Low-impact specialized pilates is better than low intensity steady state for increasing fitness level

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ABSTRACT

Background: Elderly individuals with disabilities often face challenges in maintaining physical fitness, highlighting the need for effective and appropriate exercise methods tailored to their limitations.

Objectives: This study compares the effectiveness of low-impact specialized Pilates and Low-Intensity Steady-State (LISS) exercise in improving fitness levels among older adults with mild to moderate disabilities. The unique advantage of Pilates in enhancing balance and core strength is presented as a novel contribution.

Methods: A quasi-experimental design with pre-test and post-test assessments was employed, involving 40 elderly participants with disabilities divided into two intervention groups over 8 weeks. Participants were selected through purposive sampling based on the inclusion criteria of 60–75 years with mild to moderate disabilities. Fitness levels were assessed using the Senior Fitness Test, which evaluates muscular strength, balance, flexibility, and aerobic capacity.

Results: Data analysis was conducted using the Shapiro–Wilk test, paired sample t-test, and independent sample t-test. The results demonstrated that the low-impact specialized Pilates group showed significant improvements in core strength, balance, and flexibility, whereas the LISS group exhibited greater improvements in aerobic capacity.

Conclusions: In conclusion, low-impact specialized Pilates is more effective in enhancing overall fitness among elderly individuals with disabilities. Therefore, it is recommended as a suitable exercise modality for rehabilitation and health maintenance programs to improve this population's quality of life and functional independence.

Keywords: disability, elderly fitness, LISS, low-impact specialized pilates, senior fitness test.

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INTRODUCTION

The aging process is associated with progressive declines in anatomical and physiological functions. Recent data from Indonesia's Central Statistics Agency indicate a continued increase in the elderly population. In 2024, older adults are projected to comprise 11.75% of the total population, an increase from 10.48% in the previous year (Astuti & Soleman, 2024). This demographic trend contributes to a higher old-age dependency ratio, defined as the proportion of elderly individuals relative to the working-age population, reaching 17.76. Consequently, for every 100 individuals of productive age, approximately 17 are elderly dependents (Fitriana et al., 2024).

Physiologically, aging is accompanied by a progressive decline in organ function, contributing to overall physical deterioration (Carcelén-Fraile et al., 2024). Appropriate physical activity has been shown to mitigate some of these age-related effects. Routine daily tasks also constitute a form of physical activity, typically performed by an individual's functional capacity (Li et al., 2024). However, reduced levels of physical activity among older adults are associated with diminished cardiorespiratory endurance, negatively affecting overall physical fitness. Furthermore, the decline in physiological function increases the risk of falls, a significant health concern in the elderly population (Kang et al., 2021).

A growing body of evidence supports the positive impact of physical exercise on older adults' health and functional capacity. Pereira et al. (2022) demonstrated that Pilates significantly improves balance and muscle strength in healthy elderly individuals. Similarly, Yu et al. (2023) reported that regularly low-intensity exercise enhances cardiorespiratory capacity. Yang et al. (2022) found that older adults with mobility impairments experienced improvements in flexibility and stability following a 12-week Pilates program. In addition, Park et al. (2023) observed that combining strength and flexibility training yields notable benefits for elderly individuals with mild disabilities. Franks et al. (2023) further confirmed that Pilates-based interventions positively affect both static and dynamic balance in the elderly.

Low-impact specialized Pilates is a form of exercise that emphasizes mat-based movements designed to strengthen the core muscles, enhance flexibility, improve balance, and promote body awareness (Pereira et al., 2024). This form of training utilizes body weight as resistance and strongly emphasizes controlled movement, proper breathing, and correct posture. It can be adapted to meet specific needs or goals, such as injury rehabilitation, athletic performance enhancement, or general health improvement (Morucci et al., 2022). One of its key advantages lies in its ability to improve posture, reduce the risk of injury, and enhance core stability without additional equipment (Parolini et al., 2024).

On the other hand, low-intensity steady-state (LISS) training is a form of endurance exercise characterized by low intensity, extended duration, and a consistent tempo. It typically involves repetitive movements such as walking, cycling, or swimming while maintaining the heart rate within the aerobic zone (Karatrantou et al., 2023). LISS is particularly suitable for individuals seeking to effectively burn fat, enhance cardiovascular endurance, or recover following high-intensity workouts (Parra-Rizo et al., 2022). Its primary advantage lies in its ability to promote cardiovascular and metabolic health without placing excessive strain on the body, making it accessible to individuals across various age groups and fitness levels (Wołoszyn et al., 2023). Although numerous studies have demonstrated the benefits

of low-impact specialized Pilates and LISS for older adults, there remains a lack of research directly comparing the effectiveness of these two exercise modalities in elderly populations with disabilities. Most existing studies have focused on healthy older adults or those with mild mobility impairments, with limited consideration given to individuals with functional limitations due to disability.

