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A Systematic Review about Results of Low Load on Resistance Training for Muscle Hypertrophy.

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ABSTRACT

Background & Aims: *This review investigated systematically if high loads are superior to low loads in muscle hypertrophy, considering the volume load applied. The bibliographic review used on this work was based on existing clinical trials about volume load and muscle hypertrophy, where compared low-load and high-load in individuals with or not resistance training experience.*

Methods: *PubMed database up to the 31th of December 2024. The search was performed using a Boolean search strategy (operators "AND" and "OR") and a combination of the following keywords: ("high load" OR "low load" OR "load" OR "volume load" OR "muscle hypertrophy" OR "hypertrophy" OR "muscle") AND ("hypertrophy load" OR "muscle architecture" OR "cross sectional area" OR "muscle volume" OR "muscle circumference" OR "fascicle length" OR "muscle power" OR "explosive strength" OR "power" OR "muscle strength" OR "strength") AND ("adolescent" OR "adult" OR "young adult" OR "older Adults" OR "aged" OR "seniors" OR "elderly") AND ("controlled trial" OR "randomized controlled trial"). These keywords were identified using literature searches, expert opinion, and a controlled vocabulary (e.g., Medical Subject Headings [MeSH]).*

Results: *After all searches, 104 records were found. Of this total, 10 humans' clinical trials with or not resistance training experience that investigated hypertrophy levels by comparing high and low loads, were selected for the following analyses.*

Conclusions: *In summary, it seems that the volume load can become an interesting point for muscle hypertrophy, because the studies demonstrate that low loads (20, 30% or 40% 1RM) were able to induce similar muscle hypertrophy when compared to high loads (80% 1RM) in equivalent volumes.*

Key Words: *Resistance Training, Volume Load, Low Load, Muscle Hypertrophy.*

Introduction

The main goals of individuals engaged in resistance training (RT) programs are to improve strength and muscle hypertrophy. Thus, the neuromuscular adaptations are maximized by the appropriate manipulation of RT (resistance training) variables, such as volume, intensity, frequency of training, rest interval, selection and order of exercises, velocity of execution, muscular actions, and range of motion [1], where the volume load is one of the most critical variables in this regard [2]. An adequate method to quantify training volume if all the other variables are kept constant would be the total number of sets to failure or the volume load, i.e, the total worked load in the training sessions [3]. Therefore, has been previously demonstrated that a moderate (5–9 sets per muscle group) to high (10 sets per muscle group) weekly training volume is indicated to induce muscle growth as compared to lower training volume (5 sets per muscle group) [4]. Which makes it seem like volume loading is an important point in muscle hypertrophy. This was explained by a systematic reviews with meta-analyses have consistently shown a clear dose-response relationship between the total weekly number of sets per muscle group and neuromuscular adaptations, muscle strength [5, 6], and muscle hypertrophy [7]. This could be related to the fact that the total weekly number of sets per muscle group would be directly linked to the increase in load volume. Therefore, it remains unclear as to whether RT, when performed with a higher volume, can enhance the hypertrophic response and at what point these results reach the plateau. This is due to there are few systematic review studies that exclusively evaluated if the volume load of clinical trials would conclude whether high loads are always superior to low loads in muscle hypertrophy. Thus, given the existing gaps in current literature and the growing interest in this topic, the purpose of this study was to investigate systematically if high loads are superior to low loads in muscle hypertrophy, considering the amount of volume load applied.

Methods

The present systematic bibliographic review is based on existing evidence on the volume load and muscle hypertrophy. The literature search was conducted independently and separately by the author in the electronic databases PubMed database up to the 31th of December 2024. The search was performed using a Boolean search strategy (operators "AND" and "OR") and a combination of the following keywords: ("high load" OR "low load" OR "load" OR "volume load" OR "muscle hypertrophy" OR "hypertrophy" OR "muscle") AND ("hypertrophy load" OR "muscle architecture" OR "cross sectional area" OR "muscle volume" OR "muscle circumference" OR "fascicle length" OR "muscle power" OR "explosive strength" OR "power" OR "muscle strength" OR "strength") AND ("adolescent" OR "adult" OR "young adult" OR "older Adults" OR "aged" OR "seniors" OR "elderly") AND ("controlled trial" OR "randomized controlled trial"). These keywords were identified using literature searches, expert opinion, and a controlled vocabulary (e.g., Medical Subject Headings [MeSH]).

