Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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High- and low-load resistance training and the effect on neuromuscular fatigue

Bachelor's thesis in Human Movement Science
Supervisor: Yngvild Gagnat
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Abstract

Purpose: Resistance training can be performed with vast variations, creating different neural and physiological adaptions. The purpose of this thesis was to review the literature surrounding muscle fatigue, and more specifically if high- and low-load resistance training could cause different levels of neuromuscular fatigue. **Method:** Google scholar was used as a search database. A total of seven studies were included as the main literature of the thesis. For the studies to be included in the thesis they had to; use healthy young adults, include both a high- and low-load resistance training protocol, and had to use EMG as one of the given measurement tools. **Results:** Of the seven studies included, five reported a greater observed muscular fatigue post performing the low-load protocol compared to performing a similar high-load protocol. Secondary findings also discovered slight differences between genders. Different time responses to muscular fatigue between high- and low-load protocols were also reported. **Conclusion:** Given that the majority of the studies has similar results, this thesis suggest that low-load based resistance training create a greater neuromuscular fatigability compared to a similar high-load protocol. However, variance in study protocols and smaller sample sizes makes it difficult to draw an absolute conclusion on the topic.

Abstrakt

Formål: Styrketrening kan gjennomføres med flere variasjoner, som skaper forskjellige nevrale og fysiologiske tilpasninger. Formålet ved denne oppgaven er å vurdere litteraturen rundt muskel tretthet, og om høy- og lav-motstands styrketrening kan føre til ulike nivåer av nevromuskulær tretthet. **Metode:** For å finne relevant litteratur, så ble google scholar brukt som database for søkene. Syv studier ble inkludert som hovedkildene til oppgaven. For at studiene kunne bli inkludert i oppgaven måtte de; bruke friske og unge deltakere, inkludere både høy- og lav-motstand styrketrening protokoller, og må bruke EMG som en av målings verktøyene sine. **Resultat:** Av de syv inkluderte studiene, så hadde fem av studiene like resultat. De fem studiene resulterte med et høyere observert muskulær tretthet etter å ha gjennomført lav-motstands protokoll i forhold til en like høy-motstands protokoll. Sekundærfunn inkluderte noen forskjeller blant kjønn. Det ble også observert noen forskjeller blant tids responsen til muskulær tretthet mellom høy- og lav-mostands protokollene. **Konklusjon:** Gitt at majoriteten av studiene hadde like resultater, så foreslår denne oppgaven at lav-motstands basert styrketrening vil skape et høyere nivå av nevromuskulær tretthet sammenlignet med det av en lik høy-motstands protokoll. Men, variansen blant studienes

gjennomføring, samt små populasjons utvalg blant studiene, så blir det vanskelige å ta frem en absolutt konklusjon.

1. Introduction

Resistance training is today one of the most widely used forms of physical exercise. It can be defined as a systematic program which involves an exertion of force against a form of load, where the goal is to develop and improve strength, endurance and/or hypertrophy of the muscular system (Davies & Barnes, 1972).

Resistance training can be used for a wide range of different purposes and goals. It has been widely accepted by the scientific community that resistance training, when prescribed correctly, is an effective method for developing good health and fitness, as well as being a solid preventive and rehabilitating measure for orthopedic injuries (Feigenbaum & Pollock, 1999). Moreover, regularly or periodically performing resistance training show benefits in sports performance for both strength athletes as well as endurance and concurrent athletes (Harries et al., 2012; Yamamoto et al., 2008). Along with the wide range of purposes and goals for engaging in resistance training, there is an equally large range of variables for which one can perform resistance training. In the book *Physiological Aspects of Sport Training and Performance* (Hoffman, 2014, p. 119), it is suggested that exercise intensity, which is synonymous with training load (i.e. the amount of weight lifted per repetition in a selected exercise) is the variable with the highest probability of being the most important for resistance training.

High-load and low-load resistance training is normally defined within the ranges of; above 60% of 1 repetition maximal strength (1RM) and below 60% of 1RM. When practiced within a resistance-based training program the working sets tend to be limited to a given number of repetitions to be performed. Within research studies it is usual to define the working sets by training until failure or near-failure, where the number of repetitions of a high-load set tend to be less compared to a low-load set.

Although fatigue is a well-known occurrence from both resistance training as well as other forms of exercise and activity, the broad usage of the term in research literature has made it somewhat difficult to understand the physiological mechanisms responsible (Enoka & Duchateau, 2008) The Heart Lung and Blood Institute (NHLBI) defines fatigue as "*a condition in which there is a loss in the capacity for developing force and/or velocity of a muscle, resulting from muscle activity under load which is reversible by rest*" (NHLBI, 1990).

