Vergleich eines Power Plate Beschleunigungstrainings und konventionellen Krafttraining auf die Kraftausdauerleistung der Oberkörpermuskulatur.

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Ziel der Studie: Vergleich eines Power Plate Beschleunigungstrainings und konventionellen Krafttraining auf die Kraftausdauerleistung der Oberkörpermuskulatur bei Studenten.

Dauer: 6 Wochen

Gerät: Power Plate

Probanden: 24 gesunde Studenten, Ø Alter 23 Jahre

Gruppen: Power Plate Gruppe
3 x pro Woche/ 5 Oberkörperübungen
30 sec/ Übung.

Konventionelle Trainingsgruppe:
3 x pro Woche/ 5 Oberkörperübungen
8 - 12 Wh.

Parameter: Kraftausdauertest der Oberkörpermuskulatur (Liegestütze)

Ergebnisse: Beide Trainingsgruppen zeigten eine deutlich signifikante Verbesserung der Liegestützanzahl. Die konventionell trainierende Gruppe konnte ihre Leistung um 30,49% und die Power Plate Gruppe um 28,35% steigern.

Fazit: Die Studie zeigt, dass ein Power Plate Beschleunigungstraining für die Oberkörpermuskulatur zu vergleichbaren Ergebnissen wie ein konventionelles Krafttraining bei erheblich geringerem Zeitaufwandführt. Das Power Plate Beschleunigungstraining bietet demnach eine effektive und zeitsparende Möglichkeit, die Oberkörpermuskulatur zu kräftigen.

Abb 1: Durchgeführte Power Plate Übungen

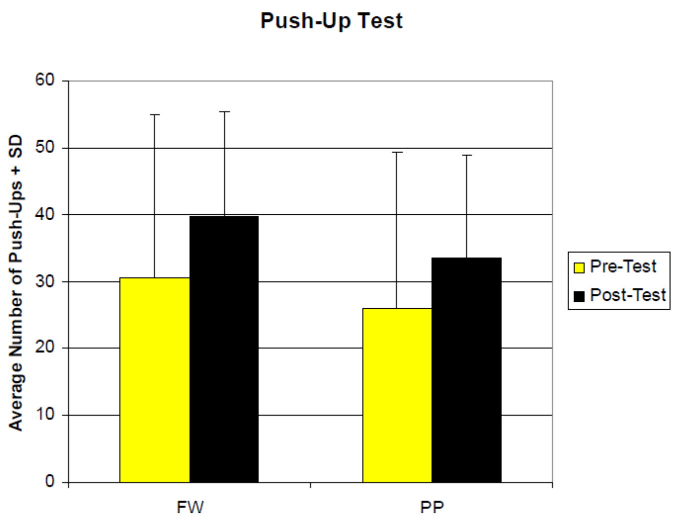

Abb 2: Durchschnittliche Liegestütz-Wh der konventionellen Gruppe (FW) und Power Plate Gruppe (PP)

Comparison of the Power Plate and Free Weight Exercises on Upper Body Muscular Endurance in College Age Subjects

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ABSTRACT

Int J Exerc Sci 2(3): 215-222, 2009. The power plate (PP) is designed to reduce training time while providing a muscle stimulus that leads to positive changes in muscle mass. This study investigated the effect that training on the PP has compared to a free-weight (FW) program, on upper body endurance, defined as the number of push-ups completed at one time prior to failure. Following IRB approval a pre-test was used to assess push-up endurance in PP and FW cohorts. Each group exercised for six consecutive weeks, working out three times per week, on non-consecutive days performing five exercises of two sets of 8-12 repetitions. Twenty-two females and 2 males enrolled in the investigation. Eleven with a mean age of 22 years (20-24) participated in the PP cohort. Thirteen participated in the FW arm of the study with a mean age of 24.5 (20-29) years. Shapiro-Wilk found lack of data normality. Wilcoxon Rank Sum testing yielded statistically significant differences within groups. The FW comparison between pre and post test showed a p value of 0.016. The PP group pre to post test p value was 0.005. Nonparametric testing (Mann Whitney) found no statistical differences (p=0.62) between Group A (FW) and Group B (PP) on the push-up pre-test. The post-test comparing post testing differences between groups (PP and FW) found no statistical differences (p=0.55) in the push-up test. Subjects in both groups saw increases in upper-body endurance with statistically significant differences within groups. Based on our findings the PP is a useful tool which enhances upper body muscle endurance.

