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EFFECT OF SEGMENTAL VIBRATION ON HAND AND PINCH GRIP STRENGTHS IN HEALTHY SUBJECTS

Rami L. Abbas  
*Associate Professor of physical therapy for cardiopulmonary disorders and geriatrics, Faculty of Health Sciences, Beirut Arab University, Beirut, Lebanon, r.abbas@bau.edu.lb*

Ayman El Khatib  
*Associate Professor of Physical Therapy for Basic Sciences, Faculty of Health Sciences, Beirut Arab University, Beirut, Lebanon, a.elkhatib@bau.edu.lb*

Ibtissam M. Saab  
*Associate Professor of Physical Therapy for Musculoskeletal Disorders and its Surgeries, Physical Therapy Department – Faculty of Health Sciences – Beirut Arab University, ibtissam.saab@bau.edu.lb*

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EFFECT OF SEGMENTAL VIBRATION ON HAND AND PINCH GRIP STRENGTHS IN HEALTHY SUBJECTS

Abstract

Handgrip and pinch strengths are important markers in many sports as well as in determining health status. Many interventions have been proposed for increasing hand muscle strength. The aim of this study was to investigate the effect of segmental hand vibration on hand and pinch grip strengths. Ninety-two healthy university students were randomly assigned into two equal groups. By the end of the study, Group (A) and (B) consisted of 40 and 37 participants, respectively. The measurements consisted of the hand grip and pinch grip strengths using electronic dynamometer, measured in Kg, before, after three weeks, and after six weeks of training. Group (A) underwent isometric exercise training using hand gripper as follows: 4 seconds maximum grip, release for 2 seconds, repeated for 1 minute for three sets and with 3 minutes rest in between. Group (B) had the same exercise implemented in group (A) with the addition of five minutes of segmental vibration on both upper limb with 30Hz and amplitude of 2mm. The training was done two times per week for six weeks. Results revealed that both groups did demonstrate significant increase in hand and grip strengths after six weeks (p.05). It can be concluded that, segmental upper limb vibration does not have additional effect over isometric muscle training alone on hand grip and pinch grip strengths.

Keywords

Hand grip, pinch grip, segmental vibration, dynamometer

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1. INTRODUCTION

Handgrip strength can be quantified by measuring the amount of static force that the hand can squeeze around a dynamometer. The force has most commonly been measured in kilograms and pounds, but also in milliliters of mercury and in Newtons. Handgrip strength is a reliable measurement when standardized methods and calibrated equipment are used, even when there are different assessors or different brands of dynamometers (Massy-Westropp et al., 2011). It is assumed that grip strength can be predictive for whole body strength (Habibi et al., 2013).

Adequate strength of hand and forearm flexor has been reported to be of high importance in performing many functional daily activities including writing, locking a door with a key, cutting with scissors, and pulling up a zipper (Brorsson et al., 2014). Additionally, it has been considered crucial in many upper limb related sports such as rock climbing (Vigouroux et al., 2015) and tennis (Chadefaux et al., 2017), and many other sports. More recently, hand grip and pinch strength were considered as a marker of health-related quality of life (Musalek & Kirchengast, 2017) and were also used to determine many health related conditions in elders (Wearing et al., 2018).

The training of one’s grip strength is usually performed by conventional methods. However, there are many exercises are currently used in fitness and gym centers targeting grip strength training. Many methods have been proposed to increase muscle strength. Resistance training addressing grip strength has been widely studied especially that grip strength has been claimed important in several sports. The use of free weight bars with different thickness and grip enhancers are other proposed methods of grip strength training (Ratamess et al., 2007).

Vibration training has been proposed as a modality of rehabilitation, sport, and exercise. It increases metabolic rate and enhance muscular work (Bazett-Jones et al., 2008). It has been also considered as a neuromuscular training method with the potential to elicit neural adaptation similar to those produced by explosive strength training. Studies on vibration have shown transient increases in muscle power output. This is why, whole body vibration has been recently proposed as an exercise intervention because of its potential for increasing force-generating capacity of muscles (Cardinale & Wakeling, 2005).

The main purpose of this study was to determine the effect of adding segmental upper limb vibration to 6 weeks of isometric hand training on hand grip and pinch grip strengths.

