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The Effect of a Combination of Dynamic Balance Training and Closed Kinetic Chain Exercise on Balance Changes in Osteoarthritis Knee Conditions

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Abstract

Aims:Osteoarthritis (OA) is a common form of joint inflammation that affects all joint tissues, including cartilage damage, the growth of osteophytes around the joint, swelling, unchanged synovial fluid and damage to ligaments and tendons. Clinical symptoms include pain, joint stiffness, instability, functional decline and muscle weakness. The impact of OA on muscle strength, resulting in weakness and changes in joint position, leads individuals with knee OA to experience increased balance disturbances. Balance is the body's ability to maintain stability, both when stationary and during movement. It also refers to the capacity to control the body through coordination, which involves sensory systems such as vision, the vestibular system and proprioception, as well as motor systems including muscle strength and flexibility.

Purpose: To determine whether a combination of dynamic balance training and closed kinetic chain exercises affects changes in balance in individuals with knee osteoarthritis

Methods: This study used a pre-experimental one-group pretest-posttest design with 19 participants diagnosed with knee OA. The participants underwent closed kinetic chain exercises and balance training exercises three times a week for one month. The Berg Balance Scale (BBS) was used to measure balance.

Results: Analysis using paired sample t-test indicated a p-value of 0.000, which is less than 0.05 meaning there is an effect of the combination of dynamic balance training and closed kinetic chain exercises on balance changes in knee osteoarthritis. Thus, the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected.

Conclusion: The study found that a combination of dynamic balance training and closed kinetic chain exercises affects changes in balance in individuals with knee osteoarthritis.

Keywords: Balance; Berg balance scale; Closed kinetic chain exercise; Dynamic balance training; Osteoarthritis knee

Introduction

Osteoarthritis (OA) is a common type of joint inflammation that affects all the tissues within the joint, including damage to cartilage, the growth of osteophytes around the joint, swelling, reduced synovial fluid, damage to ligaments and tendons and muscle weakness [1].

OA is a chronic pain condition that is a leading cause of disability, morbidity, physical activity limitations and impacts the quality of life for individuals over 60 years old, with a prevalence of 60-70% [2-4]. By 2050, it is estimated that there will be 642 million individuals suffering from OA, with 279 million having knee OA [5]. In Indonesia, the prevalence of knee OA is higher in women compared to men, with a ratio of 14.9% to 8.7%. This prevalence is expected to continue increasing with age [6].

OA generally presents with clinical symptoms such as pain, joint stiffness, instability, functional decline, and muscle weakness. Typically, individuals with osteoarthritis experience a significant muscle strength deficit, ranging from 20 to 45% [7]. Due to the decrease in muscle strength and changes in joint position, individuals with knee OA will experience increased balance disturbances.

Balance disorders are not only caused by muscle weakness but also by disruptions in joint proprioception, as well as issues with bones, muscles, and ligaments. Proprioception is crucial for maintaining body balance. Balance refers to the ability to maintain stability, both when stationary and during movement [8]. This concept involves body control that requires coordination between sensory systems (such as vision, vestibular balance, and proprioception) and the motor system, which includes muscle strength and flexibility [9,10]. Increased balance disturbances in OA patients can significantly impact physical and social function. If not addressed, this condition may lead to disability and a reduced quality of life [11].

In a study conducted by Wolf et al.[10], balance exercises, including dynamic balance exercises such as stepping exercises and dynamic walking, were shown to improve balance [12]. Other research has indicated that DBT can enhance strength and balance in the elderly. Another study suggested that square stepping exercise (SSE) can improve balance and reduce the risk of falls in older adults [14].

The CKCE involve active movements that engage multiple muscle groups and joints simultaneously. Several studies have demonstrated that CKCE is effective in improving muscle strength and power, stability, balance, and synergy in functional loading positions [16-18].

Methods

This study is a pre-experimental study with a one-group pretest-posttest design. The study was conducted at the IV Army Hospital in Samarinda from May to June 2024. The sample comprised 19 respondents, who were assessed using the Berg Balance Scale and received interventions consisting of dynamic balance training and closed kinetic chain exercises for 4 weeks, with a frequency of 3 times a week, each session lasting 30 minutes, with 15 minutes per day. The respondents were aged 40-80 years, including both men and women diagnosed with osteoarthritis.

The choice of DBT and CKCE represents an effective approach to addressing balance disturbances in knee osteoarthritis. DBT and CKCE are effective in stimulating proprioceptive and visual sensory systems, improving neurotransmitter synthesis such as acetylcholine and Brain Derived Neurotrophic Factors (BDNF), and enhancing balance and coordination in the lower limbs.

To evaluate changes in balance, the BBS was used: scores of 41-56 indicate high balance levels (independent), 21-40 indicate moderate balance levels (requires assistive devices), and 0-20 indicate low balance levels (requires a wheelchair).

