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REVIEW ARTICLE

Effect of movement velocity during resistance training on muscle-specific hypertrophy: A systematic review

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Abstract
Currently, it is unclear whether manipulation of movement velocity during resistance exercise has an effect on hypertrophy of specific muscles. The purpose of this systematic review of literature was to investigate the effect of movement velocity during resistance training on muscle hypertrophy. Five electronic databases were searched using terms related to movement velocity and resistance training. Inclusion criteria were randomised and non-randomised comparative studies; published in English; included healthy adults; used dynamic resistance exercise interventions directly comparing fast training to slower movement velocity training; matched in prescribed intensity and volume; duration ≥4 weeks; and measured muscle hypertrophy. A total of six studies were included involving 119 untrained participants. Hypertrophy of the quadriceps was examined in five studies and of the biceps brachii in two studies. Three studies found significantly greater increases in hypertrophy of the quadriceps for moderate-slow compared to fast training. For the remaining studies examining the quadriceps, significant within-group increase in hypertrophy was found for only moderate-slow training in one study and for only fast training in the other study. The two studies that examined hypertrophy of the biceps brachii found greater increases for fast compared to moderate-slow training. Caution is required when interpreting the findings from this review due to the low number of studies, hence insufficient data. Future longitudinal randomised controlled studies in cohorts of healthy adults are required to confirm and extend our findings.

Keywords: *Musculoskeletal, exercise, body composition, resistance*

Highlights

- Moderate-slow compared to fast resistance training appears to be more effective for promotion of hypertrophy of the quadriceps.
- Manipulation of movement velocity during resistance training may lead to different hypertrophic responses for muscles groups such as the quadriceps and biceps brachii.
- Until further studies are conducted, it is recommended that resistance trainers use a combination of fast and moderate-slow movement velocities to optimise muscular hypertrophy.

Introduction

To maximise the hypertrophic response to resistance training appears to involve manipulation of exercise program variables (Kraemer & Ratamess, 2004). The primary resistance training variables include exercise selection, sets per exercise, repetitions per set, rest between sets, training volume, intensity (load and effort), and movement velocity (Ratamess et al., 2009). Of these resistance training variables, movement velocity is often overlooked. Proponents of intentionally slower movement velocities claim that a greater hypertrophic response can be achieved compared to actual faster movement velocities due to increased mechanical tension on a muscle throughout an exercise (Westcott et al., 2001). However, it is unclear whether muscular hypertrophy can be enhanced through implementing intentionally slow movement velocities, if superior to intentionally faster movement velocities, and whether it is dependent on the interaction with other factors (e.g. load, muscular failure, and training status).

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Movement velocities during resistance training are generally prescribed by the time taken to perform the contraction phases, such as 1–2 second concentric action and 2 seconds eccentric action (i.e. 1:2) (Ratamess et al., 2009). The main factors that affect movement velocity are the intensity of load and effort (i.e. proximity to muscular failure) (Ratamess et al., 2009). Lifting at actual fast movement velocities becomes increasingly difficult as an individual approaches their one-repetition maximum (1RM) (Sanchez-Moreno, Rodriguez-Rosell, Pareja-Blanco, Mora-Custodio, & Gonzalez-Badillo, 2017). Also, during a set using heavy loads with maximal voluntary effort during the concentric phase, there is an unintentional decrease in force, velocity and hence power output as fatigue develops and the number of repetitions approaches failure (Gorostiaga et al., 2012; Pareja-Blanco, Rodríguez-Rosell, Sánchez-Medina, Gorostiaga, & González-Badillo, 2014). Therefore, the first repetition will be the fastest when performing a set with maximal effort during concentric contractions using heavy loads. When lifting at intentionally slower movement velocities, the heaviest load that can be performed for a specific number of repetitions (e.g. 8–10 RM) will be lighter compared to faster movement velocities due to reductions in force (Keogh, Wilson, & Weatherby, 1999). This may have implications when the objective of training is to increase muscle mass due to the greater hypertrophic responses that have been associated with heavy loads (Fry, 2004). However, recent evidence suggests that provided sets are performed to muscular failure similar increases in muscle mass can be achieved with both low (≤60% 1RM) and high loads (>60% 1RM) (Schoenfeld, Grgic, Ogborn, & Krieger, 2017).

