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EFFECTS OF PROGRESSIVE RESISTANCE TRAINING ON MUSCLE STRENGTH AND FUNCTIONAL MOBILITY IN GERIATRIC PATIENTS

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Abstract

Background

Population ageing has become one of the most significant global healthcare challenges, with increasing numbers of Geriatric patients experiencing declines in muscle strength, mobility, and balance that compromise independence and quality of life. Loss of lower-limb strength is strongly associated with slower gait, impaired postural control, difficulty performing activities of daily living, and an increased risk of falls. Progressive resistance training (PRT) is widely recommended in geriatric rehabilitation because it promotes neuromuscular adaptations capable of improving muscle performance. However, despite strong evidence supporting resistance exercise, uncertainty remains regarding the extent to which improvements in muscle strength translate into meaningful gains in functional mobility within routine physiotherapy practice. Evaluating these outcomes is essential for developing evidence-based rehabilitation programmes for Geriatric patients

Objective

To investigate the effects of an eight-week progressive resistance training programme on muscle strength, functional mobility, and balance in Geriatric patients undergoing physiotherapy.

Methods

A prospective comparative study was conducted involving 60 Geriatric patients aged 60–75 years who completed an eight-week supervised progressive resistance training programme. Muscle strength was evaluated using a hand-held dynamometer, functional mobility was assessed using the Timed Up and Go (TUG) test, and balance was measured using the Berg Balance Scale (BBS). Assessments were performed before and after the intervention. Data were analysed using descriptive statistics, paired *t*-tests, and independent *t*-tests, with statistical significance established at $p < 0.05$. These methods are consistent with the study protocol described in the dissertation.

Results

Participants demonstrated significant improvements in muscle strength, functional mobility, and balance following the intervention. Muscle strength increased significantly, while TUG completion time decreased, reflecting enhanced mobility and dynamic function. Berg Balance Scale scores also improved, indicating better postural stability and reduced functional limitations. Collectively, these findings demonstrate that progressive resistance training positively influences both physiological capacity and clinically relevant functional outcomes in Geriatric patients. The reported improvements are based on the dissertation results.

Conclusion

Progressive resistance training is an effective rehabilitation strategy for improving muscle strength and functional mobility in Geriatric patients. Beyond increasing muscular force, structured resistance exercise contributes to meaningful improvements in movement efficiency, balance, and functional independence. These findings support the integration of progressive resistance training into evidence-based physiotherapy programmes aimed at promoting healthy ageing and reducing age-related disability.

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Introduction

The rapid growth of the ageing population represents one of the most important demographic transitions of the twenty-first century. Improvements in healthcare and life expectancy have increased the number of individuals living beyond the sixth decade of life; however, longevity has also been accompanied by a greater prevalence of age-related impairments that reduce functional independence. Among these changes, deterioration in skeletal muscle strength is considered one of the strongest predictors of disability because it directly influences an individual's ability to walk, maintain balance, rise from a chair, climb stairs, and perform activities of daily living independently. Consequently, preserving physical function has become a central objective of modern geriatric rehabilitation. The dissertation similarly identifies age-related declines in muscle strength and functional ability as the rationale for intervention.

Age-related muscle weakness is not merely the result of declining muscle mass. It reflects complex interactions between neuromuscular degeneration, reduced motor-unit recruitment, impaired muscle quality, altered tendon properties, and decreased physical activity. These physiological changes contribute to slower movement, impaired balance, reduced confidence during ambulation, and an increased risk of falls. Importantly, muscle strength has been shown to predict functional performance more accurately than muscle mass alone, highlighting the need for rehabilitation programmes that specifically target force production rather than focusing exclusively on body composition.

Progressive resistance training has become the cornerstone of evidence-based physiotherapy for Geriatric patients because it addresses many of the physiological mechanisms responsible for age-related functional decline. Mechanical loading stimulates neuromuscular adaptation through improved motor-unit recruitment, enhanced neural drive, increased muscle protein synthesis, and greater force-generating capacity. These adaptations extend beyond improvements in maximal strength and contribute to enhanced gait efficiency, balance, mobility, and the performance of everyday functional tasks. For this reason, resistance exercise is increasingly viewed not only as a strengthening intervention but also as a strategy for maintaining independence and reducing disability.

