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Whole body vibration is a safe exercise training method and induces no impaired alterations on rat plasma parameters

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Whole body vibration (WBV) has been regarded as an exercise training method and as a non-pharmacological supportive treatment option appearing to be efficient for chronic disease conditions, such as bone disorders and cardio-respiratory fitness. Since, data on the safety and efficacy of vibration on plasma parameters are lacking, therefore, it was decided to assess the effects of WBV on the plasma parameters in adult male Wistar rat model.

Methods: Male Wistar rats, weighing 140–180 g, were divided into control and the vibration group. Vibration training consisted of vertical sinusoidal whole body vibration for 8 weeks, followed by blood collection.

Results: The vibrated rats weighed more than the control group (approximately 14% more). Plasma CK, E2 and IL-6 levels were significantly higher in the vibration group compared with the controls. The mean of Vit. D level was 15% higher; hsCRP level was 11% lower and IL-6 level was 32% higher in the vibration group. No difference was observed for other selected plasma parameters.

Discussion: The potential effects of physiological responses of WBV on several physiological systems are without deteriorations in plasma parameters.

Keywords: whole body vibration, male Wistar rat, blood plasma, hematological parameters

Physical activity as an effective strategy, recommended in general practice, can be used to increase lean mass and bone mass while decreasing fat mass and is also beneficial in improving health status of the individuals (6). Recently, whole body vibration (WBV) has been regarded as an exercise training method with a potential of improving body composition (12). It is suggested that WBV training program as a non-pharmacological supportive treatment option appears to be an efficient alternative treatment for chronic disease conditions, such as bone disorders and cardio-respiratory fitness. High-frequency mechanical strain seems to stimulate bone strength in animals (17, 23). The findings suggest that WBV training might be useful in the prevention of osteoporosis and bone mass loss (8–9, 15–16, 21–22), it improved isometric and dynamic muscle and muscle strength (3, 14, 21), and it has been reported to reduce body fat accumulation and serum leptin concentration (11).

In a broad experiment, members of our group are studying the effect of a combination therapy including the simultaneous effects of vibration, supplementation of the selected minerals and Vit D plus different fatty acids on cardiovascular risk factors and bone

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mechanical properties in healthy male Wistar rats. Furthermore, at present it was decided to report the primary findings obtained from the first two groups, and further completed results from whole experimental groups concerning other variables will be presented in the next paper. Meanwhile, since the effects of vibration exercise on the plasma parameters have rarely been studied and data on the safety and efficacy of vibration on plasma parameters are lacking, the effects of high-frequency loading by means of WBV on the plasma parameters in adult male Wistar rat model will be assessed and presented in this report.

Materials and Methods

Male Wistar rats, weighing 140–180 g, were obtained from Animal House of Physiology Group, Baqiyattallah University of Medical Sciences. Eight rats in each group (Control vs. Vibration) were randomly kept in plastic cages (four rats per cage) in a controlled environment with a 12-hour light/dark cycle and a constant temperature (22 ºC) and humidity (65–70%), with free access to food and water. Animals were weighed and provided clean cages weekly. Food intake was determined three times per week. Vibration training started after a week.

For vibration training, animals in the vibration group were placed in a compartment attached to a vibration platform (China). The vibration intervention for this group consisted of one – three 5 – min cycles of vertical sinusoidal whole body vibration for four sessions in the first week and increased gradually to 45 min until day 24 (with three sessions per week); followed by 60 min per set for the next 20 sessions until the end of 8 weeks of the experiment. Each training session was performed between 8.30–10.00 A.M.

After each vibration cycle, the animals were given 1–2 min rest break between cycles. The vibration was performed at mode 1 with amplitude of 1–10 and at a frequency of 10–50 Hz. The speed of mode 1 in each cycle increases gradually and then it decreases with the same trend within each specific time period. The control animals remained in their cages and were placed over the vibration platform, without vibration treatment.

Eight weeks after training program, rats from both groups were weighed after 12-h fasting and anesthetized for the collection of blood by cardiac puncture with a syringe and needle. Rats were restrained from food for 12 h but had access to drinking water. Since, some parameters such as steroid hormones are subject to circadian rhythm, therefore blood samples were collected at the peak time in the afternoon between 2–4 P.M. All animals were euthanized immediately after blood sampling. Plasma samples were separated, immediately and stored at –20 ºC until analysis, on the next day.

Commercially available assay kits were used to determine the blood parameter levels.

Plasma lipid concentrations were measured enzymatically by commercially available kits (Cholesterol and Triglycerides by Greiner, Bahlingen, Germany; LDL by Pars Azmun, Tehran, Iran; and HDL by Randox, Antrim, UK).

