yoga	everyday twice (morning and evening) during the intervention period of 7 days	TUG, Sit-to-Stand (STS)	There was a significant improvement in balance after Yoga (p < 0.001).
Levinger et al/ 2017[22]	30	60–90	pilot randomized	Resistance and balance exercise	twice a week for 8 weeks	TUG	It is demonstrated that resistance and balance

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
			controlled trial				training is beneficial for subjects with knee OA to reduce their risk of falling (P< 0.05).
Takacs et al/ 2017[9]	40	66.6	RCT	Balance exercise	4 times per week (10 weeks)	Community Balance and Mobility Scale (CB&M)	There was no alter in a dynamic balance as measured by the CB&M[3].
Cheung et al/ 2017[23]	83	71.7	Pilot Randomized Controlled Trial	Yoga or aerobic/strengthening exercise	8 weekly 45-min group classes with 2–4 days/week		Yoga was more effective than aerobics in improving balance in knee osteoarthritis patients p = 0.002.
Ariayi et al/ 2017[7]	24 M	53.1	Quasi-experimental research with a control group (pre/post-test design)	Tai Chi	3 sessions per week, 60 minutes for duration of 8 weeks	Berg Balance Scale (BBS)	It is demonstrated that Tai Chi exercises have a significant effect on balance (P=0.002).
Zangi et al/2017[8]	18	53	Comparative study	Lateral wedged insoles	4 weeks, they were asked to use the insole for at least 5 to 10 hours during their daily activities	Kistler force plate (Swiss, AMTI)	The findings indicated that those lateral wedges do not have an immediate effect on the balance parameters of individuals diagnosed with knee OA (P=0.70).

[3] Community Balance 14 and Mobility Scale (CB&M)

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
Ghandali et al/ 2017[24]	20	64.9	Pre-post study	Tai Chi	60 min of Tai Chi sessions (twice a week for 8 weeks)	Berg Balance Scale	After practicing tai chi, increases in postural stability were observed ($P < 0.001$).
Al-Khlaifat et al 2016[25]	14	more than 50 years	Pilot experimental before-and-after study design	Exercise (bilateral, split, and unilateral 233 squats, step-ups, side lowers, side lying hip abduction, clam, bridging, knee extension exercises, and cycling on a stationary bike)	once a week for six weeks	TUG	In patients with knee OA, the exercise programme was effective in improving dynamic balance ($p < 0.001$).
Osugi et al/2014[26]	28	72.4	RCT	Whole body vibration (WBV) exercise plus squat training	Squat training was performed during a 4-minute WBV exercise session. The study period was 6 months.	TUG	This study reported that WBV exercise alone improved the body's balance index. However, WBV exercises and squat training were more effective for improvement ($P< 0.05$).
PAIN /2014[27]	40	61.0	Pre-post study	Custom- -molded insoles with a 5º lateral wedge and arch support	1 h per day until full-time use was achieved (6 months)	the Biodex Stability System	Lateral wedges do not have an immediate impact on balance ($P>0.05$). It may

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
							be helpful in the long run.
Bressel et al/2014[28]	18	64.5	Pre-post study	Aquatic exercise	6-weeks (3 exercise sessions each week with each session lasting 30 minutes or less)	limits of stability test (LOS)	Aquatic exercise improved balance in subjects with knee OA($P<0.05$).
Wortley wt al/(2013)[29]	31	70	RCT	Tai chi	10-weeks	TUG	The results showed that Tai chi was effective for improving balance ($p = 0.001$).
Wibelinger et al/ 2013[30]	71	66.7	Comparative study	wii therapy	two weekly sessions, being that conventional physiotherapy sessions would last 50 minutes and wii therapy sessions 30 minutes		Wii therapy improved the balance of older women with knee OA more than traditional physiotherapy $p = 0.00$.
Rhon et al/2013[31]	15	55	prospective observational cohort study	physical therapy and perturbation exercises	twice weekly for 4 weeks	Step-up test	Participants indicated an improvement in balance after the intervention ($p= 0·001$).
Tsai et al/(2013)	55	78.9	Pilot Cluster-Randomized Trial	Tai chi	8 weeks	TUG	There were improvements in the balance after tai chi ($p<0.05$).
Nambi et al/2013[32]	30	53	Pre-post	Yoga /biofeedback	8 weeks	The Western Ontario and McMaster Universities Arthritis	Adding Yoga provides better balance in individuals with knee OA $P = 0.001$.