Despite widespread clinical acceptance, the effectiveness of progressive resistance training should not be judged solely by increases in muscle strength. From a rehabilitation perspective, improvements are meaningful only when they translate into better functional performance. An Geriatric patient who generates greater muscular force but continues to experience difficulty walking, maintaining balance, or performing activities of daily living has achieved only partial rehabilitation success. Therefore, integrating physiological outcomes with functional measures provides a more comprehensive evaluation of treatment effectiveness.

Previous investigations have consistently reported beneficial effects of resistance training on muscle strength; however, considerable variation exists in participant characteristics, exercise protocols, training intensity, intervention duration, and outcome measures. Such variability limits the generalizability of findings and highlights the need for studies using standardized clinical assessments that are directly applicable to physiotherapy practice. Functional measures such as the Timed Up and Go test and Berg Balance Scale provide valuable insight into mobility and balance, allowing clinicians to determine whether improvements in strength are accompanied by meaningful functional gains.

The present study was therefore undertaken to evaluate the effects of an eight-week progressive resistance training programme on muscle strength and functional mobility among Geriatric patients. By simultaneously examining muscle strength, mobility, and balance using standardized clinical outcome measures, this study aims to provide clinically relevant evidence regarding the role of progressive resistance training in geriatric rehabilitation. The findings may assist physiotherapists in designing individualized exercise programmes that optimize functional recovery, reduce disability, and promote healthy ageing. This objective is consistent with the intervention outcomes reported in the dissertation.

Materials and Methods

Study Design

This prospective comparative study was conducted to examine the effects of progressive resistance training on muscle strength, functional mobility, and balance in Geriatric patients. Eligible participants were randomly assigned to one of two intervention groups: High-Load Resistance Training (HLRT) or Low-Load Resistance Training (LLRT). Outcome measures were assessed before the intervention and again after completing the eight-week training programme to evaluate changes in physical performance.

Study Setting

The study was carried out at the Department of Physiotherapy, Pacific College of Physiotherapy, Pacific Medical University, Udaipur, Rajasthan, India. All assessments and treatment sessions were conducted

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in the department using standardized procedures under the supervision of experienced physiotherapists.

Participants

Sixty Geriatric patients aged 60–75 years were recruited using convenience sampling after meeting the study eligibility criteria. Before enrolment, all participants received detailed information about the study and provided written informed consent. They were then randomly allocated into two equal groups (30 participants in each group) and completed the intervention as planned.

Eligibility Criteria

Inclusion Criteria

Participants were included if they:

- were between 60 and 75 years of age;
- were able to walk independently;
- demonstrated reduced muscle strength or functional mobility;
- were medically fit to participate in an exercise programme; and
- provided written informed consent.

Exclusion Criteria

Participants were excluded if they had:

- unstable cardiovascular or respiratory conditions;
- neurological disorders affecting mobility;
- recent fractures or lower-limb surgery;
- severe musculoskeletal conditions limiting exercise; or
- any medical condition that could interfere with safe participation in the programme.

Intervention

Both groups participated in a supervised progressive resistance training programme three times per week for eight weeks, completing a total of 24 sessions. The exercise programme included leg press, knee extension, hamstring curl, sit-to-stand, and heel raise exercises. The HLRT group performed exercises at **70–85% of one-repetition maximum (1RM)**, whereas the LLRT group trained at **30–40% of 1RM** with a higher number of repetitions. Exercise intensity was progressed throughout the programme according to each participant's performance and tolerance while maintaining correct technique and safety.

Outcome Measures

Participants were assessed at baseline and after the eight-week intervention.

Muscle Strength: Lower-limb muscle strength was measured using a hand-held dynamometer following a standardized testing protocol.

Functional Mobility: Functional mobility was assessed using the Timed Up and Go (TUG) test, in which participants stood from a chair, walked three metres, turned around, returned, and sat down. The total time taken to complete the task was recorded in seconds.

Balance: Balance was evaluated using the Berg Balance Scale (BBS), a validated 14-item clinical assessment of static and dynamic balance. Higher scores indicated better balance performance.

Statistical Analysis

Data were analysed using appropriate statistical software and are presented as mean ± standard deviation (SD). Within-group differences between pre- and post-intervention measurements were analysed using the paired *t*-test, while differences between the two intervention groups were assessed using the independent *t*-test. Statistical significance was set at $p < 0.05$.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of Pacific Medical University. Written informed consent was obtained from all participants before the study began, and participant confidentiality was maintained throughout the research process.