Older adults with disabilities often experience a decline in physical fitness, which can significantly reduce quality of life and increase the risk of falls (Balogh et al., 2022). While physical activity is widely recognized as an effective intervention to improve fitness and slow aging, studies directly comparing the effectiveness of different exercise modalities in elderly populations with disabilities remain limited (Sortino et al., 2023). This study addresses this gap by directly comparing the effectiveness of low-impact specialized Pilates and low-intensity steady-state (LISS) training in improving physical fitness among older adults with disabilities.

In this study, low-impact specialized Pilates is tailored to the type and degree of disability, a focus that has not been previously explored in existing literature. This research aims to analyze and evaluate the effects of low-impact specialized Pilates and LISS on key components of physical fitness, including balance, muscular strength, and cardiorespiratory capacity in elderly individuals with disabilities. The findings are expected to provide empirical evidence supporting the development of more effective and safe physical exercise programs for older adults with functional limitations.

Furthermore, this study contributes to the broader global efforts to address the rising number of older adults with health challenges. By identifying the most effective training approaches, the international community may be better equipped to adapt Pilates-based programs to meet the specific needs of elderly individuals with disabilities while fostering cross-national collaboration to enhance the well-being of aging populations worldwide.

METHODS

Study Design and Participants

This study compares the effectiveness of low-impact specialized Pilates and low-intensity steady-state (LISS)training in improving physical fitness among older adults with special needs. A quasi-experimental design with a two-group pre-test and post-test model was employed, involving one group participating in a low-impact specialized Pilates intervention and another group undergoing LISS training. Participants were selected through purposive sampling based on inclusion criteria, which included female older adults aged 60–75 years with mild to moderate disabilities and with medical clearance to participate in physical exercise. Participants in this category typically exhibit physical, sensory, or cognitive limitations that allow them to perform daily activities with minimal assistance. Exclusion criteria included individuals with acute cardiovascular conditions, severe musculoskeletal disorders, or cognitive impairments that could hinder active participation. A total of 40 participants were randomly assigned to two groups of 20 each.

Table 1 outlines the eight-week intervention program for both the low-impact specialized Pilates and LISS groups, each conducted three times per week. Each session included a warm-up, core activity, and cool-down, with exercise intensity

tailored to each participant's condition. Progress was regularly monitored to ensure safety and comfort throughout the intervention.

Table 1. Exercise Program Design

Week	Component	Low-Impact Specialized Pilates	Low-Intensity Steady-State (LISS)	Intensity
1–2	Warm-up	Diaphragmatic breathing, neck and shoulder rotation (seated)	Light marching in place, shoulder circles, breathing	50% HRmax
	Core	Pelvic curl, spine twist (supine), leg slides (focus: control)	Walking on treadmill or outdoors at steady pace (5 km/h)	60% HRmax
	Cool-down	Light stretching (core and lower body)	Calf and thigh stretches, breathing exercises	50% HRmax
3–4	Warm-up	Cat-cow spinal mobility, shoulder rolls	Same as above	50% HRmax
	Core	Bridging, single-leg stretch, seated twist (focus: balance/flexibility)	Same as above	60% HRmax
	Cool-down	Hamstring, quadriceps, and lower back stretches	Same as above	50% HRmax
5–6	Warm-up	Roll-down, scapular movement, side bend	Same as above	50% HRmax
	Core	Hundred prep, swimming (prone), side-lying leg lifts (focus: core strength/hip stability)	Same as above	60% HRmax
	Cool-down	Core muscle stretches, diaphragmatic breathing	Same as above	50% HRmax
7–8	Warm-up	Spinal rotation, thoracic extension, dynamic stretching	Same as above	50% HRmax
	Core	Double-leg stretch, modified plank, saw (focus: total body strength/flexibility)	Same as above	60% HRmax
	Cool-down	Full-body stretching, progressive relaxation	Same as above	50% HRmax

Initial fitness levels were assessed using the *Senior Fitness Test (SFT)* to evaluate muscular strength, flexibility, balance, and cardiovascular endurance. The experimental group engaged in low-impact specialized Pilates sessions for 45–60 minutes, focusing on core strength, balance, and mobility. The control group followed an equally timed LISS program involving treadmill walking or stationary cycling at 50–60% of their maximum heart rate. Resting heart rate and SFT scores were used as cardiovascular and functional fitness outcome measures. Certified instructors trained in Pilates and elderly disability-focused exercise protocols supervised all exercise sessions. Their responsibilities included guiding exercises, correcting participants' movement, and ensuring safe adherence to the intervention protocol. Prior to participation, individuals were screened for eligibility and instructed to avoid heavy physical activity outside the program, maintain stable health conditions, and refrain from consuming heavy meals or certain medications before sessions, based on medical guidance.

