The Effectiveness of Frequency-Based Resistance Training Protocols on Muscular Performance and Hypertrophy in Trained Males: A Critically Appraised Topic

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Clinical Scenario: Manipulation of exercise variables in resistance training (RT) is an important component in the development of muscular strength, power, and hypertrophy. Currently, most research centers on untrained or recreationally trained subjects. This critically appraised topic focuses on studies that center on the well-trained subject with regard to frequency of training. **Clinical Question:** In well-trained male subjects, is there an association between RT frequency and the development of muscular strength and hypertrophy? **Summary of Key Findings:** Four studies met the inclusion criteria and were included for analysis. All studies showed that lower-frequency training could elicit muscular strength and hypertrophy increases. One study suggested that a higher frequency compared with a lower frequency may provide a slight benefit to hypertrophic development. One study reported a greater level of delayed onset muscle soreness with lower frequency training. The 4 studies demonstrate support for the clinical question. **Clinical Bottom Line:** Current evidence suggests that lower-frequency RT produces equal to greater improvements on muscular strength and hypertrophy in comparison to higher-frequency RT when volume is equated. The evidence is particularly convincing when lower-frequency RT is associated with a total-body training protocol in well-trained male subjects. **Strength of Recommendation:** There is moderate-to-strong evidence to suggest that lower-frequency RT, when volume is equated, will produce equal to greater improvements on muscular strength and hypertrophy in comparison to higher-frequency RT.

Keywords: total body, split routine, training frequency

Clinical Scenario

Resistance training (RT) is a common and well-accepted method for the development of muscular strength, power, and hypertrophy. Numerous studies have been undertaken to provide insight into the differences between the frequency of training,¹⁻⁶ number of muscle groups exercised,^{7,8} training volume,⁹⁻¹⁴ rest intervals,¹⁵⁻¹⁷ and velocity of the weight being lifted,¹⁸ although many of these studies have focused on the untrained or novice recreational athlete.^{1,3,9,16} In the untrained or novice subject, RT can produce substantial gains in a short period of exposure to a training protocol. Studies have shown that a great deal of muscle growth occurs in the initial weeks of training,^{4,19-21} primarily in neural adaptations but also in muscle hypertrophy.²¹ As the muscle begins to adapt to RT, muscle growth attenuates, as it becomes difficult to provide a more effective stimulus to increase muscle growth.^{4,22,23} This is the paradigm that the well-trained subject must overcome to obtain significant training improvements.

The well-trained subject must follow RT protocols that manipulate training variables, such as training frequency, volume, and others, to promote additional improvements beyond muscle growth and adaptation plateaus. Manipulation of training frequency has been proposed as an effective stimuli to provide adaptations beyond the initial training.^{2,4,6,24} Training volume has also been suggested as an appropriate means of increasing muscular adaptations, such as

hypertrophy.^{10,12} What is unclear is whether manipulation of the training frequency or manipulation of the volume of exercises provides the most effective protocol for well-trained subjects.

In addition, much of the research that has been previously done has included split-routine (SR; or split-body) protocols.^{5,22,25} Although limited in scope, there is some evidence purporting the implementation of total-body (TB) training protocols in conjunction with reduced training frequency per week in trained individuals, particularly males.^{6,26,27} Understanding the research into frequency and volume manipulation in comparison to SR and TB routines could have a profound effect on training recommendations for trained individuals, particularly those in male athletic sports, where the development of power through RT is at a premium. Therefore, the purpose of this critically appraised topic (CAT) was to review the recent evidence in training frequency (controlling for volume) on the development of performance indices, such as muscular strength and hypertrophy, in the well-trained male resistance-trained subjects.

Focused Clinical Question

In well-trained male subjects, is there an association between RT frequency and the development of muscular strength and hypertrophy?

Summary of Search, "Best Evidence" Appraised, and Key Findings

- The literature was searched for studies of level 2 evidence or higher (based on Oxford Center of Evidence-Based Medicine

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2011, Levels of Evidence²⁸) that compared frequency as a training method for the development of muscular strength and hypertrophy.

- Six randomized controlled trials met the inclusion and exclusion criteria and then were further screened for methodology.^{4,6,10,26,29,30} One article was excluded, as it did not control for training volume,³⁰ and another, as it used a daily undulating periodization plan.¹⁰
- Four articles were chosen to be included in the CAT.^{4,6,26,29}

Clinical Bottom Line

There is moderate-to-strong evidence to suggest that a lower-frequency RT program, when volume is equated, will produce equal and, in some instances, greater improvements on muscular strength and hypertrophy in comparison to higher-frequency RT. The evidence is particularly convincing when lower-frequency RT is combined with a TB training protocol in well-trained male RT subjects.