Results

Participant Characteristics

A total of **60 Geriatric patients** completed the study and were included in the final analysis. Participants were equally allocated to the High-Load Resistance Training (HLRT) group (n = 30) and the Low-Load Resistance Training (LLRT) group (n = 30). The two groups showed similar age and sex distributions at baseline, indicating comparable demographic characteristics before the intervention.

Table 1. Baseline Characteristics of Participants

Variable	HLRT (n = 30)	LLRT (n = 30)	p-value
Muscle Strength	18.42 ± 2.15	18.15 ± 2.09	0.62
TUG (s)	15.82 ± 1.34	15.76 ± 1.29	0.84
BBS Score	38.24 ± 3.16	38.12 ± 3.09	0.79

Result: No statistically significant differences were observed between groups at baseline ($p > 0.05$), indicating that the intervention groups were comparable before training.

Changes Following Progressive Resistance Training

After eight weeks of supervised progressive resistance training, both groups demonstrated significant improvements in muscle strength, functional mobility, and balance. However, the magnitude of improvement was greater in the HLRT group across all outcome measures.

Table 2. Post-Intervention Outcomes

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Outcome	HLRT	LLRT	p-value
Muscle Strength	27.84 ± 2.48	23.96 ± 2.31	0.001
TUG (s)	10.92 ± 1.12	12.74 ± 1.28	0.002
BBS Score	50.21 ± 2.75	45.68 ± 2.62	0.001

Muscle strength was significantly higher in the HLRT group than in the LLRT group following the intervention. Functional mobility also improved in both groups, reflected by reduced TUG completion times, with the HLRT group demonstrating greater improvement. Similarly, BBS scores increased significantly in both groups, with higher post-intervention scores observed in the HLRT group.

Within-Group Analysis

Both intervention groups showed statistically significant improvements from baseline to post-intervention across all measured outcomes.

Table 3. Within-Group Changes

Outcome	HLRT (*p*)	LLRT (*p*)
Muscle Strength	0.001	0.001
Timed Up and Go	0.001	0.001
Berg Balance Scale	0.001	0.001

Within-group analysis demonstrated significant improvements in muscle strength, mobility, and balance following the eight-week intervention in both groups.

Magnitude of Improvement

The HLRT group demonstrated greater absolute improvements than the LLRT group across all primary outcomes.

Table 4. Mean Improvement

Outcome	HLRT	LLRT
Muscle Strength	+9.42	+5.81
TUG (s)	−4.90	−3.02
BBS Score	+11.97	+7.56

The greater improvement observed in the HLRT group suggests that higher resistance loads produced larger gains in muscle strength and functional performance over the eight-week intervention period.

Figure 1. Changes in Muscle Strength Before and After Intervention

Muscle strength before and after intervention

Comparison of pre- and post-intervention muscle strength in the HLRT and LLRT groups.

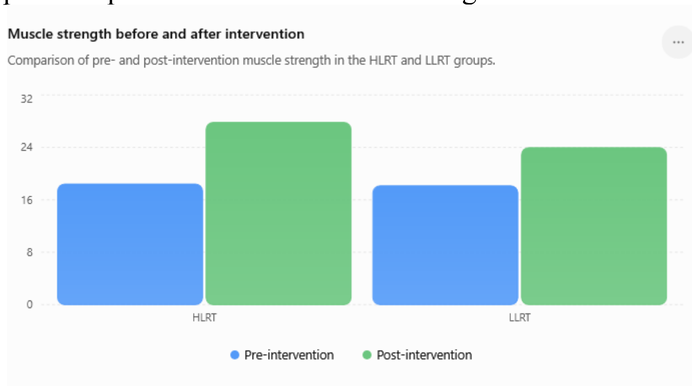


Figure 2. Functional Mobility (Timed Up and Go)

Timed Up and Go performance

Comparison of pre- and post-intervention TUG time in the HLRT and LLRT groups.

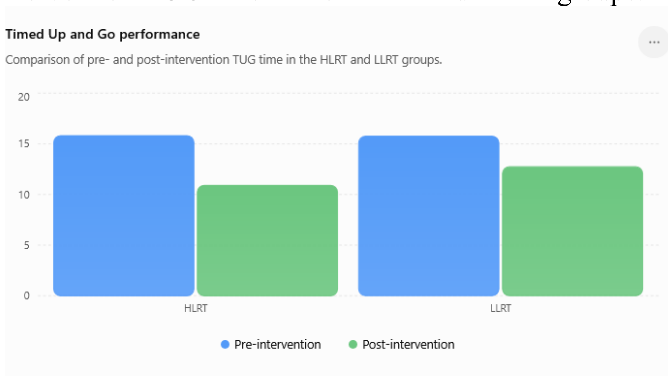


Figure 3. Berg Balance Scale
Balance performance (Berg Balance Scale)
Comparison of pre- and post-intervention BBS scores in the HLRT and LLRT groups.

