

Original Research Article

Enhancing Arm Strength with High and Low Repetition Training

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Abstract: Arm strength is critical for functional movement, athletic performance, and overall fitness. This quasi-experimental study compared the effectiveness of two resistance training protocols—high-repetition, light-load (HRLL) and low-repetition, heavy-load (LRHL)—in improving arm strength among 57 male engineering students enrolled in PATHFit courses at a state university in Surigao del Sur. Anchored in Neuromuscular Adaptation Theory and the Specificity Principle, participants were assigned to HRLL ($n = 30$) or LRHL ($n = 27$) groups and completed a six-week training program involving functional upper-body exercises. Pre- and post-intervention arm strength was measured using the USFD Push-up Test, with performance converted to estimated one-repetition maximum (1RM) via the Epley formula. Both protocols resulted in statistically significant improvements in muscular strength ($p < .05$), but ANCOVA results showed that HRLL yielded more substantial gains ($F(1, 86) = 427.608, p < .001, \eta_p^2 = 0.888$). These findings challenge the conventional belief that low-repetition heavy-load training is superior for strength development. HRLL protocols appear particularly advantageous for beginners or individuals with limited training experience, due to their reduced injury risk, enhanced adherence, and improved neuromuscular efficiency. This study supports the integration of high-repetition training into tertiary physical education, aligning with CHED's inclusive fitness goals and contributing to SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education). Ultimately, the research underscores the importance of adaptable, evidence-based training approaches that cater to diverse learner needs in both academic and recreational fitness contexts.

Keywords: Arm strength, high repetition training, low repetition training, resistance exercise, PATHFit

Introduction

Globally, resistance training research has increasingly questioned the traditional emphasis on low repetition, heavy-load exercise models. The “repetition continuum” posits that different loading schemes yield distinct physiological adaptations, i.e., heavy loads maximize strength, moderate loads enhance hypertrophy, and light loads improve muscular endurance (Schöenfeld *et al.*, 2021). Recent studies, however, suggest that high-repetition, low-load resistance training (HRLL) may also generate meaningful strength improvements through neural adaptations and reduced fatigue (Painter *et al.*, 2020). Beyond fatigue resistance and hypertrophy, HRLL is thought to be beneficial for cardiovascular health and to reduce the risk of injury (Ben-Zeev *et al.*, 2024; Grzyb *et al.*, 2020; João *et al.*, 2021), making it a multifaceted training regimen.

Despite the emerging evidence favoring HRLL, resistance training studies have mostly focused on high-load, low-repetition strategies (at the expense of greater muscle hypertrophy), while frequently disregarding the strength-enhancing potential of high-repetition protocols (Grgić *et al.*, 2020; Schöenfeld *et al.*, 2021). This gap is especially important for those who are not used

to lifting, such as beginners or those in the rehabilitation phase. In the Philippines, strength training is mainly influenced by sports such as boxing and basketball, where maximal strength is developed using heavy weights (Galam 2022). Nevertheless, recent and evolving institutional practices and increasing awareness of diversity within the field of training (Jacomina *et al.*, 2024) demand more inclusive, flexible, and evidence-based PE to respond to a variety of learner needs and contexts.

Addressing this knowledge gap is consistent with the Commission on Higher Education (CHED) Memorandum Order No. 39, Series of 2021, which emphasizes inclusive and culturally relevant PE practices at the tertiary level (Commission on Higher Education, 2021). Additionally, this research contributes to the achievement of SDGs 3 and 4, specifically Good Health and Well-being, and Quality Education, by examining training procedures that are effective in increasing participation, preventing injuries, and promoting lifelong physical activity. Knowledge on the effectiveness of HRLL in strength development is important not only for refining physical education practices but also for creating inclusive and responsive fitness programming for Filipino learners (Engwerda *et al.*, 2020; Kato *et al.*, 2023; Martorelli *et al.*, 2020; Whittal *et al.*, 2020).

This investigation is grounded in a multifaceted theoretical framework that seeks to assess the efficacy of high-repetition, light-load (HRLL) and low-repetition, heavy-load (LRHL) resistance training for improving arm muscle strength. HRLL is based on the Metabolic Stress and Neural Adaptation theories, which involve hormonal responses and neuromuscular control resulting from submaximal repeated efforts (Fardi *et al.*, 2022; Naderi *et al.*, 2020). In turn, LRHL is underpinned by the Size Principle, Specificity Principle, and Mechanical Tension Theory, with all three emphasizing the relevance of maximal load and neural activation for force production (Joyce *et al.*, 2024; Schöenfeld *et al.*, 2021; Vossel *et al.*, 2023). With these, the study employed functional exercise interventions to test these mechanisms using overhead presses, rows, and lateral raises with varying rep-load protocols among college students.