2. MATERIALS AND METHODS

2.1 Participants:

Ninety-two healthy young individuals participated in this study including 38 males and 54 females divided into two equal groups, each containing 46 subjects. Group (A), undergoing only exercise training using hand gripper; and group (B), undergoing the same training with the gripper in addition to segmental upper limb vibration. Sessions were performed two times per week for six weeks. The participant’s age ranged between 18 and 26. They were selected from the physical therapy department at Beirut Arab University.

The study was granted the approval by the Institutional Review Board at BAU “2015H-008-HS-R-0057” and abiding to the declaration of Helsinki for human research and each participant signed an informed consent sheet. The study was a single-blinded randomized clinical trial; therapists who participated in the measurement were not involved in the training part and vice versa. Moreover, individuals were instructed not to reveal any details about the training method they received during their measurement assessments.

Participants were given a form to fill which covers the aspects of their personal information, demographics, general health condition including sleeping habits, smoking, caffeine, soft drinks and alcohol intake. Subjects were excluded if they had any history of upper limb musculoskeletal condition, any related health illness, or did not commit to the full requirement of the study period.
Fifteen Individuals were excluded not meeting the set inclusion criteria as follow; three of which were having musculoskeletal conditions (golfer’s elbow, plate and screws inserted in the fingers, surgery), five did not participate in the measurement part and seven were excluded later on due to failure to commit to the training several times in a row. Consequently, by the end of the training program Group (A) and (B) consisted of 40 and 37 subjects, respectively (Figure 1).

![Flow chart of the study](https://digitalcommons.bau.edu.lb/hwbjournal/vol2/iss2/2)

**Fig.1: Flow chart of the study**

### 2.2 Measurement

Prior to testing, the length of both forearms (from the olecranon process to the lateral styloid) was taken using a tape measure. In addition, the distance from the tip of the middle finger to the palmar crease was measured preceding testing in both hands.

#### 2.2.1 Grip strength measurement

This was measured using Saehan™ digital hand dynamometer (Figure 2). The device was calibrated using Fess’ method (Fess, 1986). Measurement were recorded in seated position with elbow flexed at 90 degrees; the forearm was put in neutral position; the wrist in 30⁰ extension and 10⁰ ulnar deviation. The handle position was adjusted suitable to the participant’s hand.

#### 2.2.2 Pinch gauge measurement

Measured using Saehan™ digital pinch gauge (Figure 3). The patient assumed the same position utilized in grip strength recording. However, the pinch gauge was put between the lateral border of the index and the thumb (Lam et al, 2016).

![Digital hand dynamometer](https://digitalcommons.bau.edu.lb/hwbjournal/vol2/iss2/2)

![Digital pinch gauge](https://digitalcommons.bau.edu.lb/hwbjournal/vol2/iss2/2)

**Fig.2: Digital hand dynamometer**  **Fig.3: Digital pinch gauge**
Measurements were done for both right and left hands and the dynamometer was reset to zero preceding each reading of the grip or pinch strength. Participants were instructed to squeeze the hand grip or pinch dynamometer as hard as they can for 5 seconds then release. Three trials were made with a minute of rest in between. The recorded intensity was the mean of the three trials in Kg (Liu et al, 2017). The equipment used for measurement were proven for their validity and reliability (Reis & Arantes, 2011). Measurements of grip and pinch strength were taken in the first week (pretest), end of third week, and last day of the sixth week.

2.3 Training:

2.3.1 Resistance training

Adjustable hand exerciser (gripper) was used for both groups (A) and (B) (Figure 4). Subjects received training for the dominant hand using the hand gripper. The hand gripper was adjusted to 75% of the individual grip force according to the measurements taken previously. The force was recalculated at the third week to reset the gripper resistance. Training session began with 1 minute of warming up including stretches for flexor and extensors of the wrist and fingers (Anandhi et al, 2018). Individuals were asked to grip the adjustable hand gripper with their dominant hand until both the handles are touched for 4 seconds, release for 2 seconds and contract again repeatedly for a minute. Three sets of one minute were done with a 3 minutes rest in between (Millar et al, 2007).