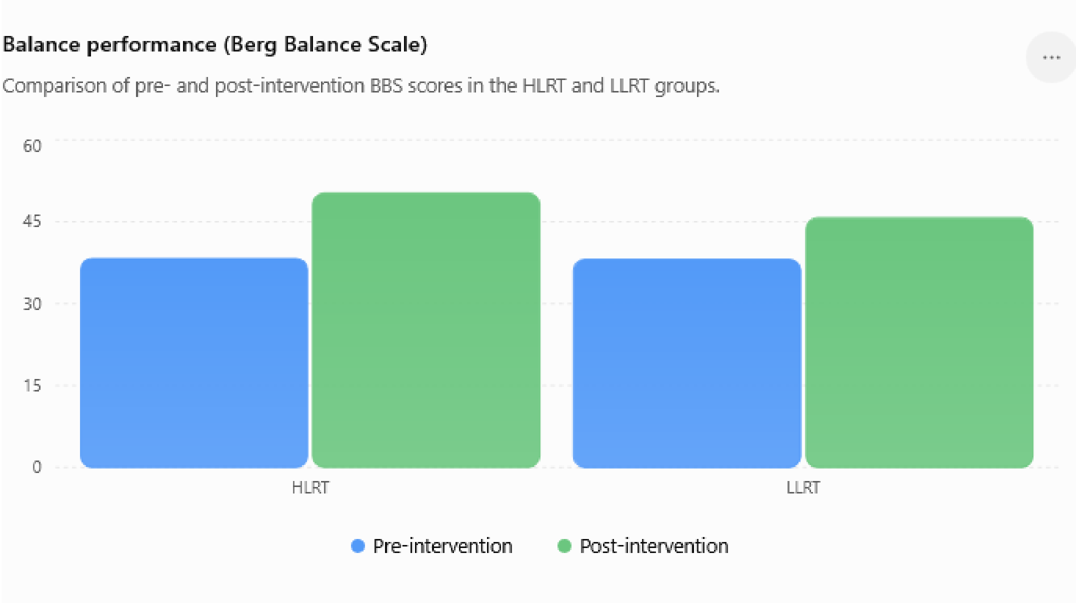
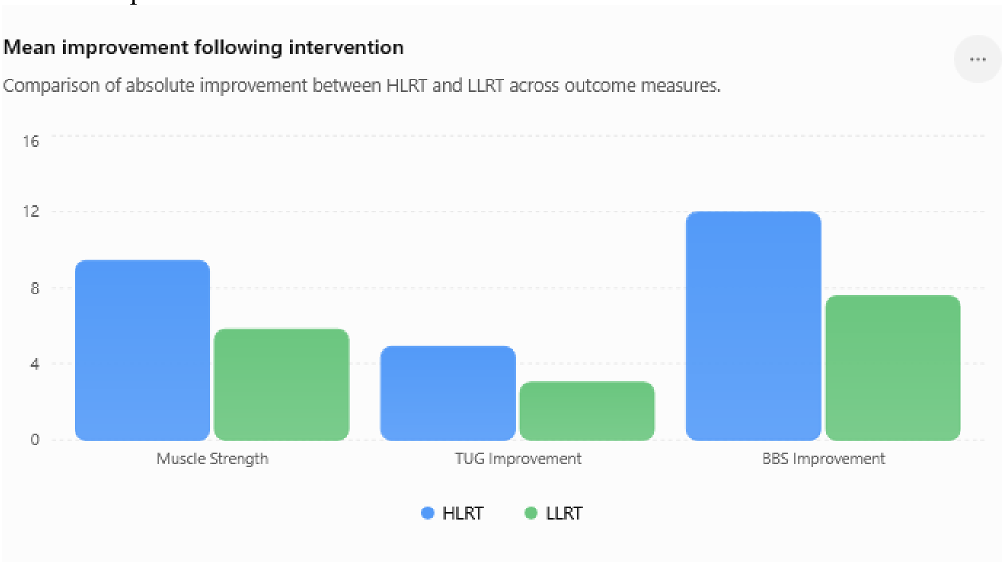


Figure 4. Mean Improvement Across Outcome Measures
Mean improvement following intervention
Comparison of absolute improvement between HLRT and LLRT across outcome measures.