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
						Index (WOMC) physical function	
Wi and Kang/ 2012[33]	40	65 or older	Experiment group and a control group	Virtual reality interactive games (Xbox 360 Kinetic Sensor)	three times a week and for 30 minutes each time for a four-week period	Biorescue (RM, INGENIER I, France)	The virtual reality interactive games can be a viable balance-improving intervention for older women with knee OA)(p<.05).
Hiyama et al/ 2012[34]	40	72.85	RCT	walking exercise program	4 weeks	TUG and tandem walk	This study indicated that walking improves balance and diminishes the frequencies of falls (P < 0.001).
Sayers et al/ 2012[35]	33	67.6	Pilot study	Power exercise	12 weeks	Berg balance scale	In participants with knee OA, power training improved balance (P=0.04).
Duman et al/2012[36]	54	64	RCT	Proprioceptive exercises	3 weeks	Kinesthetic Ability Trainer 2000 balance system (KAT 2000, OEM Medical, Carlsbad, CA)	The improvement in static balance scores was statistically significant (p<0.05). The results for the dynamic balance did not significantly improve.
Tok et al/2011[37]	40	64.19	RCT	Electrical stimulation combined with continuous passive motion versus	3 weeks, 5 days per week	Balance system machine KAT 2000	This study found that combined CPM-ES or isometric exercise therapy improved balance (p 0.05), which suggests that this

First Author (Year) [Ref]	[1]	Age (years)	Design	Intervention	Duration and length of interventions	Assessment Tools	Results
				isometric exercise			improvement may prevent knee OA patients from falling.

Details of Sample Population Characteristics of the reviewed articles

The subjects included in these studies consisted of people with knee OA. The total number of participants in the 34 studies in this review is 1826 subjects with knee OA. Among the 34 studies included in this review, according to Table 2, the minimum sample size was 8,[15, 17] and the maximum was 350.[11] Most of the participants are predominantly women (82.18%). The participants in the eligible studies had a mean age of 63.35 years and, 78.57 percent of the participants had mild to moderate knee OA according to the Kellgren–Lawrence scale.

Details of study design of the reviewed articles

The study design of most papers was RCT, including 16 studies.[1-3, 9, 11, 13, 19-23, 26, 29, 34, 36, 37] There is also 1 randomized trial[12] and 1 pilot cluster-randomized trial.[38] In addition, there are 9 pre/post-assessment studies,[7, 14, 17, 18, 24, 25, 27, 28, 32] 3 pilot studies,[15, 16, 35] 1 prospective observational cohort study,[31] 2 comparative studies[8, 30] and experiment group and a control group.[33]

Details of types of interventions of the reviewed articles

Table 2, studies in this review have examined various interventions on balance in patients with knee OA. The interventions used in these studies can be divided into exercise interventions (15 papers), dance-based interventions (8 papers), brain stimulation and neuroscience interventions (3 papers), combined biofeedback and yoga (1 paper), orthosis (3 papers), and games (3 papers).

Most studies have used exercise interventions to improve balance and prevent falls in patients with knee OA, including balance exercises (3 studies[3, 9, 11]), balance and strength exercises,[1] balance and resistance exercises,[22] strength exercises,[18] Otago exercise,[19] walking exercise,[34] power training,[35] aquatic exercise,[28] Wuqinxi exercises,[13] body vibration (WBV) exercise plus squat training,[26] perturbation exercises,[31] proprioceptive exercises[36] and other exercise interventions.[20, 25] Dance-based interventions have also been used in these studies. For example, the effectiveness of tai chi has been explored in 6 studies, [7, 15, 16, 24, 29, 38] and 1 study has examined Yoga and aerobics.[23] Of the 3 studies assessing neuroscientific interventions on balance in patients with OA, 1 included neurofeedback,[17] 1 study included TDCS,[2] 1 study included electrical stimulation,[37] and 1 study determined the effect of biofeedback.[32] Orthosis has also been used in these studies, including insole with a lateral wedge (2 studies[8, 27]) and knee brace (1 study[12]). Among the studies included in this review are some studies that have used games such as Wii games,[14, 30] and Xbox[33] to enhance balance and prevent falls in patients with knee OA.