2.3.2 Segmental vibration

Performed using the Crazy fit™ body vibration plate exercise machine with a plate base providing vibration for the whole body or the desired part (Figure 5). The machine has dials showing time, speed and body fat. Training began off with 5 minutes of vibration, elbows fully extended and both upper limbs perpendicular to the vibrator. Frequency applied was 30Hz and an amplitude of 2mm (Annino et al, 2019). Individuals rested for three minutes followed by the same training method used for group A (Warman et al, 2002).

2.4 Data Analysis

All statistical measures were performed using the Statistical Package for Social science (SPSS) program version 22 for windows. The current test involved two independent variables. The first one was the (tested group); between subjects factor which had two levels (group (A) receiving strengthening exercises and group (B) receiving strengthening exercises and vibration). The second one was the (measuring periods); within subject factor which had three levels (pre-treatment, post three weeks, and post six weeks of treatment). In addition, this test involved four tested dependent variables (dominant and non-dominant handgrip and pincher grip). Prior to final analysis, data were screened for normality assumption, and presence of extreme scores.
This exploration was done as a pre-requisite for parametric calculation of the analysis of difference and analysis of relationship measures. Descriptive analysis using histograms with the normal distribution curve showed that the data were normally distributed and not violates the parametric assumption for the all dependent variables. Additionally, testing for the homogeneity of covariance using Box’s test revealed that there was no significant difference with \( p \) values of > 0.05. The box and whiskers plots of the tested variables were done to detect the outliers. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed for most dependent variables. All these findings allowed the researchers to conduct parametric analysis. Therefore, 2×3 mixed design MANOVA was used to compare the tested variables of interest at different tested groups and measuring periods. With the initial alpha level set at 0.05.

3. RESULTS

A total of 77 participants were checked and included in the final data analysis. They were divided into two groups; group A consisted of 41 participants and group B consisted of 36 participants. The independent t test revealed that there were no statistically significant differences (\( P>0.05 \)) between subjects in both groups concerning age, weight, height, and BMI (Table 1). As well as Chi square test revealed that there were no statistically significant differences (\( P>0.05 \)) between groups for the frequency distribution and percent of sex, smoker, and energy drinks (Table 1).

Table 1: Demographic characteristics of participants in both groups and frequency distribution and percent of sex, smoker, and energy drinks in both groups.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group A (n=41)</th>
<th>Group B (n = 36)</th>
<th>( t ) and ( \chi^2 )</th>
<th>( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>19.95±1.62</td>
<td>20.05±1.54</td>
<td>( t=-0.287 )</td>
<td>0.775</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.46±17.23</td>
<td>73.7±19.73</td>
<td>( t=-1.006 )</td>
<td>0.318</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.66±0.07</td>
<td>1.69±0.09</td>
<td>( t=-1.574 )</td>
<td>0.120</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>24.66±5.03</td>
<td>25.37±5.39</td>
<td>( t=-0.598 )</td>
<td>0.552</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td>( \chi^2=1.409 )</td>
<td>0.258</td>
</tr>
<tr>
<td>Female</td>
<td>26 (64%)</td>
<td>18 (50%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (36%)</td>
<td>18 (50%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td></td>
<td></td>
<td>( \chi^2=0.032 )</td>
<td>0.99</td>
</tr>
<tr>
<td>Yes</td>
<td>14(34%)</td>
<td>13 (36%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>27(66%)</td>
<td>23 (64%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy drinks</td>
<td></td>
<td></td>
<td>( \chi^2=0.432 )</td>
<td>0.557</td>
</tr>
<tr>
<td>Yes</td>
<td>8 (19.5%)</td>
<td>5 (14%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>33 (80.5%)</td>
<td>31 (86%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values of age, weight, height, and BMI are expressed as mean (SD).

*Significant level is set at alpha level <0.05.

