EFFECTS OF VIBRATION TRAINING ON MUSCLE STRENGTH: A META-ANALYSIS

PEDRO J. MARÍN[1] **AND MATTHEW R. RHEA**[2,3]

[1]Laboratory of Physiology, European University Miguel Ole Cervantes, Valladolid, Spain; [2]Human Movement Program, A. T. Still University, Mesa, Arizona; and [3]RACER Academy of Exercise Sciences, Logan, Utah

ABSTRACT

Marín, PJ and Rhea, MR. Effects of vibration training on muscle strength: A meta-analysis. *J Strength Cond Res* 24(2): 548–556, 2010—The purpose of this meta-analysis was to attempt to gain a clear picture of the magnitude of strength improvements expected after acute and chronic vibration training and to identify specific factors that influence the treatment effects. Studies employing a strength training intervention and containing data necessary to calculate effect size (ES) were included in the analysis. A total of 31 studies met the inclusion criterion. Analysis of ES demonstrated that the type of vibration platform employed is a moderator of the treatment effect of vibration on strength development. Differences were noted in both acute and chronic changes in muscle strength when vertical vibration platforms are compared with oscillating platforms. Vertical platforms elicit a significantly larger treatment effect for chronic adaptations (ES = 1.24) compared with oscillating platforms (ES = −0.13). However, oscillating platforms elicit a greater treatment effect for acute effects (ES = 0.24) compared with vertical platforms (ES = −0.07). The data also show that gender, training status, and exercise protocol are moderators of the response to vibration exercise for strength development (vertical platforms). Based on the overall analysis, it is apparent that vibration exercise can be effective at eliciting chronic muscle strength adaptations. The vibration exercise can be used by exercise professionals to enhance muscular strength.

KEY WORDS WBV, acceleration training, performance enhancement

INTRODUCTION

Muscular strength represents the ability to generate force and serves as the basis for all human movement. Much research has been devoted to the development of muscular strength (39) with various methods used to stimulate adaptations. Conventional resistance training has involved the use of weights, weight machines, body weight, resistance bands, and other devices designed to provide mechanical resistance. Each form of resistance can result in overload, a point where the neuromuscular system experiences a stress to which it is unaccustomed, and adaptation in the mechanical properties or physiological mechanisms responsible for force generation.

Our search is one attempting to find the most effective and efficient application of exercise stress to elicit positive adaptations. Generally, this search involves an evaluation of prescription differences (i.e., volume and intensity of training, periodization, etc.). Other evaluations involve comparisons of exercise modalities (i.e., free weights vs. exercise machines), and at other times, a combination of technology and prescription is employed; the body of research examining vibration as a form of exercise stress is one such example of the latter. The purpose of this meta-analysis was to examine strength improvements elicited through the application of different training prescriptions of vibration exercise. Combining the bulk of published research on this topic in a quantitative fashion allows for the evaluation of the effectiveness of this technology and attempts to identify the optimal training prescription for a variety of different populations.

Vibration training has become increasingly accessible and used at sports and rehabilitation centers. Vibration training or whole body vibration (WBV) constitutes a mechanical stimulus that enters the human body via hands when griping a vibration dumbbell or bar, pulley system, via feet when standing on vibration platform, or applied directly to the muscle belly or the tendon of muscle by a vibration unit (punctual system). The use of platforms represents the most common form of vibration exercise. There are basically 2 types of vibration platforms: platforms that vibrate in a predominantly vertical direction (vertical platform) and the platform that vibrates through rotation about a horizontal axis such that distances farther from the axis of rotation result in larger amplitude vibrations (oscillating platform) (1).

There are a few theories of how vibration stimuli can have effect on the neuromuscular system (7,44), such as a stimulation of Ia afferents via spindle, resulting in facilitating

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Address correspondence to Matthew R. Rhea, mrhea@atsu.edu.