There is evidence of different hypertrophic responses following resistance training for upper compared to lower body muscles (Abe, DeHoyos, Pollock, & Garzarella, 2000; Chilibeck, Calder, Sale, & Webber, 1998). Furthermore, differences in hypertrophic responses have also been found between muscles groups of the same body region (Ogasawara, Yasuda, Ishii, & Abe, 2013). Whether manipulation of movement velocity during resistance exercise has an effect on hypertrophy of specific muscles is unknown, but it is of particular interest to guide resistance training prescription. Therefore, the purpose of the current review was to use the systematic review approach to examine the effect of intentionally fast compared to moderate-slow movement velocity resistance training on muscle-specific hypertrophy. Information gathered from this systematic review may be useful to coaches, athletes, and recreational resistance trainers when devising resistance training programs to maximise muscular hypertrophy.

Methods

Search strategy and study selection

A search from the earliest record up to and including August 2017 was carried out using the following electronic databases: Medline, PubMed, Scopus (first 2000 articles in order of relevance), SPORTDiscus, and Web of Science. The search strategy employed combined the terms ('tempo' OR 'speed' OR 'slow' OR 'fast' OR 'velocity' OR 'power' OR 'cadence' OR 'explosive') AND ('weightlifting' OR 'weight lifting' OR 'weight training' OR 'weight training' OR 'resistance training' OR 'resistance training' OR 'resistance exercise' OR 'strength training' OR 'strength training'). Titles and abstracts of retrieved articles were individually evaluated by two reviewers (T.B.D. and K.K.) to assess their eligibility for review and meta-analysis. Any disagreements were solved by consensus by a third reviewer (D.H.). The reviewers were not blinded to the studies' authors, institutions or journals of publication. Study abstracts that did not provide sufficient information according to the inclusion criteria were retrieved for full-text evaluation. Corresponding authors of potentially eligible articles were contacted for any missing data or clarification on data presented. This systematic review and meta-analysis were conducted in accordance with the recommendations outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009).

Eligibility criteria

Articles were eligible for inclusion if they met the following criteria: (1) randomised and non-randomised comparative studies; (2) scientific articles published in English; (3) adult participants (≥18 years of age); (4) participants recruited had no known medical condition or injury; (5) dynamic resistance training intervention; (6) an intervention group (fast) where the concentric phase alone or concentric phase and the eccentric phase of each repetition was performed in ≤ 1 second or described as lifting with maximal concentric velocity (e.g. 'explosive'); (7) a comparison group (moderate-slow) that performed repetitions (i.e. concentric plus eccentric phase) at a slower movement velocity (≥2 seconds); (8) matched in prescribed load (% 1RM) and volume (repetitions x sets); (9) interventions ≥4 weeks duration; and (10) measured changes in muscular hypertrophy using a direct measure (e.g. muscle thickness and cross-sectional area).

Data extraction

Two reviewers (T.B.D. and D.H.) separately and independently evaluated full-text articles and conducted data extraction, using a standardised, predefined form. Relevant data regarding participant characteristics (age, sex, training status, height and body weight), study characteristics (muscular hypertrophy measurement, training frequency, exercises prescribed, sets, repetitions, rest between sets, intensity, tempo of exercise(s), intervention length and compliance) and muscular hypertrophy testing were collected. Shortly after extractions were performed, the reviewers crosschecked the data to confirm their accuracy. Any discrepancies were discussed until a consensus was reached with any disagreements being resolved by consultation with a third reviewer (M.H.).