Statistical analysis using mixed design MANOVA revealed that there were significant within subject effect (\( F = 10.921, p = 0.0001 \)). While there was no significant between subject effect (\( F= 1.03, p = 0.398 \)) and treatment*time effect (\( F = 1.091, p = 0.38 \)). Tables (2 and 3) present descriptive statistic and multiple pairwise comparison tests (Post hoc tests) for the all dependent variables. In the same context regarding within subject effect, the multiple pairwise comparison tests revealed that there were significant increase in dominant and non-dominant handgrip (\( p<0.05 \)) at post 2 of treatment in compare with pre and post 1 of treatment at both groups. While there were no significant differences (\( p>0.05 \)) between post 1 of treatment and pre-treatment at both groups. Concerning pincher grip, there were significant increase in dominant pincher grip (\( p<0.05 \)) at post 1 and post 2 of treatment in comparison with pre-treatment at group A. While there were significant increase in dominant pincher grip (\( p<0.05 \)) at post 2 of treatment in comparison with pre and post 1 of treatment while there were no significant differences (\( p>0.05 \)) between post 1 of treatment and pre-treatment at group B. Additionally, there was significant increase in non-dominant pincher grip (\( p<0.05 \)) at post 2 of treatment in compare to pre-treatment at group B only.
Regarding between subject effects multiple pairwise comparisons revealed that there were no significant difference of all dependent variables between both groups at different measuring periods (p >0.05).

Table 2: Descriptive statistics for the all dependent variables for both groups at different training periods.

<table>
<thead>
<tr>
<th>Group A (n=41)</th>
<th>Group B (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post 1</td>
<td>Post 2</td>
</tr>
<tr>
<td>Dominant handgrip</td>
<td>29.16±10.71</td>
</tr>
<tr>
<td>Non dominant handgrip</td>
<td>25.78±10.27</td>
</tr>
<tr>
<td>Dominant pincher grip</td>
<td>7.7±2.38</td>
</tr>
<tr>
<td>Non dominant pincher grip</td>
<td>7.28±2.22</td>
</tr>
</tbody>
</table>

Values of all dependent variables are expressed as mean±SD.

Table 3: Multiple pairwise comparison tests (Post hoc tests) for all dependent variables at different treatment periods for both groups.

<table>
<thead>
<tr>
<th>Within groups</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-value</td>
<td>Pre Vs. post 1</td>
<td>Pre Vs. post 2</td>
</tr>
<tr>
<td>Dominant handgrip</td>
<td>0.99</td>
<td>0.001*</td>
</tr>
<tr>
<td>Non dominant handgrip</td>
<td>0.472</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Dominant pincher grip</td>
<td>0.001*</td>
<td>0.001*</td>
</tr>
<tr>
<td>Non dominant pincher grip</td>
<td>0.575</td>
<td>0.146</td>
</tr>
</tbody>
</table>

Between groups (group A Vs. group B)

<table>
<thead>
<tr>
<th>P-value</th>
<th>Pre</th>
<th>Post 1</th>
<th>Post 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant handgrip</td>
<td>0.085</td>
<td>0.113</td>
<td>0.122</td>
</tr>
<tr>
<td>Non dominant handgrip</td>
<td>0.101</td>
<td>0.204</td>
<td>0.134</td>
</tr>
<tr>
<td>Dominant pincher grip</td>
<td>0.187</td>
<td>0.604</td>
<td>0.25</td>
</tr>
<tr>
<td>Non dominant pincher grip</td>
<td>0.362</td>
<td>0.386</td>
<td>0.217</td>
</tr>
</tbody>
</table>

*Significant at alpha level <0.05

4. DISCUSSION

Grip and pinch strength are most important factors associated with proper function of hand (Habibi et al., 2013). However, rare are the studies that investigate therapeutic interventions towards increasing pinch grip. On the other hand, the strength training was done solely on the dominant but the vibration was done on both upper limbs. Measurements were taken for both upper limbs in order to detect if there are any possible facilitation in the non-exercised limb. This study aimed to investigate the effect of adding segmental hand vibration along with 6 weeks of isometric handgrip training on hand grip and pinch grip strengths. For this purpose six weeks of biweekly isometric handgrip training, with and without segmental upper limb vibration was implemented randomly on two groups of university students. Measurements were taken using digital dynamometer for both hand and pinch grips. The effect of handgrip exercise training did reveal significant increase in muscle strength, and that increase was marked after both 3 and 6 weeks of training. These results are compatible with others stating that strength training safely increases dynamic and static grip strength (Rogers & Wilder, 2007).

