Effects of Vibration Intervention on Grip Strength and Endurance Time of Young College Students.

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Abstract

BACKGROUND: Maximal voluntary contraction (MVC) is widely regarded as signal of maximum grip strength and active muscle contraction in the forearm.

AIM: The aim of the study is to investigate the muscular performance and effects of anthropometric measurement on grip strength (GS) and endurance time (ET) of young college students before and after vibration therapy (VT) in supination forearm posture.

METHODS: A observational study design (4 days x 2 levels (before vibration exposure (BVE) and after exposure to vibration at frequency of 45 Hz, amplitude of 3g and duration of vibration exposure of 60 seconds) x 24 subjects) was used in this study. Changes due to intervention were assessed by measuring GS and ET at 50% MVC (before and after vibration training).

RESULTS: MANCOVA results showed vibration training frequency and training days significantly affect the GS ($p<0.001$) and ET ($p<0.05$) with maximum increase on day 4 after VT. Compared with day 1 before vibration exposure (BVE) and day 4 after 45 Hz vibration training, MVC grip strength increased by 53.1% and endurance time increased by 37.07%. The Pearson correlation test showed that frequency of VT and days of exposure were not significantly associated with ET and GS.

CONCLUSIONS: Results showed a significant increase in GS and ET relative to VT frequency and training days. In addition, body weight and PL were the most important factors affecting ET, and palm circumference and forearm circumference were the most important factors affecting grip strength.

Keywords: Supination posture, maximal voluntary contraction, grip strength, grip endurance time, and anthropometric measurements.

Introduction

Mechanical oscillations, called "vibrations", were revealed in ancient Greco-Roman as a therapeutic method (Cited in: [1]). In the 16th century, the Japanese used vibrations treatment to release inflexible and occasional muscle contractions. Physician John Kellogg fabricated a vibrating device in 1880s, such as a chair and portable devices, to treat patients with constipation, headaches, lower and back pain. However, John Kellogg did not perform experimental trials to certify his hypothesis. The first use of the vibratory intervention was carried out in 1881 by Granville (Cited in: [1] to treat pain, then used as a therapeutic technique to increase the volatility of alpha and gamma motor neurons, thus allowing the patients to produce improved voluntary control [2].

Vibration intervention is considered as a potential neuromuscular training approach and has recently been accepted by health departments, fitness and rehabilitation centers as an addition or alternative to routine training [3]. This is due to the fact that vibration training improves muscular performance and strength [4], increases flexibility [5], and other fitness assistances [6]. Previous studies reported that training programs with vibration intervention [7, 8] improved muscle performance compared to training programs without vibration intervention. Earlier, ergonomics experts usually debated the adversative effects of VT [9]; however, recently, vibrating massagers or vibrating plates have been used for training and to enhance muscular performance [10, 11].

Grip strength (GS) assesses the ability of the hand to exert strength at maximum capability, and it also measures the degree of active muscular contraction of the hand and forearm muscles [12]. Significant differences in GS were reported between the vibration-treated and non-vibration-treated populations. In addition, a significant increase in the handgrip strength was reported after application of vibration treatment in healthy women [13]. Many researchers had performed VT using fixed frequencies: 25 Hz [14, 15], 35Hz [10, 15], 40 Hz [15] and 45 Hz [11, 14] and reported significant improvements in muscular performance. However, no consensus was found in defining the optimum VT frequency, which was confused by the use of different methods in different studies.

Grip strength is affected by a variety of factors, including hand posture, gender, shoulder and forearm posture, full-body posture, and anthropometry [16]. In the literature, various previous results have provided more accurate estimates of forearm and/or hand size than common anthropometric measurements and better interpretation of grip strength. Anthropometric measurements: height and weight [17]; and forearm and/or hand anthropometric variables: forearm circumference [17], palm length and palm width or circumference [17, 18] have been shown to be significant independent predictors of grip strength factor. Therefore, posture significantly affects grip endurance and grip strength [19, 20]. Fiebert et al. [21] pointed out that the supination posture is the most important grasping pose in endurance tasks [20]. However, Alam et al. [22] showed that the highest grip strength in men was in the forearm pronated position. Therefore, the purpose of this study was twofold: first, to investigate the effect of vibration intervention on muscle performance in terms of grip strength and grip time; second, to investigate the effect of anthropometric variability in young college students in the forearm supination position with GS and ET. However, no studies have examined the effects of frequency, amplitude, duration of exposure, and days of training on NPs delivering VT using vibrating plates. Therefore, the novelty of this study is the method of vibration processing using an in-house designed vibration plate. Specifically, this study measured the GS and grip ET at 50% maximal voluntary contraction (MVC) before and after vibration therapy.