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homonymous α-motor neurons and/or perturbation of the gravitational field during the time course of intervention (7). A relevant question arises as to the strength of the evidence scientific for vibration training. Several narrative reviews have been published examining the results of a small number of studies and have reported contradictory conclusions. Cardinale and Bosco (7) reviewed 6 articles and concluded that vibration exercise showed good potential to enhance neuromuscular performance. Two years later, Luo et al. (27) reviewed 14 studies (8 acute effect, 5 acute residual effect, and only 3 chronic effects) and concluded, "Current findings suggest that vibration training may have positive acute and chronic effects on neuromuscular performance and training." In the same year, Jordan et al. (24) by means of 14 studies (7 acute effects and 7 chronic effects) concluded, "It would appear, based on the limited scientific evidence, that vibration training may serve as a tool to develop explosive ability in athletes." Cardinale and Wakeling (8) after reviewing 23 studies (9 acute effects and 14 chronic effects) concluded, "The current evidence indicates that WBV may be an effective exercise intervention for reducing the results of the aging process in musculoskeletal structures." In 2007, Rehn et al. (36) stated in a systematic review of 19 studies (14 chronic effects and 5 acute effects), "There is strong to moderate evidence that long-term WBV exercise can have positive effects on muscular performance among untrained and elderly women. There is no clear evidence for effects on muscular performance after short-term vibration stimuli." In the same year, Nordlund and Thorstensson (32) concluded that 12 studies resulted in "no or only minor additional effects of WBV."

These types of reviews, which may be perceived as more of an art than science, contain numerous areas in which bias may persuade the conclusions drawn by the reviewers (34). The narrative review relies on *probability* values to make conclusions about the body of literature. Unfortunately, the probability value can be misleading, especially when studies are performed with small sample sizes that limit statistical power and increase the likelihood of the researcher failing to express differences between treatments when in fact such differences exist. A significant p value may also be misleading, *type I error*, if the actual magnitude of the difference between treatments is so small as to be of little consequence (38).

On the other hand, a powerful method of research synthesis is the meta-analysis (38). The steps of the meta-analytic review increase the scope, objectivity, and quantification of the overall body of literature on a particular topic. Steps for thoroughly searching the literature, coding of study characteristics, extracting and standardizing data from individual studies, and statistically evaluating treatment effects make the meta-analysis a useful tool when attempting to draw conclusions about the research examining vibration exercise for strength improvements. Therefore, the purpose of this meta-analysis was to attempt to gain a clear picture of the magnitude of strength improvements expected after acute and chronic training and to identify specific factors that influence the treatment effects.

METHODS

Experimental Approach to the Problem

To evaluate the effectiveness of vibration training for increases in strength, a meta-analytic review was conducted. Literature searches identified relevant studies, which were combined and analyzed statistically to provide an overview of the body of research on this topic. Statistical results were interpreted to draw conclusions based on the literature with suggestions for applications and future research presented for strength and conditioning professionals.

Literature Search

Electronic databases (MEDLINE, PubMed, SPORT DISCUS, and Embase) were searched on February 29, 2008, back to the earliest available time (1966) for the word *vibration* in combination with *training*, *performance*, *strength*, or *power*. Exclusion of studies with irrelevant content and doublets was carried out in 3 steps. First, the titles of the articles were read. Second, the abstracts were read. Third, the entire article was read. The reference lists of relevant articles were, in turn, scanned for additional articles (published or unpublished) that met the inclusion criteria. Attempts were made to contact authors requesting any unpublished work. Conference abstracts and proceedings were excluded.

Criteria

Criteria for study inclusion were that articles must be about vibration training (107 articles satisfied this criterion), the study must employ a muscle strength assessment (36 articles fulfilled this criterion), the participants must be healthy subjects (32 articles), and the study must include all necessary data to calculate effect sizes (ESs) (i.e., mean, standard deviation, and numbers of subjects) (31). A total of 31 studies were included in the analysis: 13 acute effects (5,9,10,12,14,18,20,25,29,31,40,41,47) and 18 chronic effects (2–4,15–17,19,22,23,26,28,35,42–44,46,48,49). Many of the initial studies were excluded because they evaluated the effectiveness of vibration exercise for improving muscle power, balance, bone density, and/or range of motion assessments and will be synthesized in separate meta-analyses.

Coding of Studies

Each study was read and coded by the primary investigator for the following variables: descriptive information including gender and age, training status of the participants, frequency of training, number of sets performed, volume (seconds of vibration stimuli per session), period of rest between sets in seconds, vibration application, frequency (Hz, average per session), peak to peak amplitude ($mm_{p\text{-}p}$, double the amplitude), protocol exercise (isometric, dynamic, or both), exercise type (squat or squat plus other exercises, e.g., lunges), alteration of training parameters during workouts, and acute or chronic effects.