Results

1. Respondent Characteristics

Table 1. Characteristics of Research Subjects Data

Variabel	f	%
Gender		
Male	4	21,1
Female	15	78,9
Age		
40-50 year	3	15,8
51- 60 year	10	52,6
61-70 year	3	15,8
71-80 year	3	15,8
Occupation		
Housewife	9	47,4
Entrepreneur	8	42,1
Farmer	1	5,3
Retiree	1	5,3
Body Mass Index		
Underweight (<18,5)	1	5,3
Normal (18.5-24.9)	6	31,6
Overweight (25-29.9)	2	10,5
Obesitas (≥30)	10	52,6

f: frequency

Table 1 above illustrates the characteristics of the study respondents, indicating a predominance of females compared to males, with a percentage of 78.9% versus 21.1%. Most respondents are within the age range of 51-60 years. In terms of occupation, housewives represent the largest group, accounting for 47.4%. Regarding body mass index, 10 respondents (52.6%) fall into the obesity category.

2. Descriptive Data of Berg Balance Scale

Table 2. Description of Berg Balance Scale Measurements

(n = 19)			
	Min	**Max**	**Mean±SD**
BBS Score			
Pre	34	55	42.79±5.46
Post	37	55	44.84±4.78

Table 2 indicates that the BBS scores before the intervention with DBT and CKCE ranged from a maximum of 55 (high balance level) to a minimum of 34 (moderate balance level). After the intervention, the BBS scores ranged from a maximum of 55 (high balance level) to a minimum of 37 (moderate balance level).

3. Test of Mean Difference in Balance Before and After DBT and CKCE Intervention

Tabel 3. Test of Mean Difference in Balance Before and After DBT and CKCE Intervention

Data Group	**Mean±SD**	***p-value***
Osteoarthritis		
Pre	42.79±5.46	0,000
Post	44.84±4.78	

Table 3 shows that there was a significant improvement in balance in individuals with osteoarthritis ($p<0.05$), with the mean score increasing from 42.79±5.46 to 44.84±4.78. Thus, the intervention with DBT and CKCE can enhance balance in osteoarthritis patients.

Discussion

Based on the results of this study, the combination of DBT and CKCE leads to improvements in balance among samples diagnosed with knee osteoarthritis.

DBT through square stepping exercises can stimulate the body's sensory systems, including proprioceptive and visual systems, which are crucial and effective in maintaining balance. This exercise involves various movements, such as stepping forward, backward, and sideways. In addition to stimulating sensory systems, this exercise also enhances the production of the neurotransmitter acetylcholine, which is crucial for rapid information transmission to the brain and BDNF, which act as protective proteins against neural function decline and nerve degeneration in both the brain and peripheral nerves [14].

Strength training for the legs using light weights, approximately 20% of maximum strength, can improve balance because the muscles function actively during the concentric phase and maintain stable strength output. This DBT exercise can also improve function by shortening response latency, effectively recruiting postural muscles, and enhancing sensory information processing. Moreover, multi-directional stepping activities in DBT better activate synergistic and agonist leg muscles, which may contribute to improvements in various aspects of functional fitness in the lower extremities, thereby affecting stability and balance [20].

The CKCE have proven effective in improving balance in individuals with knee osteoarthritis. These exercises significantly stimulate proprioception and kinesthetics through joint

approximation. The muscle contractions occurring during these exercises, involving body weight or axial loading, lead to joint approximation. This stimulates mechanoreceptors in the muscles and receptors around the joint, developing sensory input essential for movement control. CKCE also promotes co-contraction, which is the simultaneous contraction of agonist and antagonist muscles, and activates various muscles essential for functional movement. This co-contraction helps stabilize the joint and improves movement quality, while joint approximation stimulates joint receptors and enhances joint congruence, supporting overall stability. Additionally, varied muscle contractions contribute to synergistic movement that follows normal movement stages and daily functional activities [8,21].

CKCE can improve functional deficits and enhance balance control by strengthening tendons, capsules, and ligaments that have become lax due to degenerative or operative processes. Improvement through CKCE can also restore joint space when there are issues with intra-articular geometry, leading to better joint control. CKCE strengthens by stimulating mechanoreceptors and releasing tense muscles, and has been shown to improve postural control and balance. When the knee joint is in an optimal position, postural control is maintained because 80% of knee OA abnormalities affect the pelvic floor. If there is a knee joint abnormality, attention should also be given to the pelvic muscles. CKCE activates the strengthening of internal muscles by stimulating simultaneous contraction of agonist and antagonist muscles to provide better joint stability, which can also enhance proprioception. This type of exercise can improve or restore functional movement, particularly in the lower extremities, through concentric and eccentric contractions of the muscles involved in hip, knee, and ankle movements [22].

The combination of Dynamic Balance Training and Closed Kinetic Chain Exercises leads to improvements in balance, as SSE and CKCE stimulate the proprioceptive and visual sensory systems, enhance the synthesis of acetylcholine and BDNF neurotransmitters, and develop coordination and balance in the lower limbs, especially in the elderly, proving effective in improving balance in knee osteoarthritis.

Limitations

Limitations of this study include the inability of the researchers to monitor the participants' activities at home. Additionally, the study utilized a one-group pretest-posttest design, involving only one group without a control group for comparison.

Conclusion

Dynamic balance training and closed kinetic chain exercises can improve balance in individuals with osteoarthritis. This is evidenced by the Paired Sample T-Test results, which indicate a p-value of 0.000 < 0.05, meaning there is a significant effect of dynamic balance training and closed kinetic chain exercises on balance changes in individuals with knee osteoarthritis.

Author Contribution

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest

Authors state no conflict of interest.

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