Quality analysis

Methodological quality of studies meeting the inclusionary criteria was assessed using a modified Downs and Black quality assessment tool (Downs & Black, 1998) (Electronic Supplementary Material

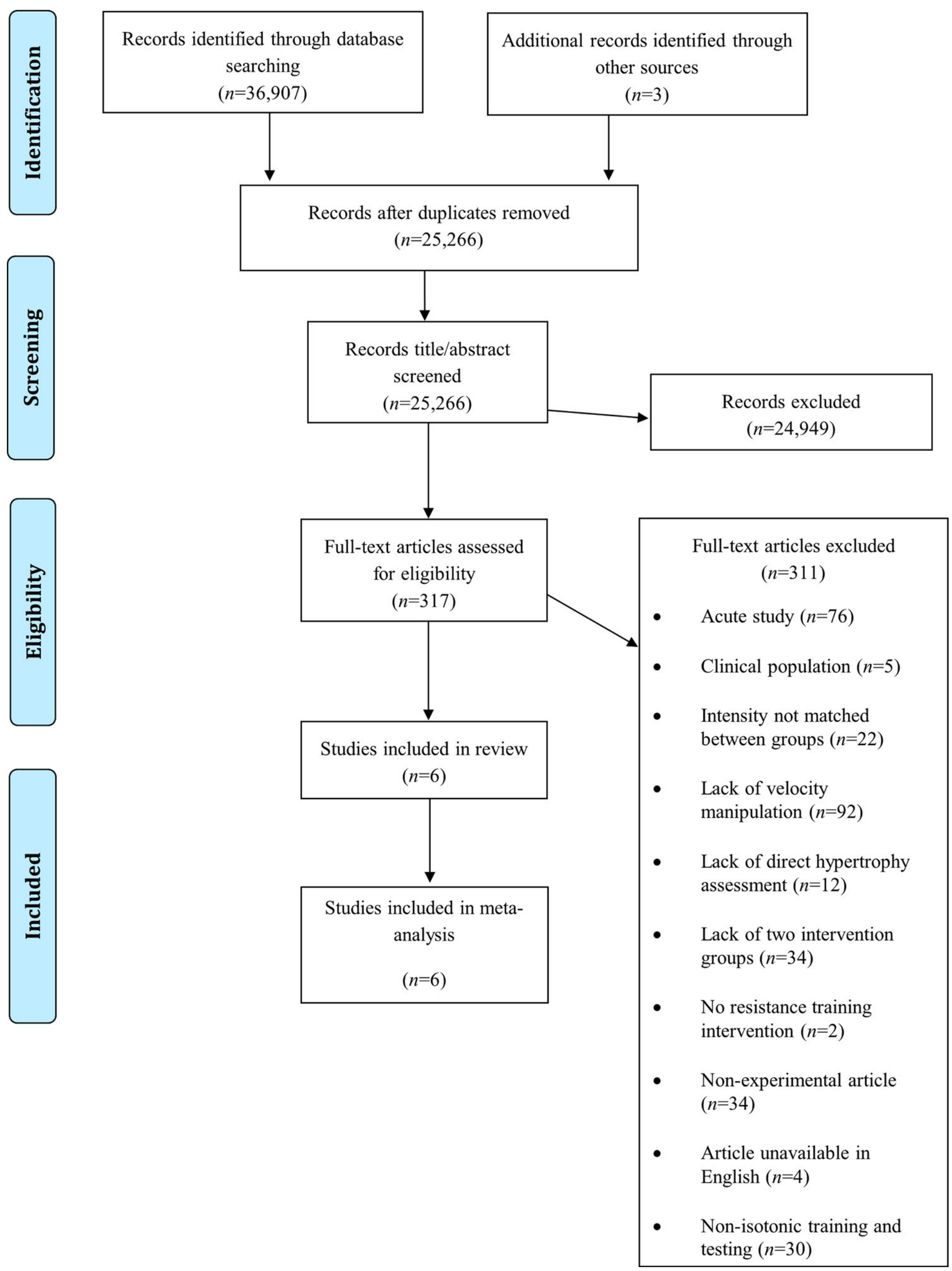

Figure 1. Flow chart of study retrieval process.

Appendix S1). Scores range from 0 to 29 points, with higher scores reflecting higher-quality research. Studies were independently rated by two reviewers (T.D. and K.K.) and checked for internal (intra-rater) consistency across items before the scores were combined into a spreadsheet for discussion. If disagreements between ratings occurred, they were resolved by discussion or consensus was reached through the assistance of a third reviewer (M.H.).