The null hypothesis for present study was: "days of exposure and training days had a no significant effect on MVC grip strength and grip endurance time."

Methodology of the Study

Design of Experiment

An observational study with 4 days x 2 levels (before vibration exposure (BVE) and after exposure to vibration exposure at a frequency of 45 Hz, amplitude of 3g and duration of vibration exposure of 60 seconds) x 24 subjects) were used in the current study. The frequency of exposure to vibration and the number of training days were independent factors. The number of training days (4 days) was chosen based on a pilot study in which the most enhancements in dependent variables were witnessed on day 4. Changes due to VT intervention were assessed by assessing MVC GS, grip ET at 50% MVC (before vibration exposure (BVE) and after vibration exposure).

Participants

In this study, 24 sedentary lifestyle (SL) participants who did not report any neuromuscular problems were voluntarily selected. Informed written consent was obtained and the study protocol was explained. The protocol of the experiment was approved by the Ethics Committee of department. The participants' anthropometric measurements were based on previous research [10, 11] (Table 1).

Table 1.
The anthropometric measurements of the participants

Item	Mean ± SD
Age (years)	21.1±3.2
Height (cm)	165.4±8.3
Weight(kg)	60.4±5.4
Palm Length (PL) (cm)	10.5±0.4
Palm Circumference (PC)(cm)	22.6±1.9
Forearm Length (FL) (cm)	24.7±0.6
Forearm Circumference (FC)(cm)	26.2±1.2

Experimental Rig

A spring-loaded vibration plate is invented in-house [11] to maintenance the forearm in a supination forearm posture. A vibrating device was installed in the midpoint below the vibrating plate. It is enclosed in a metal casing and its frequency is ranged from 15-65Hz. Eccentric masses are also designed and manufactured to deliver the chosen frequency and amplitude combination.

Protocol and procedure for the experiment

To perform vibration training, participants were instructed to sit in a chair which can be adjusted with a supine forearm position for MVC recordings and placed the forearm on the vibrating plate during training. Chair height was adjusted in such a manner that right forearm of the participant is in 0° of shoulder abduction, ensuring angle of elbow as the 90°-120°. Follow the steps below to give vibration training along with measurement (for detail about the experimental setup, recording of grip strength, endurance, vibration levels and instrumentation refers to [10, 11]):

1. Ask participants to grip the dynamometer in a supine position (twice with a 120 seconds of rest prior to measure MVC) with a fixed span of grip prior to vibration exposure (BVE).
2. After a 5-minute rest, measure the ET at 50% MVC (with reference as the extreme of two trials).
3. The detaching of the grip dynamometer.
4. Apply four rounds of VT at 45 Hz for 60 seconds with a 30 second rest after each round.
5. A rest of 15 minutes.
6. Ask participants to repeat the trial according to point No. 1 and 2.
7. The detaching of the grip dynamometer.
8. Ask participants to repeat the trial for 4 days according to point No. 1 to 7 and on 5th day repeat the point No. 1 and 2.

Results

The data of GS and ET are summarized in Table 2. Multivariate analysis of covariance (MANCOVA) was performed using SPSS 25.0 to examine various factors and their interactions with covariates on dependent variable (Table 3). Pearson correlation test were also accomplished to assess the association between dependent variable and the covariates (Table 4).

The effect of vibration training frequency significantly affects both the GS ($p < 0.001$) and grip ET ($p=0.021$). Moreover, training days were also significantly affecting both GS and ET ($p<0.001$), (Table 3). In addition, Figures 1 and 2 showed significant increase in GS and ET with respect to training days with maximum increased on day 4 after VT. Compared with day 1 before vibration exposure (BVE) and day 4 after 45 Hz vibration training, MVC grip strength increased by 53.1% and endurance time increased by 37.07%. Further, the GS and ET after post training on day 5 was also increased as compared with day 4 before vibration exposure (Table 2, Figure 1 and 2).

