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EFFECTIVENESS OF HIGH-LOAD VERSUS LOW-LOAD RESISTANCE TRAINING ON MUSCLE STRENGTH AND FUNCTIONAL PERFORMANCE IN GERIATRIC PATIENTS: A COMPARATIVE STUDY

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Abstract

Background

Age-related declines in skeletal muscle strength and functional performance are major contributors to frailty, impaired mobility, falls, and loss of independence among geriatric patients. Progressive resistance training is recognized as one of the most effective non-pharmacological interventions for preserving muscle function; however, the optimal training intensity for maximizing functional recovery remains uncertain. High-load resistance training (HLRT) has traditionally been recommended for improving maximal muscle strength, whereas low-load resistance training (LLRT) has emerged as a feasible alternative for geriatric patients with reduced exercise tolerance. Comparative evidence regarding the effectiveness of these two training strategies in geriatric rehabilitation remains limited.

Objective

To compare the effectiveness of high-load resistance training and low-load resistance training in improving muscle strength, functional mobility, and balance among geriatric patients.

Methods

A randomized comparative study was conducted at the Department of Physiotherapy, Pacific College of Physiotherapy, Pacific Medical University, Udaipur. Sixty participants aged 60–75 years were recruited using convenience sampling and randomly allocated into two groups: HLRT ($n = 30$) and LLRT ($n = 30$). Both groups underwent supervised resistance-training sessions three times per week for eight weeks. The HLRT group trained at 70–85% of one-repetition maximum (1RM), whereas the LLRT group trained at 30–40% of 1RM with higher repetitions. Muscle strength, functional mobility using the Timed Up and Go (TUG) test, and balance using the Berg Balance Scale (BBS) were assessed before and after the intervention. Paired *t*-tests were used for within-group comparisons and independent *t*-tests for between-group comparisons. Statistical significance was set at $p < 0.05$.

Results

Both intervention groups demonstrated statistically significant improvements in muscle strength, functional mobility, and balance following the eight-week training programme ($p < 0.001$). Baseline characteristics did not differ significantly between groups. Post-intervention analysis revealed significantly greater improvements in the HLRT group compared with the LLRT group. Mean muscle strength increased to 27.84 ± 2.48 in the HLRT group and 23.96 ± 2.31 in the LLRT group ($p = 0.001$). Mean TUG time decreased to 10.92 ± 1.12 seconds in the HLRT group and 12.74 ± 1.28 seconds in the LLRT group ($p = 0.002$). Mean BBS scores improved to 50.21 ± 2.75 in the HLRT group compared with 45.68 ± 2.62 in the LLRT group ($p = 0.001$). The HLRT group also demonstrated greater overall improvements in muscle strength (+9.42 vs. +5.81), TUG performance (−4.90 vs. −3.02 seconds), and BBS scores (+11.97 vs. +7.56) than the LLRT group.

Conclusion

Both high-load and low-load resistance training significantly enhanced muscle strength, functional mobility, and balance in geriatric patients. However, high-load resistance training produced superior improvements across all outcome measures, suggesting that it may be more effective for maximizing functional recovery in medically stable geriatric patients. Low-load resistance training remains a clinically valuable alternative for individuals who are unable to tolerate higher mechanical loads. These findings support individualized resistance-training prescriptions based on patient characteristics, rehabilitation goals, and exercise tolerance.

Introduction

The global population is ageing at an unprecedented rate, making healthy ageing one of the foremost public health priorities of the twenty-first century. Advances in healthcare, nutrition, and disease management have substantially increased life expectancy; however, these improvements have also resulted in a growing number of geriatric patients experiencing age-related declines in physical function. Maintaining functional independence rather than simply extending lifespan has therefore become a primary objective of geriatric healthcare. Declining physical performance adversely affects mobility, balance, participation in activities of daily living (ADLs), and overall quality of life, increasing the burden on healthcare systems and caregivers. Consequently, effective rehabilitation strategies that preserve muscle function and mobility are essential for promoting healthy ageing.

One of the most significant physiological consequences of ageing is the progressive decline in skeletal muscle mass, muscle strength, and neuromuscular performance, collectively referred to as sarcopenia. Muscle strength declines more rapidly than muscle mass and has been identified as a stronger predictor of disability, hospitalization, falls, frailty, and mortality in geriatric patients. Reduced lower-extremity strength compromises gait speed, stair climbing, chair-rise ability, postural stability, and balance, ultimately leading to functional dependence and reduced participation in community activities. Because skeletal muscle plays a central role in maintaining mobility and independence, interventions that preserve or improve muscle function have become a cornerstone of evidence-based geriatric rehabilitation.