The phenomenon of muscle fatigue, which appears to include a level of failure for at least one of the chains of events that leads to muscular contraction, is still somewhat controversial. Muscle fatigue can be caused by many different mechanisms, but is mostly categorized as either central-based (which refers to the central nervous system) or peripheral-based (specific sites local to or near the skeletal muscle) (Zając et al., 2015). But most likely is all muscle fatigue a result from a combination of many different mechanisms and factors, such as type of exercise, muscle fiber type, nutrition, level of fitness from individual and so on.

As the processes that creates muscle fatigue are still not fully understood, there has been a lack of consensus in the literature on what a gold standard of measure could be. However, there have been several efforts made to both measure the different processes of muscular fatigue, as well as better understanding the complete phenomenon of fatigue.

Most frequently is muscle fatigue evaluated by the use of electromyography (EMG) which measures the electrical signals, or activity, that is made in the contractions from muscle groups. This creates a measurable amplitude and power spectrum, which reflects the number and size of action potentials in the muscle or muscle group over a given time (Basmajian & DeLuca, 1985). Most studies in the literature use surface EMG (sEMG), which unlike intramuscular EMG (iEMG), measure activity in the superficial muscles. Surface EMG will from here on out be referred to as EMG. If any changes in muscle activity were to occur, either by changed excitation rates or changes in the number of active muscle fibers, the EMG would be able to pick this up, although it is not possible to differentiate between the two. This makes EMG measurement a feasible way to detect and measure peripheral muscular fatigue.

High-load and low-load resistance training can be implemented for different goals, as they yield somewhat different results, and depending on their effect on neuromuscular fatigue, it is hypothesized that a higher level of fatigue directly correlates with a higher need for recovery (Bishop et al., 2008). Thus, better long-term results could be yielded, if one load has a more reducing effect on neuromuscular fatigue than the other. This could further be used in a variety of fields, such as sports performance, rehabilitation or injury prevention. Thus, the overall aim of this study was to investigate if high-load and low-load resistance training affects EMG measurable neuromuscular fatigue differently in a young, healthy adult population. More specifically, by investigating the acute changes in EMG activity after exercise.

2. Method

The literature search used for this study was conducted on the 1st of march, 2022 and the database used were Google Scholar. The advanced search tool was used, with the key words: “muscle fatigue”, “neuromuscular fatigue”, “high-load”, “low-load”, “resistance training”, “EMG”, “Electromyography”, combined with “AND” and/or “OR” to more precisely find relevant literature. This resulted in 669 papers. By further excluding papers using the keyword “bloodflow restriction”, review papers and metanalyses, we ended up with 175 papers.

Titles and abstracts were briefly reviewed and studies were included if they were clinical trials, performed on a young, healthy adult population. The studies had to use EMG for evaluation of neuromuscular fatigue for both high-load and low-load resistance training, in which measurement occurred either during training or within at least 60 minutes of completed training session. The high-load and low-load groups had to match the 1RM% as established with high-load groups performing sets with more than 60% estimated 1RM and low-load groups performing less than 60% of estimated 1RM. There were no restrictions made on either publication date, length of study or gender. The exclusion criteria were studies made on an older population (40+ years of age), studies where subjects had underlying diseases and studies with supplements used in either groups. Thus, through the original 175 papers, seven studies were selected for further analysis.

3. Results

A total of seven studies were included, with a total of 111 participants where 83 of the subjects were male and 28 were female. The studies had different requirements of training experience, however all studies were based around young healthy adults. These characteristics are further described in table 1.

All studies were based on resistance training, where four of the studies used a type of leg extension as the performed exercise, one used dumbbell forearm flexion, one used elbow flexion and one used the barbell benchpress. Further descriptions of targeted muscle groups, tests performed and main findings of each study can be found in Table 2.

Each of the studies had different protocol with regards to weight and implementation of the performed exercises, however all seven studies had a high-load and a low-load protocol. In six of the studies the participants performed both high-load and low-load protocols. One study had different groups perform high-load and low-load protocols. This resulted in a total of 96 participants that performed both high- and low-load protocols, eight participants performing only high-load protocol, seven performing only the low-load protocol. All performed with concurrent EMG measurements.

