



Elastic Knee Sleeve on Dynamic Balance in Pre-Elderly Women: A Community-Based Study

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Abstract

Population aging is associated with progressive declines in neuromuscular function and proprioceptive sensitivity that may impair postural stability beginning in middle adulthood. Reduced balance performance is associated with an increased risk of falls and functional limitations later in life. Elastic knee sleeves are widely used orthotic devices that may enhance proprioceptive feedback and joint awareness; however, evidence regarding their functional effects in community-dwelling pre-elderly populations remains limited. This study aimed to evaluate the effect of elastic knee sleeve use on dynamic balance among pre-elderly women participating in community exercise programs. A community-based quasi-experimental pre-post intervention study was conducted involving 30 pre-elderly women aged 45–59 years. Participants were instructed to wear elastic knee sleeves for approximately five hours daily over six weeks. Dynamic balance was assessed using the Y Balance Test before and after the intervention. Differences in balance performance were analyzed using paired t-tests with statistical significance set at $p < 0.05$. Dynamic balance performance improved significantly after the intervention. Mean Y Balance Test scores increased from 74.93 ± 13.32 to 108.50 ± 12.74 for the left leg and from 75.20 ± 12.32 to 108.10 ± 13.72 for the right leg ($p < 0.001$). These findings indicate a substantial improvement in dynamic postural control following knee sleeve use. Elastic knee sleeves may represent a simple orthotic strategy to enhance proprioceptive feedback and improve dynamic balance among pre-elderly women participating in community exercise programs.

Introduction

Population aging has become a major global public health issue. Increasing life expectancy has resulted in a growing proportion of middle-aged and older adults who face age-related declines in physical function. One of the most significant health risks associated with aging is the increased incidence of falls. Falls are a major cause of injury, disability, and reduced independence among older adults and impose a substantial burden on healthcare systems. Globally, approximately one-third of adults aged over 65 years experience at least one fall each year, and the prevalence increases further among individuals with musculoskeletal disorders (Song *et al.*, 2021; Shen *et al.*, 2024).

This study focuses on pre-elderly individuals aged 45–59, foregrounding a preventive health strategy. Declines in balance and proprioception are not exclusive to older adults but begin gradually in middle age. Research shows that early sensorimotor changes, such as decreased muscle strength, slower neuromuscular responses, and reduced joint position sense, are already evident in this group and can increase the risk of subsequent collapse (Woo *et al.*, 2021; Hussein *et al.*, 2023). Addressing these issues early offers a valuable chance for intervention, particularly through simple, community-based approaches to maintain functional ability. Additionally, these early functional declines are strongly linked

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to decreased knee proprioception, which has been associated with impaired balance in aging populations (Solanki & Iyer, 2020).

Balance control is a complex physiological function integrating visual, vestibular, and somatosensory systems. Among these systems, proprioception plays a critical role in maintaining postural control and joint stability. Proprioceptive receptors located in muscles, tendons, ligaments, and joint capsules provide the central nervous system with information about body position and movement, allowing the body to adjust motor responses to maintain stability during movement (Shen *et al.*, 2024). Impairment in proprioceptive function has been identified as one of the most important contributors to declines in balance among aging populations (Song *et al.*, 2021). Balance regulation is a complex biomechanical process that requires continuous interaction between sensory inputs and neuromuscular responses to maintain the body's center of mass within the base of support during movement tasks (Olsson *et al.*, 2023). Postural orientation and equilibrium are controlled by integrating sensory information and coordinated motor responses that allow individuals to maintain stability during both static and dynamic activities (Bianchi *et al.*, 2020).

Proprioception represents a fundamental sensory system that provides the central nervous system with information about limb position, movement, and force generation, thereby supporting the regulation of posture and coordinated movement (Pšeničnik & Kozinc, 2024). The relationship between proprioception and balance control has been widely documented, with reduced proprioceptive acuity contributing to impaired postural stability and increased fall risk in aging populations (Wang & Fu, 2022). Previous studies have demonstrated that proprioceptive acuity decreases with age, leading to reduced sensitivity to changes in joint position and impaired postural control. Reduced proprioceptive function may increase the risk of instability during movement and increase the likelihood of falls (Woo *et al.*, 2021). Consequently, interventions aimed at enhancing proprioceptive feedback may represent an effective strategy for improving

balance performance and preventing fall-related injuries.