Results

Description of studies

The database search yielded 25,266 potential studies (Figure 1). Six studies met the eligibility criteria and were included in the systematic review and meta-analysis (Table I). There were a total of 119 participants (91 males and 28 females) aged 19–69 years. Of the six studies that were included in the analysis, three studies included exclusively elderly participants (Nogueira et al., 2009; Watanabe et al., 2013; Watanabe, Madarame, Ogasawara, Nakazato, & Ishii, 2014), with the remaining studies including younger adult participants (Tanimoto & Ishii, 2006; Usui, Maeo, Tayashiki, Nakatani, & Kanehisa, 2016). All participants had no previous resistance training experience.

Training specifics of each study are presented in Table I. Training interventions consisted of 3–6 sets of 8–13 repetitions at loads of 30–60% 1RM. One study stated that one intervention (fast group) performed resistance exercise to concentric failure (Tanimoto & Ishii, 2006). Velocity of repetitions was prescribed by tempo of concentric and eccentric phases in all six studies. Participants in the fast condition performed the concentric phase of repetitions explosively in two studies (Hisaeda, Nakamura, Kuno, Fukunaga, & Muraoka, 1996; Nogueira et al., 2009), while the remaining four studies provided a 1 second tempo (Tanimoto & Ishii, 2006; Usui et al., 2016; Watanabe et al., 2013; Watanabe et al., 2014). The eccentric phase in the fast condition was performed with a 1–3 second tempo (Hisaeda et al., 1996; Nogueira et al., 2009; Tanimoto & Ishii, 2006; Usui et al., 2016; Watanabe et al., 2013; Watanabe et al., 2014). Participants in the moderate-slow condition performed the concentric phase of each repetition with a tempo of 2–3 seconds whilst the eccentric phase was performed with a tempo of 2–3 seconds (Hisaeda et al., 1996; Nogueira et al., 2009; Tanimoto & Ishii, 2006; Usui et al., 2016; Watanabe et al., 2013; Watanabe et al., 2014).

All studies assessed muscular hypertrophy using a direct measure. Three studies measured muscle hypertrophy using cross-sectional area (Hisaeda et al., 1996; Tanimoto & Ishii, 2006; Watanabe et al., 2014), with the remaining three studies using muscle thickness (Usui et al., 2016; Watanabe et al., 2013). Of all the studies included in the review, three measured change in hypertrophy of the quadriceps femoris muscle group (Tanimoto & Ishii, 2006; Usui et al., 2016; Watanabe et al., 2014), one study measured both the quadriceps femoris (knee extensors) and hamstrings (knee flexors) muscle groups (Watanabe et al., 2013), another study measured both the quadriceps femoris and biceps brachii (Nogueira et al., 2009), and the final study measured the biceps brachii muscle (Hisaeda et al., 1996). Therefore, hypertrophy of the lower body muscles were examined in five studies and of the upper body muscles in two studies.

Methodological quality

The mean ± SD quality rating score was 20.8 ± 1.3 out of a possible score of 29. All studies scored 0 (not reported or unable to determine) for attempting to blind participants and researchers to interventions and randomisation assignments. All studies also scored 0 for the reporting of the time period in which participants were recruited within as well as the reporting of actual probability values (all studies reported $p < 0.05$ instead of $p = 0.035$ for example). All studies reported the aims/purpose of the study, outcome measures, characteristics of participants, details of each intervention, main findings, and point estimates of random variability. All participants were randomly allocated into interventions and considered representative of untrained populations. Outcome measures of muscular hypertrophy were considered valid and reliable. Two studies reported adherence to each intervention with the range being 87.5–100% (Watanabe et al., 2013; Watanabe et al., 2014). Also, only one study reported that their intervention was supervised by trained personnel (Nogueira et al., 2009), while it could not be determined whether the remaining studies provided supervision.

Hypertrophy of lower body muscles

Three of the five studies that examined changes in hypertrophy of the lower body muscles found that moderate-slow compared to fast training resulted in significantly greater increases in hypertrophy of the quadriceps (Table II). Of the other two studies, significant increases in quadriceps hypertrophy were found within groups. Usui et al. (2016) found that moderate-slow training led to a significant increase in hypertrophy of quadriceps whereas no increase

Table I. Participant and training characteristics of included studies.