Table 1: Characteristics of the seven studies population

Authors:	***Buckner et al. 2018***	***Cook et al. 2013***	***Delgadillo et al. 2021***	***Jenkins et al. 2015***	***Linnamo et al. 1997***	***Tsoukos et al. 2021***	***Marshall et al. 2021***	**TOTAL**
Participants (N)	22	8	20	15	16	14	16	**111**
Male/female (N)	Male: 12 Female: 10	Male: 8 Female: 0	Male: 10 Female: 10	Male: 15 Female: 0	Male: 8 Female: 8	Male: 14 Female: 0	Male: 16 Female: 0	**Male: 83** **Female: 28**
Age, yr (mean ± SD)	22 ± 2 yr	22 ± 2 yr	22.2 ± 1.3 yr.	21.7 ± 2.4 yr	Male: 27.1 ± 0.7 yr Female: 23.3 ± 0.5 yr	26.1 ± 5.5 yr	26.9 ± 5.8 yr	**23.68 yr**

Table 2: Performed tests and main findings of the seven studies.

Author	Targeted muscle group	Performed tests	Main findings
Buckner et al. 2018	M biceps brachii	**Exercise:** Elbow flexion **High-load (70% 1RM):** 4 sets until failure **Low-load (15% 1RM):**	From the first three repetitions of the first set, to the three last repetitions of the fourth set the high-load protocol observed a 9.87% decrease in EMG activity (P = 0.04). The low-load protocol resulted in a 6.87% decrease in EMG activity between the same sets (P<0.01).

		4 sets until failure	
Cook et al. 2013	M Quadriceps femoris	**Exercise:** Knee extension **High-load (70% PT):** Three sets until volitional failure **Low-load (30% PT):** Three sets until volitional failure	High-load protocol had a higher level of EMG activity compared to the low-load protocol through all sets (P = 0.001). Both protocols resulted in a~19% increase in EMG activity at the end of completed exercise (P = 0.02)
Delgadillo et al. 2021	M Quadriceps femoris	**Exercise:** Leg extension **High-load (~80% 1RM):** Four sets of eight repetitions w/ fast contractions **Low-load (~30% 1RM):** Four sets of eight repetitions w/ slow contractions	The decrease in twitch amplitude after completing the fourth set resulted in a significant bigger decrease for the low-load protocol (14 ± 12%) compared to the high-load protocol (7 ± 11%, P = 0.014).
Jenkins et al. 2015	Forearm flexors	**Exercise:** Dumbell forearm flexion **High-load (80% 1RM):** 1RM test, followed by three sets until failure after 48-72 hours	A decrease in EMG activity was observed for the low-load protocol, whilst the high-load protocol resulted in no difference in EMG amplitude between all sets. The total volume (reps x load) resulted in no significant differences between the two protocols.

		Low-load (30% 1RM): 1RM test, followed by three sets until failure after 48-72 hours	
Marshall et al. 2021	M Quadriceps femoris	**Exercise:** Leg extension **High-load (≥80% 1RM):** Seven sets with different rep ranges based on the given weight percentage **Low-load (50% 1RM):** Five sets until failure	Upon measuring the vastus medialis muscle the low-load protocol had a significant lower decrease (8.62%) compared to that of the high-load protocol (25.47%, P<0.05). Both protocols had essentially regained full neuromuscular recovery one hour after completed exercise.
Linnamo et al. 1997	M Quadriceps femoris	**Exercise:** Bilateral leg extension **High-load (10RM):** Five sets of 10RM **Low-load (40% HL):** Five sets of 10 repetitions performed as explosive as possible	For the men, the low-load protocol had a significant bigger decrease in EMG activity (-36.4 ± 4.8%) compared to that of the high load (-16.2 ± 9.4%, P < 0.05). For the females the low-load protocol had a lower decrease in EMG activity (-14.8 ± 10.1%) compared to that of the high-load protocol (-26.8 ± 10.9%, P < 0.05). For the males the EMG activity of the high-load protocol recovered within one day, whilst that of the low-load still had an observable difference after two days (-14.9 ± 3.7%). For the femaes both protocols recovered within one hour.

