Effects of Customized, Integrated Exercise Therapy on Posture Control among Older Adults with Knee osteoarthritis during obstacle crossing

Peixin. **Shen**[1], Qipeng. Song[1], Dewei. Mao[1,2]
[1]College of Sports and Health, Shandong Sport University, Jinan, China
[2]Physical Education Unit, The Chinese University of Hong Kong, Shenzhen, China
Email: songqipeng@163.com

Introduction

Knee osteoarthritis (KOA) is associated with a significantly higher risk of falls in older adults, with a fall rate of 50% among individuals aged 65 years and older — 17% higher than their healthy counterparts[1]. This increased fall risk is particularly evident during weight-bearing activities, such as obstacle crossing, which pose significant challenges for patients with KOA due to activity limitations[2]. Successful obstacle crossing requires precise postural control, including accurate swing foot trajectory, coordinated bilateral joint movements, and dynamic balance maintenance[3]. Postural control is influenced by multiple factors, such as proprioception, muscle strength, and joint range of motion. However, conventional single-modality exercise therapies often fail to adequately address these multifaceted requirements.This study aimed to evaluate the effects of a customized, integrated exercise therapy program on postural control during obstacle crossing in older adults with KOA.

Methods

Sixty-six older adults with KOA were enrolled and randomly allocated into three groups: the exercise group (EG; age: 67.0±2.7 years, BMI: 25.7±2.3 kg/m²), the physiotherapy group (PG; age: 67.5±4.4 years, BMI: 25.7±3.0 kg/m²), or the control group (CG; age: 65.7±1.9 years, BMI: 27.4±2.1 kg/m²). Participants in the EG received an 8-week integrated exercise intervention comprising proprioceptive neuromuscular facilitation, muscle strength training, and gait training. The PG underwent standard physical therapy, while the CG received a series of health education sessions. All interventions were conducted for 1 hour, three times per week.

At baseline (Week 0) and post-intervention (Week 8), participants performed an obstacle-crossing test. They were instructed to walk along an 8-meter walkway at a self-selected speed and cross an obstacle, ensuring the leading limb cleared the obstacle first, followed by the trailing limb (involved leg). Kinematic and kinetic data were collected using a 12-camera motion capture system and a force platform, with sampling frequencies of 100 Hz and 1000 Hz, respectively. Two-way (time*group) repeated measures ANOVA was used to analyze the data.

Results and Discussion

Significant group-by-time interactions were observed for center of mass velocity in the anteroposterior direction ($vCOM_{ap}$, p=.038, η^2_p=.119), center of mass-center of pressure medial-lateral displacement ($COM\text{-}COP_{ml}$, p=0.021, η^2_p=0.138),foot clearance (p=0.037, η^2_p=0.119), and knee extension moment (p=0.006, η^2_p=0.179). Post-hoc analyses revealed that, compared to Week 0, the EG exhibited a reduction in $COM\text{-}COP_{ml}$ (p=0.007, Cohen's d=0.867) and increases in $vCOM_{ap}$ (p=0.010, Cohen's d=0.485), foot clearance (p=0.030, Cohen's d=0.436), and knee extension moment (p=0.016, Cohen's d=0.372).

These findings suggest that the comprehensive exercise intervention program positively influenced postural control during obstacle crossing. Center of mass velocity during obstacle crossing is a critical indicator of dynamic stability and is strongly associated with fall risk[4]. A reduction of 0.1 m/s in center of mass velocity corresponds to a 10% decline in physical performance capacity[5]. Thus, the increased crossing speed observed in the EG reflects enhanced dynamic stability. The faster $vCOM_{ap}$ in the EG likely result from improvements in physical function, mediated by pain relief, enhanced joint mobility, and increased muscle strength.

The decrease in COM-COP_ml, a measure of lateral stability, indicates a reduced discrepancy between the center of mass and center of pressure, reflecting diminished body sway and improved lateral stability. Furthermore, greater foot clearance during obstacle crossing in older adults reduces the likelihood of obstacle contact and subsequent falls, with larger toe clearance serving as a marker of robust dynamic stability[6]. These results collectively underscore the efficacy of the integrated exercise intervention in enhancing postural control and reducing fall risk in older adults with KOA.

Conclusions

The study confirmed that a comprehensive exercise intervention program positively improves postural control when crossing obstacle in older adults with KOA.

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