Inclusion criteria for eligible studies were defined according to the PICOS (Population, Intervention, Comparison, Outcome, Study Design) approach [8]. The following criteria were defined: (1) Population: healthy participants without restriction regarding age, sex, or training status, (2) Intervention: SS interventions with a minimum duration of two weeks (36), (3) Comparison: active/ passive control group/leg, (4) Outcome: at least one measure of muscle hypertrophy (i.e., muscle thickness, muscle cross-sectional area) in a stretched muscle group, and (5) study design: (randomized) control trials with measurements at baseline and after completion of the intervention (within and/or between subjects). Studies were excluded if they included participants with existing medical conditions (e.g., musculoskeletal disorder, cardiovascular diseases), if there was no active/passive control group, if muscle hypertrophy/architecture was not assessed in the stretched muscle group, and/or if baseline or follow-up data were not available. Articles that evaluated strength levels but without evaluating hypertrophy results were also not included in the post-hoc analyses. All retrieved articles were screened in duplicate. The first screening, based on the title and abstract, was independently conducted in all the studies. After, it was determined whether the documents that led to discrepancies between authors had to be included or excluded.

Results

After all searches, 104 records were found. Of this total, 10 humans' clinical trials with or not resistance training experience that investigated hypertrophy levels by comparing high and low loads, were selected for the following analyses. An article that selected twenty-seven participants in 3 experimental groups applied 16 weekly sets per muscle group for a group (G16, n=9), 24 weekly sets for others (G24, n=9), or 32 weekly sets per muscle group for another (G32, n=9). Their results provides evidence that a higher RT volume (32 weekly sets per muscle group) augments muscular strength and establishing a dose-response relationship for the increase in muscle hypertrophy in to relationship with volume load. [9]. Thirty health young men were selected within-subject design, in which one leg and arm trained at 20% 1RM (G20; n=30) and the contralateral limb was randomly assigned to one of the three conditions: 40% (G40; n=10); 60% (G60; n=10), and 80% 1RM (G80; n=10), respectively. In the final, the article findings demonstrated that intensities ranging from 20% to 80% 1RM are effective for increasing muscle strength and hypertrophy in men with no experience in RT. However, the lowest RT intensity (20% 1RM) was suboptimal for maximizing muscular adaptations. [10].

Twenty-three untrained women were selected for a RT to failure intervention at either 30% 1RM (n=11) "low load" or 80% 1RM (n=12) "high load". During weeks 2–7, the subjects completed 2 sets to failure for each exercise and 3 sets during weeks 8–11. The results of this study demonstrated RT failure at low (30% 1RM) and high (80% 1RM) loads are effective for increasing 1RM strength in untrained women [11]. Thirty-two male individuals were allocated in a randomized fashion to: HL-RT leading to repetition failure (High-load repetitions to failure, n=13) or LL-RF leading to repetition failure (low-load repetitions to failure, n=12). The contralateral leg was allocated to the same loading protocol of the opposing leg but without achieving failure: HL-RNF not leading to repetition failure (High-load repetitions not to failure) and LL-RNF not leading to repetition failure (Low-load repetitions not to failure). Based on these findings, a high level of effort is required to elicit hypertrophic adaptations in low-load resistance training in beginners, even with total training volume matched [12].

Fifteen healthy young men were selected for a study that used loads was set to 30 % and 80 % for the LLHR and HLLR groups, respectively. LLHR group performed a resistance-training program with a load of 30% 1RM, consisting of 12 sets with 8 repetitions, and the HLLR group performed resistance training with a load of 80% 1RM, consisting of 3 sets with 8 repetitions. At the final, no statistically significant differences were found between the LLHR and HLLR groups, respectively for 1RM (40.9% vs 36.2% improve), maximum isometric strength (24.0% vs 25.5% improve) and muscle thickness (11.3% vs. 20.4% improve) [13]. Forty-nine resistance-trained men were randomly allocated into a higher-repetition (HR) group who lifted loads of 30-50% of their maximal strength (1RM) for 20–25 repetitions/set (n=24) or a lower-repetition (LR) group (75–90% 1RM, 8–12 repetitions/set, n=25), with all sets being performed to volitional failure. In conclusion, the researchers described that a high- and low-repetition (low and high load, respectively) training paradigms elicit a comparable stimulus for the accretion of skeletal muscle mass when resistance exercise is performed until volitional failure, i.e. when the volume load is the same [14].