Tsoukos et al. 2021	M pectoralis major & m Triceps brachii	**Exercise:** Barbell benchpress **High-Load (80% 1RM):** One set until failure **Low-load (40% 1RM):** One set until failure	The low-load protocol resulted in a greater drop of EMG activity for both the pectoralis major muscle (-25.7 % ± 8.3%, P < 0.01) and the triceps brachii (-29.1% ± 7.6%, P < 0.01), compared to that of the high-load protocol; pectoralis major (-20.5% ± 8.6%, P < 0.01) and triceps brachii (-20.7% ± 4.9%, P < 0.01)

1RM = 1 Rep maximum, EMG = Electromyography, PT = Peak Torque

3.1 High-load vs low-load

Out of the seven studies included, five found similar results. These results were that working on a lower load until failure, or close to failure accumulated a greater neuromuscular fatigue than working with a higher load. One study even found an increase of EMG activity post exercise, for both protocols (19% P = 0.02), although the high-load protocol had a higher level of EMG activity through all sets (Cook et al. 2013). Only one of the seven studies reported that high-load protocol had a greater fatigability, resulting in in a 9.87% decrease in EMG activity from the first to the fourth performed set (P = 0.04, Buckner et al. 2018). The low load protocol showed a 6.15% decrease (P<0.01).

Linnamo and co-workers (1997) found that the men who partook in the experiment had regained pre-test levels within one day after the high-load protocol, while after the low-load protocol there was still a 14.9 (3.7 SEM)% decrease compared to the pre-exercise levels, even after 2 days (Linnamo et al. 1997).

Two studies found similar results when measuring acute fatigue. Marshall (2021) reported that the high-load protocol created significant higher levels of fatigue immediately after performed exercise although the low-load protocol ended with the same results 1hr post exercise (Marshall, 2021). The second study had a similar conclusion that high-load would cause higher levels of acute fatigability of both central and peripheral origin (Linnamo, 1997).

3.2 Gender differences

Two of the studies compared results from female and male, in addition to the difference between high-load and low-load protocols. One study reported no significant gender differences in fatigability after both high-load and low-load, however a greater fatigability was observed for the females during the concentric phase of the high-load protocol (Delgadillo, 2021). On the contrary, the second study resulted in the females showing a greater decline in EMG activity post high-load protocol than the males. However, the low-load protocol resulted in a slower decline of EMG activity for the female, compared to the male (Linnamo et al., 1997).

4. Discussion

All studies included, with exception of the studies by Marshall (2022) and Cook et al., (2013) concluded with low-load resistance training having a lower level of measurable EMG activity immediately following the resistance training protocols. The conflicting findings from

Marshall and co-workers, found the high-load exercise to be more fatiguing through acute EMG measurements. Cook and co-workers (2013) reported no significant difference between the EMG data from high- and low-load protocols. While the majority of our findings reached similar conclusions, there are several discussion points to address through the analysis of the seven studies included.

4.1 Limited number of studies and participants

Although our findings where concordant with the exception of Marshall et al., (2022) and Cook et al., (2013), the literature were somewhat limited. A large number of studies regarding differences in muscular fatigue between high- and low-load resistance training have focused their measurements on peripheral biomarkers (Theofilidis et al., 2018). Several papers focused on blood-flow restriction resistance training, which were excluded from further analysis as the effects of blood-flow restriction could alter results between the high- and low-load groups (Wernbom & Aagaard, 2020). There were also a large number of studies that focused solely on velocity markers for muscle fatigue.

Furthermore, the average number of participants per trial is 14, with the highest number of participants being 22 and the lowest number of participants being eight. The sample size is therefore not great, which increases the margin of error. There were also significant variances in the study populations. Differences in sex and individual experience with resistance training could make differences in neural and muscular adaptations. This could make a difference in the responses of muscular fatigue, thus making comparisons between studies difficult. There was an overwhelming larger sample size for male (83 participants in seven studies) vs. female (28 in three studies). Females are often reported to be more resistant to fatigability than their male counterpart, thus it could be expected to see a general difference in results (Hunter, 2016). Results from Linnamo and co-workers (1997) supports this as the female participants were reported to have less fatigue than the male participants. However, the authors hypothesized a reasoning that the female participants were unable to exhaust themselves to the same degree as the male counterparts.

The limited number of studies in this field has made the inclusion criteria broader than initially thought. Thus, several of the studies have implemented different protocols, with some key factors that will be discussed below.

4.2 Velocity differences

One of the key differences in protocol implementation in between the studies were velocity differences. It is thought that slower velocities in movements of resistance training has a greater impact on muscle fatigue. Although this did not seem to correlate with the results from Linnamo and co-workers (1997) where the male in the low-load, high velocity group had a significantly higher fatigue level than the high-load, slow-eccentric velocity group. However, the females had almost opposite results. While, as earlier mentioned, authors hypothesized that this could be a result from the females not being able to reach the proper level of exhaustion in the low-load, high velocity group. Linnamo and co-workers (1997) based their hypothesis on the fact that the females recovered to close-to baseline levels after one hour, while the males needed significantly more time.