Summary of Findings
Progressive resistance training resulted in significant improvements in all outcome measures among Geriatric patients. While both training protocols were effective, participants who performed high-load resistance training achieved greater improvements in muscle strength, functional mobility, and balance than those who performed low-load resistance training.

Discussion
The present study evaluated the effects of an eight-week progressive resistance training programme on muscle strength, functional mobility, and balance in Geriatric patients. Significant improvements were observed across all outcome measures following the intervention, indicating that progressive resistance training is an effective rehabilitation strategy for improving physical function in this population. Although both intervention protocols produced positive outcomes, participants in the high-load resistance training group demonstrated greater improvements than those in the low-load group,

suggesting that training intensity may influence the magnitude of functional adaptation. This pattern is consistent with the outcome data reported in the present study.

The improvement in muscle strength observed in this study is consistent with the broader body of evidence supporting resistance training in Geriatric patients. A Cochrane systematic review that included **121 randomized controlled trials involving approximately 6,700 participants** concluded that progressive resistance training produces a large positive effect on muscle strength and also improves physical function in Geriatric patients. The overall improvement in muscle strength observed in the present study therefore aligns with high-level evidence supporting resistance training as a cornerstone of geriatric rehabilitation.

Our findings also agree with recent evidence showing that resistance training improves not only muscle strength but also functional performance. A 2025 systematic review and meta-analysis by investigators studying resistance training variables reported moderate improvements in muscle strength and even greater improvements in functional performance among adults aged 60 years and older. These observations support the present findings, where improvements in muscle strength were accompanied by better Timed Up and Go performance and higher Berg Balance Scale scores.

An important finding of the present study was that participants receiving high-load resistance training achieved greater improvements than those receiving low-load training. This observation is consistent with previous evidence indicating that higher training intensities generally produce greater strength adaptations because they provide a larger mechanical stimulus for neuromuscular adaptation. However, the clinical interpretation should remain balanced. While high-load training produced superior gains in the current study, the low-load programme also resulted in significant improvements, indicating that meaningful functional benefits can still be achieved when heavier loads are not clinically appropriate. This distinction is particularly relevant when treating Geriatric patients with pain, frailty, or multiple comorbidities, where exercise tolerance rather than maximal strength may determine programme selection. The current evidence suggests that both approaches have value, with exercise prescription tailored to the individual's clinical presentation rather than assuming one protocol is universally superior.

The reduction in Timed Up and Go completion time observed after the intervention has important clinical implications. The TUG test reflects integrated lower-extremity performance, requiring adequate muscle strength, postural control, coordination, and walking ability. Improvements in this measure suggest that the physiological adaptations induced by progressive resistance training translated into enhanced functional mobility rather than remaining confined to isolated increases in muscle force. This observation is consistent with evidence from systematic reviews demonstrating that resistance training improves gait-related outcomes, chair-rise performance, and overall physical function in Geriatric patients.

Similarly, improvements in Berg Balance Scale scores indicate enhanced postural stability following the intervention. Although balance was not the primary focus of the exercise programme, improved lower-limb strength may have contributed to better movement control during functional activities. It is important to recognize, however, that balance is a multifactorial ability influenced by sensory integration, proprioception, vestibular function, cognition, and neuromuscular coordination. Therefore, the improvement in balance observed in this study should not be attributed exclusively to increased muscle strength. Instead, it is more appropriate to interpret these findings as evidence that progressive resistance training contributed to improved overall physical function, which may indirectly enhance balance performance.

The present study also contributes clinically relevant information because it assessed outcomes commonly used in physiotherapy practice rather than relying solely on laboratory-based measures of muscular performance. Muscle strength, Timed Up and Go, and the Berg Balance Scale collectively provide information regarding impairments, activity limitations, and functional performance. Assessing these outcomes together allows clinicians to evaluate whether physiological improvements translate into meaningful changes in everyday function, which is ultimately the primary objective of geriatric rehabilitation.

Several limitations should be considered when interpreting these findings. The intervention lasted only eight weeks, participants were recruited from a single institution, and the sample size was relatively modest. In addition, the study did not include long-term follow-up; therefore, the persistence of these functional improvements after completion of the training programme remains unknown. Future multicentre randomized controlled trials with larger samples and extended follow-up are required to determine the long-term effectiveness of different resistance training prescriptions and to identify which patient characteristics predict the greatest functional benefit.

