นิพนธ์ต้นฉบับ • Original Article

ผลของการสั่นสะเทือนทั่วร่างกายต่อองค์ประกอบของร่างกายและความแข็งแรงของกล้ามเนื้อในผู้ที่มีภาวะน้ำหนักเกินเพศหญิง

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Effect of Whole Body Vibration on Body Composition and Muscular Strength in Overweight Females

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หลักการและวัตถุประสงค์: ภาวะน้ำหนักเกินและโรคอ้วนมีความสัมพันธ์ที่เกี่ยวกับโรคเรื้อรังหลายชนิด การออกกำลังกายจึงถูกนำมาใช้ในการควบคุมหรือลดน้ำหนักเพื่อป้องกันโรคต่างๆ ที่อาจเกิดขึ้นตามมาแต่ผู้มีภาวะน้ำหนักเกินอาจจะไม่สามารถออกกำลังกายให้มีระดับที่หนักพอเพื่อการลดน้ำหนักได้ การศึกษานี้จึงมีวัตถุประสงค์ในการศึกษาผลของการสั่นสะเทือนทั่วร่างกายต่อน้ำหนักตัว องค์ประกอบของร่างกายอื่นๆ และความแข็งแรงของกล้ามเนื้อในผู้ที่มีภาวะน้ำหนักเกินเพศหญิง

วิธีการศึกษา: อาสาสมัครเพศหญิงที่มีน้ำหนักเกินจำนวน 37 ราย (ดัชนีมวลกาย เท่ากับ 25.0-29.9 กิโลกรัมต่อเมตร^2) แบ่งออกเป็น กลุ่มควบคุม (CT) จำนวน 18 ราย และกลุ่มสั่นสะเทือนทั่วร่างกาย (WBV) จำนวน 19 ราย กลุ่มควบคุมจะไม่ได้รับการฝึกส่วนอาสาสมัครกลุ่มสั่นสะเทือนทั่วร่างกายทำท่าทางต่างๆ 5 ท่า 3วันต่อสัปดาห์ นาน 2 เดือน อาสาสมัครทั้งหมดจะถูกวัดองค์ประกอบของร่างกายความแข็งแรงของกล้ามเนื้ออัตราการเต้นของหัวใจ และความดันเลือดก่อนและหลังการออกกำลังกาย

Background and Objective: Overweight and obesity are associated with many chronic conditions. Exercise is used in term of control body weight which aims to prevent diseases. Generally, overweight may not exercise to the target heart rate which aims to decrease weight. This study investigated the effect of whole body vibration (WBV) training on body weight, other body compositions and muscular strength in overweight females.

Methods: Thirty-seven overweight females (BMI=25.0-29.9 kg/ m^2) were assigned into two groups: control (CT, n=18) and whole body vibration (WBV, n=19). The participants in the WBV group were performed 5 exercise postures during vibration, 3 days a week for 8 weeks. CT group did not perform vibration training. Body composition, muscular strength, heart rate at rest and blood pressure were measured at before and after training.

Results: Compared between CT and WBV groups, WBV showed significant lower in body weight (70.21 ± 9.39 vs 62.56 ± 9.06 kg; $p< 0.05$), BMI (28.52 ± 2.58 vs 25.73 ± 2.41 kg/m^2; $p< 0.05$), WC (88.10 ±7.82 vs 86.33 ± 8.40 cm;

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ผลการศึกษา: พบว่าเมื่อเปรียบเทียบระหว่างกลุ่ม CT และกลุ่ม WBV ภายหลัง 2 เดือน พบว่า มีการลดลงอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) ของค่าต่างๆ ดังนี้ น้ำหนักตัว (70.21 ± 9.39 vs 62.56 ± 9.06 กิโลกรัม) ดัชนีมวลกาย (28.52 ± 2.58 vs 25.73 ± 2.41 กิโลกรัมต่อเมตร^2) เส้นรอบเอว (88.10 ± 7.82 vs 86.33 ± 8.40 เซนติเมตร) เส้นรอบสะโพก (104.83 ± 3.57 vs 102.00 ± 4.83 เซนติเมตร) และไขมันในร่างกาย (28.01 ± 4.10 vs 21.62 ± 5.54 กิโลกรัม) ความแข็งแรงของกล้ามเนื้อขาแบบไอโซเมตริก (isometric) ไอโซโทนิก (isotonic) และไอโซไคเนติก (isokinetic) ของขาเพิ่มขึ้น

