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Whole Body Vibration Training Impact on Pulse Wave Velocity in Obese Postmenopausal Women with Arterial Stiffness

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ABSTRACT

Background: Menopause boosts the age-related increment in blood vessel firmness during the early postmenopausal stage and that this increase is likely related, to estrogen lack.
Aim of the study: is to determine the effect of whole body vibration training (WBVT) on pulse wave velocity in obese postmenopausal women with arterial stiffness.
Materials and Methods: Forty obese postmenopausal women with arterial stiffness participated in this study. They were selected from the vascular department, Kasr El Einy hospital. Their ages were ranged from 60 - 70 years and Body mass index (BMI)>35 kg/m2. They were randomly divided in two groups, Group (A) included 20 patients who received WBVT for 12 weeks, 40 minutes/session, in addition to their regular medications prescribed by their physician. Group (B) only received their regular medications prescribed by their physician. Brachial-ankle PWV, femoral-ankle PWV (legPWV) were measured before and after 12 weeks.
Results: Both brachial-ankle PWV and leg PWV showed statistically significant decrease in group A, while there was no significant reduction in group B.
Conclusions: Whole body vibration is a useful tool in decreasing arterial stiffness in obese postmenopausal women.

Introduction

Arterial stiffness is a term utilized to characterize the arteries" ability to expand and contract during the cardiovascular cycle (1). It is a unique property dependent on vascular capacity and structure. It is affected by frustrating elements like blood pressure, age, gender, body mass index, pulse rate. Arterial stiffness happens as an outcome of natural maturing and arteriosclerosis. Expanded blood vessel solidity is related with an expanded danger of cardiovascular events, for example, myocardial localized necrosis and stroke (2).

Stiffening of large arteries is by all accounts an unavoidable succession of the typical maturing procedure and age is thusly the most significant determinant of blood vessel firmness, the enormous focal conduits harden continuously with age, the flexible properties of the smaller muscular arteries change little with age (3).

It is shown that age is a more significant determinant of brachial-ankle pulse wave velocity (baPWV) in females than in males, autonomous of blood pressure variables (4).Furthermore, baPWV increments with respect to the square of increment in age beginning around the age of 50–60 years in females. These discoveries recommend that menopause is a significant factor affecting blood vessel firmness in healthy female subjects. A few investigations have shown that estrogen beneficially affects stiffening of arteries (5).

There was a rising pattern in predominance of higher blood vessel firmness with menopause and the propelling span of menopause. As maturing is an unmistakable list for arterial stiffness, It is affirmed that menopause expanded the age-related blood vessel firmness, which bolstered the view that menopause for itself may raise the arterial stiffness estimated by baPWV (6), due to effect of the exhaustion of the ovarian hormones after menopause on vascular maturing by breakage and denaturation of elastin formation and expanding collagen deposition in arteries(7).

Pulse wave velocity has been assumed as a biomarker legitimately identified with vessel stiffening that can possibly give signals on early vascular maturing and foresee cardiovascular events. It is regularly decided through Pulse wave velocity (PWV) between two blood vessel sites (8).

Pulse wave velocity Index (PWV) estimated by ultrasonography was determined as the proportion between the distance and the foot-to-foot time delay and was represented in meters every second (9). It is the speed at which the pressure wave produced via cardiovascular contraction propelling from the aorta to the fringe arteries is chiefly controlled by the conduit artery wall stiffness and lumen diameter (10).

It has been all around perceived that PWV increments with age, hypertension and hyperglycemia and in this way mirrors the summation of major cardiovascular dangers (11).

A cross-sectional investigation among postmenopausal women done by Lebrun et al (12), gives proof that the vast majority of the set up cardiovascular hazard factors are determinants of aortic PWV. Expanded PWV marks an expanded danger of stroke, coronary illness, and passing inside 10–12 years.

Treatment is regularly as preventive procedures prophylaxis. Medication treatment for fundamental conditions and sorts of medical procedure, for example, Angioplasty and stent position, Coronary artery bypass surgery, Endarterectomy and Thrombolytic therapy (13)

Physical movement both preclude and helps treat many set up hazard factors, including hypertension, insulin resistance and glucose intolerance, elevated triglycerides and obesity. Exercise combined with weight reduction can reduce low-density lipoprotein cholesterol (LDL-C) and bound the decline in HDL-C that frequently happens with a decrease in dietary saturated fat (14).

Stiffness of large arteries increments with age, even in sound people with no cardiovascular malady, however is less articulated in the individuals who participate in standard continuance endurance exercise. Indeed, even once settled, large artery stiffening can be reduced by a program of physical exercise (15)

Whole body vibration (WBV) is a conventional term utilized where any vibration of any frequency is moved to the human body. Vibration training then again is where differing frequencies/amplitudes/forces will be moved into isolated body parts utilizing exact joint plots for the time being (approximately1minute sets). This is done to make a pure eccentric muscle response and empower anaerobic action (consuming energy without oxygen something contrary to cardio) (16)

It is a training technique utilizing low amplitude, low frequency mechanical stimulus to exercise musculoskeletal structures for the improvement of muscle power and malleability. Vibration training has been supported as a helpful strategy in the treatment of osteoporosis, sarcopenia, and metabolic syndrome.(17)

Whole Body Vibration is a basic and advantageous exercise for old and immobile patients since it doesn't require using traditional powerful exercise, for example, free weight or dynamic movement. Though, there have been hardly any studies researching the impact of WBV on arterial stiffness. This research was implemented to find out the impact of

WBV on arterial stiffness in obese postmenopausal women, which could be added to rehabilitation program for managing arterial stiffness.