Ethical approval statement

This study adhered to ethical principles by the seven standards of the WHO (2011), including: (1) Social Value, (2) Scientific Validity, (3) Fair Participant Selection, (4) Risk-Benefit Ratio, (5) Independent Review, (6) Informed Consent, and (7) Respect for Enrolled Subjects, as outlined in the CIOMS 2016 International Ethical Guidelines. Ethical approval was granted by the Research Ethics Committee of the Universitas Negeri Surabaya under registration number No.004/UN18.III.9/DL.02.04/2024.

Research Instruments

The primary instrument used in this study was the Senior Fitness Test (SFT), a standardized assessment tool widely utilized to evaluate functional fitness in older adults. The SFT comprises six test components designed to measure key domains of physical fitness: muscular strength, aerobic endurance, flexibility, and balance/agility. These include:

1. Chair Stand Test (CST) – to assess lower body strength,
2. Arm Curl Test (ACT) – to measure upper body strength,
3. Chair Sit-and-Reach Test (CSART) – for lower body flexibility,
4. Back Scratch Test (BST) – for upper body flexibility,
5. 8-Foot Up-and-Go Test (8-FUGT) – to assess agility and dynamic balance,
6. 2-Minute Step Test (2-MST) – to evaluate aerobic endurance.

All measurements were conducted before and after the 8-week intervention period. Standardized procedures were followed as outlined in the official Senior Fitness Test manual to ensure reliability and validity. Each test was administered by trained assessors experienced in working with elderly populations with mild to moderate disabilities. Participants were encouraged to perform to the best of their ability while being closely monitored to prevent discomfort or injury.

Data Analysis

Data were analyzed using SPSS version. Normality was tested using the Shapiro–Wilk test. The paired samples t-test was used to examine pre- and post-test differences within each group, while independent samples t-tests were employed to compare post-test outcomes between the two groups. Descriptive statistics were also used to describe participant characteristics.

RESULTS

Based on the data displayed in Table 2, the characteristics of the research subjects are explained. Table 2 explains the average age, body mass index, physical activity level, sitting duration/day, and calorie intake/day.

Based on Table 3, The paired sample t-test analysis results in the low-impact specialized Pilates group showing significant improvement ($p < 0.05$) in all items in the Senior Fitness Test. The percentage of participants in the "below average" category decreased drastically, while the "normal" and "above average" categories increased in almost all tests, including the Chair Sit-and-Reach Test, Back Scratch Test, Chair Stand Test, Arm Curl Test, 8-Foot Up-and-Go Test, and 2-Minute Step Test. This suggests that Pilates training positively impacts flexibility, muscle strength, balance, and aerobic capacity in older adults with mild to moderate disabilities.

Table 2. Descriptive Characteristics of the Subject

Variable	Intervention groups	
	low impact specialized pilates	low intensity steady state
Age		
60-64	45%	50%
65-70	35%	40%
71-75	10%	10%
Body mass index		
<18.5	30%	40%
18,5 - 24,9	20%	25%
25,0 – 29,9	40%	30%
>30	10%	5%
Physical activity level		
Light	80%	75%
Moderate	20%	25%
Heavy	0%	0%
Sitting time / day		
1-2 hours/day	10%	20%
3-4 hours/day	10%	5%
>5 hours/day	80%	75%
Calorie intake		
<1300kcal/day	40%	35%
1300 – 2000 kkal/day	60%	50%
>2000 kkal/day	0%	15%

Table 3. Paired Sample T-test in the Low Impact Special Pilates Group

Item test	**Senior Fitness Test**		**Paired sample t-test**
	Pre-test	Post-test	
Chair Sit-and-Reach Test (CSART)			
Below average	55%	20%	
Normal	45%	60%	**0,01
Above average	0%	20%	
Back Scratch Test (BST)			
Below average	62%	40%	**0,01
Normal	38%	51%	
Above average	0%	9%	
Chair Stand Test (CST)			
Below average	60%	20%	**0,01
Normal	40%	70%	
Above average	0%	10%	
Arm Curl Test (ACT)			
Below average	50%	10%	**0,01
Normal	40%	60%	
Above average	10%	40%	
8-Foot Up-and-Go Test (8 FUGT)			
Below average	70%	40%	**0,01
Normal	30%	50%	
Above average	0%	10%	
2-Minute Step Test			
Below average	30%	0%	**0,01
Normal	60%	70%	
Above average	10%	30%	

Description: ** mean that p value is less than 0.05 ($p<0.05$) then can be interpreted as having a significant impact.