Table 1. Method of vibration application on effect size for strength training.*

	Vertical platform					Oscillating platform				
	Acute		Chronic			Acute		Chronic		
	Mean (95% CI)	*n*	Mean (95% CI)	*n*		Mean (95% CI)	*n*	Mean (95% CI)	*n*	
Overall	−0.07 (−0.83 to 0.70)	10	1.24 (0.91 to 1.57)	45	$p < 0.01$	024 (−0.14 to 0.62)	17	−0.13 (−0.53 to 027)	15	$p > 0.05$
Moderators										
Gender										
Men	0.33 (0.10 to 0.56)	8	ID		$p < 0.01$	0.15 (−0.48 to 0.79)	9	ID		
Women	ID		1.53 (1.06 to 2.00)	31		ID		ID		
Both	ID		0.75 (0.02 to 1.48)	13		ID		−0.24 (−1.08 to 0.61)	7	
Age										
<25 y	−0.16 (−028 to −0.05)	8	1.18 (0.71 to 1.66)	31	$p > 0.05$	0.15 (−0.45 to 0.76)	13	ID		
25–50 y	ID		ID			ID		ID		
>50 y	ID		1.83 (1.04 to 2.62)	11		ID		0.16 (−0.87 to 0.80)	10	
Training status										
Untrained	ID		1.78 (1.31 to 225)	27	$p < 0.01$	0.05 (−0.52 to 0.63)	12	0.16 (−0.48 to 0.8)	10	
Trained	ID		ID			ID		ID		
Athletes	ID		0.54 (−0.05 to 1.12)	17		ID		ID		
Parameters change										
Yes	ID		1.28 (0.87 to 1.69)	43		ID		−0.10 (−0.62 to 0.42)	14	
No	−0.06	10	ID			0.11 (−0.43 to 0.65)	15	ID		
Exercise protocol										
Isometric	−0.06	10	0.78 (−0.23 to 1.79)	7	$p < 0.05$	0.49 (0.09 to 1.01)	9	ID		
Dynamic	ID		ID			ID		ID		
Both	ID		1.40 (0.96 to 1.84)	31		−0.06 (−0.72 to 0.59)	8	033 (−0.31 to 0.97)	6	
Exercise										
Squat	−0.06	10	ID			0.105 (−0.44 to 0.65)	14	−0.55 (−1.34 to 024)	6	$p > 0.05$
Squat + others (e.g., lunges)	ID		1.28 (0.87 to 1.69)	43		ID		0.33 (−0.31 to 0.97)	6	

*ID = insufficient data (<6 ESs); CI = confidence interval; ES = effect size.

TABLE 2. Descriptive data of the vertical platform and the oscillating platform for strength training.

			n	Minimum	Maximum	Mode	Mean	*SD*
Vertical platform	Acute	Hz	10	20	30	30	28	4.21
		mm (p-p)	10	2.5	5	2.5	3.6	1.02
		Sets	10	1	10	1	5.6	4.24
		Volume (s)	10	30	600	30	312	268.77
		Rest (s)	10	0	120	0	48	47.32
	Chronic	Hz	60	23.6	40	40	33.66	5.91
		mm (p-p)	60	1	9	8	5.36	2.18
		Weeks	60	2	48	24	13.55	9.09
		Days/week	60	3	5	3	3.43	0.81
		Sets	56	1	21.1	15	10.88	5.18
		Volume (s)	56	60	1056	690	485.29	265.33
		Rest (s)	53	0	80	60	43.79	16.76
Oscillating platform	Acute	Hz	17	22	30	26	26.76	2.43
		mm (p-p)	17	6	12	10	9.39	1.46
		Sets	17	1	10	1	4.59	3.62
		Volume (s)	17	240	600	600	464.76	151.14
		Rest (s)	17	0	120	0	49.41	52.97
	Chronic	Hz	15	20	30	26	24.12	3.04
		mm (p-p)	15	5	12	6	7.05	1.78
		Weeks	15	8	24	8	10.33	4.1
		Days/week	15	1	3	3	2.41	0.79
		Sets	15	1	6.4	6	3.89	2.18
		Volume (s)	15	77	384	375	267.56	130.45
		Rest (s)	15	0	120	62	65	42.14

Chronic effects were defined as those measured after repeated over a period of at least 1 week. Training status of the participants was divided into athletic, trained, and untrained classifications. Participants must have been weight training for at least 1 year before the study to be considered as trained, and for athlete classification, participants must have been in competitive athletics at the high school, collegiate, professional, or international level.