As such, the primary objective of this investigation is to compare the efficacy of HRLL and LRHL resistance exercises in improving arm musculoskeletal resistance strength. It tests whether there is a fundamental difference between the two protocols before and after the intervention and assesses which of the two strategies provides a better outcome. The study's outcomes will provide practical implications for students and teachers in Physical Education, promote evidence-based work around strength development, and contribute to the literature by presenting inclusive resistance training schemes in school and sports environments.

Methods and Materials

This study employed a quasi-experimental, pretest-posttest non-equivalent group design to investigate the effectiveness of two resistance training protocols, high-repetition, light-load and low-repetition, heavy-load, in enhancing arm strength among tertiary-level students. Given the academic setting and logistical limitations in randomly assigning participants, this design was deemed suitable for maintaining ecological validity while enabling structured intervention comparisons (Rambe *et al.*, 2022; Tian & Chunara, 2020). The design has proven effective in similar applied research contexts in education and health sciences (Lapui *et al.*, 2023; Pamungkas, 2022), supporting its appropriateness for this study.

A total of 57 students participated in the study, with Group 1 ($n = 30$) performing the high-repetition, light-load protocol and Group 2 ($n = 27$) performing the low-repetition, heavy-load protocol. Participation criteria required that respondents be at least 18 years of age, enrolled in the course, taught by the researcher, and medically capable of performing the exercises. This purposive sampling helped ensure that participants were closely matched, context-rich, and had similar academic backgrounds in their studies, thereby minimizing variations and maximizing comparability.

The USFD Strength and Endurance Push-Up Test, as described by Gomez (2025), was the primary data-gathering tool, which includes the Epley formula for predicting one-repetition maximum (1RM) from push-up performance. This technique considers the average push-up load, which is the average between two conditions: when the arms are straight and when they are bent or in a forearm plank position. It also takes into account the number of repetitions performed. This approach provides a more accurate and personalized estimate of muscle strength compared to using absolute counts. During the testing protocol, all testing was conducted at a standardized 3-second cadence, and participants were familiarized to aid in the reliability and quality of the data that was collected.

The validity and reliability of the push-up protocol were demonstrated. The Epley-transformed scores also showed a strong concurrent validity with the seated chest press 1RM test ($r = 0.781$) and high test-retest reliability ($r = 0.91$), indicating the validity and consistency of the instrument. The design of the protocol minimized extraneous factors, such as pacing variation and fatigue, that affected the reliability of pre- and post-training measurements of strength compared with the two training methods (Gomez, 2025).

Scoring was based on percentile rank and developed using pilot data collected from 180 students. According to 1RM values, five performance levels were created: Outstanding (62.4–75.0 kg), Very Good (51.6–62.3 kg), Good (44.6–51.5 kg), Fair (37.7–44.5 kg), and Poor (24–37.6 kg). This categorization provided a general quantification of mass-normalized muscular strength, supporting comparisons between subjects.

The study received ethical clearance from the Lourdes College Research Ethics Committee (LC-REC) and was also granted preliminary approval from school authorities. An informed consent form explaining the purpose, procedures, benefits, and risks associated with study participation was provided to participants. A pre-intervention orientation and health screening were conducted, and a pilot test was used to refine implementation processes. All procedures adhered to the ethical principles of Belmont Report (i.e., respect for persons, beneficence, and justice), protecting the welfare and privacy of participants during the study.

The intervention lasted six weeks and consisted of structured exercise protocols tailored to the two groups. The high-repetition group performed lateral raises, overhead dumbbell presses, and dumbbell rows with two 500 ml water bottles, increasing the number of repetitions from 30 to 50 per set each week. The low-repetition group performed similar exercises using two 1-liter bottles filled with sand or gravel, increasing resistance every two weeks, while performing 8–10 repetitions per set. During each training session, warm-up and cool-down activities were incorporated, and the researcher and trained assistants closely observed the exercise performance to ensure correct execution and adherence to the training regimen. The objective was to compare endurance-focused versus intensity-focused training strategies in enhancing arm strength.