Strength of Recommendation

Based on the Oxford Center for Evidence-Based Medicine strength of recommendation,²⁹ there is level A evidence to support the use of lower-frequency RT protocols for the development of muscular strength and muscle hypertrophy in trained males. The results were consistent across all 4 studies included in this appraisal.

Search Strategy

Terms Used to Guide Search Strategy

- Patient/Client group: trained males OR resistance-trained males
- Intervention: TBRT OR split-body routine
- Comparison: training frequency (high OR low)
- Outcome: performance gains (muscular strength OR hypertrophy)

Sources of Evidence Searched

- EBSCOhost
- Academic Search Complete
- SPORTDiscus
- PubMed
- Health Source
- Google Scholar
- Additional articles obtained through review of reference lists

Inclusion and Exclusion Criteria

Inclusion Criteria

- Date range: 2014–2019 (time frame selected to include most recent evidence)
- Peer-reviewed or academic journal articles, full text

- Inclusion terms: resistance training, strength training, weight training, resistance exercise, frequency, trained men/males, TB (or full body or whole body), SR (or split body, or upper body/lower body)
- English language
- Randomized controlled trials

Exclusion Criteria

- Chronic disease or physical injury studies
- Studies that centered on females, menopause, or untrained individuals
- Single exercise comparisons
- Unequal training volume
- Meta-analysis, systematic reviews, reviews of literature, or position statements

Results of Search

Four relevant studies^{4,6,26,29} were identified and categorized in Table 1 (based on Levels of Evidence, Center for Evidence-Based Medicine).³¹

Best Evidence

The studies selected for inclusion in this CAT are listed in Table 2. The 4 studies included were identified as the best evidence and selected as the most appropriate, given the inclusion criteria and focused clinical question. The PEDro scale was used to assess the quality index of the studies. This scale has been validated and is used to assess the methodological quality of clinical trials.^{31,32}

Implications for Practice, Education, and Future Research

Previous research has explored modifications to training volume and frequency,^{1–6,10–14} but very few have studied the effects of training manipulation on well-trained subjects. The articles reviewed in this CAT reported frequency differences while controlling for volume, the number of exercises, or the muscle groups trained.^{4,6,26,29} The results from this appraisal support both the lower- and higher-frequency RT protocols for the development of muscle hypertrophy and other performance measures, such as muscular strength. However, in 3 of the 4 studies, the groupings that were considered low frequency produced greater gains in both 1 repetition maximum bench press and 1 repetition maximum squat.^{4,6,29} The most important implication for practice is that well-trained RT males can benefit from a lower training frequency per week (number of sessions per week), particularly if the volume is increased.²⁹

As asserted in one of the focused research articles, about two-thirds of muscle growth occurs in the first weeks of RT, and through adaptive processes by the muscles, the rate of growth reduces.⁴ Those RT subjects who are well trained may not provide the muscle with enough stimuli to increase muscle growth. However, it appears employing a training protocol with a low frequency per week that increases the total volume per training session may

Table 1 Summary of Study Designs of Articles Retrieved

Level of evidence ^a	Study design/methodology of articles retrieved	Study
1b	Test–retest repeated measures and correlation design	Gomes et al ⁴
1b	Test–retest repeated measures and correlation design	Schoenfeld et al ⁶
1b	Test–retest repeated measures and correlation design	Brigatto et al ²⁶
1b	Test–retest repeated measures and correlation design	Yue et al ²⁹

^aLevel of evidence assessed using the Oxford Center for Evidence-based Medicine 2011 criteria.²⁸

produce body mass enhancements, as well as increases in strength, particularly upper-body strength.²⁹ Yue et al²⁹ suggest that higher metabolic stress associated with a high-volume low-frequency protocol may represent the stimulus necessary to create an enhanced anabolic response by skeletal muscle. Increased volume routines have been associated with a greater posttraining increase in growth hormone and testosterone, accentuating the potential for muscle tissue remodeling.²⁹

The evidence from the CAT articles provides a strong rationale for lower-frequency training. It should also be noted that protocols that are structured with a lower weekly training frequency could be beneficial to the time-restricted athlete or RT subject. Often, time constraints, like those of the college athlete, do not allow for daily training that could elicit the needed physiological response to RT for substantial muscular growth or adaptations. Increased training volume in subsequent training sessions, with adequate recovery time between sessions, could be an appropriate consideration, considering that it would be “day saving” and induce hypertrophic, body composition, and muscular strength gains.