สรุป: การศึกษานี้แสดงให้เห็นว่าโปรแกรมการสั่นสะเทือนทั่วร่างกายทำให้องค์ประกอบของร่างกายบางค่าความแข็งแรงของกล้ามเนื้อ ความดันเลือด และอัตราการเต้นของหัวใจปรับตัวดีขึ้นในผู้ที่มีภาวะน้ำหนักเกินเพศหญิง

คำสำคัญ: เปอร์เซ็นต์ไขมัน เส้นรอบเอว เส้นรอบสะโพก ความดันเลือด

Conclusions: The present study revealed that WBV training improved body composition, muscular strength, blood pressure and heart rate at rest in overweight females after 8 weeks of whole body vibration training.

Keywords: Percentage of body fat, Waist circumference, Hip circumference, Blood pressure

ศรีนครินทร์เวชสาร 2560; 32(4): 344-50. • Srinagarind Med J 2017; 32(4): 344-50.

Introduction

Overweight and obesity are known as abnormal or excessive fat accumulation that present a risk to health. Obesity increases the risk of many physical and mental conditions include type 2 diabetes, cardiovascular disease, obstructive sleep apnea, osteoarthritis and certain types of cancer[1]. In 1997 the WHO formally recognized obesity as a global epidemic[2] and in 2008 the WHO estimated that at least 500 million adults (greater than 10%) were obese, and found in women more than men[3]. The classification of overweight and obese for public health action should be 23.0 kg/m^2. The categories suggested for Asians are: less than 18.5 kg/m^2 for underweight; 18.5-23.0 kg/m^2 for normal; 23.0-27.5 kg/m^2 for overweight and 27.5 kg/m^2 or higher for obesity[3].

Regular exercise is important in term of control body weight and also beneficial in many ways, such as increasing cardiorespiratory endurance and even in the absence of weight loss[4]. Aerobic based exercise is thought to be an effective strategy to control body weight and lose weight which duration of exercise should longer than 30 minutes per day and up to three months. To see the results or experience a change, people need to exercise regularly and keep optimal intensity. However, no changes have occurred after such exercise, this may due to the overweight or obese people cannot keep the optimal level of exercise to stimulate physiological adaptations. Generally overweight and obese people have low level of physical fitness compared with others, and then they cannot continue their work load during the period of training program. One major problem of exercise in obese is musculoskeletal injury, the more body weight the more injury to musculoskeletal structure such as muscle, tendon, ligament and joint. These injuries may due to the weight that comes against the bones and joints. However, the exercise in overweight people is not theoretically. This study investigated the new strategy which practical and effective to help reduce weight and improve overall fitness for overweight people without any muscle, ligament, tendon and joint injury.

The whole body vibration (WBV) machine produces adjustable frequency that enhances muscle contraction in response to the vibrations. This mechanical vibration stimulates the response of muscle to achieve automatic muscle contraction (involuntary contraction or reflex), resulting in increased muscle strength and may cause an increase in bone mass[5]. The tonic vibration reflex can cause an augmentation of motor unit recruitment via muscle spindle activation and polysynaptic pathway[6]. Consequently, muscle contract

autonomically, this bring the muscle exercise and improved muscle strength thereafter. Whole body vibration may mimic the effect of conventional light aerobic exercise, due to increase fat utilization and glucose oxidation, resulting in fat or body weight loss thereafter.

Exercises for weight loss in females present more difficult than males, this may due to the differentiation of sex hormones. Testosterone is a powerful anabolic androgen hormone in male that stimulates muscle protein synthesis and intramuscular amino acid uptake, and increase lipolysis[7]. The effect of whole body vibration on the changes of body composition and muscular strength in overweight people are less information. The physiological parameters: blood pressure and heart rate are also another issue that has less study in particular after WBV in overweight and obese adults. Therefore, this study investigated the whole body vibration training to improve body composition especially body weight reduction and increase muscular strength in overweight females.