Risk factor (RF) or a predictor of CHD risk was simply obtained as the TC/HDL-C ratio, and atherogenic index (AI) as the LDL/HDL ratio.

Plasma creatin kinase (CK) was measured by CK-NAC, Photometric test using a kit from Pars Azmun, Tehran, Iran.

The assays for serum total testosterone (T), free testosterone (FT), and estradiol (E2) were performed by ELISA methods using reagent kits (Diagnostics Biochem Canada Inc., Ontario, Canada).

Plasma 25-hydroxy Vit. D was measured by EIA method using a reagent kit obtained from Immunodiagnostic System Ltd (IDS Ltd), Boldon, UK.

Plasma rat calcitonin Vit. was performed by ELISA method using reagent kit (Rat CT, USCN Life Science Inc. Wuhan, China).

PTH was determined utilizing a two-site ELISA kit (Rat PTH, USCN Life Science Inc. Wuhan, China).

Alkaline phosphatase (Alk.Ph) activity in rat plasma was measured by kinetic photometric test using a kit from Pars Azmun, Tehran, Iran.

Plasma calcium concentrations were determined by atomic absorption spectrophotometry (Chemtech Analytical, CTA-2000 AAS, Kempston, UK).

Plasma uric acid concentrations were measured by enzymatic photometric test using kit from Pars Azmun, Tehran, Iran.

High-sensitivity C-reactive protein (hs-CRP) was measured by ELISA method using the kit from Biovendor Research and Diagnostics, Heidelberg, Germany.

Tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) were measured by ELISA method using the kit from Diaclone, Besancon, France.

Statistical analysis

Data are expressed as mean±SD and a Statistical Package for the Social Sciences [(SPSS), New York: McGraw-Hill] was used to perform all comparisons. Independent sample T-tests weres used to evaluate the effects of training between two groups. A P-value of less than 0.05 was considered significant for the differences. No multiplicity was performed for the comparisons.

Results

The rats in both groups adjusted to the vibration and tolerated and acclimated well to the vibration with no signs of stress after one week. Furthermore, no major differences was observed in the amount of food and water intake between the control and vibration group and were consuming food and water normally (Table I) and stayed healthy throughout the study.

Table I. Food and water consumption, body weight of control and vibrating groups

	Control (n=8)	**Vibration (n=8)**
Food Intake (g/d) Water (ml/d)	17.1 20–25	17.8 20–25
Body Wt (g): 1st day	145.0±10.0	149.0±6.0
4 wks	229.0±27.0	242.0±34.0
8 wks	280.0±31.0	306.0±41.0
Difference in Body Wt or Wt gain (g)	135.0±21.0	157.0±36.0*

*P<0.048

The vibrated rats weighed more than the control group at the end of the study.

They weighed approximately 14% more (weight gain: 135.0±21.0 vs 157.0±36.0). Significant differences were only observed in plasma levels of CK, E2, and IL-6 between the vibration and control group (Table II). Plasma CK, E2 and IL-6 levels were significantly higher in the vibration group compared with the controls.

The mean of Vit. D level was 15% higher; hsCRP level was 11% lower and IL-6 level was 32% higher in vibration group.

Table II. Effects of vibration training on serum parameters in vibration and control groups

Group Variable	Control	Vibration	P value
Chol (mmol/l)	1.37±0.18	1.35±0.10	N.S.
LDL (mmol/l)	0.54±0.10	0.47±0.13	N.S.
HDL (mmol/l)	0.44±0.08	0.44±0.08	N.S.
TG (mmol/l)	0.82±0.12	0.96±0.16	N.S.
AI	1.30±0.28	1.02±0.31	N.S.
RF	3.20±0.42	3.03±0.48	N.S.
CK (U/L)	188.0±20.0	240.0±37.0	0.02
T (nmol/l)	6.24±1.39	6.24±2.18	N.S.
FreeT (nmol/l)	1.52±0.65	1.38±0.58	N.S.
E2 (pmol/l)	30.65±4.77	36.04±8.07	0.031
Vit D (nmol/l)	91.0±19.0	108.0±22.0	N.S.
Calcitonin (ng/l)	80.3±11.5	81.0±10.0	N.S.
PTH (ng/l)	36.1±8.90	38.7±5.50	N.S.
Alk.Ph (U/L)	215.0±19.0	215.0±32.0	N.S.
Ca (mmol/l)	1.20±0.07	1.15±0.07	N.S.
Uric acid (umol/l)	208.0±41.0	214.0±53.0	N.S.
hsCRP (µg/ml)	321.0±42.0	285.0±77.0	N.S.
TNF-α (pg/ml)	33.0±5.0	33.0±4.0	N.S.
IL-6 (pg/ml)	35.0±5.0	52.0±15	0.014

N.S. = non-significant

Discussion

At its most basic, exercise is any type of physical exertion we perform in an effort to improve our health, shape our bodies and boost performance. Obviously that covers a broad range of activities and, luckily, there are plenty to go around whether one wants to lose weight, get healthy or train for a sport.