To evaluate outcomes, descriptive statistics were used to summarize arm strength levels before and after the intervention. Paired samples t-tests assessed within-group improvements, while Analysis of Covariance (ANCOVA) was applied to compare posttest results between groups, controlling for pretest scores. All statistical tests were conducted at a 0.05 level of significance to determine the effectiveness of each resistance training protocol.

Results

Results are presented based on the research questions: (1) What is the arm strength of the two groups before and after the intervention? (2) Do the two groups' arm strength significantly differ before and after the interventions? And (3) Which of the interventions is more effective in enhancing the participants' arm strength? Tables 1, 2, and 3 (see p. 41) summarize descriptive statistics, within-group comparisons, and between-group comparisons. All tables are referenced and discussed within the text.

In Group A, the mean performance increased from 52.44 kg (SD = 12.81) in the pretest to 58.20 kg (SD = 13.96) in the posttest, reflecting a gain of 5.76 kg. Similarly, Group B showed an increase from 55.87 kg (SD = 14.13) to 59.18 kg (SD = 13.89), with a mean difference of 3.31 kg. Both training modalities resulted in improvements but remained within the *very good* category before and after the intervention. The consistency in standard deviations across test periods suggests that participant scores remained comparably dispersed, even as overall performance improved.

For the HRLL group, the mean score significantly increased from 52.439 kg (SD = 12.814) to 58.202 kg (SD = 13.955), with a $t(29) = -8.365$, $p < .001$, and a large effect size of Cohen's $d = -1.527$. Similarly, the LRHL group showed a significant improvement from 55.869 kg (SD = 14.129) to 59.178 kg (SD = 13.890), $t(26) = -3.122$, $p < 0.004$, with a Cohen's d of -0.601 , indicating a moderate to large effect. These findings confirm that the null hypothesis, stating there is no significant difference between the pretest and posttest scores for both training groups, is rejected. Thus, it can be concluded that both high- and low-repetition training programs significantly enhanced participants' performance from pretest to posttest.

As shown in Table 3, the ANCOVA revealed a statistically significant difference in posttest scores between the two training groups after controlling for pretest scores, $F(1, 86) = 427.608$, $p < .001$, with a partial eta squared (η_p^2) of 0.888, indicating a very large effect size. Given this result, the null hypothesis (H_{02}) that none of the interventions is more effective is rejected. Therefore, it can be concluded that the HRLL training was significantly more effective in enhancing participants' arm strength compared to the LRHL training.

Discussion

The analysis of pretest and posttest scores revealed that both the HRLL (Group A) and LRHL (Group B) resistance training protocols significantly improved participants' arm strength, shifting their average performance from the *very good* category to the same category after the intervention. These findings align with the existing literature, which highlights the effectiveness of both high and low repetition training in untrained individuals, driven by mechanisms such as neuromuscular adaptation, motor unit recruitment, and progressive overload. High-repetition training likely enhanced local muscular endurance and stimulated

hypertrophy through metabolic stress, while low-repetition training facilitated strength gains via maximal tension and neural adaptations. The 'Fair' strength rating at baseline was indicative of a likely absence of previous structured resistance training among participants, as well as supporting a requirement for exercise interventions in academic institutions. Both protocols led to strength improvements, and therefore, implying that one size does not fit all. Each protocol can be effective when consistent effort and load management are applied. These findings are a powerful argument for including a broad range of evidence based training methods in physical education to meet different needs, preferences, and fitness levels.

In addition, the results also indicate that both HRLL and LRHL training paradigms led to a significant increase in arm muscle strength from pre to post, demonstrating that both strength training techniques similarly increased strength. The results are consistent with theories such as the Specificity Principle and Neuromuscular Adaptation theory, which suggests that varying the resistance training protocols can target different adaptation pathways: muscular endurance for high repetitions and maximal strength for low repetitions. These findings are supported by previous studies (Gäbler *et al.*, 2021; Nugent *et al.*, 2022; Schöenfeld *et al.*, 2021), which indicate that both modalities are effective for strength development, provided that training is structured and progressive. These outcomes support the need for an adaptable individualized resistance training prescription, where load and volume can be manipulated without attenuating muscular strength outcomes, especially in untrained or moderately trained cohorts.