Methods

Study design and Population

A volunteer of 37 participants with overweight female were recruited in this study. This study is a r andomized control trial. The participants were randomly divided into control (CT) and whole body vibration (WBV) groups. The WBV group was exposed to vibration using a Power Plate pro 5 silver (Power plate International Ltd., USA). The frequency used for this study was set at 40 Hz, while CT did not perform any exercise training. All participants were recorded daily food intake and maintain their normal lifestyle. All participants were asked to avoid other exercises during experimental period. A written informed consent approved by the Khon Kaen university ethics committee for human experiments research was given to all participants prior to the start of the study. The participants performed 5 exercise postures on the vibration platform: deep squats, calf raises, wide-stance squats, Rt. lunges and Lt. lunges. Time of exercise: 30 sec/posture x 8 sets. Resting time was set for 30 sec between set. Training frequency was 3 days per week for 8 weeks. All participant were recorded the body composition such as body weight (BW), body mass index (BMI), waist circumference (WC), hip circumference (HC), waist hip ratio (WHR), lean body mass (LBM), body fat (BF) and percentage of body fat (PBF) by using body composition analyzer (ioi 353 of Jawan Medical, Korea). All variables were recorded before (pre) and after (post) whole body vibration training. Daily monitoring: blood pressure and heart rate at rest were recorded along the experimental period.

Statistical analysis

Statistical calculations were performed using the statistical package for the social science (SPSS) version 16.0 for Windows. Analysis of covariance (ANCOVA) was used to testfor differences betweenthe groups. Results were considered significant if $p < 0.05$. Values are expressed as mean ± SD.

Results

The participant's characteristics, there were no significant differences between the two groups as shown in Table 1.

In Table 2 shows the body composition before and after 8 weeks training in two groups. Compared to CT, WBV group presented significantly decreased ($p<0.05$) in body weight, body mass index, waist circumference hip circumference, and body fat after 8 weeks training program.

Compared with CT group, WBV significantly increased ($p<0.05$) muscular strength in most parameters: Right MVC_6, Left MVC_6, Right number of repetition, Left number of repetition, Right Concentric, Right Eccentric, Left Concentric, and Left Eccentricafter 8 weeks training program (Table 3).

There were decreased significantly ($p<0.05$) in systolic blood pressures (CT=112.14 ± 8.31 mm Hg vsWBV=108.16 ± 9.86; $p = 0.015$) and diastolic blood pressure (CT=72.94 ± 7.48 mm Hg vs WBV=69.10 ± 7.04; $p = 0.004$) (Fig 1).

In Figure 2 show that heart rate at rest decreased significantly in WBV group (CT=81.00 ± 8.43 vsWBV= 75.11 ± 8.39 bpm; $p<0.05$).

Table 1 The characteristics and physiological variables of participants in two groups Data are mean ± SD, Control (CT, n=18), Whole body vibration (WBV, n=19) (CT & WBV)

	CT (n=18)	WBV (n=19)
Age	29.39 ± 6.63	30.04 ± 7.02
Body weight (kg)	70.12 ±10.71	65.25 ± 10.85
Body mass index (kg/m^2)	27.86 ± 2.54	27.73 ± 3.30
Waist circumference (cm)	87.31 ± 8.28	90.26 ± 8.43
Hip circumference (cm)	103.92 ± 3.57	104.42 ± 5.44
Waist to hip ratio (cm)	0.84 ± 0.06	0.86 ± 0.05
Heart rate at rest (bpm)	84.89 ± 11.12	81.00 ± 10.43
Systolic blood pressure (mm Hg)	111.50 ± 9.62	112.73 ± 10.31
Diastolic blood pressure (mm Hg)	72.94 ± 7.48	70.21 ± 8.17
Arterial of oxygen saturation (SpO_2)	98.44 ± 0.86	98.18 ± 0.67

Table 2 Body composition

Body composition	CT (n=18)		WBV (n=19)	
	Pre	Post	Pre	Post
Body weight (kg)	70.12 ±10.71	70.21±9.39	65.25±10.85	62.56 ±9.06*
BMI (kg/m^2)	27.86 ± 2.54	28.52±2.58	27.73±3.30	25.73±2.41*
WC (cm)	87.31±8.28	88.10±7.82	90.26±8.43	86.33±8.40*
HC(cm)	103.92±3.57	104.83±3.57	104.42±5.44	102.00±4.83*
WHR (cm)	0.84±0.06	0.84±0.05	0.86±0.05	0.83±0.04
Body fat (kg)	27.82 ±5.51	28.01 ± 4.10	22.20 ±5.35	21.62 ±5.54*
LBM (kg)	48.87±8.47	48.64±8.10	42.68±6.01	41.66 ±7.70
% of body fat	34.47 ±4.54	34.86±5.12	34.08±3.52	33.06 ±4.22