Study	Group	Sex: M (%)[a]	Age (y)[a]	Training Status	Exercise Prescription	Duration (wk)	Frequency (d/wk)	Velocity manipulation
Hisaeda et al. (1996)	Fast ($n = 14$)[b]	59	22.0 ± 2.0	Untrained	UBC: 6 × 10 repetitions @ 50% 1RM, 30 s rest between sets	8	4	2 s ECC, explosive CON
	Slow ($n = 14$)[b]	59	22.0 ± 2.0	Untrained				2 s ECC, 2 s CON
Nogueira et al. (2009)	Fast ($n = 11$)	100	66.6 ± 5.8	Untrained	LP, KE, KF, CP, SR, EE, EF: 3 × 8–10 repetitions @ 60% 1RM (16/20 sessions performed at this intensity), 1 min 30 s rest between sets.	10	2	2–3 s ECC, explosive CON
	Slow ($n = 11$)	100	66.3 ± 4.8	Untrained				2–3 s ECC, 2–3 s CON
Tanimoto and Ishii (2006)	Fast ($n = 8$)	100	19.8 ± 0.7	Untrained	KE: 3 sets of 8 repetitions @ ~50% 1RM (slow group achieved repetition failure), 1 min rest between sets	12	3	1 s ECC, 1 s CON, 1 s relax
	Slow ($n = 8$)	100	19.0 ± 0.6	Untrained				3 s ECC, 3 s CON, 1 s pause
Usui et al. (2016)	Fast ($n = 7$)	100	22.5 ± 0.5	Untrained	PS: 3 × 10 repetitions @ 50% 1RM, 1 min rest between sets	8	3	1 s ECC, 1 s CON, 1 s pause
	Slow ($n = 9$)	100	22.2 ± 2.1	Untrained				3 s ECC, 3 s CON
Watanabe et al. (2013)	Fast ($n = 17$)	48.5	66.8 ± 3.8	Untrained	KF, KE: 3 × 8 repetitions @ 50% 1RM, 1 min rest between sets	12	2	1 s ECC and 1 s CON, 1 s relax
	Slow ($n = 18$)	50	66.8 ± 5.2	Untrained				3 s ECC, 1 s ISO, 3 s CON
Watanabe et al. (2014)	Fast ($n = 9$)	77.8	69.0 ± 4.7	Untrained	KE: 3 × 13 repetitions @ 30% 1RM, 1 min rest between sets	12	2	1 s ECC and 1 s CON, 1 s relax
	Slow ($n = 9$)	77.8	69.9 ± 5.1	Untrained				3 s ECC, 1 s ISO, 3 s CON

Notes: *BB* = biceps brachii; *CON* = concentric; *CP* = Chest press; *CSA* = cross-sectional area; *d* = days; *ECC* = eccentric; *EE* = elbow extension; *EF* = elbow flexion; *HA* = hip abduction; *HE* = hip extension; *HF* = hip flexion; *HS* = half squat; *ISO* = isometric; *KF* = knee flexion; *KE* = knee extension; *LP* = leg press; *M* = males; *MT* = muscle thickness; *min* = minutes; *PS* = parallel squat; *QUAD* = quadriceps; *RF* = rectus femoris; *RM* = repetition maximum; *s* = second; *SMS* = Smith machine squat; *SR* = seated row; *UBC* = unilateral bicep curl; *wk* = weeks; *y* = years.

[a]Data are reported as mean ± SD = standard deviation.

[b]Participants trained their arms using the two different protocols.

Table II. Summary of the results of fast versus moderate-slow resistance training on muscular hypertrophy.