Progressive resistance training is widely recognized as one of the most effective exercise interventions for improving muscular strength, neuromuscular function, and physical performance in geriatric patients. Unlike aerobic exercise, resistance training provides an external mechanical stimulus that promotes muscle protein synthesis, enhances motor-unit recruitment, improves neural activation, and increases force-generating capacity. These physiological adaptations contribute not only to improvements in maximal muscle strength but also to enhanced balance, gait efficiency, mobility, and performance of functional tasks required for independent living. Consequently, resistance training has been consistently recommended as a first-line physiotherapeutic intervention for preventing or reducing age-related functional decline. The dissertation similarly identifies resistance training as a primary intervention to improve strength, balance, and functional performance in geriatric patients.

Resistance-training programmes can be prescribed using different combinations of exercise intensity, training volume, repetition range, and frequency. Among these variables, training intensity remains one of the most debated factors influencing rehabilitation outcomes in geriatric patients. High-load resistance training (HLRT), typically performed at approximately 70–85% of one-repetition maximum (1RM), has traditionally been considered the gold standard for maximizing muscle strength because higher mechanical loading recruits a greater proportion of high-threshold motor units and stimulates substantial neuromuscular adaptations. Numerous investigations have demonstrated that HLRT produces significant improvements in maximal strength, muscle quality, and functional capacity, making it a preferred intervention for healthy geriatric patients capable of tolerating heavier loads.

Despite these advantages, the clinical application of HLRT in geriatric rehabilitation may be limited by several factors. Geriatric patients frequently present with osteoarthritis, osteoporosis, chronic musculoskeletal pain, cardiovascular disease, or reduced exercise tolerance, all of which may affect their ability to safely perform high-intensity resistance exercises. Increased joint loading, greater cardiovascular demand, and higher perceived exertion may reduce adherence to exercise programmes or increase the risk of adverse events in medically compromised individuals. Therefore, although HLRT is highly effective for improving strength, it may not be appropriate for every older adult receiving physiotherapy.

Low-load resistance training (LLRT), generally performed at 30–40% of one-repetition maximum with higher repetitions, has emerged as an alternative strategy that places less mechanical stress on joints while still promoting meaningful neuromuscular adaptations. By increasing training volume rather than external load, LLRT may improve muscular endurance, functional capacity, and exercise adherence while minimizing discomfort and perceived effort. Because of these characteristics, LLRT is increasingly prescribed for frail geriatric patients, individuals with pain, and patients who are unable to tolerate conventional heavy resistance exercise. The dissertation describes LLRT using these loading characteristics and positions it as a potentially safer alternative for geriatric patients with reduced exercise tolerance.

Although both HLRT and LLRT have demonstrated beneficial effects on muscular performance, evidence comparing their relative effectiveness in geriatric rehabilitation remains inconsistent. Previous investigations have reported that HLRT generally produces greater improvements in maximal muscle strength, whereas LLRT may achieve comparable improvements in muscle hypertrophy when sufficient training volume or exercise to fatigue is performed. However, muscular strength alone does not fully explain functional recovery. Successful rehabilitation in geriatric patients depends on improvements in mobility, balance, gait performance, and the ability to perform activities of daily living independently. Therefore, evaluating the clinical effectiveness of resistance training requires assessment of both physiological and functional outcomes.

Another limitation of the existing literature is the heterogeneity of exercise protocols, intervention duration, participant characteristics, and outcome measures used across studies. Many investigations have focused on healthy community-dwelling geriatric patients, whereas fewer studies have examined structured resistance-training programmes within physiotherapy settings using standardized functional outcome measures. Furthermore, direct comparisons between HLRT and LLRT using clinically meaningful measures such as muscle strength, Timed Up and Go (TUG), and Berg Balance Scale (BBS) remain relatively limited. This lack of consistent evidence creates uncertainty regarding the optimal resistance-training intensity for maximizing functional recovery in geriatric patients. The dissertation similarly identifies the limited direct comparison of HLRT and LLRT in geriatric rehabilitation as the principal research gap.

The present study was therefore undertaken to compare the effectiveness of high-load and low-load resistance training in improving muscle strength, functional mobility, and balance among geriatric patients. By evaluating changes in muscle strength together with clinically relevant functional outcomes following an eight-week supervised intervention, this study aims to provide evidence that may assist physiotherapists in selecting individualized resistance-training programmes according to patient characteristics, rehabilitation goals, and exercise tolerance. The findings are expected to contribute to evidence-based geriatric physiotherapy by clarifying the relative clinical effectiveness of different resistance-training intensities and supporting the development of safe, effective, and patient-centred rehabilitation strategies for the ageing population.