Eighteen men had each leg was randomly assigned in counterbalanced fashion to one of three possible unilateral training conditions: one set of knee extension performed to voluntary failure at 80% of 1RM (80%-1); three sets of knee extension performed to the point of fatigue at 80% of 1RM (80%-3); or three sets performed to the point of fatigue with 30% of 1RM (30%-3). After the analysis, the researchers report that similar resistance training induced muscle hypertrophy can result from lifting loads to failure with higher (80% of 1RM) and lower (30% of 1RM) loads than are currently recommended for novice lifters [15]. 24 male volunteers were selected to a low-load RT routine (LL; N=12) in which 25–35 repetitions (approximately 30–50% 1RM) were performed to failure per exercise or a high-load RT routine (HL; N=12) where 8–12 repetitions (approximately 70–80% 1RM) were performed per exercise. On this study each group performed 3 sets of 7 exercises per session. In summary, the researchers concluded that low-load training can be an effective method to increase muscle hypertrophy of the extremities in well-trained men. The gains in muscle size from low-load training were equal to that achieved with training in a repetition range normally recommended for maximizing muscle hypertrophy [16].

Twenty-seven cadets were allocated to either a high-load group (HL; men: 12, women: 2, 10RM) or a low-load group (LL; men: 10, women: 3, 30RM). The training protocol consisted of 3 sets of 7 exercises per session, performed 2 days a week during the first 10 weeks and 3 days a week during the last 9 weeks. The training volume was 13,687 (12,324 - 15,049) kg to HL group and 25,119 (23,720 - 26,518) kg LL group. No significant differences were found between groups for CSA of the vastus lateralis. The mean total lean mass among men increased from 60.2 kg to 62.8 kg (difference of 2.6 kg) in the LL group, while in the HL group it was from 57.7 to 59.7 (difference of 2 kg) [17]. 30 male collegiate students recreationally active (twice/week of running and other recreational activities) were allocated in 3 groups: low-load to volitional failure (LVoF, n=9), low-load velocity fatigue (LVeF, n=8), and high-load (n=10). LVeF and LVoF performed 40% 1RM and HL 80% 1RM. Each session involved the performance of 3 sets of the bench press exercise, with 2.5 minutes of rest between sets. The volume load was on average 1762.6, 1697.9, and 999.6, performed to LVoF, LVeF, and HL, respectively. The muscle thickness (mm) had an average difference of 5, 3.1, and 2.6, to LVoF, LVeF, and HL, respectively [18]. The author of this work systematically gathered the main data from the analyzed articles in a table (Table 1), including methodological data and conclusions from the authors themselves.

Table 1. Study descriptive characteristics from the documents included in this systematic review.

Study	Participants	Time	RT Experience	Experimental Design	Findings
[9]	Twenty-seven healthy men: 27.2 (±7.1) years. Height: 176 (±6.1) cm. Body mass: 80.6 (±6.5) kg.	8 weeks	4.9 (±0.9) sessions per week.	3 experimental groups: 16 weekly sets per muscle group (G16, n=9), 24 weekly sets per muscle group (G24, n=9), or 32 weekly sets per muscle group (G32, n=9).	This study provides evidence that a higher RT volume (32 weekly sets per muscle group) augments muscular strength and a dose-response relationship was observed for the increase in muscle hypertrophy.
[10]	Thirty healthy young men: 24.5 (±2.4) years. Height: 180 (±0.7) cm. Body mass: 77 (±16.5) kg.	12 weeks	Recreationally active with no experience in RT.	Within-subject design, in which one leg and arm trained at 20% 1RM (G20; n=30) and the contralateral limb was randomly assigned to one of the three conditions: 40% (G40; n=10); 60% (G60; n=10), and 80% 1RM (G80; n=10).	These findings demonstrated that intensities ranging from 20% to 80% 1RM are effective for increasing muscle strength and hypertrophy in men with no experience in RT. However, the lowest RT intensity (20% 1RM) was suboptimal for maximizing muscular adaptations.
[11]	Twenty-three untrained women: 21.2 (±2.2) years. Height: 167.1 (±5.7) cm. Body mass: 62.3 (±6.2) kg.	12 weeks	Untrained was defined as not having participated in a structured (>2 days per week for at least 4 weeks) RT program for the past 2 years.	RT to failure intervention at either 30% 1RM (n=11) “low load” or 80% 1RM (n=12) “high load”. During weeks 2–7, the subjects completed 2 sets to failure for each exercise and 3 sets during weeks 8–11.	The results of this study demonstrated RT failure at low (30% 1RM) and high (80% 1RM) loads are effective for increasing 1RM strength in untrained women.