KEY WORDS: Power plate, free weights, muscle endurance

INTRODUCTION

Proponents of whole-body vibration technology (WBVT) claim that it provides comparable results to traditional resistance training programs. Vibrations generated by WBVT are believed to cause muscle perturbations at a rate of 30-50 Hz compared with a normal rate of 1-2 Hz in active muscle. The Power Plate® (PP), (Power Plate North America, Northbrook, IL) a form of WBVT was developed by Nazarov, a Russian scientist. The original role for WBVT was to reduce muscle and bone atrophy when astronauts were exposed to microgravity for prolonged periods of time. Since that time the PP has been shown to be effective in the training of elite athletes (7,9) with particular increases noted in vertical jump performance (6,11,12). Benefits of WBVT has been shown in physical therapy, especially in the areas of postural control and reduction in falls (1,5), sports rehabilitation (18), and with osteoporosis prophylaxis (9,14,25).

The mechanism by which WBVT enhances bone and soft tissue development is unclear. Exaggerated neuromuscular activation through the tonic vibration reflex is commonly cited as the mechanism providing enhancement, however the relationship between these two variables has not been definitively determined (19). In addition, study protocols have been variable and this topic needs further investigation to better understand the specific relationship between WBVT and changes in muscle hypertrophy.

Although WBVT protocols vary widely in the literature, performance appears to be dependent on exposures of amplitude, frequency and acceleration magnitudes (17). Examples of protocol differences include a study in which a single 30 second WBV bout was employed (12) compared with 10 minutes of WBV spaced over 16 minutes (6). Torvinen et al., in 2002 (24) found that an increase in WBV amplitude led to improved performance while others have hypothesized that the most important variable for increased performance is training frequency (15-16). Cardinale and Lim compared squat and counter movement jumps at 20 and 40 Hz for five minutes and reported increases in the squat jump at 20 Hz, but a decrement in squat and countermovement jumps at 40 Hz (8). Cochrane and Stannard used WBV at 26 Hz for five minutes and showed an increase in countermovement jump (11). Cormie et al. reported a modest increase in countermovement jumps after a single WBV bout (12).

Therefore, the literature apparently supports acute and chronic use of WBV. However, the specific protocol which leads to optimal performance enhancement is difficult to determine because study results are difficult to compare.

Contraindications for PP use are not well documented in the literature other than through one case report (19). This case report of nephrolithiasis, which is presence of renal calculi (kidney stones) due to accumulation of organic and inorganic salts, found that WBV caused significant morbidity following one session of WBV training in a patient with asymptomatic nephrolithiasis.

The scientific evidence related to use of WBVT for muscle strengthening and as a form of warm-up has been investigated in the literature. Based on our review the effects of WBVT on upper body muscular endurance is unavailable. Therefore, in this investigation muscular endurance was measured following an upper-body training routine. The results of PP training were compared to the results of resistance training using free-weights (FW) and body-weight exercises. We hypothesized that no significant differences would be observed between PP and FW groups due to the homogeneity of the study subjects compared.

METHOD

Participants

Twenty-four members of a local fitness center were enrolled (22 females, 2 males) in the investigation. Eleven subjects participated in the PP arm of the study with a mean age of 22 (20-24) years. Thirteen participated in the FW arm of the study with a mean age of 24.5 (20-29 years). Both males were randomly assigned to the FW arm of the study.

Protocol
Following IRB approval all subjects signed an informed consent prior to study participation. Subjects for this investigation were solicited from a membership list at a local fitness center from those who met the inclusion criteria. To be included, fitness club members must have had a regular routine of exercising 2-3 times/week and willingly volunteer for the study.

PP and FW training was compared using upper body muscular endurance differences of each participant as measured by the International Fitness Association's (IFA) push-up test (PUT). Study participants executed this test from a prone position, their chin on the floor and their fingers pointed forward with their hands directly under their shoulders. One repetition of the PUT was counted when the subject pushed up by completely extending at the elbow, and returned back to the starting position, with no resting at the bottom of the movement. Subjects were instructed to repeat these steps with as straight an upper body as possible without resting at the top or bottom of the push-up position. Demonstration of proper PUT technique and verbal instructions were given to each individual prior to commencement of the pre-test regarding how to maintain body alignment as they executed their push-ups. For males, the legs were extended and positioned together, using the forefoot as a pivot point. For females, the upper leg was in a straight line from the hips and shoulders, using the knees as a pivot point, feet crossed and kept off of the floor. There was no time limit for this test. Individuals were instructed to complete as many push-ups as they could before failure. Failure was defined as subject inability to execute a push-up in the prescribed fashion. Pre- and post-tests were completed in the same fashion. Upper body muscle endurance, the dependent variable, was defined as the number of push-ups completed at one time without stopping to rest.