		Fast		Moderate-Slow		
Study	Outcome measure	Pre-training	Post-training	Pre-training	Post-training	Between groups
Lower body						
Nogueira et al. (2009)	MT of RF (mm)	18.6 ± 1.7	20.7 ± 2.0 (11.3% increase; $p < 0.05$)	19.0 ± 2.7	20.0 ± 2.6 (5.5% increase)	No differences ($p > 0.05$)
Tanimoto and Ishii (2006)	CSA of KE (cm^2)	68.3 ± 11.7	68.9 ± 11.7	72.8 ± 9.1	76.7 ± 8.7 ($p < 0.05$)	Greater increases for Moderate-slow ($p < 0.05$)
Usui et al. (2016)	MT of RF-DIS (mm)	28.7 ± 4.5	29.0 ± 4.2	15.8 ± 2.9	17.1 ± 3.2 (10% increase; $p = 0.026$)	No differences ($p > 0.05$)
	MT of RF-MID (mm)	27.9 ± 3.2	27.4 ± 3.4	28.4 ± 2.6	29.0 ± 3.4 (6% increase; $p = 0.01$)	
	MT of RF-PROX (mm)	30.5 ± 3.2	30 ± 4.2	32.1 ± 2.6	32.1 ± 2.6	
	MT of VI-DIS (mm)	21.6 ± 3.4	22.1 ± 5.3	24.5 ± 5.3	25.8 ± 5.8 (9% increase; $p = 0.002$)	
	MT of VI-MID (mm)	25.8 ± 4.2	25.8 ± 4.5	27.1 ± 3.4	27.9 ± 29.5	
	MT of VI-PROX (mm)	30.5 ± 5.0	29.0 ± 4.2	32.4 ± 4.5	33.4 ± 4.7	
	MT of VL (mm)	27.4 ± 3.7	27.4 ± 3.7	27.9 ± 3.2	29.5 ± 3.7	
	MT of VM (mm)	50.0 ± 4.2	49.5 ± 5.3	53.2 ± 5.8	54.7 ± 5.3	
Watanabe et al. (2013)	MT of KE (mm)	42.3 ± 4.7	42.6 ± 4.3	41.3 ± 6.6	43.8 ± 7.0 ($p < 0.001$)	Greater increase for Moderate-slow ($p < 0.001$).
	MT of KF (mm)	60.5 ± 6.3	62.6 ± 4.9	56.8 ± 5.6	60.1 ± 5.0	No differences ($p > 0.05$)
Watanabe et al. (2014)	CSA of quadriceps (cm^2)	49.0 ± 9.1	49.5 ± 9.2 (1.1% increase)	51.0 ± 10.2	53.6 ± 11.2 (5.0% increase; $p < 0.001$)	Greater increases for Moderate-slow ($p < 0.001$)
Upper body						
Hisaeda et al. (1996)	CSA of BB (cm^2)	40.8 ± 11.7	47.0 ± 13.8 (14.2% increase)	41.3 ± 11.2	45.6 ± 12.4 (11.2% increase)	Greater increases for Fast ($p < 0.05$)
Nogueira et al. (2009)	MT of BB (mm)	21.3 ± 2.0	24.3 ± 3.2 (14.3% increase; $p < 0.05$)	22.9 ± 2.9	24.4 ± 3.5 (6.7% increase; $p < 0.05$)	Greater increases for Fast ($p < 0.05$)

Notes: % = percentage; BB = biceps brachii; cm = centimetres; CSA = cross-sectional area; DIS = Distal; KE = knee extensors; KF = knee flexors; MID = middle; MT = muscle thickness; mm = millimetres; p = p-value; PROX = proximal; RF = rectus femoris; VI = vastus intermedius; VL = vastus lateralis; VM = vastus medialis.

was found for the fast training group. In contrast, Nogueira et al. (2009) found a significant increase in hypertrophy of the quadrceps following fast but not moderate-slow training. Usui et al. (2016) also found no significant increase in hypertrophy of the hamstrings following either fast or moderate-slow training.

Hypertrophy of upper body muscles

The two studies that examined muscle hypertrophy of the upper body muscles found that fast compared to moderate-slow training resulted in significantly greater increases in hypertrophy of the biceps brachii (Table II).