Table 4. Paired Sample t-test of Low-intensity Steady State Group

Item test	Senior Fitness Test		Paired sample t-test
	Pre-test	Post-test	
Chair Sit-and-Reach Test (CSART)			
Below average	60%	40%	
Normal	40%	60%	*0,666
Above average	0%	0%	
Back Scratch Test (BST)			
Below average	55%	55%	
Normal	45%	45%	*0,111
Above average	0%	0%	
Chair Stand Test (CST)			
Below average	50%	30%	
Normal	40%	60%	**0.01
Above average	10%	10%	
Arm Curl Test (ACT)			
Below average	50%	40%	
Normal	30%	30%	*0,333
Above average	20%	30%	
8-Foot Up-and-Go Test (8 FUGT)			
Below average	60%	30%	
Normal	40%	50%	**0,01
Above average	0%	20%	
2-Minute Step Test			
Below average	20%	0%	
Normal	60%	20%	**0,01
Above average	10%	80%	

Description: ** means that the p value is less than 0.05 ($p<0.05$) then it can be interpreted as having a significant impact, while * has the meaning that the p value is more than 0.05 ($p>0.05$) then it can be interpreted as not having a significant impact.

In the low-intensity steady state (LISS) group (Table 4), results showed that only a few items in the Senior Fitness Test improved significantly ($p < 0.05$), namely the Chair Stand Test, 8-Foot Up-and-Go Test, and 2-Minute Step Test. The other three tests (Chair Sit-and-Reach, Back Scratch, and Arm Curl) showed no significant difference ($p > 0.05$). This indicates that LISS training had a limited impact on flexibility and upper body muscle strength, but was more effective in improving aerobic endurance and dynamic balance.

Table 5. Comparison of Senior Fitness Tests Low Impact Specialized Pilates and Low Intensity Steady State

Variable	Paired sample t-test pre-test & post-test		Independent sample's t-test
	Low impact specialized pilates	Low intensity steady state	
Chair Sit-and-Reach Test	0.001	0,666	**0.001
Back Scratch Test	0.001	0,111	**0.001
Chair Stand Test	0.001	0.001	**0.001
Arm Curl Test	0.001	0,333	**0.001
8-Foot Up-and-Go Test	0.001	0.001	**0.001
2-Minute Step Test	0.001	0.001	*0.001

Description: ** indicates that low impact specialized pilates has a better average pre-test and post-test improvement, while a figure marked * indicates that low intensity steady states have a better average pre-test and post-test improvement.

A comparison of the independent sample t-test results in Table 5 shows that the low-impact specialized Pilates group was significantly superior in almost all aspects of the fitness test compared to the LISS group, except for the 2-Minute Step Test. In

this test, LISS showed better results due to the exercise's characteristics that focus on cardiorespiratory capacity. Overall, Pilates proved to be more effective in improving core strength, flexibility, and balance, which are crucial for older adults with disabilities in maintaining functional function and preventing falls.

DISCUSSION

The findings of this study indicate that the low-impact specialized Pilates program is more effective than low-intensity steady state (LISS) training in improving fitness levels among older adults with mild to moderate disabilities. The primary outcomes reveal that participants in the low-impact specialized Pilates group experienced significant improvements in balance, flexibility, and core strength, all contributing to enhanced mobility and reduced risk of falls. In contrast, the LISS group showed more notable improvements in aerobic capacity, although gains in strength and balance were less prominent than in the Pilates group.

These results are consistent with previous studies demonstrating that Pilates-based exercises significantly enhance older adults' balance, postural stability, and motor function (Su et al., 2022). Moreover, other research has found that while LISS is efficacious in improving cardiovascular endurance, it does not yield comparable benefits in core strengthening and flexibility compared to Pilates (Fernandes et al., 2022). This supports the current findings that mat-based exercises involving controlled movements are more effective in enhancing holistic physical function, particularly among elderly populations with limited mobility (Almeida et al., 2022).