Types of the instruments of the reviewed articles

This review includes studies investigating the effects of different interventions on patients with knee OA and assessing the balance and falls in these

patients using a variety of tools. The most common scale used in studies includes Times Up and Go test (TUG) and Berg Balance Scale (BBS). Other scales and instruments used in the studies to assess balance included the Biodex Balance System, force plate, Center of pressure (COP) and center of mass (COP) separation distance, Kinesthetic Ability Trainer 2000 balance system (KAT 2000, Original Equipment Manufacturer (OEM) Medical, and Carlsbad, CA), Community Balance and Mobility Scale (CB&M), Stanford Ballroom Dance Team (SBDT), and Activities-Specific Balance Confidence Scale (ABC).

DISCUSSION

This literature review was developed to evaluate the effect of different interventions on balance and falls in patients with knee OA. Five categories can be used to classify various interventions to help patients with knee OA maintain their balance and avoid falling: exercise intervention, dance-based intervention therapy, neuroscience interventions, orthosis, and game.

Exercise intervention on balance and falls

Exercise is highly recommended, and all of the studies in this review showed that exercise interventions help people with knee OA improve their balance and keep them from falling. Anderson et al. and Jahanjoo et al. reported that balanced exercise could enhance balance, and postural stability and lower the incidence of falls in patients with knee OA while performing routine activities that require balance.[3, 11] A balance exercise program, derived from a sound theoretical framework that targets the major subsystems of postural control, can contribute to a significant improvement in balance control, and a reduction in subsequent falls. The exercises in these studies attempt to increase balance in various ways, such as strength, flexibility, and kinetic motion, within a constrained support base. Contrary to these results, Takacs et al. reported no difference in dynamic balance, as measured by the CB&M after balanced exercise.[9] It is possible that there was not much emphasis on certain factors, such as strength. Ince et al., Gezginaslan and, Levinger et al. reported similar results. They indicated that adding resistance and strength exercises increases the effect of balance exercises since they enhance muscle strength, and force and joint stability and power. [1, 18, 22] Therefore, this exercise is healthy, and safe for those who have osteoarthritis of the knee and can lower the probability of falls.

Aquatic exercise is another exercise intervention that was reported in this review. Bressel et al. demonstrated the positive effect of aquatic exercises on balance in subjects with knee OA. Water-based exercise has a positive effect on some biomechanical factors of gait patterns.[28] Progression of positive motor symptoms after water-based exercise is associated with rhythmic patterns and performance of tasks based on constant postural control, which may suggest that these benefits derive from learning process.

A regular power training program includes strength and resistance training to make up for the neuromuscular and functional loss that comes with age and disease. It was shown in a study by Sayers et al. that power training increases balance in patients with knee OA.[35] Since it improves joint metabolism and regeneration processes in people with knee osteoarthritis, in other words, increased partial pressure of oxygen improves blood flow and diffusion in the joints, improving the performance and balance of individuals in knee OA.

Findings from the research by Sumaiyah et al. illustrated that patients with knee OA benefited from Otago exercise in terms of balance.[19] Otago exercise program comprises of strengthening, balance, walking, and aerobic exercises that can be done at home depending on personal tolerance. By assisting in boosting balance, and muscle strength, this program aims to minimize falls.

Wuqinxi exercises are a type of exercise therapy for people with knee osteoarthritis. These exercises target the muscles around the hips and ankles and increase blood flow to the whole body. A study by Xiao and Li showed that exercise has a significant positive effect on improving knee function and balance.[13]

In another study, Osugi et al. indicated that Whole Body Vibration (WBV) exercise combined with squat exercise was more successful in enhancing balance in the subjects with knee OA.[26] WBV exercise was introduced as a practice to strengthen balance and Squat training strengthens the quadriceps and gluteus medius muscles and improves the mobility of joints in the lower limbs. One possible reason would be that the neuromuscular network in the lower limbs may be immediately activated as a result of a series of fast muscular contractions that occur during this exercise. Additional idea is that this activity was documented to result in a neuromuscular reaction and abrupt change in hormonal profile promptly following exercise, which may be a quick acceleration of growth hormone release after exercise. Nevertheless, as opposed to WBV exercise alone, the frequency of falls was not dramatically decreased by WBV exercise and squat training. Insufficient statistical power may be why WBV exercise and squat training did not significantly affect the frequency of falls.