Another notable RT protocol manipulation from the CAT-focused articles was that 2 of the 4 studies included SR versus TB routine protocols. The TB protocols were a component of the lower-frequency training protocols. The American College of Sports Medicine, in their position statement, recommends a frequency of 3 d/wk if training is following a TB protocol, and a frequency of 4 d/wk if training utilizes an SR protocol.²² In comparing the SR to the TB in the articles, it was found that they produced similar results, with the TB showing greater hypertrophic results in the Schoenfeld et al⁶ research study. The Gomes et al⁴ study produces similar increases between SR and TB routines, but higher levels of delayed onset muscle soreness were observed in the TB protocol as compared with the SR protocol. It was suggested that the higher daily volume present in the TB protocol may have influenced the increased delayed onset muscle soreness, whereas a repeated bout effect from the SR protocol may have contributed to a protective effect against delayed onset muscle soreness.⁴

The current study has some limitations that offer opportunities for future research. The studies in this CAT show that a lower frequency of training sessions will produce muscular strength and hypertrophy improvements; however, only 2 of the studies compared the SR protocol to the TB protocol.^{4,6} SR protocols have been a staple in both powerlifting and weight training and have been a recommended protocol by the American College of Sports Medicine for RT in healthy adults.²² Recently, TB protocols have become a popular method of RT, particularly with trained athletes,³³ and further comparisons should be undertaken. Also, the studies themselves ranged from a low of 9 exercises utilized²⁶ to a high of 21 exercises utilized⁶ to produce outcome measures for strength improvement and hypertrophy

changes. The wide range of exercises cause some limitations for direct comparison between each of the studies. Even though volume was constant within all studies, the volume between studies varied greatly due to the number of exercises prescribed. Finally, another limitation was that the training frequency ranged from a minimum of 2 sessions per week found in 2 studies^{26,29} to 1 study, which had 5 training sessions per week for all study subjects.⁴ Meta-analytical data have shown that training a muscle group 2 times per week in well-trained individuals produced the highest effect size.^{22,34}

Each of the studies used 1 repetition maximum of both the bench press and back squat as standards for muscular strength. The back squat is well recognized as a useful exercise in assessing lower-body muscular strength, as it involves the movement of several joints (ankle, knee, and hip joints), as well as engaging a large number of lower-body muscle groups.^{25,35} The bench press has also been one of the most frequently performed strength-training exercises and is a recommended testing mechanism by the American College of Sports Medicine for determining upper-body strength.³⁶ All protocols included exercises that targeted major muscle groups for the development of strength and hypertrophy, although the variability in the number and type of exercises selected was so varied that determining the most effective exercise grouping cannot be made from these studies. Further research should include a comparison of SR to the TB protocols including the same exercises, with a number of exercises closer to that of Schoenfeld et al,⁶ which utilized 21 distinct exercises. The use of a great number of exercises would ensure that the muscles would be activated for the greatest potentiation of muscular strength development and hypertrophy. Further research should also investigate how a lower-frequency TB protocol may be compared with a higher-frequency SR protocol in college athletes, where time constraints due to schedule and college time contact rules may affect training.

The limited number of studies that evaluate trained male subjects with regard to high- or low-frequency training sessions, as well as the scarcity of literature available on this topic, makes it challenging to properly determine if a lower frequency of training sessions with an increase in volume can be successfully administered to other well-trained groups, such as those in college or professional athletics. Studies that incorporate frequency and volume modifications, as well as training protocols that include TB training sessions, can further justify or support the evidence presented in this CAT. As mentioned previously, future research should consider administering studies that focus on the well-trained athlete, particularly those who participate in sports that require increased muscle size and muscular strength development. This CAT should be reviewed in 2 years to determine whether additional best research evidence has been published that could aid in answering the focused clinical question.