Age-related decline in sensorimotor function has been associated with reduced joint position sense and impaired neuromuscular control, both of which contribute to instability during locomotion (Jamshidi *et al.*, 2020). Compression-based orthotic supports have been proposed as an intervention to enhance cutaneous sensory input and improve postural regulation during dynamic activities (Angelakos *et al.*, 2020). Systematic evaluations of knee orthoses have reported improvements in functional performance and joint stability in several clinical and non-clinical populations (Milner *et al.*, 2022). Orthotic supports have been widely used in rehabilitation and injury prevention to improve joint stability and neuromuscular control. Elastic knee sleeves are among the most commonly used orthotic supports because they are inexpensive, easy to use, and widely accessible. These devices provide mild compression around the knee joint and may enhance proprioceptive feedback by stimulating cutaneous mechanoreceptors. Compression garments have been shown to improve joint position sense and reduce proprioceptive error during movement tasks (Ghai *et al.*, 2024).

Several studies have reported beneficial effects of knee sleeves on joint stability, gait symmetry, and functional movement control. For example, knee sleeves have been shown to improve gait symmetry during fast walking in older adults (Inai *et al.*, 2024). Similarly, research examining gait biomechanics has reported reduced variability in knee and ankle joint angles during walking when knee sleeves are worn, suggesting improved movement stability (Tsuchida *et al.*, 2025). However, most existing studies have focused primarily on clinical populations with knee pathology, such as osteoarthritis or ligament injuries. Recent studies have begun to explore the effects of elastic knee sleeves and compression-based orthotic supports on dynamic balance in community-dwelling populations. The use of a prophylactic orthosis significantly improved postural balance performance in functional tasks among physically active individuals (Romain *et al.*, 2023). Improvements in both

static and dynamic balance following the use of knee sleeves during movement tasks, indicating enhanced sensorimotor integration (Mazniku *et al.*, 2021). Compression garments may reduce inter-limb asymmetry in balance performance, particularly in individuals with lower baseline stability (Noé *et al.*, 2022). These findings suggest that compression-based orthotic interventions may enhance dynamic balance, even in non-clinical and community-based populations.

Evidence regarding the effectiveness of knee sleeves among healthy or community-dwelling middle-aged populations remains limited. In particular, few studies have examined the role of simple orthotic supports in improving dynamic balance among individuals participating in community exercise programs. This population represents an important target for preventive health interventions because early functional decline may begin during the pre-elderly stage. Community exercise programs provide an important platform for promoting physical activity and maintaining musculoskeletal health among middle-aged populations. Regular participation in structured exercise programs has been shown to improve balance, strength, and functional mobility among community-dwelling adults (Fong *et al.*, 2023). Integrating simple orthotic interventions such as knee sleeves into community-based exercise programs may provide additional benefits by enhancing proprioceptive feedback and improving joint stability during physical activities.

From a public health perspective, balance impairment is not only a clinical issue but also a population-level concern associated with reduced mobility, increased fall risk, and decreased involvement in physical activity. Preventive interventions targeting balance performance during middle adulthood may therefore play an important role in maintaining functional independence and promoting healthy aging. Despite the potential benefits of knee sleeves for enhancing proprioceptive feedback and improving postural control, evidence regarding their effectiveness among community-dwelling pre-elderly individuals remains limited. Therefore, the present study aimed to evaluate the effect of elastic knee

sleeves on dynamic balance performance among pre-elderly women participating in community exercise programs.

Methods

This study employed a quasi-experimental design using a one-group pre-test and post-test approach to evaluate the effects of knee sleeve use on dynamic balance performance among pre-elderly women. The study was conducted in Tohudan Village, Central Java, Indonesia. Participants were recruited from two community health posts that routinely organize exercise programs for middle-aged women. The study was conducted between March and June 2026 during routine community exercise activities organized by local health posts in Tohudan Village. Participants regularly attended community exercise sessions organized by local health posts. These sessions followed a standardized low-to-moderate intensity training protocol consisting of warm-up exercises, aerobic movements, balance-oriented activities, and stretching, with a typical duration of 45–60 minutes per session. The exercise program was conducted two to three times per week and was supervised by trained community health facilitators.

As many as 30 pre-elderly women aged between 45 and 59 years participated in the study. Participants were included if they regularly participated in community exercise programs, were able to stand and walk independently, and provided written informed consent. Individuals were excluded if they had neurological disorders that could affect balance performance, severe musculoskeletal injuries, or significant cognitive impairment that could interfere with participation in the study procedures. The sample size was considered adequate for detecting within-subject changes in balance performance in small community intervention studies. The study specifically focused on female participants due to both epidemiological and biomechanical considerations. Women have been reported to exhibit a higher prevalence of balance impairment and fall risk compared to men, partly due to differences in muscle mass, joint laxity, and hormonal influences affecting

neuromuscular control (Chittrakul *et al.*, 2020). In addition, previous studies have indicated that females may demonstrate greater reliance on proprioceptive input for postural control, making them an appropriate population for evaluating interventions targeting sensorimotor enhancement (Song *et al.*, 2021). From a methodological perspective, restricting the sample to a single sex also reduces variability related to sex-based biomechanical differences, thereby improving internal validity in small-sample quasi-experimental designs.