In addition, age ($p=0.002$), PC ($p=0.018$), height, FL and FC ($p<0.001$) significantly affecting ET only. However, weight ($p=0.006$) also significantly affecting GS. The interaction of frequency of VT and training days were not significantly affecting GS and ET. Pearson correlation exhibited no substantial association of vibration training frequency and days of training with endurance time and grip strength (Table 4). PC ($r=0.236$, $p=0.008$), and FC ($r=0.303$, $p<0.001$) have found significantly positive correlation with GS. In addition, age ($r=0.220$, $p=0.013$), weight ($r=0.603$, $p<0.001$), height ($r=0.306$, $p<0.001$), PL ($r=0.597$, $p<0.001$), PC ($r=0.426$, $p<0.001$) and FL ($r=0.361$, $p<0.001$) had a significant positive correlation with grip ET.

Table 2. Summary of mean GS and ET with respect to training days and frequency of vibration training

Training Days	MVC Grip Strength (Kgf)		Endurance Time (Seconds)	
	BVE	45 Hz	BVE	45 Hz
Day 1	49.14	57.02	59.84	64.51
Day 2	56.15	62.71	67.24	71.27
Day 3	65.07	69.86	71.09	74.55
Day 4	70.66	75.23	77.81	82.02
Day 5	71.23		78.79	

Table 3. Summary of results of MANCOVA

Variables	Tests of Between-Subjects Effects						
	Source		Type III Sum of Squares	df	Mean Square	F	Sig. p-value
Co-variates	Age	MVC	7.124	1	7.124	0.22	0.636
		Endurance Time	844.36	1	844.36	9.94	0.002
	weight	MVC	248.61	1	248.61	7.86	0.006
		Endurance Time	127.90	1	127.90	1.50	0.222
	height	MVC	118.51	1	118.51	3.74	0.055
		Endurance Time	1199.5	1	1199.5	14.1	<0.001
	PL	MVC	17.329	1	17.329	0.54	0.461
		Endurance Time	149.05	1	149.05	1.75	0.188
	PC	MVC	91.649	1	91.649	2.89	0.092
		Endurance Time	490.69	1	490.69	5.77	0.018
	FL	MVC	4.536	1	4.536	0.14	0.706
		Endurance Time	1372.4	1	1372.4	16.1	<0.001
	FC	MVC	23.995	1	23.995	0.75	0.386
		Endurance Time	2094.8	1	2094.8	24.6	<0.001
Independent Variables	Frequency	MVC	990.79	1	990.79	31.3	<0.001
		Endurance Time	469.27	1	469.27	5.52	0.021
	Days of Exposure	MVC	7785.0	4	1946.2	61.5	<0.001
		Endurance Time	5741.8	4	1435.4	16.9	<0.001
	Frequency* Days of Exposure	MVC	51.469	3	17.156	0.54	0.654
		Endurance Time	5.310	3	1.770	0.02	0.996

In addition, age (p=0.002), PC (p=0.018), height, FL and FC (p<0.001) significantly affecting ET only. However, weight (p=0.006) also significantly affecting GS. The interaction of frequency of VT and training days were not significantly affecting GS and ET. Pearson correlation exhibited no substantial association of vibration training frequency and days of training with endurance time and grip strength (Table 4). PC (r=0.236, p=0.008), and FC (r=0.303, p<0.001) have found significantly positive correlation with GS. In addition, age (r=0.220, p=0.013), weight (r=0.603, p<0.001), height (r=0.306, p<0.001), PL (r=0.597, p<0.001), PC (r=0.426, p<0.001) and FL (r=0.361, p<0.001) had a significant positive correlation with grip ET.

Table 4. Summary of the results of Pearson Correlation

		Age	weight	height	PL
MVC	Pearson Correlation	-0.173	-0.003	0.173	-0.104
	Sig.(2tailed)	0.052	0.970	0.052	0.247
Endurance Time	Pearson Correlation	0.220*	0.603**	0.306**	0.597**
	Sig.(2tailed)	0.013	0.000	0.000	0.000
		PC	FL	FC	
MVC	Pearson Correlation	0.236**	0.127	0.303**	
	Sig.(2tailed)	0.008	0.158	0.001	
Endurance Time	Pearson Correlation	0.426**	0.361**	0.119	
	Sig.(2tailed)	0.000	0.000	0.184	