Materials and Methods

Study Design

A comparative study was conducted to compare the effects of High-Load Resistance Training (HLRT) and Low-Load Resistance Training (LLRT) on muscle strength and functional performance in geriatric patients.

Study Setting

The study was conducted at the Department of Physiotherapy, Pacific College of Physiotherapy, Pacific Medical University, Udaipur, Rajasthan, India.

Participants

Sixty participants aged 60–75 years were recruited using convenience sampling and randomly allocated into two groups: HLRT (n = 30) and LLRT (n = 30).

Intervention

Both groups underwent supervised resistance training three times per week for eight weeks (24 sessions). The HLRT group trained at **70–85% of 1RM** (3 sets, 8–12 repetitions), whereas the LLRT group trained at **30–40% of 1RM** (3 sets, 18–25 repetitions). Both groups performed leg press, knee extension, hamstring curl, sit-to-stand, and heel raise exercises.

Outcome Measures

The primary outcome was **muscle strength**,

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assessed using a hand-held dynamometer. Secondary outcomes included **Timed Up and Go (TUG)** for functional mobility and **Berg Balance Scale (BBS)** for balance. Assessments were performed before and after the intervention.

Statistical Analysis

Data were analyzed using descriptive statistics (mean ± SD). Paired *t*-tests were used for within-group comparisons, and independent *t*-tests were used for between-group comparisons. Statistical significance was set at **$p < 0.05$**.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee of Pacific Medical University. Written informed consent was obtained from all participants before enrollment.

Results

Participant Characteristics

A total of 60 geriatric patients completed the study and were randomly allocated into two groups: High-Load Resistance Training (HLRT, n = 30) and Low-Load Resistance Training (LLRT, n = 30). Both groups had comparable age and gender distributions, with no statistically significant differences at baseline.

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 (seconds)	15.82 ± 1.34	15.76 ± 1.29	0.84
BBS Score	38.24 ± 3.16	38.12 ± 3.09	0.79

Interpretation: No significant baseline differences were observed between the groups ($p > 0.05$).

Table 2. Post-Intervention Outcomes

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

The HLRT group demonstrated significantly greater improvements in muscle strength, functional mobility, and balance compared with the LLRT group following the 8-week intervention.

Table 3. Within-Group Changes

Outcome	HLRT (*p*)	LLRT (*p*)
Muscle Strength	<0.001	<0.001
TUG	<0.001	<0.001
BBS	<0.001	<0.001

Both groups showed statistically significant improvements from baseline to post-intervention across all outcome measures.

Table 4. Mean Improvement Between Groups

Outcome	HLRT	LLRT	p-value
Muscle Strength	+9.42	+5.81	0.001
TUG (seconds)	−4.90	−3.02	0.003
BBS Score	+11.97	+7.56	0.001

The HLRT group achieved significantly greater improvements than the LLRT group in all outcome measures after eight weeks of training.

Main Findings

Both resistance-training protocols significantly improved muscle strength, functional mobility, and balance among geriatric patients. However, participants receiving **high-load resistance training** demonstrated significantly greater improvements than those receiving **low-load resistance training**, supporting the superiority of higher training intensity for enhancing physical function in this study population.

Discussion

The present study compared the effects of high-load resistance training (HLRT) and low-load resistance training (LLRT) on muscle strength, functional mobility, and balance in geriatric patients. Following an eight-week supervised intervention, both groups demonstrated significant improvements in all outcome measures; however, participants receiving HLRT achieved significantly greater improvements than those receiving LLRT. These findings support the effectiveness of progressive resistance training in geriatric rehabilitation while suggesting that higher training intensities may provide superior functional benefits in medically stable geriatric patients.

The most notable finding of this study was the significantly greater increase in muscle strength observed in the HLRT group. Muscle strength improved from 18.42 ± 2.15 to 27.84 ± 2.48 in the HLRT group, compared with 18.15 ± 2.09 to 23.96 ± 2.31 in the LLRT group. These findings indicate that although both interventions effectively enhanced muscular performance, higher mechanical loading produced a greater magnitude of strength adaptation. This is consistent with the principle that greater external loading promotes increased motor-unit recruitment, neural adaptation, and force-generating capacity.

Our findings are consistent with previous systematic reviews reporting that resistance training improves muscle strength in geriatric patients and that higher training intensities generally produce larger improvements in maximal strength than lower-load protocols. Recent evidence also indicates that while low-load resistance training can improve strength, particularly when performed with sufficient effort, heavy resistance training remains advantageous for maximizing strength development.