Coder drift was assessed (33) by randomly selecting 10 studies for recoding. Per case agreement was determined

TABLE 3. Descriptive data of the vibration devices: punctual, pulley, and dumbbell.

		n	Minimum	Maximum	Mode	Mean	*SD*
Punctual	Hz	7	7.5	65	65	43.57	27.75
	mm (p-p)	7	2.4	4	2.4	3.02	0.78
	Sets	7	3	16	3	4.86	4.91
	Volume (s)	7	45	3,000	45	905.71	1431.28
	Rest (s)	7	0	180	180	103.57	95.33
Pulley	Hz	3	10	44	10	21.33	19.63
	mm (p-p)	3	1.4	5	5	3.8	2.07
	Sets	3	4	6	4	4.67	1.15
	Volume (s)	3	80	120	80	93.33	23.09
	Rest (s)	3	120	165	120	135	25.98
Dumbbell	Hz	1	26	26	26	26	0
	mm (p-p)	1	6	6	6	6	0
	Sets	1	5	5	5	5	0
	Volume (s)	1	300	300	300	300	0
	Rest (s)	1	0	0	0	0	0

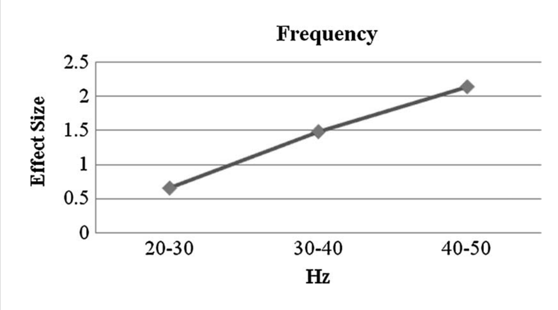

Figure 1. Dose-response for vibration frequency of vertical platform, chronic effects.

by dividing the variables coded the same by the total number of variables. A mean agreement of 0.90 was required for acceptance.

Calculation and Analysis of Effect Size

Pre/post ESs were calculated with the following formula: ([posttest mean − pretest mean]/pretest *SD*) (11). Effect sizes were then adjusted for sample size bias (21). This adjustment consists of applying a correction factor to adjust for a positive bias in smaller ($n < 20$) sample sizes (21). Descriptive statistics were calculated, and analysis of variance by groups was used to identify differences between training status, gender, vibration application, parameter change during workouts, acute vs. chronic effects, protocol exercise, exercise type, and age with level of significance set at $p \leq 0.05$. All calculations were made with SPSS statistical software package v.16.0 (SPSS, Inc., Chicago, IL, USA). The scale proposed by Rhea (37) was used for interpretation of ES magnitude.

RESULTS

Overall ESs and moderating variables are presented in Table 1. The descriptive data of the vertical platform and oscillating platform are shown in Table 2, and the descriptive data of the vibration devices punctual, pulley, and dumbbell are shown in Table 3. The 71 ESs for chronic training and 37 ESs for acute training were obtained from a total of 31 primary studies.

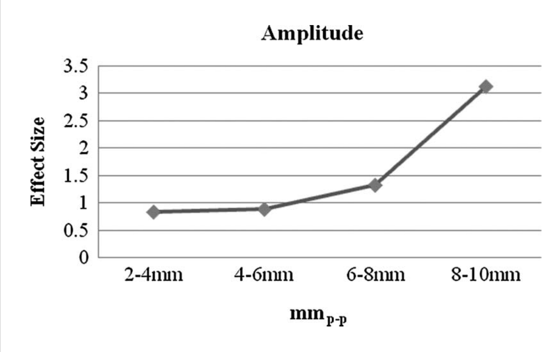

Figure 2. Dose-response for vibration amplitude of vertical platform, chronic effects.