The study protocol was reviewed and approved by the Health Research Ethics Committee of Aisyiyah University of Surakarta, NO. 840/I/AUEC/2026. Written informed consent was obtained from all participants prior to participation in the study. This study was conducted in accordance with ethical principles for research involving human participants. All participants were informed about the purpose of the study, the procedures involved, and their right to withdraw from the study at any time without consequences. Written informed consent was obtained from all participants before data collection. Participant confidentiality and anonymity were maintained throughout the study process. Participants were provided with elastic knee sleeves and instructed to wear them daily for approximately 5 hours over a six-week intervention period. The knee sleeves were worn during routine daily activities along with community exercise sessions. The elastic compression produced by the knee sleeve was intended to enhance proprioceptive feedback around the knee joint and improve neuromuscular coordination during movement.

Dynamic balance performance was assessed using the Y Balance Test, a validated clinical assessment for evaluating dynamic postural control. During the test, participants stood on one leg while reaching with the opposite leg in three directions: anterior, posteromedial, and posterolateral. Reach distances were recorded in centimeters. Each participant performed three reach attempts in each direction for both limbs. Reach distances were normalized to limb length and expressed as percentage scores to reduce the influence of anthropometric differences between

participants. Baseline data collected from participants included age, body mass index (BMI), cognitive status assessed using the Mini-Mental State Examination (MMSE), and limb length measurements. Dynamic balance performance was assessed twice, namely before the intervention and after six weeks of knee sleeve use. Data were analyzed using SPSS software. The normality of the data distribution was assessed using the Shapiro–Wilk test. Differences between pre-intervention and post-intervention dynamic balance scores were analyzed using paired sample t-tests. Statistical significance was determined at a p-value of less than 0.05. Effect size was calculated using Cohen's d to quantify the magnitude of change between pre- and post-intervention measurements.

Results and Discussion

A total of 30 pre-elderly women participated in this study and completed the six-week intervention period. The mean age of participants was 54.7 years with a standard deviation of 3.6 years, indicating that they were in the upper range of the pre-elderly age category. Most participants regularly participated in community exercise programs organized by local health posts, which included routine physical activities aimed at maintaining musculoskeletal health and mobility. Participant demographic characteristics are presented in Table 1. The sample consisted of pre-elderly women who regularly participated in community exercise programs. Overall, participants demonstrated relatively homogeneous anthropometric characteristics.

Baseline characteristics showed that the participants had relatively homogeneous demographic and physical characteristics. The average body mass index (BMI) indicated that most participants were within the normal weight range. Cognitive function assessed using the Mini-Mental State Examination (MMSE) indicated that all participants had normal cognitive status, confirming that they were able to follow instructions during the balance assessment and intervention period.

Dynamic balance performance measured using the Y Balance Test showed demonstrated a significant improvement following the six-week

Table 1. Participant Characteristics (n = 30)

Characteristics	Mean $\pm$ SD
Age (years)	54.7 $\pm$ 3.6
Body Mass Index (kg/m ²)	21.4 $\pm$ 3.8
Limb Length (cm)	85.6 $\pm$ 4.3
MMSE Score	27.8 $\pm$ 1.2

Table 2. Dynamic Balance Performance Before and After Intervention

Variables	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	p-value
Y Balance Test (Left Leg)	74.93 $\pm$ 13.32	108.50 $\pm$ 12.74	<0.001
Y Balance Test (Right Leg)	75.20 $\pm$ 12.32	108.10 $\pm$ 13.72	<0.001

intervention (Table 2). Mean reach distance increased from 74.93 cm to 108.50 cm for the left leg and from 75.20 cm to 108.10 cm for the right leg. Paired sample t-test analysis confirmed that these improvements were statistically significant ($p < 0.001$). The calculated Cohen's d indicated a large effect size ($d \approx 0.80$), suggesting that the observed improvement was not only statistically significant but also clinically meaningful. Age-related declines in proprioceptive sensitivity may impair balance regulation and increase the risk of postural instability. Reduced proprioception has been identified as a key factor contributing to balance impairment among aging populations (Song *et al.*, 2021). These findings indicate that six weeks of elastic knee sleeve use produced a measurable improvement in dynamic postural control among pre-elderly women participating in community exercise programs. Elastic knee sleeves provide mild compression around the knee joint, which may stimulate cutaneous mechanoreceptors located in surrounding tissues. Increased sensory stimulation may enhance proprioceptive feedback to the central nervous system, improving joint position awareness and neuromuscular coordination during movement tasks. Improved sensorimotor integration may therefore contribute to better control of the body's center of mass relative to the base of support during dynamic activities such as those assessed in the Y Balance Test (Woo *et al.*, 2021; Ghai *et al.*, 2024). Orthotic supports that combine mechanical support with compression-based sensory stimulation have also been shown to improve postural balance performance in dynamic tasks such as the Y Balance Test (Romain *et al.*, 2023).