Each cohort followed the prescribed exercise regiment for a period of six weeks working out three times per week, on non-consecutive days and performing five exercises for two sets of 8-12 repetitions.

The following five FW exercises (or corresponding PP movements) were used in this study; (1) the standard or modified push-up, (2) the dumbbell bicep curl, (3) the triceps dip off a bench, and both (4) the front dumbbell shoulder raise and (5) lateral dumbbell shoulder raise. One set of FW exercise was defined as 8-12 repetitions, with the optimum goal being twelve, using a strenuous weight. "Strenuous" was defined as challenging, but not uncomfortable. The five exercises selected were chosen because of their pertinence and contribution to upper-body muscular endurance.

The corresponding two sets of PP exercises consisted of the same body positions as in the aforementioned exercises with the exception of hand placement being completely on the PP. One set on the PP was one thirty-second time period at a strenuous vibration setting, with strenuous meaning a level of vibration that was challenging, but not uncomfortable. The PP provided a vertical vibration with a frequency between 30-50 Hz and an excursion of 2-5 mm. Study participants were encouraged to rest 1-2 minutes between exercises and sets.

Schematic representations of the five exercises on the PP are shown in the five figures below.

(1) Push-Up

(2) Dumbbell Biceps Curl

(3) Triceps Dip Off a Bench

(4) Front Dumbbell Shoulder Raise

(5) Lateral Dumbbell Shoulder Raise

The study design was a pretest-posttest control group design. Each group was administered a pre-test of how many push-ups they could complete before failure. Participants were matched for sex, age and fitness status based on the pre-test. The FW Group trained using only free weights while the PP Group trained using only the PP.

Participants signed a Letter of Commitment, stating that they would complete all of the workouts, complete the study, and would also not train their upper-body muscles outside of their assigned exercises for the duration of the six-week study in order to maintain the integrity of the results. Female participants signed a medical waiver, approved by the IRB, stating that they were healthy, were not pregnant, had not had a recently placed IUD or had any known medical problem that would prevent them from participating in the study. Participants were allowed to work on their cardiorespiratory system as well as their lower-body and abdominal muscle groups as desired. Core training is an important component of overall fitness and may have positively affected post testing in both groups.

Every subject participated in the first workout under the direct supervision of one of the researchers in order to ensure the use of proper technique and to answer any questions about the exercises. Furthermore, each subject was explicitly instructed to contact one of the researchers immediately if any questions or problems arose throughout the study and to discontinue the study if any discomfort or concerns arose from the exercise programs. Study subjects were minimally supervised following the initial training session. Study authors were present during training to manage and/or correct any participant question or problem.

Twenty-four members of a local fitness center were enrolled (22 females/2 males) in the investigation. Eleven participated in the PP arm of the study with a mean age of 22 (20-24) years. Thirteen participated in the FW arm of the study with a mean age of 24.5 (20-29) years.

Statistical Analysis
Non parametric testing with Wilcoxon Rank Sum Testing was used to assess within group differences. Mann Whitney was used for between group differences. The alpha level was set at $p \leq 0.05$. Statistical analysis was performed with SPSS for Windows Version 16 (SPSS Inc., Chicago, IL, USA).

RESULTS

Due to small samples sizes and lack of data normality based on Shapiro-Wilk non-parametric testing was used for within and between group comparisons. Wilcoxon Rank Sum testing yielded statistically significant differences within groups. The FW comparison between pre and post-test showed a p value of 0.016 (see table 1). The PP group pre to post test p value was 0.005 (see table 1).

Nonparametric testing (Mann Whitney) found no statistical differences (p=0.62) between FW and PP groups on the push-up pre-test**.** Comparing post-tests between groups (PP and FW) found no statistical differences (p=0.55) in the PUT (figure 6).

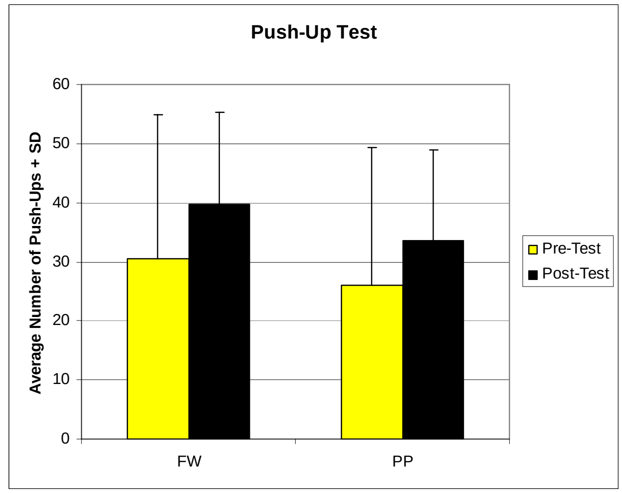

Figure 6. Free weight (FW) and power plate (PP) push-up averages and standard deviations.