Discussion

Based on the results from this systematic review it appears that moderate-slow training is more effective for promotion of hypertrophy of the quadriceps and that fast training is more efficacious for hypertrophy of the biceps brachii. Therefore, these interesting findings may indicate different hypertrophic responses for the quadriceps and biceps brachii to manipulation of movement velocity during resistance training. However, caution is required due to the low number of studies hence insufficient data for assessing the effect of movement velocity on muscle-specific hypertrophy via a meta-analytic approach. Future research studies are required in cohorts of healthy adults in longitudinal randomised controlled studies to confirm and extend our findings.

Findings from a previous review suggested that a wide range of movement velocities can be used during resistance training to maximise muscular hypertrophy (Schoenfeld, Ogborn, & Krieger, 2015). However, this previous review on muscular hypertrophy only included studies that had participants perform resistance exercise to muscular failure, despite conflicting evidence for the superiority of this practice for muscular hypertrophy (Nóbrega & Libardi, 2016). Furthermore, the authors of previous review did not attempt to control for training volume, which has been shown to influence muscular hypertrophy gains (Schoenfeld, Ogborn, & Krieger, 2017). Therefore, due to the strict study inclusion criteria used for the present review it could be argued that the independent variable (i.e. movement velocity) was better isolated. However, the present review is not without its own limitations that may have confounded the findings and will be discussed later in this paper.

It has been recommended that intentionally moderate to slow movement velocities should be used by novice (no resistance training experience or not training for several years) and intermediate-trained (~6 months consistent resistance training experience) individuals when targeting muscular hypertrophy (Ratamess et al., 2009). Lifting of lighter loads at slower compared to fast movement velocities in training volume-equated conditions is likely to result in completion of sets to or close to muscle failure. This was reported in one of the studies included in the present review where the participants in the moderate-slow group performed 8RM compared to eight repetitions by the fast groups for the knee extension exercise, both at ~50% 1RM (Tanimoto & Ishii, 2006). Therefore, the potential for moderate-slow compared to fast velocities with light loads to stimulate greater muscular hypertrophy of the quadriceps may be linked to factors that increase the metabolic effect (i.e. closer proximity to muscular failure) (Schoenfeld, 2010). It should also be noted that for the studies favouring the slower velocity for quadriceps hypertrophy (within or between groups), both the concentric and eccentric velocities were manipulated. Therefore, the effects of altered eccentric compared concentric velocities on hypertrophy of quadriceps could not be examined.

In contrast to the findings on the leg muscles, faster compared to moderate-slower movement velocities may maximise biceps brachii hypertrophy when using ≤ 60% 1RM loads. It is important to note that only the concentric velocity was manipulated (performed explosively) in the two studies used in this analysis. A slower eccentric movement velocity has been shown to enhance hypertrophy of the biceps brachhi (Pereira et al., 2016), therefore it is interesting that an intentionally faster concentric contraction was found to enhance the hypertrophic effect on this muscle. The potential mechanisms that may explain how intentionally faster compared to moderate-slower concentric velocities may maximise muscular hypertrophy include greater muscle activation (Sakamoto & Sinclair, 2012), rate of fatigue (due to compromised blood flow) (Hoelting, Scheuermann, & Barstow, 2001), and acute decrements in muscular strength and power post-exercise (Ide et al., 2011). Furthermore, studies that have compared fast to slow concentric velocity resistance training at ≥60% 1RM have shown greater velocity loss and slightly higher metabolic stress with faster training (Gonzalez-Badillo, Rodriguez-Rosell, Sanchez-Medina, Gorostiaga, & Pareja-Blanco, 2014; Pareja-Blanco et al., 2014).