Table 2 Characteristics of Included Studies

Authors	Brigatto et al ²⁶	Gomes et al ⁴	Schoenfeld et al ⁶	Yue et al ²⁹
Study title	Effect of RT frequency on neuromuscular performance and muscle morphology after 8 wk in trained men.	HFRT is not more effective than LFRT in increasing muscle mass and strength in well-trained men.	Influence of RT frequency on muscular adaptations in well-trained men.	Comparison of 2 weekly-equalized volume resistance-training routines using different frequencies on body composition and performance in trained males.
Study design	RCT	RCT	RCT	RCT
Participants	20 healthy young well-trained men with 2- to 8-y RT experience, randomly assigned to either 1 session per week per muscle group or 2 sessions per week per muscle group.	23 well-trained men, aged 18–32 y with 3 y of uninterrupted RT.	20 male volunteers recruited from a Lehman College population, aged 19–29 y.	18 recreationally trained men.
Inclusion and exclusion criteria	All subjects regularly performed all exercises utilized in the training intervention and were free from any existing musculoskeletal disorders or history of injury, and free from anabolic steroids or illegal agents known to increase muscle size.	All subjects have practiced RT for at least 3 y without interruption. Back squat/body mass ratio ≥ 1.5 and bench press/body mass ratio ≥ 1.0 . Absence of myopathies, arthropathies, neuropathies; muscle, thromboembolic and gastrointestinal disorders; cardiovascular diseases; and, infection diseases. Subjects were also nondrinkers, nonsmokers, and did not use supplements or pharmacological substances.	All subjects regularly performed the barbell back squat and bench press for at least 1 y prior to entering the study. Subjects were free from any existing musculoskeletal disorders and free from anabolic steroids.	Participants were free of injury in the 3 mo prior to the study. Subjects trained regularly between 2 and 3 times per week, whole-body routines including squat and bench press exercises for a minimum of 2 and a maximum of 5 y. Only recreationally trained individuals with no regular participation in other sports. In addition, only individuals not having ingested ergogenic aids or any type of nutritional supplements affecting muscular performance 12 wk or longer prior to the start of the study.
Intervention Investigated	RT groups performed 9 exercises targeting major muscle groups with equated volume. Exercises chosen were based on common inclusion in bodybuilding and strength-type RT programs. Both groups consisted of 2 split routines. A _{Routine} : Bench press Dumbbell flat fly Cable triceps Parallel back squat Leg extension B _{Routine} : Lat pulldown Straight-arm pulldown, bicep curl Seated leg curl G1: A _{Routine} (Mon) B _{Routine} (Thu) G2: A _{Routine} (Mon, Thu) B _{Routine} (Tue, Fri) G1: 8 sets $\times$ 8–12 repetitions per muscle group per week (80 total sets) G2: 4 sets $\times$ 8–12 repetitions, 2 sessions per week per muscle group (80 total sets)	RT groups 5-d/wk regimen, 10 sets per exercise, 8–12 repetition maximums with 70%–80% 1RM per set and 90 s rest recovery between sets and exercise in the training week. LFRT (low frequency): 2 specific RT exercises in each training session. HFRT (high frequency): Performed all RT exercises in each training session. Exercises: Bench press Triceps extension Leg press Squat Seated row Barbell curl Hamstring curl Calf standing Lateral raises Abdominal crunch solo	RT procedures experimental groups: SPLIT, where multiple exercises were performed for a specific muscle group in a session with 2–3 muscle groups trained per session and TOTAL, where 1 exercise was performed per muscle group in a session with all muscle groups trained in each session. RT protocol consisted of 21 exercises with all exercises performed at the same repetition volume. Training protocol consisted of 3 weekly sessions on nonconsecutive days for 8 wk, 2–3 sets per exercise for a total of 18 sets per session, 8–12 repetitions with 90 s of rest	RT groups included low volume-high frequency (LV-HF) and high volume-low frequency (HV-LF). Each group performed 2 training routines involving 9 exercises per session. Routine 1 was designed to target pectorals, deltoids, and arm flexors. Routine 2 focused on back, arm extensor, and lower body. LV-HF: Trained 4 times per week Routine 1 (Mon and Thu) Routine 2 (Tue and Fri) HV-LF: Trained 2 times per week Routine 1 (Mon) Routine 2 (Thu) Both groups completed the same number of total sets per exercise and routine per training week, 8–12 repetitions, ~75% of 1RM with 2-min rest between sets.

(continued)

Table 2 (continued)