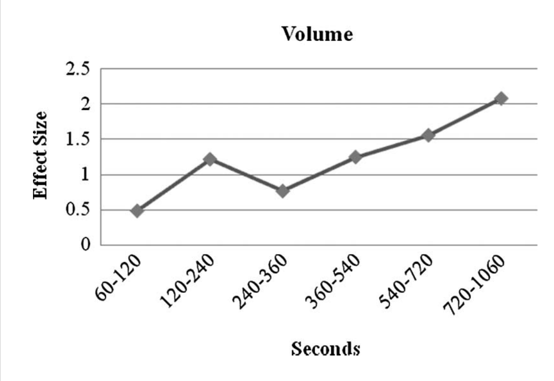

Figure 3. Dose-response for volume of vertical platform, chronic effects.

Vertical Platform

The mean overall ES for vertical platform used for chronic training was 1.24 (95% confidence interval [CI]: 0.91–1.57; $n = 45$) and for acute training was −0.07 (95% CI: −0.83 to 0.70; $n = 10$). Effect size calculations for acute and chronic changes were significantly different ($p < 0.01$) (Table 1). Significant difference was found between vertical and oscillating platforms for chronic training ($p < 0.01$). Insufficient data were obtained for an analysis of other forms of vibration application.

Moderating Variables. An analysis of the differences in strength gains achieved in women and combined gender groups from all included studies was performed to determine whether gender influenced strength gains. The female group gained more strength than the combined group (1.53, [95% CI: 1.06–2.00; $n = 31$] vs. 0.75 [95% CI: 0.02–1.48; $n = 13$], $p < 0.01$, respectively). Strength gain was unaffected by age ($p > 0.05$). However, significant differences were found between untrained and athletes (1.78, [95% CI: 1.31–2.25; $n = 27$] vs. 0.54 [95% CI: −0.05 to 1.12; $n = 17$], $p < 0.01$, respectively). On the other hand, the exercise protocol with dynamic plus isometric muscle contraction was significantly greater than isometric contraction alone (1.40, [95% CI: −0.96 to 1.84; $n = 31$] vs. 0.78 [95% CI: −0.23 to 1.79; $n = 7$], $p < 0.05$, respectively) (Table 1).

Oscillating Platform

The mean overall ES for oscillating platform used for chronic training was −0.13 (95% CI: −0.53 to 0.27; $n = 15$), and for acute training, the mean was 0.24 (95% CI: −0.15 to 0.62; $n = 17$). These measures were not significantly different ($p > 0.05$).

Moderating Variables. There was a trend toward greater strength gain after chronic training by means of the squat plus other exercises (e.g., lunges) compared with the squat exercise only; however, this difference was not statistically significant (0.33, [95% CI: −0.31 to 0.97; $n = 6$] vs. −0.55 [95% CI: −1.34 to 0.24; $n = 6$], $p > 0.05$, respectively). For other moderating variables, there were no sufficient data that responded to the analysis methodology criteria of this meta-analysis (Table 1). Figures 1–3 demonstrate the trends and differences in treatment effects for frequency, amplitude, and volume among vertical vibration platforms for chronic strength adaptations.

DISCUSSION

This meta-analysis analyzed the magnitude of the strength gains elicited by acute and chronic vibration training and examined specific factors that influence the treatment effects. Through meta-analytic procedures, the body of literature examining this form of exercise becomes much clearer. Although the results may shed light on additional areas of research needed, numerous key points of knowledge are identified in this analysis.

Differences in acute responses compared with chronic adaptations and the differences identified between vertical and oscillating platforms are important beginning points. Acute changes in strength are negligible; however, chronic improvements in strength compare favorably with conventional resistance training for vertical vibration platforms. The average treatment effect for chronic vertical vibration exerciser (over an average of 13.5 weeks of training) was 1.24 with mean effects for untrained and athletic populations being 1.78 and 0.54, respectively. Based on a scale proposed by Rhea (37) for the examination of ESs in strength training research, this represents a *moderate* treatment effect. For comparison, the average treatment effect in meta-analyses of conventional strength training (34,39) was found to be 1.55 (untrained) and 0.47 (athletic). Although such comparisons across meta-analyses should be done with caution, it is apparent that vibration exercise can result in similar or greater strength improvements compared with conventional resistance training.