Furthermore, the results of the ANCOVA also established that HRLL training was significantly more effective than LRHL training for increasing arm strength. While the raw posttest means of the groups are close, the adjusted analysis shows that the high repetition group makes more reliable and statistically significant gains. High-repetition, low-load training may therefore have significant potential for untrained individuals, as it can improve neuromuscular efficiency, increase participant adherence, reduce the fear of injury, and enhance local muscular endurance through mechanisms such as time under tension or metabolic stress. Informed by the Neuromuscular Adaptation Theory and the Specificity Principle, the results align with previous research (e.g., Nugent *et al.*, 2022; Schöenfeld *et al.*, 2020), which supports the notion that high-repetition protocols provide a scalable and effective means of developing strength in different populations.

Conclusion

In this study, the researcher examined the effects of HRLL resistance training and LRHL resistance training on arm muscle strength in young, untrained participants. Recognizing the decline in upper limb strength in this population and the ongoing debate over optimal training strategies, the study aimed to identify accessible and practical approaches suitable for various groups, including beginners and those undergoing rehabilitation.

Grounded in neuromuscular adaptation theory and principles, such as specificity and progressive overload, the research addressed three key questions: baseline strength levels, intra-group changes, and the relative effectiveness of each intervention. Employing a quasi-experimental, pretest-posttest design with non-equivalent groups, college student participants engaged in progressive overload training, and arm strength was assessed using the USFD Push-up Test, converted to 1RM through Epley's formula. Data were analyzed using descriptive statistics, paired samples t-tests, and ANCOVA, with findings offering insights into evidence-based and adaptable resistance training methods.

The findings suggest that while both resistance training interventions can induce improvements in arm strength, incorporating high-repetition, light-load resistance training into PATHFit courses and fitness programs can offer a safer, more accessible, and more effective approach for enhancing muscular strength, especially among beginners and populations with limited training experience.

Conflict of Interest: *The author declares that there is no conflict of interest regarding the publication of this article.*

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Ethical Approval: The study was reviewed and approved by the Institutional Ethics Committee of the researcher's academic institution, adhering to the ethical standards outlined in the Belmont Report. Informed assent was obtained from student participants, alongside written parental consent, ensuring full ethical compliance.

AI Declaration: This study utilized artificial intelligence tools to assist in the preparation of this article. Specifically, ChatGPT was used to convert the full thesis manuscript into a reduced journal article format with human supervision and editing, ensuring academic rigor and integrity. Additionally, Grammarly AI was used to enhance the language quality, clarity, and tone of the final manuscript. All outputs were carefully reviewed and edited by the authors to maintain scholarly standards.

Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Access requests will be evaluated by ethical guidelines and data privacy policies.

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Table 1

Descriptive Statistics of Pretest and Posttest Scores by Performance Category for High and Low Repetition Trainings

			Group A				Group B			
			Handgrip Strength Exercises				Balance Exercises			
Range			Pretest		Posttest		Pretest		Posttest	
(kg)		Description	f	%	F	%	f	%	f	%
62.4	75	Outstanding	6	20.0	12	40.0	7	25.9	10	37.0
51.5	62.3	Very Good	10	33.3	9	30.0	11	40.7	11	40.7
44.6	51.5	Good	5	16.7	3	10.0	3	11.1	2	7.4
37.7	44.5	Fair	6	20.0	4	13.3	2	7.4	3	11.1
24	37.6	Poor	3	10.0	2	6.7	4	14.8	1	3.7
TOTAL			30	100	30	100	27	100	27	100
Mean			52.44		58.20		55.87		59.18	
Description			Very Good		Very Good		Very Good		Very Good	
Standard Deviation			12.81		13.96		14.13		13.89	

Table 2

Paired Samples T-test Results Comparing Pretest and Posttest Scores for High and Low Repetition Trainings

Groups	Pretest		Posttest		df	t	p	Cohen's d
	M	SD	M	SD				
High Repetition Light-Load Training	52.439	12.814	58.202	13.955	29	-8.365*	<.001	-1.527
Low Repetition, High -Load Training	55.869	14.129	59.178	13.890	26	-3.122*	0.004	-0.601

* Significant at 0.05 level.

Table 3

Analysis of Covariance Results for Posttest Scores Controlling for Pretest

Groups	Pretest		Posttest		F(1,86)	p	η_p^2
	M	SD	M	SD			
High Repetition Light-Load Training	52.439	12.814	58.202	13.955	427.608*	<.001	0.888
Low Repetition, High -Load Training	55.869	14.129	59.178	13.890			

*Significant at 0.05 level.