Others stated that such inexpensive training mode could significantly lead to increase in hand grip strength (Milne et al, 2019). Thus, it seems that the exercise regimen applied for two times per week has significantly increased the grip strength. Additionally, the exercise gave positive results on the other grip strength, which means that the increase in strength had irradiated its effect to the contralateral limb and this effect was significant.
In 2011, a study investigated the effect of vibration on eighteen subjects (nine male and nine female) (Widia & Dawal, 2011). The experiments were performed with two exposure times, five and 15 minutes. Subjects were required to drill wood specimen using an electric drill and a bench drill. Electromyography (EMG) and hand dynamometer were used in the experiment. Results showed strong relationships between muscle activity, interval time and vibration level. It was conclude that muscle activity increase as the vibration level and exposure duration increase. Such reporting's are not compatible with the results of the current study. Another study that contradicts with the current study stated that prolonged exposure to hand-arm vibration may lead to loss of grip strength and proper functioning of the hand (Goonetilleke & Karwowski, 2017). This can be the result of long exposure to a high vibration doses. Taking it all together, it seems that the frequency of vibration used in this study did not induce increase in muscle strength, and we can deduce that the results expected from the effect of vibration on muscle strength are highly correlated with the frequency of vibration. Such conclusion has been also reported by others (Goonetilleke & Karwowski, 2017).

Many neural mechanisms were recently proposed to explain the fact that exercises in one limb can eventually cause increase in muscle strength in exercising limbs and contralateral ones (Killen, Zelizney, & Ye, 2019).

A study concluded that, rhythmic resistance exercise could potentially induce increased venous flow and volume in the contralateral limbs in stroke patients (Hayashi et al, 2018).

When investigating the segmental vibration effect, it was shown that vibration did increase strength of muscles trained however, this increase was not significant at both instances of measurement, after 3 and six weeks. Vibration has been claimed to provide mechanical signals to bone and musculo-tendinous system. However, the best effect was observed when low intensity stimulus along with high frequency is applied (Cerciello et al., 2016), the findings in this study were not aligned with the current study.

Other authors concluded that intervention with vibration is efficient in neutralizing the decrease in muscle strength in sarcopenic patients. They also reported that vibration might have induced changes on cellular and molecular levels (Pietrangelo et al, 2009).

In this study, the frequency used was 30 Hz, thus it seems that the range of frequency might play an important role in determining the effect produced. In another study, it was reported that 300Hz of vibration frequency, with an extended time (30 minutes), did induce significant increase in muscle strength in hemiplegic upper limbs (Costantino et al, 2017). In a recent systematic review, it was concluded that, local vibration on specific muscle groups possess the potential to increase muscle strength in healthy subjects (Alghadir et al, 2018). On the other hand, the results of this study are compatible with others who found that 35 Hz to 50 Hz of vibration did not have any additional effect on muscle strength over strength training alone (Fisher et al, 2015). Taking this altogether, it seems that segmental vibration might have beneficial effect on increasing muscle strength, however the parameters used must be taken into consideration.

The final observation to be discussed was that related to the significant increase in muscle strength observed on pinch. In a study performed on rheumatoid arthritis, it was found that hand exercises produced not only hand grip strength, but it also did induce significant pinch strength (Cima et al, 2013). Such observation is compatible with the current findings.

The last observation drawn from this study was that the training was performed on hand grip muscles however there was a significant increase in pinch grip muscles, taking in consideration that the whole upper limb underwent the vibration. Such observation might be explained by the fact that exercising synergistic muscles might be the basis of such increase in muscle improvement in non-exercised muscles, this might be due to the irradiation effect by the exercise regimen implemented (Singh et al, 2014).

5. CONCLUSION

Six weeks of strength training for hand grip muscles, with or without vibration, induces increase hand and pinch grip strength. However, segmental upper limb vibration does not have additional effect over isometric muscle training alone on hand grip and pinch grip strength. Additionally, if health care workers are seeking increase in pinch grip strength for any therapeutic goal, hand grip training is effective in inducing pinch grip strength.
LIMITATIONS

This study was limited by the possible involvement of participants in non reported exercise activities or ingestion of energy drinks that might affect result reading. Additionally, in female participants it might happen that menstrual cycle might have interfered with the muscle output registered.

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REFERENCES