[12]	Thirty-two male individuals volunteered to participate in this study (age range 19 to 34 years old).	8 weeks	Subjects were physically active, but no one had engaged in any kind of regular resistance training or regular participation in any strength-based sporting activity for the lower limbs in the past 6 months before study.	Each subject was allocated in a randomized fashion to: HL-RF leading to repetition failure (HL-RF, n=13) or LL-RF leading to repetition failure (LL-RF, n=12). The contralateral leg was allocated to the same loading protocol of the opposing leg but without achieving failure: HL-RF not leading to repetition failure and LL-RF not leading to repetition failure.	A high level of effort is required to elicit hypertrophic adaptations in low-load resistance training in beginners, even with total training volume matched.
[13]	Fifteen healthy young men who were non-athletes: LLHR: 22.9 (±2.0) years Height: 175.0 (±4.9) cm Body mass: 68.6 (±8.2) kg, HLLR: 23.4 (±3.2) years Height: 169.6 (±5.5) cm Body mass: 62.1 (±6.6) kg,	8 weeks	The study only explains that the participants were non-athletes.	The load was set to 30% and 80% for the LLHR and HLLR groups, respectively. LLHR group performed a resistance-training program with a load of 30% 1RM, consisting of 12 sets with 8 repetitions, and the HLLR group performed resistance training with a load of 80% 1RM, consisting of 3 sets with 8 repetitions.	No statistically significant differences were found between the LLHR and HLLR groups, respectively for 1RM (40.9% vs 36.2% improve), maximum isometric strength (24.0% vs 25.5% improve) and muscle thickness (11.3% vs. 20.4% improve).
[14]	Forty-nine resistance-trained men: 23 (±1) years Height: 181 (±1) cm Body mass: 86 (±2) kg.	12 weeks	The participants should have been engaged in at least 2 years of exercise. [4 (±2) yr, training >2 sessions per week (range 3–6 days/week), including at least one weekly dedicated lower body session].	The subjects were randomly allocated into a higher-repetition (HR) group who lifted loads of 30-50% of their maximal strength (1RM) for 20–25 repetitions/set (n=24) or a lower-repetition (LR) group (75–90% 1RM, 8–12 repetitions/set, n=25), with all sets being performed to volitional failure.	In conclusion, high- and low-repetition (low and high load, respectively) training paradigms elicit a comparable stimulus for the accretion of skeletal muscle mass when resistance exercise is performed until volitional failure.
[15]	Eighteen men: 21 (±1) years Height: 176 (±0.04) cm Body mass: 73.3 (±1.4) kg.	10 weeks	Subjects were recreationally active with no formal weightlifting experience or regular weightlifting activity over the last year.	Each leg was randomly assigned in counterbalanced fashion to one of three possible unilateral training conditions: one set of knee extension performed to voluntary failure at 80% of 1RM (80%-1); three sets of knee extension performed to the point of fatigue at 80% of 1RM (80%-3); or three sets performed to the point of fatigue with 30% of 1RM (30%-3).	Researchers report that similar resistance training induced muscle hypertrophy can result from lifting loads to failure with higher (80% of 1RM) and lower (30% of 1RM) loads than are currently recommended for novice lifters.

[16]	24 male volunteers (age = 23.3 years; age range: 18–33 years, body mass = 82.5 kg; height = 175 cm.	8 weeks	3.5 years.	A low-load RT routine (LL; N=12) in which 25–35 repetitions (approximately 30–50% 1RM) were performed to failure per exercise or a high-load RT routine (HL; N=12) where 8–12 repetitions (approximately 70–80% 1RM) were performed per exercise. Where each group performed 3 sets of 7 exercises per session.	In conclusion, our results provide compelling evidence that low-load training can be an effective method to increase muscle hypertrophy of the extremities in well-trained men. The gains in muscle size from low-load training were equal to that achieved with training in a repetition range normally recommended for maximizing muscle hypertrophy.
[17]	Twenty-seven cadets: 20 (±1) year Height: 182 (±9) cm Weight: 75.5 (±12.9) kg, from the second year of the Norwegian Defense Cyber Academy.	22 weeks	Before enrollment, the cadets conducted 2 weekly exercise training sessions throughout the last year.	Subjects were allocated to either a high-load group (HL; men: 12, women: 2, 10RM) or a low-load group (LL; men: 10, women: 3, 30RM). The training protocol consisted of 3 sets of 7 exercises per session, performed 2 days a week during the first 10 weeks and 3 days a week during the last 9 weeks.	The training volume was 13,687 (12,324 - 15,049) kg to HL group and 25,119 (23,720 - 26,518) kg LL group. No significant differences were found between groups for CSA of the vastus lateralis. The mean total lean mass among men increased from 60.2 kg to 62.8 kg (difference of 2.6 kg) in the LL group, while in the HL group it was from 57.7 to 59.7 (difference of 2 kg).
[18]	30 male collegiate students: 20.0 (±0.8) years Height: 170.7 (±7.1) cm Body mass: 63.6 (±8.0) kg.	8 weeks	Subjects were recreationally active (twice/week of running and other recreational activities).		