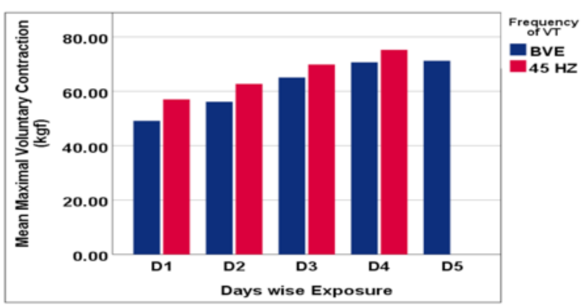

Fig. 1. Mean maximal voluntary contraction value with day's wise vibration exposure

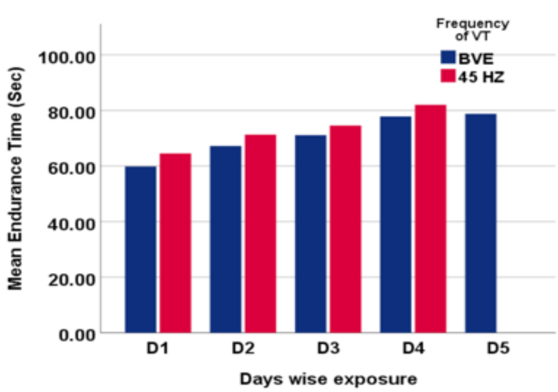

Fig. 2. Mean endurance time value with day's wise vibration exposure

Discussion

The interaction of the human with the applied vibration training depends to a large extent on the characteristics of the participants. In current study, vibration training frequency and training days had significant effects on both GS (p<0.001) and ET (p<0.05). In contrary, Alam et al. [10] found that VT frequency significantly affecting ET (p<0.001), but not the GS (p=0.161). However, the number of contact days significantly effect on both GS and ET (p<0.001).

In line with existing study, significant difference in grip strength between with and without vibration groups were stated [13]. Alam et al. [23] revealed significant differences in contact days, vibration training frequency, PL, and FL on GS and ET. Wu et al. [20], investigated GS in 482 participants in Taiwan, stated significant differences in GS by gender, age, and PL. In addition, they found, PL, second only to gender and age, were the most important variable influencing GS.

In addition, present study also shows that PL (r=0.236, p=0.008), and FC (r=0.303,

$p<0.001$) significantly having positive correlation with GS. Moreover, age ($r=0.220$, $p=0.013$), weight ($r=0.603$, $p<0.001$), height ($r=0.306$, $p<0.001$), PL ($r=0.597$, $p<0.001$), PC ($r=0.426$, $p<0.001$) and FL ($r=0.361$, $p<0.001$) had a significant positive correlation with grip ET. In another study by Alam et al. [24], they found that height ($p = 0.012$), age ($p = 0.044$), and FL ($p = 0.039$) significantly affects in supine posture. However, PC significantly affecting GS only in pronation ($p = 0.036$). The forearm pronated position produced 7.4% more GS than in the supination position. Moreover, grip ET was enhanced in the supination posture related to neutral and pronated forearm positions. Similarly, the current study showed a 53.1% increase in grip strength and a 37.07% increase in endurance time compared to day 1 before vibration exposure (BVE) and day 4 after 45 Hz vibration training.

Fiebert et al. [21] establish that PL was closely related to GS. PL offers superior thenar musculature, which may account for the robust correlation. Nicolay and Walker [19] established that anthropometric changes were autonomous of grip ET compared to GS. Additionally, they reported that forearm and hand dimensions were superior forecasters of GS than the height and weight. Contrary to the current findings, Heidi and Jonathan [25] reported a considerable difference between age and GS ($p<0.001$), but no substantial association between age and ET ($r=-0.13$, $p=0.38$). Likewise, Petrofsky and Lind [26] stated a significant enhancement in GS ($p < 0.01$), but endurance time in men was not significantly associated with aging ($r=0.11$, $p>0.05$). Differences in these outcomes may be due to differences in experimental methods, GS measurement devices, or methods used to measure anthropometric changes.

Conclusions

The present results showed significant effect of VT frequency and training days on both GS and ET. Therefore, the proposed combination of frequency, amplitude and exposure durations may be used as a guideline by the therapist to improve the muscular performance of young and elderly.

Conflict of Interest

None to declare.

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