The bicep brachii tends to display a higher proportion of type II muscle fibers (Johnson, Polgar, Weightman, & Appleton, 1973; Srinivasan, Lungren, Langenderfer, & Hughes, 2007). This may indicate that fast resistance training has the potential to enhance muscular hypertrophy of the bicep brachii due to increased recruitment of faster twitch fibers with fast movement velocities (Paddon-Jones, Leveritt, Lonergan, & Abernethy, 2001). The single joint quadriceps muscles tend to show a greater amount of type I muscle fibres (Gouzi et al., 2013; Johnson et al., 1973), while the rectus femoris (two-joint muscle) display a tendency towards a greater portion of type II muscle fibres (Garrett, Califf, & Bassett, 1984; Johnson et al., 1973). Of the studies included in the present review only two studies exclusively measured changes in hypertrophy of the rectus femoris (Nogueira et al., 2009; Tanimoto & Ishii, 2006), while the other studies assessed a combination of quadriceps muscles. Therefore, it was not possible to discern the hypertrophic effect on individual muscles due to the limited data available from the studies included in this review. However, it seems plausible that the hypertrophic response of muscles following different movement velocity conditions may be dependent on muscle fiber type.

It is well documented that actual movement velocity is inversely related to the load with the heaviest loads eliciting the slowest movement velocity, whereas lighter loads can be moved with much faster movement velocities (Ratamess et al., 2009). In contrast, when attempting to perform repetitions at intentionally slow velocities, force output declines and the loads need to be reduced to achieve a targeted training volume (sets x repetitions). Whilst hypertrophy of type I and II muscle fibres are achieved at intensities from 40% to 90% 1RM, greater hypertrophic responses are associated with greater relative intensities (Fry, 2004). Also, reductions in load of a significant amount (e.g. reducing load from 85% to 55% 1RM), so that intentionally slower movement velocities can be achieved, will ultimately decrease muscle activation and generation of force (Keogh et al., 1999), thus creating a less optimal environment for muscular hypertrophy. There is also evidence to suggest that slower lifting speeds are less effective for stimulating the highest threshold motor units (Schuenke et al., 2012), which is important since type II muscle fibres have a greater relative growth than type I fibers (Campos et al., 2002). Unfortunately, there were no studies included in the present review that used loads >60% 1RM and therefore changes in muscle hypertrophy following intentionally fast versus moderate-slow movement velocities with heavier loads could not be examined.

From the limited data included in this review, it appears that the upper body has a greater capacity for hypertrophy compared to the lower body as has been previously reported (Abe et al., 2000; Chilibeck et al., 1998). This is supported by larger effect sizes (which were calculated) for the biceps brachii (ES = 0.37–0.65) compared to the quadriceps (ES = 0.25–0.39). This phenomenon is thought to be due to the lower training response of the legs due to their greater everyday use (Cureton, Collins, Hill, & McElhannon, 1988) and greater hypertrophy potential of upper body muscles due to greater androgen receptor content (Kadi, Bonnerud, Eriksson, & Thornell, 2000).

Across the six studies that were included in the review process, 19 out of 29 items were fully met on the Downs and Black quality assessment (Downs & Black, 1998). There were six items mainly related to internal validity that were not met by any study. Based on the poor results for the internal validity items, it could be concluded that bias and confounding may have influenced the results. Although, it should be noted that the scoring of many of the internal validity items could not be determined due to a lack of information reported in the papers which contributed to the poor score. Therefore, the poor scoring for internal validity of the studies included in the present review may have been exaggerated.

There are several limitations that should be taken into account when interpreting the results of this study. Firstly, there were only a small number of studies that met the inclusion criteria for this review and due to the insufficient data a meta-analysis could not be conducted. Therefore, the precise effects of manipulation of movement velocity for enhancing muscular hypertrophy could not be determined. Secondly, the participants included in the review varied in terms of age (young versus old) and sex which may have influenced the results. Finally, muscle hypertrophy was assessed via different imaging techniques which may have influenced the results.

Practical applications

Based on the findings of this systematic review and meta-analysis, resistance trainers can use a combination of fast and moderate-slow movement velocities during resistance training to enhance muscular hypertrophy. There may be benefit with devoting more training towards moderate-slower movement velocities when targeting the quadriceps and faster concentric velocities when targeting the biceps brachii. Further research needs to be conducted with heavier loads, therefore when lifting >60% 1RM trainers are encouraged to incorporate a combination of movement velocities when the training goal is muscle hypertrophy.

Disclosure statement

No potential conflict of interest was reported by the authors.

Supplemental data

Supplemental data for this article can be accessed here http://dx.doi.org/10.1080/17461391.2018.1434563

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