In the study by Delgadillo and co-workers (2021) the low-load, low-velocity protocol showed greater fatigability across both male and female participants, compared to the high-load, high-velocity protocol. As a slower movement accumulates a greater time under tension, it is logical to think this would create larger muscular damage or affect neuromuscular responses at a higher degree. However, the female participants showed a substantially smaller differentiation between the two protocols. The authors hypothesize that female participants are thought to accumulate a larger level of muscular fatigue in the high-load, high-velocity protocol because they performed the concentric phase slower than their male counterparts. This is further supported in a paper by Lacerda and co-workers (2019) where a slower concentric contraction is shown to accumulate more muscular fatigue than the eccentric part of a movement.

4.3 Training volume

Training volume is also one of the factors which have varied between the different studies. Both high- and low-load resistance training have shown to have equal hypertrophic potential when total volume (weight x repetitions x sets) is matched. This is supported in a metanalysis by Schoenfeld and co-workers (2017) where the paper described the hypertrophic potential between high-load and low-load training equal when total volume is matched. However, strength gains were reported to be substantially greater with the high-load training. Optimally, the different studies should all have had matched volume protocols between the high-load and low-load resistance training to better compare the different loads' effect. Total training volume has shown to be a significant factor for especially hypertrophy, as a dose-response relationship between the two has been documented. (Schoenfeld, Ogborn, et al., 2017). Therefore, it could have a significant effect on muscular fatigue as well. However, this conflicts with the findings from Linnamo and co-workers (1997). High-load protocol showed less fatigability by EMG measurements, even with considerably higher training volume than the low-load protocol.

It is generally thought that lower loads are easier for accumulating higher volumes as it is easier to compensate by doing a higher number of sets and reps, than it is for high loads as it has a harder difficulty for adding more weight, or sets and reps. All-though, one of the seven studies had opposite results, they found minimal to no difference in total volume between the two protocols (Jenkins et al, 2015) when the goal was to reach volitional failure. The remaining six studies did not report any measurements of total volume in the high-load and low-load protocols.

4.4 Volitional failure

Volitional failure, or momentary muscle fatigue, is the point where one cannot perform an exercise any longer with a given load (Steele et al., 2017). This is usually a result from either peripheral neuromuscular fatigue, or the discomfort that comes from the production of blood lactate, shortness of breath, etc. from repetitive, longer-lasting activities, which happens in the low-load, high repetitions protocols. Momentary muscle fatigue could be reached in the high-load, low repetition protocols, but this is usually from a reduction in firing rate in muscle fibers as well as a reduction in neural drive from the central nervous system. Thus, the low-load resistance training could be more susceptible to peripheral fatigue, while the high-load resistance training could be more susceptible to central fatigue. This is also discussed by Cook and co-workers (2013) where high-load protocols had significant higher EMG measurements in comparison to the low-load protocol. Even with a significant difference in muscle activation, they found a similar torque decrement, along with similar reported neuromuscular fatigue after all protocols. Thus, they conclude fatigue could be attributed to peripheral factors for both the high- and low-load protocols. This is contrary to the authors original hypothesis that central fatigue would have a greater impact, especially on the high-load protocol. This could indicate that load used in the high-load protocol was too low, although this is not reported in the original study.

Resistance training with high-load protocols might have a higher degree of difficultness to reach total volitional failure than the low-load protocols. With a higher load, closer to an individual's 1RM max, one could have more to give even when an additional single repetition is not feasible, as the load itself already have such high demands. If the individual reaches failure at three repetitions with a load of 80% 1RM, it is likely that they could perform additional repetitions if load dropped down to 40% of 1RM as an example. Thus, the low-load resistance training will reach a closer range to their true volitional failure, as the demands for a single repetition is much less than of those in the high-load group. This is also discussed in the study from Buckner and co-workers (2019). EMG activity is thought to progressively have a greater increase from baseline levels with low-load exercise in comparison to high-load exercise. The nervous system will compensate with the increased fatigue occurring during a submaximal exercise by increasing the motor units involved to maintain the constant force output. Whereas with a maximal exercise, as seen with high-load protocols, the amount of motor units activated begins at a much higher rate to compensate for the increased force required (Enoka & Duchateau, 2017). This is supported by the findings by Jenkins and co-workers (2015) where EMG amplitude increased linearly for all subjects in the low-load group while only one subject had a significant increase in the high-load group. Due to the larger increase in motor unit requirement when performing a low-load resistance exercise for higher repetitions, one could think they would a get closer to volitional failure than their high-load counterpart.