Additional supportive interventions, including kinesiotaping and compression wear, have also demonstrated improvements in postural stability during functional activities (Choi & Hwang, 2020). Clinical perspectives suggest that orthotic supports may serve as complementary tools alongside exercise-based rehabilitation programs aimed at improving proprioception and postural control (Bartsch *et al.*, 2025). Similarly, impaired proprioceptive control has been associated with decreased postural stability among individuals with knee-related musculoskeletal conditions (Shen *et al.*, 2024). Studies investigating inter-limb balance asymmetry reported that compression garments may reduce asymmetry in individuals with poor baseline balance performance (Noé *et al.*, 2022).

Previous studies have investigated various rehabilitation and compression-based interventions aimed at improving balance performance and joint stability. Research has shown that compression garments may improve lower-limb movement control and perceived stability during physical activity (Boschert

et al., 2020). Exercise-based rehabilitation interventions have also been reported to improve proprioception and physical function among individuals with knee musculoskeletal disorders (Chen *et al.*, 2021). The use of knee sleeves has also been associated with improvements in static and dynamic balance performance during functional tasks (Mazniku *et al.*, 2021). In clinical rehabilitation settings, proprioceptive training combined with joint support interventions may enhance mobility and balance outcomes among individuals with knee osteoarthritis (Raza *et al.*, 2022). Postoperative balance impairment has also been identified as a factor contributing to fall risk among patients undergoing knee-related medical procedures (Sadiq *et al.*, 2024).

Additional research has demonstrated that proprioceptive training programs may improve postural stability among older adults with musculoskeletal conditions (Mollova *et al.*, 2025). Compression-based garments have also been explored as supportive interventions to reduce musculoskeletal discomfort and improve functional performance during physical activity (Agarwal & Juneja, 2023). Biomechanical studies have further demonstrated the stabilizing effects of knee sleeves during locomotion. The use of knee sleeves has been reported to improve gait symmetry during fast walking among older adults (Inai *et al.*, 2024). Reduced variability in joint movement patterns during walking has also been observed when they use knee sleeves, suggesting improved movement stability (Tsuchida *et al.*, 2025). Improved movement consistency may contribute to better balance control and reduced risk of falls during locomotor activities.

Regular participation in structured exercise programs is widely recognized as an important strategy for maintaining functional mobility and preventing fall risk among community-dwelling adults (Fong *et al.*, 2023). Multi-system exercise interventions combining strength, balance, and proprioceptive training have demonstrated significant improvements in postural stability among older adults (Chittrakul *et al.*, 2020). The addition of orthotic supports such as knee sleeves may further enhance the effectiveness of these interventions by improving sensory

feedback during movement tasks. Community-based health promotion programs represent an important approach for maintaining musculoskeletal health among middle-aged populations. Movement-based physical activity programs implemented in community settings have been shown to improve physical fitness and functional performance (Nurharsono *et al.*, 2023). In addition to biomechanical factors, behavioral and nutritional determinants may also influence musculoskeletal health outcomes in community populations (Lubis *et al.*, 2023). Integrating simple orthotic interventions into community exercise programs may therefore provide additional benefits for improving balance performance and functional mobility.

Despite the promising findings of this study, several limitations should be acknowledged. First, the study employed a quasi-experimental design without a control group, which limits the ability to attribute the observed improvements solely to the intervention. Second, the relatively small sample size and the inclusion of only female participants may limit the generalizability of the findings to other populations. Third, the intervention period lasted only six weeks, and therefore, the long-term effects of knee sleeve use on balance performance remain unclear. Future research should consider randomized controlled trial designs with larger, more diverse populations to further evaluate the effectiveness of knee sleeve interventions. Additional studies may also explore optimal compression levels, duration, and potential synergistic effects between orthotic supports and structured exercise programs. Overall, the findings of this study suggest that elastic knee sleeves may be a simple, practical orthotic intervention to improve dynamic balance in pre-elderly women. Integrating such interventions into community exercise programs may help maintain functional mobility and reduce fall risk among aging populations.

Conclusion

This community-based study demonstrated that the use of elastic knee sleeves was associated with significant improvements in dynamic balance among pre-elderly women. These findings suggest that simple orthotic

interventions integrated into community exercise programs may support functional mobility and contribute to fall-prevention strategies in middle-aged populations.

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