DISCUSSION

The most statistically significant finding in this study was that there was an increase in the dependent variable, push-ups from baseline in both FW and PP groups. The FW group tended to have a higher number of post-test push-ups, but the differences did not reach statistical significance.

Encouraging people of all ages to be physically active is an important global

Table 1. Pre and Post-Test Push-Up Means and Standard Deviations

Group	Pre-Test ± SD	Post-Test ± SD
Free Weight	30.5 ±24.3	39.8 ±23.2*
Power Plate	26.1 ±15.4	33.5 ±15.5*

* significantly different compared to pretest.

goal. In this study the results from a 6-week upper-body training routine using whole-body vibration training (PP) were measured against the results of traditional resistance training using free-weights and body-weight exercises. Muscular endurance, as measured with the push-up, was comparable between PP and FW training. The exact mechanism establishing how and why the PP provided the muscle stimulus sufficient to illicit muscle changes is unclear. Some of the change from pre-test to post test could have been due to a learning effect in both groups. There may have also been a Hawthorne Effect in both groups (3). That is, both groups may have improved because they were being tested and the expectation was that they would improve.

Although the time for each training session was not carefully monitored, the PP group generally completed their routine in approximately 10 minutes including time to rest between exercises. The FW participants took considerably longer to complete their training routine. Thus, the PP group received similar benefit in a shorter period of time.

We supported the null hypothesis that there would not be statistically significant differences between PP and FW groups. In some ways technology has decreased the need for physical activity, however PP technology may be a useful application of technology which allows people to illicit an optimal muscle stimulus with less physical effort as demonstrated by the results of our study.

Subjects in both groups saw increases in upper-body muscle endurance with statistically significant differences within groups, but no statistical differences between groups over the six-week training period. Based on our review of the literature this is the first study that has examined the long-term effects of WBVT in healthy young adults.

Our findings suggest useful utility of PP training to enhance upper body muscle endurance assessed through the push-up. Recently, Rhea and Kenn found that acute application of WBV enhanced back squat power production (22). Others found similar findings for increasing vertical jump height (2,6,12), and increasing EMG activation in muscles responsible for powering vertical jumping, (21) although there have been some contradictory findings (10,13,24). WBV has also been shown to be effective in the rehabilitation of young athletic patients following ACL reconstruction by enhancing joint stability and balance (18), and among community dwelling 60 year old adult males by enhancing isometric and explosive strength knee extension strength which translates to reversal of muscle mass loss with age (4). Conflicting findings are likely the result of different research protocols.

Strengths of our work include this being the first study we are aware of in the literature that has compared the PP and FW for assessment of muscle endurance, tight control over the prospective nature of the six week study by the investigators and the practicality of the findings for college age students.

Limitations of this study include the assumption that subjects executed the correct number of repetitions, used of proper form, as instructed, and working out three times per week. It was also assumed that subjects abided by the Letter of Commitment and did not participate in other activities or exercises that would enhance their upper-body muscle endurance during the study.

Future research should allow more time for study of PP efficacy. More strictly controlled studies are needed to assess the importance of application, amplitude and frequency of whole body vibration technology. Due to the indirect nature of the vibration amplitude and frequency attenuation of the non-linear stimulus must be addressed. Muscle location with respect to the vibration source and body composition are important considerations in future study. Ideally, subjects should be exposed to different modes of training for a longer period of time, perhaps twelve weeks, in order to better understand the effects of WBVT training. Future studies should also involve more subjects with greater heterogeneity which will increase the statistical power and generalizability of the findings.

REFERENCES

1. Bautmans I, Van Hees E, Lemper JC, Mets T. The feasibility of whole body vibration in institutionalized elerderly persons and its influence on muscle performance, balance and mobility: a randomized controlled trial. BMC Geriat 5(17): 1-8, 2005.

2. Bazett-Jones DM, Finch HW, Dugan EL. Comparing the effects of various whole-body vibration accelerations on counter-movement jump performance. J Sports Sc Med 7: 144-150, 2008.

3. Berg K, Latin RW. Essentials of Research Methods in Health, Physical Education, Exercise Science, and Recreation (3rd ed). Philadelphia: Lippincott Williams & Wilkins, 2008.

4. Bogaerts A, Delecluse C, Claessens AL, Coudyzer W, Boonen S, Verschueren SMP. Impact of whole-body vibration training versus fitness training on muscle strength and muscle mass in older men: a 1-year randomized controlled trial. J Gerontol 62A(6): 630-635, 2007.