In the studies included, different protocols were used for performing exercises to momentary muscle fatigue. Total volitional failure could be difficult to reach in high-load loadings, as well as having a greater risk of injures. Thus, Marshall and co-workers (2021) only performed until volitional failure for the low-load protocol. This could make more favorable EMG measurements for high-load exercises. All remaining studies with the exception of Linnamo and co-workers (1997) performed until volitional failure for both high-load and low-load protocols.

4.5 Neural adaptations

By performing resistance training regularly, one can not only increase strength and muscle size, but will also develop and improve better adaptations of the nervous system, both central and peripheral. With the populations experience in resistance training being quite varied in the seven studies included, these neural adaptations will also differentiate in between individuals as well as study populations as a whole. With a nervous system better accumulated to resistance training, EMG results could show one load protocol to be more favorable, in contrast to if participants had a non-accumulated nervous system. Although one could argue that by having better developed neural adaptations, one will be able to push themselves harder and thus should reach closer to volitional fatigue, which in turn will increase EMG measurable fatigue.

The demand for neural adaptations is also greater when training with higher loads, as one would need to recruit larger groups of muscle fibers faster, as well as the heightened demands from the central nervous system. This is supported by the findings of Manini & Clark (2009), where muscle activation levels are higher at the initiation of high-load compared to low-load resistance training. However, all but two studies (Linnamo, 1997; Buckner, 2018) had familiarization protocols implemented. Although this could establish a better performance for both high- and low-load exercise, it could be argued that especially the high-load exercise would require more practice than a couple of sessions to truly reach the force potential. There was no significant difference observed between the studies who had familiarization protocols and the ones who did not.

4.6 Measurement timing

Another important variable which differed across the studies were measurement timing. While muscle fatigue is a frequent product of resistance training, the timing of the chain of events that lead to muscle fatigue is still in discussion. Thus, different timing of the EMG measurement could lead to potentially different results, making it noteworthy for discussion as the included studies had different protocols for the timing of EMG measurement.

The study from Linnamo and co-workers (1997) measured one and two hours after in addition to one and two days after exercise. This could differentiate the results between acute- and non-acute muscle fatigue. However, it was concluded with low-load resistance training inducing more muscle fatigue through all timed measurements. This is further supported by the findings from Delgadillo and co-workers (2021), which measured EMG immediately following exercise. The study resulted with low-load exercise having a greater impact on EMG measurements on muscular fatigue. This contradicts the results from Marshall and co-workers (2022), where EMG measurements immediately after exercise showed greater fatigability for the high-load exercise only. The last three studies (Buckner et al., 2019), (Jenkins et al., 2015) and (Tsoukos et al., 2021) measured EMG data while exercise was being performed. All three studies concluded with low-load showing greater fatigability immediately after exercise.

4.7 Future research

After an in-depth search in the current literature, it seems as the field is quite narrow on high- and low-load resistance trainings' effect muscular fatigue measured by EMG. There could be multiple reasons for the lack of research on the field. There is already a lack of studies in the sports- and exercise field as a whole. This is partly because of the difficultness of recruitment of such studies, especially for those in which goes over a longer period of time, as well as necessary financial aid. Thus, studies with the specificity of EMG measurable muscle fatigue in between high- and low-load resistance training has shown to be limited. There are different pathways one could take to investigate the relationship between resistance loading and muscle fatigue further. It would be of great interest to measure muscular fatigue at different time intervals, such as immediately after, 12 hours after, 24 hours after and even 48-72 hours after exercise to better understand the correlation between muscular fatigue and recovery.

5. Conclusion

After reviewing seven studies, there is reason to conclude that low-load based resistance training would create a greater neuromuscular fatigability, compared to a similar high-load based program. These findings are consistent with the exception of two studies, through several different protocol factors such as reaching volitational failure, equal or unequal load, exercise volume, exercise velocities and the different requirement for neural adaptations. Although, the small sample size, especially for females, in each of the individual studies should be taken into consideration. Furthermore, the results from the seven studies are presented in a variation of different ways, making comparisons difficult. For future research larger sample sizes, with equal protocols along with EMG measurement as a main investigative factor is needed to better understand the correlation between load-variances in resistance training and neuromuscular fatigue.

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