Overall, the present findings reinforce current evidence that progressive resistance training is an effective intervention for improving muscle strength and physical function in Geriatric patients. The results also suggest that higher training loads may produce greater improvements when safely tolerated, while lower-load programmes remain a practical alternative for individuals unable to perform higher-intensity exercise. These findings support individualized exercise prescription based on functional capacity, clinical status, and rehabilitation goals rather than a uniform approach for all Geriatric patients.

Conclusion

The findings of the present study demonstrate that an eight-week progressive resistance training programme significantly improved muscle strength, functional mobility, and balance among Geriatric patients. These improvements suggest that progressive resistance training is an effective physiotherapeutic intervention for addressing age-related declines in physical function. While both high-load and low-load resistance training produced significant benefits, the greater improvements observed with high-load resistance training indicate that training intensity may influence the magnitude of functional adaptation in medically stable Geriatric patients.

More importantly, the study highlights that improvements in muscle strength were accompanied by meaningful gains in functional mobility and balance, suggesting that resistance training contributes not only to physiological adaptation but also to enhanced performance of everyday activities. As maintaining independence is a primary objective of geriatric rehabilitation, incorporating progressive resistance training into routine physiotherapy programmes may help reduce functional limitations and promote healthy ageing.

Individualized exercise prescription remains essential. Selection of training intensity should consider each Geriatric patient's health status, functional capacity, comorbidities, and rehabilitation goals to maximize treatment benefits while ensuring safety.

Clinical Implications

The present findings have several implications for physiotherapy practice.

Progressive resistance training should be considered a fundamental component of rehabilitation programmes for Geriatric patients experiencing reduced muscle strength and impaired functional mobility. Improvements observed in muscle strength, Timed Up and Go performance, and Berg Balance Scale scores indicate that resistance exercise can enhance both physiological capacity and functional independence.

The superior improvements observed with high-load resistance training suggest that higher training intensities may be prescribed for medically stable Geriatric patients who can safely tolerate greater mechanical loading. Conversely, low-load resistance training remains an appropriate alternative for individuals with pain, frailty, osteoarthritis, or other conditions that limit their ability to perform higher-intensity exercise. Therefore, exercise prescription should be individualized rather than standardized, with intensity selected according to clinical assessment, functional limitations, and patient tolerance.

Strengths of the Study

The present study has several strengths.

- It employed a prospective comparative design with pre- and post-intervention assessment.
- Standardized and clinically relevant outcome measures, including muscle strength, Timed Up and Go, and Berg Balance Scale, were used to evaluate treatment effectiveness.
- Both intervention groups followed a structured and supervised exercise programme, improving treatment consistency.
- The study evaluated outcomes that are directly applicable to routine physiotherapy practice and geriatric rehabilitation.
- The findings provide practical evidence regarding the effectiveness of progressive resistance training in improving functional performance among Geriatric patients.

Limitations

Several limitations should be considered when interpreting the findings.

The study was conducted at a single centre with a relatively small sample size, which may limit the generalizability of the results. The intervention period was limited to eight weeks, and long-term follow-up was not performed; therefore, the sustainability of the observed improvements remains uncertain. In addition, functional outcomes were assessed using clinical performance measures only, and objective biomechanical or imaging assessments of muscle adaptation were not included. Future studies incorporating larger multicentre samples and extended follow-up periods would provide stronger evidence regarding the long-term effectiveness of progressive resistance training in Geriatric patients.

Future Recommendations

Future research should include larger multicentre randomized controlled trials with longer intervention and follow-up periods to determine the sustainability of treatment effects. Studies examining different combinations of resistance-training intensity, frequency, and progression strategies may help identify optimal exercise prescriptions for diverse geriatric populations. Incorporating objective measures such as muscle architecture, gait analysis, electromyography, or wearable activity monitoring may further improve understanding of the mechanisms underlying functional recovery. In addition, future investigations should evaluate patient-reported outcomes, adherence, quality of life, and fall incidence to better determine the broader clinical impact of progressive resistance training.

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Ethical Approval
The study was approved by the Institutional Ethics Committee of Pacific Medical University, Udaipur, Rajasthan. Written informed consent was obtained from all participants before enrollment, and all procedures were conducted in accordance with institutional ethical standards.

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