The meta-analysis shows that for chronic strength improvements, vertical vibration platforms are much more effective (ES = 1.24) compared with oscillating platforms (ES = −0.13). While this difference is noted, some caution should be used in drawing final conclusions about the greater effectiveness based on platform due to many moderating factors that could have resulted in such a difference. For instance, research employing the oscillating platforms tended to prescribe lower frequencies compared with vertical platforms (24.12 ± 3.04 vs. 33.66 ± 5.91 Hz, respectively) and lower volume (267.56 ± 130.45 vs. 464.76 ± 265.33 seconds, respectively). Furthermore, research employing the oscillating platforms tended to prescribe shorter training programs compared with vertical platforms (10.33 ± 4.1 vs. 13.55 ± 9.1 weeks, respectively).

Nonetheless, critical thinking regarding the difference in stimulus between vertical and oscillating platforms is warranted. One particular difference between platforms is the fact that oscillating platforms cannot generate the same frequency range as vertical platforms (vertical from 30 to 50 Hz vs. oscillating from 5 to 30 Hz). Another key difference is that vertical platform vibration translates vertically under both feet at the same time, which results in simultaneous symmetrical movement of both sides of the body. In contrast, the oscillating platform generates an asymmetric perturbation of the legs. According to Abercromby et al. (1), the transmission of vibration mechanical energy to the upper body and head was 71–189% greater during vertical vibration compared with oscillating platforms during the squat exercise.

Another important finding from this analysis is the differences in treatment effects based on age, gender, and training status. Focusing principally on chronic effects of vertical vibration machines (because those effects were found to be the largest), both younger and older populations were shown to benefit greatly from vibration exercise (ES = 1.18 and 1.83, respectively). Insufficient data were available for analysis of middle-aged populations; however, little physiological rationale would support a major difference in expected effects in this population. The large treatment effect for populations over the age of 50 is significant as research has also shown vibration exercise to be an effective tool for enhancing bone mineral density (45,49) and balance in this population (6). The combination of strength improvements and enhanced bone mineral density and balance would be expected to decrease the risk of falls and enhance overall quality of life in older populations.

Women experienced a much greater increase in strength with vibration training compared with mean; however, the difference between genders may be influenced by training status, as untrained populations show a much greater benefit from vibration exercise as previously noted. In studies employing women as participants, 22 used untrained women compared with only 5 that employed untrained men/women combined. Thus, it is uncertain if similar findings would be seen if equal groups of untrained/trained men/women were compared.

Differences in mode of contraction are also noteworthy. The use of solely isometric contractions or a combination of isometric and dynamic movements is of great practical importance. The data demonstrate that a combination of such contractions results in nearly twice the strength adaptation compared with solely isometric contractions. Isometric actions may be a good principal step when introducing exercisers to vibration exercise as it is relatively easy to learn, requires less technical ability, and will result in strength improvements. However, progression to the inclusion of dynamic movements on the platform is needed to fully achieve the benefits of vibration exercise. The differences between these types of contractions that may influence strength adaptations include the level of force needed to move the body through dynamic motions and/or the greater need for synchronization and coordination of motor unit recruitment during dynamic movements. However, the fact that most strength tests conducted in the reviewed research were dynamic tests, the principle of specificity of testing/training, cannot be discounted.

In the literature reviewed for this analysis, large ranges of training prescriptions were employed. Even with the accomplished meta-analytic procedures, it is very difficult at this point to garner any solid prescription guidelines from the body of research. However, an evaluation of the general trends in treatment effects when different amplitudes, frequencies, and volumes of vibration exercise are employed is much needed. Correlational analysis identified significant relationships ($p < 0.05$) between ESs for chronic strength gains (vertical platforms) and frequency ($r = 0.36$), amplitude ($r = 0.57$), and volume ($r = 0.38$). These 3 variables are the most commonly altered variables in vibration exercise and offer the exercise professional the greatest flexibility in program design.

A linear increase in treatment effects was demonstrated with an increase in vibration frequency with frequencies between 40 and 50 Hz and resulted in the greatest mean ES. Small amplitudes (2–6 $\text{mm}_{\text{p-p}}$) showed much smaller treatment effects compared with 8–10 $\text{mm}_{\text{p-p}}$. Insufficient data were available at frequencies above 50 Hz and 10 $\text{mm}_{\text{p-p}}$, which limits our view of the complete spectrum of training; however, it is clear that strength improvements are altered when different prescriptions are employed.