Hiyama et al. indicated walking could expand the balance of patients with knee OA and lessen the rate of falls.[34] Muscle strength, postural sway, and dynamic balance were all enhanced by walking exercises. Furthermore, walking exercises reduce the rate of falls by strengthening motor function and multitasking ability.

Moreover, Proprioceptive exercise is a movement that challenges, and develops proprioceptive receptors. Improving static balance after proprioceptive exercise in people with knee OA was observed in a study by Duman et al. They reported no significant improvement in the dynamic balance.[36] Because dynamic balance is a more complicated matter than static balance and requires more input from more receptors in different tissues. The extracapsular and intracapsular tissues must work together optimally to maintain dynamic balance.

Dance-based interventions on balance and falls

All 9 studies in this review showed that dance-based interventions improve balance and prevent falls in people with knee OA. Yang et al., Ariayi et al., Ghandali et al., Wortley et al., and Tsai et al. stated that Tai Chi training was very successful in enhancing enhance the postural balance and reducing the frequency of falls in the subjects with knee OA. [7, 15, 16, 24, 29, 38] It has gained popularity as a treatment for OA. Tai Chi's major characteristics—gentle continuous exercise, muscular strengthening, and balance training—make it an ideal therapy for those with knee OA. Tai Chi diminished dyskinesia by upgrading the capacity of the participants to use appropriate swing tactics (ankle or hip) and controlling the motions with greater balance control close to stability limits. These unique training properties improve balance and postural control.

Deepeshwar et al. concluded that yoga could improve balance and reduce falls in subjects with knee OA.[21] Yoga practice provides a sophisticated and practical approach to improving human

body perception and, body imbalance, and these techniques reallocate attentional resources. This increased awareness helps correct asymmetry, improving balance, functional mobility, and self-efficacy. In line with this study, Cheung et al. reported similar results .They point out that participants had more remarkable improvement in balance and function and a decrease in risk of falls compared to participants in the aerobic/strengthening exercise and control groups.[23] The more significant beneficial effects of yoga on OA symptoms than traditional exercise and aerobic activities may be related to the use of meditation practices and how they affect pain perception.

Games interventions on balance and falls

Based on the available data, 2 studies by Wibelinger et al. and Manlapaz et al. demonstrated that the Wii game improves balance and reduces falls in patients with knee OA.[14, 30] The Wii Fit allows participants to complete various training modes such as yoga, strength training, aerobics, and balance games. The Wii game is not only a safe and feasible activity, but it also requires minimal supervision and can be a fun and motivational activity for participants. Motivation is an essential factor in the long-term success of rehabilitation, and the games promise to provide this motivation uniquely. It uses a balance board system that tracks changes in the center of pressure (COP) during practice games.

Another intervention in the game category of this review is Xbox Kinect. The results of the studies by Wi and Kang have shown a positive effect of Xbox Kinect on improving balance and reducing falls in patients with knee OA.[33] Interactive virtual reality games are considered safe interventions for patients with knee OA. These patients can improve their ability to balance by regularly participating in physical activity and range of motion training that involves joint and trunk movements. The Kinect exercise has a diverse sports game that allows participants to try different exergames. The fact that interactive video games draw older individuals and help them perform better by requiring them to undertake position-changing motions and maintain postural control is one explanation for the improvement in balance observed following the Xbox Kinect program.

Neuroscientific interventions on balance and falls

Jamebozorgy et al., Tavares et al., and Tok et al. examined the effect of a neuroscientific intervention on balance and falls in patients with knee OA and indicated similar results concerning their beneficial effects. [2, 17, 37] Neurofeedback regulates the appropriate impulses of brain waves and can affect the cortical and subcortical motor loops. By increasing beta and reducing theta brain waves, patients appear to achieve self-regulation and self-efficacy. Because subjects are self-aware and pursue superior physiological abilities, they can improve balance by controlling brain waves in several situations and enhancing their consciousness. Of course, it should be noted that the location of the electrode is very critical in improving balance .The points “O1–O2” that were employed in studies are close to the brain structures that are included in balancing, such as the occipital lobe, cerebellum, substantia nigra, and basal ganglia. tDCS is a potent non-invasive method for regulating cortical excitability by applying low levels of direct current that pass painlessly through the scalp. TDCS regulates cortical excitability during stimulation by non-synaptic changes in cells. Thus, synaptic plasticity can permanently alter the excitability of the central nervous system. Patients with knee

osteoarthritis may experience fewer falls as a result of this improvement.