Authors	Brigatto et al ²⁶	Gomes et al ⁴	Schoenfeld et al ⁶	Yue et al ²⁹
Outcome measures	Adherence was 100% for both groups. Muscle strength: IRM bench press, IRM parallel back squat. Muscular endurance: 60% IRM bench press, 60% IRM parallel back squat Muscular thickness (ultrasound): 4 thickness: triceps brachii, elbow flexors, vastus lateralis, and anterior quadriceps. Total load lifted: Sets $\times$ repetitions $\times$ external load Internal training load: RPE $\times$ time under tension	Adherence to HFRT and LFRT was 98% and 97%, respectively. Body composition: Fat-free mass Maximum strength: IRM squat IRM squat/body mass IRM bench press IRM bench press/body mass DOMS: 0–10 scale according to the body segments (chest, elbow flexors, elbow extensors, thigh, and calf) recorded the day after (24 h) the first and last RT session.	Adherence to TOTAL was 97% and SPLIT 98%. MT: Forearm flexors Forearm extensors Vastus lateralis Muscle strength: IRM parallel back squat IRM bench press	Adherence was 100% for all groups. Body composition: Height Body mass Fat mass Fat-free mass (Bod pod) Limb circumferences: Right arm Right thigh Muscle thickness: Elbow flexors Anterior deltoids Vastus medialis Strength: IRM Bench press IRM Parallel squat Upper-body power determination: Bench press 50% IRM $\times$ 5 repetitions (optical rotary encoder)
Main findings	No significant difference between conditions for maximal strength (IRM), MT in the elbow extensors, elbow flexors, or quadriceps femoris, and muscle endurance. Effect size favored G2 for some outcome measurements, suggesting the potential of a slight benefit to the higher training frequency. Both G1 and G2 significantly enhance neuromuscular adaptations, with a similar change noted between experimental conditions. Statistical data: G1 (1/wk): IRM Bench: +7.5%, $P < .001$ IRM Squat: +13.5%, $P < .001$ G2 (2/wk): IRM Bench: +7.8%, $P < .001$ IRM Squat: +13.9%, $P < .001$	8 wk of HFRT (5 d/wk) increases muscle mass and strength similarly to LFRT (1 d/wk) in well-trained subjects. The study findings suggest that the total number of sets per week is important for muscle mass and strength gains well-trained subjects. Higher levels of DOMS were observed in LFRT, possibly due to the higher daily volume per muscle group. HFRT may have a repeated bout effect may have contributed to a protective effect against the DOMS. Overall, HFRT and LFRT are similar overload strategies for promoting muscular adaptation in well-trained subjects when sets and intensity are equated per week. Statistical data: LFRT: IRM Bench: +8.7%, $P < .001$ IRM Squat: +8.8%, $P < .001$ HFRT: IRM Bench: +5.1%, $P < .001$ IRM Squat: +5.6%, $P < .001$	Both TOTAL and SPLIT produced increases in MT of forearm flexors, extensors, and vastus lateralis. TOTAL showed greater increases in MT over that of SPLIT. Only TOTAL MT in the forearm flexors produced a significant difference in results between TOTAL and SPLIT. Significant increases in IRM bench press and back squat for TOTAL and SPLIT and no significant between-group differences. The findings of the study suggest a potentially superior hypertrophic benefit to higher weekly RT frequencies. Statistical data: TOTAL: IRM Bench: +10.6%, $P < .01$ IRM Squat: +11.3%, $P < .01$ SPLIT: IRM Bench: +6.8%, $P < .05$ IRM Squat: 10.6%, $P < .05$	Both designs were found to be effective in improving fat-free mass and performance in recreationally RT individuals. Even though no significant differences favor either protocol, HV-LF seems to be more effective in enhancing body mass and upper-body strength. HV-LF group showed significant positive changes in the reduction of fat mass, increase of fat-free mass, increase in arm circumference, vastus medialis thickness, and elbow flexors thickness over that of the LV-HF protocol. Statistical data: HV-LF: IRM Bench: +13.3%, $P < .01$ IRM Squat: +13.4%, $P < .01$ LV-HF: IRM Bench: +13.2%, $P < .01$ IRM Squat: +10.3%, $P < .01$
Level of evidence ^a	1b	1b	1b	1b
Validity score ^b	6/10	6/10	6/10	6/10

(continued)

Table 2 (continued)

Authors	Brigatto et al ²⁶	Gomes et al ⁴	Schoenfeld et al ⁶	Yue et al ²⁹
Conclusion	Training a muscle group only once a week is as efficient as training twice a week to promote an increase in maximal strength, lower-body muscular endurance and muscle size.	8 wk of HFRT increases muscle mass and strength similarly to LFRT in well-trained subjects.	The findings suggest a hypertrophic benefit to higher frequencies of training when volume is equated. Data also suggest that well-trained individuals would benefit from training muscle groups 3 d/wk when the goal is to maximize muscle hypertrophy.	Using a high and low weekly training frequency with equated volume is effective in improving fat-free mass and performance in recreationally resistance-trained individuals. Furthermore, the study suggests that higher volume sessions rather than increased frequency is a more effective strategy to increase muscle size.

Abbreviations: DOMS, delayed onset muscle soreness; HFRT, high-frequency resistance training; HV, high volume; LFRT, low-frequency resistance training; HV-LF, high volume-low frequency; LV-HF, low volume-high frequency MT, muscle thickness; RCT, randomized controlled trial; RT, resistance training; 1-RM, 1-repetition maximum.

^aLevel of evidence assessed using the Oxford Center for Evidence-based Medicine 2011 criteria.²⁸ ^bValidity score based off the PEDro scale.^{31,32}

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