Functional mobility, assessed using the Timed Up and Go (TUG) test, improved significantly in both intervention groups. However, the HLRT group demonstrated a greater reduction in TUG completion time than the LLRT group, indicating superior improvement in mobility and lower-extremity function. Improvements in TUG performance are clinically important because they reflect enhanced walking ability, transitional movements, and reduced fall risk. These improvements likely resulted from increased lower-limb strength, which facilitates more efficient performance of functional tasks.

Similarly, balance performance measured using the Berg Balance Scale improved significantly following both interventions, with significantly greater gains observed in the HLRT group. Improved balance may be explained by enhanced neuromuscular coordination, increased lower-limb force production, and improved postural control following progressive resistance exercise. Since impaired balance is a major contributor to falls among geriatric patients, these findings have important implications for fall-prevention strategies in geriatric physiotherapy.

Although HLRT produced superior improvements, LLRT also resulted in statistically significant gains in muscle strength, mobility, and balance. This suggests that LLRT remains a clinically valuable intervention, particularly for geriatric patients with pain, frailty, osteoarthritis, or reduced tolerance to high mechanical loads. Recent reviews indicate that low-load training may provide meaningful improvements in muscular function and may be especially useful when high-load exercise is not feasible, although the certainty of evidence varies across studies.

The clinical implications of these findings are important for physiotherapists working with geriatric patients. High-load resistance training may be considered the preferred intervention for medically stable individuals who can safely tolerate higher exercise intensities. Conversely, low-load resistance training provides a practical and effective alternative for individuals with greater physical limitations. Therefore, resistance-training intensity should be individualized according to each patient's medical condition, functional capacity, rehabilitation goals, and exercise tolerance rather than applying a single approach to all geriatric patients.

The present study has several strengths, including its randomized comparative design, equal group allocation, standardized intervention protocol, and the use of clinically relevant outcome measures such as muscle strength, the Timed Up and Go test, and the Berg Balance Scale. Nevertheless, some limitations should be acknowledged. The study was conducted at a single centre with a relatively small sample size and an intervention period of only eight weeks. Long-term follow-up was not performed, preventing assessment of whether the observed improvements were sustained after completion of the training programme. Future multicentre randomized controlled trials with larger samples and extended follow-up periods are recommended to determine the long-term effectiveness of different resistance-training intensities in geriatric rehabilitation.

Clinical Implications

The findings of this study support the integration of progressive resistance training into routine geriatric physiotherapy. High-load resistance training may be recommended for medically stable geriatric patients to optimize muscle strength, mobility, and balance, whereas low-load resistance training provides a safe and effective alternative for individuals with reduced exercise tolerance. Individualized exercise prescription based on functional capacity and clinical presentation may enhance rehabilitation outcomes and promote healthy ageing.

Strengths

- Randomized comparative study design.
- Supervised eight-week intervention programme.
- Equal group allocation with comparable baseline characteristics.
- Use of validated functional outcome measures (TUG and BBS).
- Clinically relevant findings applicable to geriatric physiotherapy practice.

Limitations

- The study included a relatively small sample size.
- Participants were recruited from a single centre, limiting generalizability.
- The intervention period was limited to eight weeks.
- Long-term follow-up was not performed to determine the sustainability of treatment effects. These limitations are consistent with those acknowledged in the dissertation.

Conclusion

Both high-load and low-load resistance training significantly improved muscle strength, functional mobility, and balance among geriatric patients following an eight-week supervised exercise programme. However, high-load resistance training resulted in significantly greater improvements across all outcome measures, indicating that it may be the preferred intervention for medically stable geriatric patients requiring maximal functional recovery. Low-load resistance training remains an effective alternative for individuals who cannot tolerate heavier resistance, emphasizing the importance of individualized exercise prescription in geriatric rehabilitation. These findings support the incorporation of progressive resistance training into evidence-based physiotherapy programmes aimed at preserving mobility, independence, and quality of life in the ageing population.

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Author Contributions

JohnyKharediya: Conceptualization, methodology, participant recruitment, data collection, formal analysis, investigation, manuscript preparation, and original draft writing.
Dr. Sourabh Soni: Study supervision, methodology development, critical review of the manuscript, scientific editing, and final approval of the manuscript.

Ethical Approval

The study was approved by the Institutional Ethics Committee of Pacific Medical University, Udaipur, Rajasthan. All procedures involving human participants were conducted in accordance with institutional ethical standards. Written informed consent was obtained from all participants prior to enrolment.

Informed Consent

Written informed consent was obtained from all participants before inclusion in the study.

Abbreviations

Abbreviation	Full Form

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Abbreviation	Full Form
HLRT	High-Load Resistance Training
LLRT	Low-Load Resistance Training
1RM	One-Repetition Maximum
TUG	Timed Up and Go
BBS	Berg Balance Scale
SD	Standard Deviation
ADL	Activities of Daily Living

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