Orthotic interventions on balance and falls

According to Dwarakanathan et al., lateral wedged insoles had less impact on balance and performance in those with knee OA than unloader knee orthoses.[12] An extensive sway area is visible in bipedal standing at baseline on the COP trajectory in participants with knee OA. This was minimized by orthopedic interventions, especially unloader knee orthosis. The subjects did not depend on the direction, but had a sizeable anteroposterior variation compared to the medial-lateral direction. This may be because the use of the orthotic device promotes broader support for standing support to increase stability, thereby reducing postural sway in the mediolateral direction. Similar to these studies, Zangi et al. and PAIN et al. also showed that the insoles with lateral wedged insoles had no immediate effects on balance control in patients with knee OA.[8] Prolonged use of lateral wedge insoles can reduce adduction moments during gait due to gait adjustment. Therefore, lateral wedge insoles can be used to relieve lower limb pain and improve balance.

The strength of this article is that it provides more comprehensive insights and information on the impact of the different interventions on improving balance and falls prevention in people with knee OA. The limitation of this review is that it is restricted to English papers published between 2010 and 2022. Also, like other qualitative reviews, this manuscript is limited by the author's prejudices. However, the subjective perspective provides a unique human insight into this complex subject.

Direct comparisons of the advantages of various interventions or their intensities have not been carried out in research, despite the fact that it has been shown that different therapies for longer periods of time can create superior outcomes. As a result, it is unclear which interventions are appropriate for those who have knee OA, and there are no definitive indicators or recommendations in this area. However, clinicians and physiotherapists would find this information to be extremely helpful in advising people with knee OA about their expectations for functional recovery as well as to optimize rehabilitation and prevent falls.

RECOMMENDATIONS

We recommended that additional research in the future compare the various interventions in people with knee OA and evaluate their effect on balance and fall prevention in these people. Additionally, it is recommended that more RCT studies with larger sample sizes than previous studies be carried out in the future. Another suggestion of our study is to use comprehensive media to inform people about interventions to effectively deal with balance disorders as much as possible. Another recommendation is to put fall prevention in health promotion programs for the people with knee OA in communities.

CONCLUSION

Based on the available data, different exercise interventions, if the dose is sufficient, can be effective in improving balance and preventing falls in people with knee OA by increasing muscle strength, joint stability, flexibility, gait patterns, and postural control. In addition, adding resistance and strength exercises increases the effect of balance exercises. Interventions based on dance, including Tai chi, yoga and, aerobics, are other interventions that are increasing in popularity. They are beneficial for increasing balance and preventing falls in patients with knee OA by increasing the

range of motion, flexibility and body perception, and helping to correct posture. Neurofeedback and tDCS interventions improve the balance of the subjects and reduce the number of falls in these people. However, its effectiveness depends on the placement of the electrodes and treatment protocol. Technology and games also have a positive effect and can be considered a valuable intervention to prevent falls in individuals with knee OA by improving balance. The use of Neurofeedback, tDCS, and exergaming in individuals with knee OA is limited, and further studies are needed. Regarding orthotic interventions, while insoles and lateral wedges cannot be an appropriate intervention to improve balance in patients with knee OA, knee braces may be effective. We can conclude that these interventions can assist patients with knee OA by strengthening their balance and lowering their risk of falling. As a result, they may be thought to be promoting this population's health. We found it challenging to determine which kind of interventions were more effective at improving balance and preventing falls in patients with knee OA because of the quality of the studies' methodology, variability in study design, and lack of homogeneity in the variables and measuring tools. However, more investigation is needed to determine which intervention is most beneficial to individuals with knee OA. Therefore, the conclusion of this paper may have some significant implications for the clinical care of patients with knee OA. These treatments should be viewed as essential therapeutic components that ought to be implemented as a part of programs for health promotion and treatment.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest.

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