5. Bogaerts A, Verschueren S, Delecluse C, Claessens AL, Boonen S. Effects of whole body vibration on postural control in older individuals: a 1 year randomized controlled trial. Gait & Posture 26: 309-316, 2007.

6. Bosco C, Iacovelli M, Tsarpela O, Cardinale M, Bonifazi M, Tihanyi J, Viru M, DeLorenzo, Viru A. Hormonal responses to whole-body vibration in men. Eur J App Phys 81: 449-454, 2000.

7. Cardinale M, Bosco C. The use of vibration as an exercise intervention. Ex Sports Sc Rev 31:3-7, 2003.

8. Cardinale M, Lim J. The acute effects of two different whole body vibrations frequencies on vertical jump performance. Med and Sport 56: 287-292, 2003.

9. Cardinale M, Wakeling. Whole body vibration exercise:are vibrations good for you? Br J Sports Med 39:585-589, 2005.

10. Cochrane DJ, Legg SJ, Hooker MJ. The short-term effect of whole-body vibration training on vertical jump, spring and agility performance. J Strtength Cond Res 18: 828-832, 2004.

11. Cochrane DJ, Stannard SR. Acute whole body vibration training increases vertical jump and flexibilty performance in elite female field hockey players. Br J Sports Med 39(11): 860-865, 2005.

12. Cormie P, Deane R, Triplett NT, McBride JM Acute effects of whole body vibration on neuromuscular function and muscle strength and power. J Strength Cond 20: 257-261, 2006.

13. deRuiter CJ, van der Linden RM, van der Zijden MJ, Hollander AP, deHaan A. Short-term effects

of whole body vibration on maximal voluntary isometric knee extensor force and rate of force rise. Eur J Appl Physiol 88: 472-475, 2003.

14. Gilsanz V, Wren TA, Sanchez M, Dorey F, Judex S, Rubin C. Low-level, high frequency mechanical signals enhance musculoskeletal development of young women with low BMD. J Bone Miner Res 21(9): 1464-1474, 2006.

15. Griffin MJ. Handbook of Human Vibration. London:Academic Press 1996.

16. Jordan MJ, Norris SR, Smith DJ, Herzog W. Vibration training: an overview of the area, training consequences, and future considerations. J Strength Cond 19: 459-466, 2005.

17. Luo J, McNamara B, Moran K. The use of vibration training to enhance muscle strength and power. Sports Med 35: 23-41, 2005.

18. Moezy A, Olyaei G, Hadian M, Razi M, Faghihzadeh S. A comparative study of whole body vibdration training and conventional training on knee proprioception and postural stability after anterior cruciate ligament reconstruction. Br J Sports Med 42(5): 373-378, 2008.

19. Monteleone G, DeLorenzo A, Sqroi M, DeAngelis S, DiRenzo L. Contraindications for whole body vibration training:a case of nephrolitiasis. J Sports Med Phys Fitness 47(4): 443-445, 2007.

20. Nordlund MM, Thorstensson A. Strength training effects of whole-body vibration? Scan J of Med Sci in Sports 17:12-17, 2007.

21. Rhea M, Kenn JG. The effects of acute applications of whole-body vibration on the itonic platform on subsequent lower body power output during the back squat. J Strength Cond Res 23(1): 58-61, 2009.

22. Roelants M, Verschueren SMP, Delecluse C, Levin O, Stijnen V. Whole-body-vibration-induced increase in leg muscle activity during different squat exercises. J Strength Cond Res 20(1): 124-129, 2006.

23. Seidel H. Selected health risks caused by long-term, whole body vibration. Am J Ind Med 23(4): 589-604, 1993.

24. Torvinen S, Kannus P, Sievanen H, Jarvinen TAH, Pasanen M, Kontulainen S, Jarvinen TLN, Jarvinen M, Oja P Vuori I. Effect of a vibration exposure on muscular performance and body balance. Randomized cross-over study. Clin Phys Funct Imag 22: 145-152, 2002.

25. Torvinen S, Sievanen H, Jarvinen TAH, Passanen M, Kontulainen S, Kannus P. Effect of 4-minute vertical whole body vibration on muscle performance and body balance: a randomized cross-over study. Int J Sports Med 23: 374-379, 2002.

26. Verschueren SM, Roelants M, Delecluse C, Swinnen S, Vanderschueren D, Boonen S. Effect of 6-monthwhole body vibration on hip density, muscle strength, and postural control in postmenopausal women. J Bone Miner Res 19(3): 352-359, 2004.