Further analysis of the differences between low-impact specialized Pilates and LISS suggests that Pilates involves core stabilizer muscle activation, breathing control, and coordinated movement, which are crucial in improving balance and posture (Sun et al., 2021). On the other hand, LISS emphasizes repetitive low-intensity aerobic activity, which primarily targets the cardiovascular system but does not directly address core strengthening and postural stability (Lim & Hyun, 2021). Therefore, for older adults with disabilities—who frequently face challenges related to mobility and balance—low-impact specialized Pilates appears to be more suitable in supporting independence in daily activities (Długosz-Boś et al., 2021).

Pilates has demonstrated positive and significant effects on older adults with disabilities, particularly in enhancing muscular strength, flexibility, balance, and coordination (Sampaio et al., 2023). The exercises are designed with controlled movements, making them appropriate for elderly individuals with limited mobility or physical function (Lazarowitz Zanzuri et al., 2024). One of the main benefits is improving core strength, which encompasses muscles surrounding the abdomen, lower back, and pelvis (Song & Kim, 2023). By strengthening the core, older adults can maintain better posture, reduce the risk of injury, and improve their ability to perform daily tasks independently (Pereira et al., 2022).

The mechanism by which Pilates enhances physical function in older adults with disabilities lies in its principles of movement, combining breathing, concentration, and control (Hyun et al., 2022). Movements such as leg circles, pelvic tilts, and spine stretches help improve joint flexibility and muscle strength without placing excessive strain on the body (Sarashina et al., 2022). Furthermore, the exercises promote stability and balance by engaging smaller muscle groups that are often underutilized in daily activities but are essential for maintaining coordination and preventing falls, a significant risk in the elderly population (Song & Kim, 2023). This mechanism also

helps improve postural alignment, which may deteriorate with age and disability (Almeida et al., 2022).

Additionally, Pilates enhances blood circulation and body awareness through deep, coordinated breathing exercises. Improved circulation facilitates better oxygen supply, accelerates muscle recovery, and reduces joint stiffness (Długosz-Boś et al., 2021). Pilates also improves mobility by strengthening supporting muscles around joints, enabling older adults with disabilities to move more freely and comfortably. Overall, Pilates not only enhances the physical fitness of older adults with disabilities but also improves their quality of life by fostering greater confidence and independence (Fernandes et al., 2022).

Limitations of the study

This study has several limitations that should be considered. The intervention lasted only 8 weeks, which may not be sufficient to evaluate the long-term effects of low-impact specialized Pilates and LISS on fitness among older adults with disabilities. The relatively small sample size (40 participants) limits the generalizability of the findings to the broader population of elderly individuals with disabilities. The study only included participants with mild to moderate disabilities; therefore, the results may not apply to individuals with severe disabilities or more complex health conditions.

Despite these limitations, the study offers significant contributions, particularly in providing evidence-based recommendations for healthcare professionals, physical therapists, and service providers in designing safe and effective exercise programs for older adults with disabilities (de Souza Andrade et al., 2021). Moreover, these findings may serve as a reference for global health and fitness policy development for aging populations. With the global elderly population continuing to rise, this study supports the promotion of exercise interventions that improve physical fitness and enhance quality of life and functional independence in older adults with disabilities (Park et al., 2023).

CONCLUSIONS

This study concludes that low-impact specialized Pilates is more effective than low-intensity steady state (LISS) training in improving physical fitness among older adults with mild to moderate disabilities. The Pilates intervention significantly enhanced balance, flexibility, and core muscle strength, essential for promoting mobility, independence, and fall prevention in elderly individuals. In contrast, while LISS effectively improved aerobic capacity, it lacked direct impact on core stability and neuromuscular coordination, which is particularly crucial for older adults with functional limitations. Given these findings, low-impact specialized Pilates is recommended as a more holistic and adaptive exercise modality for elderly individuals with disabilities. Its emphasis on controlled movement, postural alignment, and core activation makes it particularly suitable for addressing the multidimensional aspects of functional decline in aging populations. Future research in the field of exercise science is encouraged to explore the long-term efficacy of both interventions using extended intervention periods and larger, more diverse populations, including those with severe or multiple disabilities. Furthermore, additional studies may investigate multimodal training

approaches integrating aerobic, strength, and neuromotor components to optimize physical and cognitive outcomes in geriatric populations.

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All data were collected and analyzed by ethical standards and are stored securely by the research team.

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CONFLICT OF INTEREST

The author hereby declares that this research is free from conflicts of interest with any party.

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