Data are mean ± SD, Control (CT), Whole body vibration (WBV), BMI: Body Mass Index, WC: Waist circumference, HC: Hip circumference, WHR: Waist/Hip ratio, LBM: Lean body mass,*significant difference between groups, $p < 0.05$

Table 3 The muscular strength and endurance in two groups after 8- week training

Muscular strength	CT (n=18)		WBV (n=19)	
	Pre-test	Post-test	Pre-test	Post-test
Isometric contraction				
- Right MVC_6 (kg)	85.04 ± 22.89	87.31 ± 20.35	77..97 ± 19.58	100.46 ± 20.06*
- Left MVC_6 (kg)	85.26 ± 20.91	86.70 ± 21.20	75.48± 18.77	97.60 ± 19.99*
Isotonic contraction				
- Rt. Number of repetition	123.94 ± 12.62	124.60 ± 10.15	95.63± 20.56	126.98 ± 21.40*
- Lt. Number of repetition	124.00 ± 14.51	124.83 ± 12.65	84.00 ± 16.73	116.21 ± 31.06*
Isokinetic contraction				
- Rt. Concentric	70.38 ± 13.43	70.88 ± 15.97	65.53 ± 14.05	97.42 ± 16.49*
- Rt. Eccentric	91.20 ± 20.48	91.94 ± 22.25	82.11 ± 18.51	108.79 ± 18.59*
- Lt. Concentric	76.27± 18.47	76.56 ± 15.46	68.21 ± 13.66	84.47 ± 15.48*
- Lt. Eccentric	102.72 ± 15.49	101.88 ± 14.84	82.53 ± 14.70	103.48 ± 14.85*

Data are mean ± SD, Control (CT, n=18), Whole body vibration (WBV, n=19), MVC_6: Maximum voluntary contraction at 6 seconds, *significant difference between groups, $p< 0.05$

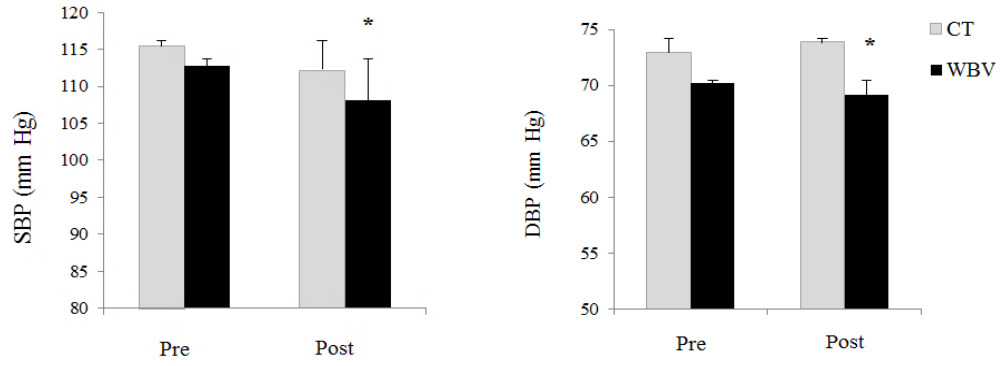

Figure 1 Blood pressure before (pre) and after training (post) in CT and WBV groups (*significant difference between groups, p< 0.05)

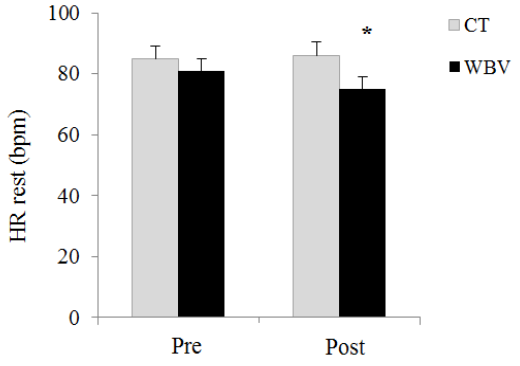

Figure 2 Heart rate at rest before (pre) and after (post) training in CT and WBV groups (*significant difference between groups, p<0.05).