Recently, whole body vibration has been proposed as a potential alternative, or adjuvant, to exercise (11). Vibration can be broken down into two basic components: magnitude and frequency. Magnitude encompasses displacement, velocity, acceleration and jerk. Currently, many companies advertise to use of WBV as an effective means by which muscle strength and bone mass (in addition to other physiological benefits) can be obtained. Both acute and chronic alterations in peripheral vasculature occur with WBV and other reports indicate that hormonal fluctuations resulting from WBV vary considerably. A comprehensive review on the potential effects of WBV on several physiological systems is presented by Prisby et al. (12). In summary, they provide some evidence of the effectiveness of WBV which may be related to tissue perfusion, fluctuations in systemic hormones, and/or occur via direct mechanical stimulation. However, there is still a lack of data in the literature to support these claims and remains obscure. One major problem is related to the applied vibratory protocols and experimental designs to make definitive conclusions. One argument for use of vibrating devices is that they promote weight loss or decrease fat mass, which requires further evidences to support these claims. Moreover, findings focused on the benefits and efficacy of WBV on skeletal tissues and mass, particularly in enhancing muscle strength, balance, and mobility; and on bone mass and tissue architecture. It is reported that twenty-four weeks of WBV slightly increased lean mass in previously untrained females (14) and after 12 weeks reduced body fat accumulation and serum leptin levels with no alteration in food consumption (11). Similar findings from human studies confirm the effectiveness of WBV in improving health status such as, improving pain and fatigue in women with fibromyalgia (1), reducing the risk of bone fracture more than walking (9), in increase in the serum levels of testosterone and growth hormone (4–5, 10), and in representing no stressful stimulus for the neuroendocrine and neuromuscular systems (7, 10). Further, it would be well-advised to study the hematological factors associated with WBV in an attempt to determine the influence of such a treatment. In our study the rats were healthy and treated well with the vibration with no signs of distress. The WBV group weighed approximately 14% more after 8 weeks (weight gain: 135.0 vs 157.0 g), while both groups consumed similar amounts of food (17.1 vs 17.8 g/d). Although, the mechanism responsible for the increased body weight was not studied, but it is assumed that the observed body weight gain may be the result of higher muscle mass and bone mass and/or the result of higher blood flow leading to the alteration on the peripheral vascular and tissue perfusion. Maddalozzo et al. reported that mature female vibrated rats weighed 10% less, with less body fat and serum leptin concentrations (11).

WBV is implemented through the use of a vibrating platform on which exercises can be performed. The vibrations generated by the engines underneath the platform are transmitted to the person standing, sitting or lying on the machine. The amplitude and frequency of these vibrations can be set on the device.

It has been shown to increase muscular strength, explosive power and anabolic hormone levels when performed for as little as 4 minutes three times a week (4). It requires relatively little exertion compared with traditional forms of exercise; yet studies comparing this training method to traditional strength training have found similar gains in strength and, in some cases, more gains in explosive power (14). Since whole-body vibration training is low impact, it may be a particularly good choice for older or obese clients who have trouble doing traditional weight-bearing exercise. In a study, Roelants et al. (13) reported a significant increase in fat-free mass and strength with whole-body vibration. This study compared the effects of 24 weeks of resistance training and whole-body vibration (frequency: 35–40 Hz; amplitude: 2.5–5 mm) on body composition and knee extensor strength in untrained young women. Although there were no significant changes in body weight or percent body fat in either group, the whole-body vibration group significantly increased fat-free mass (by 2.2%). A significant increase in knee extensor strength was also reported in both groups (13).

It is now assumed that evaluation on the issue of the effect of WBV on body weight requires a long-term study in which body composition consisting of fat, muscle and bone mass or metabolic factors in normal, overweight and obese rats needs to be determined.

Whole body vibration showed to increase creatine kinase (CK) involved in muscle damage and IL-6 levels in the vibrating group. It is assumed that increases in pro-exercise (2) has been shown to increase after infrequent exercise, typically involving eccentric actions (19); and both moderate exercise (60% VO(2) max) and intensive exercise (75% VO(2) max) significantly increased IL-6, CK, CRP and WBC, as well (20). It is also reported that the primary function of the additional IL-6 may that be the potential effects of physiological responses of WBV on several physiological systems are without deteriorations on plasma parameters (18). These findings further promote eliciting scientific inquiries into this potentially therapeutic aid through further investigations on determining the optimal frequency, duration, amplitude, and appropriate protocols.

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