Abbreviations: CSA: cross-sectional area; 1RM: one maximum repetition; RT: resistance training.

Discussion

This study investigated if high loads are superior to low loads in muscle hypertrophy, considering the amount of volume load applied. The main findings were as follows: (a) a volume load using 20% 1RM appears to influence muscle hypertrophy to the same extent as 80% 1RM and (b) high-load (80% 1RM) may be superior in strength generation when compared to low-load (20% 1RM). Based on these ideas, the studies bring results that corroborate the idea of the central conclusion brought by the author. Because, when compared to 20% 1RM com 40%, 60%, and 80% 1RM, the results demonstrated that the intensities ranging from 20% to 80% 1RM are effective for increasing muscle strength and hypertrophy. It is worth noting that this occurred due to the volume load that was adjusted. The 20%1RM group did on average 67 repetitions compared to 28 repetitions, 14 repetitions and 10 repetitions for the 40%1RM, 60%1RM and 80%1RM groups, respectively. The volume load foi de aproximadamente 20,000 kg para o treino aplicado de flexor de cotovelo e de aproximadamente 160,000 kg para unilateral leg press 45º [10]. A study with 30 male collegiate students recreationally active (twice/week of running and other recreational activities) randomized the subjects in 3 groups: low-load to volitional failure (LVoF, n=9), low-load velocity fatigue (LVeF, n=8), and high-load (n=10). LVeF and LVoF performed 40% 1RM and HL 80% 1RM. The work was performed in eight weeks, and each session involved the performance of 3 sets of the bench press exercise, with 2.5 minutes of rest between sets. The researchers measured the volume load (sets x weight x reps) and result on average 1762.6, 1697.9, and 999.6, performed to LVoF, LVeF, and HL, respectively. At the final, the results showed muscle thickness (mm) had an average difference of 5, 3.1, and 2.6, to LVoF, LVeF, and HL, respectively. I.e., the group with greater volume load performed better improve in muscle thickness (mm) [18]. The studies demonstrated here are categorical and corroborate each other in this idea, although with different research methodologies. It seems to me that the existing gaps regarding which are the best resistance training methodologies to induce greater hypertrophy rates revolve around the idea of volume load.

However, another study that selected cadets (men and women) to high-load group (10RM) or a low-load group (30RM). In this case, the training volume was ~13,687 kg to HL group and ~25,119 kg LL group and although no significant differences were found between groups for CSA of the vastus lateralis, the mean total lean mass among men increased from 60.2 kg to 62.8 kg (+2.6 kg) in the LL group, while in the HL group it was from 57.7 to 59.7 (+2 kg), being better for the LL group because apparently to the greater volume load applied [17]. So far, the discussion about the amount of load, whether the low load is worse or better than the high load in muscle hypertrophy, seems interesting. But what about when the studies will also involve repetitions of failure? So, one study applied a methodological design that had a group with high-load and another group with low-load, but both going to failure. Finally, repetitions to failure may induce hypertrophy with no differences between high or low loads. It appears that volume loading when the individual goes to muscular failure may be the main "causative agent" of muscular hypertrophy without differences into the low or high loads on this study [12]. Another study divided participants between low load (30% 1RM) and high load (80% 1RM) and finding that the resistance training to failure at low (30% 1RM) and high (80% 1RM) loads are effective for increasing 1RM strength [11]. This corroborates what was said previously.

Conclusion

In summary, it seems that the volume load can become an interesting point for muscle hypertrophy, because the studies demonstrate that low loads (20, 30% or 40% 1RM) were able to induce similar muscle hypertrophy when compared to high loads (80% 1RM) in equivalent volumes. However, further research, including larger systematic reviews with meta-analyses, besides that, another randomized clinical trials that evaluate low-loads and high-load with volume load analysis in muscle hypertrophy is needed to elucidate these ideas.

Conflicts of Interest Statement

The author declares that there is no conflict of interest.

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