Discussion

Whole body vibration (WBV) training improved body composition after 8-week program in overweight females. When compared to baseline, there were clearly decreased in some variables: body weight, body mass index, waist circumference, hip circumference and body fat after training in WBV. Energy intakes from food in this study were no significantly difference between the two groups (1,596 ± 526.1 vs 1,619.3 ± 542.7 kcal/day, p = 0.098). Therefore, energy consumption did not affect the reduction in body weight seen in this study. Several studies have supported our results which demonstrated the benefit of a WBV on body composition. Verschueren, et al[7] reported the effects of 24 weeks WBV training on fat mass reduction by 3.1% in untrained females.However, no changes were found in lean body mass. Vissers et al found that WBV would have a markedly potential to reduce visceral adipose tissue (VAT) than a combined aerobic and resistance training in middle-aged obese adults[8]. The possible mechanisms behind these changes may due to two factors such as energy expenditure during WBV (or during muscle contraction) and decrease adipogenesis resulting from WBV[9]. WBV promote increase muscle activity via tonic vibration reflex lead to increase muscle contraction in working muscles and then can cause muscle mass increasing (hypertrophy)[10]. Muscle contraction promotes glucose and fat utilization, these can causes decrease fat accumulation and total fat mass in human body. An increasing glucose and fat utilization enhance an energy expenditure[6] which leads to weight loss. Energy expenditure increased resulting from muscle contraction via tonic vibration reflex.

In the present study, we demonstrated that muscular strength were increased in WBV after 8-week training; right and left MVC_6, right and left number of repetition, right and left concentric and eccentric (Table 3). Several studies have supported this results which demonstrated the benefit of WBV on muscle strength-endurance which shown that after 6 months of WBV training improved in static and dynamic strength of the knee extensor muscles (15% and 16% respectively) in post-menopausal women[11]. Machado et al. presented increases in maximal voluntary isometric contraction (MVC) of the leg extensors (38.8%)[12]. Figueroa et al. also showed the improvements of leg extension strength by 9% after a 6-week WBV training intervention in young overweight and obese women[13]. The possible mechanisms behind these changes may due to many factors. First, the muscular strength gain found in this study may result from increased in cross-sectional area (hypertrophy), and second, increased in levels muscle activity. Machado et al. found a significant increase in thigh muscles cross-sectional area in healthy older women in 10-week WBV study. The increase was a result of increases in quadriceps muscle size such as vastusmedialis by 8.7% and bicep femoris by 15.5%[12]. However, the frequency and duration to which WBV might improve muscle hypertrophy still need further study.The second, possible mechanism may relate to the muscle activity. One study had reported muscle activity respond to the difference degree of frequencies of WBV. The greater frequency of vibration (35-45 Hz) for both static and dynamic exercises have been shown to increase greater muscle activity than lower frequencies (<35 Hz)[14]. The mechanical action of vibration lead changes in the length of the muscle-tendon complex which in turn are detected by sensory receptors (muscle spindle and golgi tendon organ) which modulate muscle contraction through reflex muscular activity via the stretch reflex loop and activation of the muscle spindles[15]. These muscle contractions or exercise described the increased levels muscle activity as illustrated by electromyography (EMG) in working muscles during WBV[16]. Whole body vibration (WBV) or Vibration training is known as a type of training that uses a vibration platform that able to set frequency as mechanical stimuli transmitted through the body[12]. Moreover, the improvement of blood pressure and heart rate at rest after WBV training may indicate that WBV is a safe tool for overweight females.

Conclusions

This study reported that 8-week of whole body vibration improved body composition: body weight, body mass index, waist circumference, hip circumference and body fat. Muscular strength increased in most parameters: right and left MVC_6(isometric), right and left number of repetition (isotonic), and concentric and eccentric strength (isokinetic) in overweight adults. The physiological parameters: blood pressure and heart rate at rest also improved after WBV training. The further studies need to confirm the mechanisms behind the changes.

Acknowledgements

This study was granted by the Faculty of Medicine Invitation Research Grant (IN 59241) and Graduate Research Fund (IN 58211112), KhonKaen University. I would like to thank the volunteers used in this research.

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