One particular fact of importance when considering the reported amplitude of vibration in the published research and among the different platforms available to the public is the fact that body mass is expected to affect the vibration amplitude of vibration. Larger masses are expected to dampen the vibration amplitude generated by the platform, with potentially large variations in vibration between individuals of different body masses. For this reason, amplitude of vibration, unless specifically measured in each subject by the use of accelerometer, carries only theoretical importance with relation to exercise prescription.

Training volume also seems to alter treatment effects with a general increase in strength adaptation as greater training volumes are employed. Maximum gains were measured with volumes around 12–15 minutes of vibration stimulus per training session. More research is needed with volumes greater than this to examine the point at which excessive volume begins to result in a diminished return. Also, the relationship between total training volume and the number of sets performed is unclear. Most treatment sessions consisted of short bouts (30–90 seconds) with ~60-second rest between sets. It is doubtful that 1 set of 15 minutes of vibration would be an optimal stimulus and most likely could not even be tolerated; however, more research is needed to identify the optimal total volume and the most effective manner to perform that volume.

There is little doubt based on this analysis that vibration exercise can result in significant strength improvements. However, physiological mechanisms to explain such adaptations are important to our understanding for this form of exercise. Different mechanisms have been suggested in the literature how vibration stimuli can have effect on the neuromuscular system (7,44) such as a stimulation of Ia afferents via spindle, resulting in facilitating homonymous α-motor neurons and/or perturbation of the gravitational field during the time course of intervention (7). Although these mechanisms have been suggested, and do appear valid, little basic scientific research has examined vibration exercise effects on the function of different physiological properties. Research examining the physiological and physical mechanisms of increased strength from vibration exercise is sorely needed and would serve to further our understanding of both vibration technology as employed as an exercise tool and the physiological processes/properties that are influenced by vibration stimulus.

Of additionally paramount importance, contraindications have been reported including erythema, itching of the legs (43,46), edema (43), and shin pain (17). One case of significant morbidity after one session of vibration training in a patient with asymptomatic nephrolithiasis (30) has been reported; however, little research has been conducted to examine these conditions. Such research would prove helpful in ensuring that only those healthy enough to participate in vibration exercise use this technology and enable exercise professionals to balance the risk to benefit ratio.

This meta-analysis has provided vital information regarding many questions about vibration exercise. It also identified a number of key areas that require greater research attention. Future research should examine the maximal healthy volume (exposure seconds) for vibration training according to several factors: exercise type, status training on vibration training, and the use of external load during vibration exercise. Additional focus on frequency and amplitude of stimulus would also serve to further appropriate exercise prescription. The combination of vibration exercise and conventional resistance training is a protocol that is very deserving of research examination although sufficient data were not available for review in this analysis. Where time, exercise technique, equipment availability, plateaus in training adaptation, or boredom are issues, a combination of vibration and resistance training may be an effective way to enhance long-term adherence to exercise programs.

On the other hand, challenges do exist when applying vibration as an exercise stimulus, aside from the challenges of exercise prescription previously discussed, and include the ability to perform exercises on the platform that truly overloads all major muscle groups. For instance, performing exercises for the back muscles is virtually impossible on the vibration platform. Some companies have developed resistance bands/cables that are connected to the platform in hopes of providing some vibration stimulus during pulling exercises used to stimulate adaptations in the muscles of the back. Little research has examined the effectiveness of these bands; however, transference of the vibration stimulus to the materials of the bands is only slight at best and may not prove beneficial at all. Advancements in the design of the platforms to allow for a greater variety in exercises to stress all major muscle groups in the body are suggested.

PRACTICAL APPLICATIONS

Applications of the information contained in this analysis are important to translating research into practice. Of greatest importance is the fact that vibration exercise was shown to compare with traditional resistance training in terms of overall strength adaptations. Vibration exercise requires less technical abilities compared with the performance of free weight resistance training, less space compared with traditional resistance training machines, and less time generally needed to perform workouts on vibration platforms. The use of vibration exercise in an overall strength training routine can result in strength development, and this tool should be viewed as a potential mode of training in appropriate exercise settings.

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