Methods

Study design and randomization

This study is a single blind randomized controlled study. The participants were randomly allocated to Study group (A) (n=20) or control group (B) (n=20) by an independent individual who chose at random from sealed envelopes containing numbers made by an random number generator. The randomization was limited to permuted squares to guarantee that equivalent numbers were designated to each group A and group B. The successions appointed to the participants were set in envelopes containing the allocation to each group A and group B. The aim and procedures of the study were informed to eligible patients. All patients signed a written informed consent.

Ethical approval

All relevant national laws and institutional policies have been followed up in human use research, followed the principles of the Helsinki Declaration and affirmed by the Research Ethics Committee of the Faculty of Physical Therapy, University of Cairo.

Subjects

Forty obese postmenopausal women with arterial stiffness shared in this study. They were chosen from alluded Patients from the vascular department, Kasr EL Einy Hospital, Cairo, Egypt. The patients were chosen according to the inclusion and exclusion criteria as follows;

Inclusion criteria: Forty postmenopausal women (over one year without menstruation),Obese (BMI>35.0kg/m2), their age from 60-70 years of age, sedentary non-smokers, free from obvious CV diseases or psychiatric conditions as surveyed by clinical history, and not taking medication or hormone treatment in the year prior to the examination.

Exclusion criteria: Participants were excluded in the event that they had joint prosthetic gadgets, recent thrombosis, or wounds in the legs, Heart failure, Cardiac dysrhythmias, Metal or artificial inserts (for example pacemaker, artificial cardiac valves, or recent stents) ,Chronic back pain (after fracture, disc disorders or spondylosis), Uncontrolled Diabetes Mellitus with peripheral vascular illness or neuropathy, Tumors (excluding metastases in the musculoskeletal system),Spondylolisthesis without gliding movement disorder and Parkinson ,Chondromalacia of the joints of the lower limbs, Venous deficiency with ulcuscruris and Epilepsy.

All Patients were randomly divided into 2 equal groups Group (A) included 20patients who received WBVT for 12 weeks the duration of one session was 40 minutes including warming up and cooling down, in addition to their regular medications prescribed by their physician.

Group (B) only received their regular medications prescribed by their physician and dietary modifications advices**.**

Methodology

Assessment

Arterial Stiffness was measured by determining PWV through duplex scanner Ultrasonography (ATL Ultramark IV, operating frequency 7.5 MHz) connected to a vessel wall movement detector system. It is calculated by measuring the time taken for the arterial waveform to pass between two points a measured distance apart, and involves taking readings from the two sites simultaneously, or gating separate recordings to a fixed point in the cardiac cycle. Participants were asked to maintain in supine and rest for 5 minutes before the PWV examination, and then the cuffs were wrapped on both sides of their brachium and ankle together. The pressure waveforms were recorded simultaneously from the brachial and anterior tibial arteries by automatic waveform analyzer (BP-203RPE III, OMRON, Japan), conducted by experienced technicians who were blinded to the clinical information.

Treatment

Prior to beginning the first treatment session, each patient was instructed briefly about treatment procedures and benefits of WBV training to gain their confidence and cooperation throughout the training course. Their body mass index were calculated, blood pressure and resting heart rate. Each patient was instructed to drink a plenty of water before and after the exercise session to avoid loss of body water during session.

Each patient was asked to wear comfortable clothes and flat light shoes to avoid hurting from the friction of the platform. Each patient stood on the platform of the device and hands rested on hand rails to maintain balance. Platform vibration was used at lower speeds for 2 to 3 min until the patients have become used to in then slowly increased until reaching to 26 Hz lasted for 20 minutes 3 timed / week for 12 weeks.

Patients in group A were trained by whole body vibration training 3 times/week,for 12 weeks. The duration of one session was maximally 40 min, including warming up and cooling down consisted of:

1-Warming up: in the form of stretching exercise for major muscles groups and circulatory exercise time of warming up (5-10min)

2- Active phase: exercises for upper and lower body on a vibration platform. Training load was increased gradually according to the overload principle.

3- Cooling down: in calm atmosphere, relaxation, stretching exercise and breathing exercise (10-15 min)

Results

Comparing the general characteristics of the subjects of both groups revealed no significant difference between both groups in the mean age, weight, height, and BMI ($p > 0.05$), as shown in table (1)

Table 1. *Descriptive statistics and t test for the mean age, weight, height and BMIof the study and control groups.*

	Group(A)	Group(B)	MD	t- value	p-value	Sig.
	M± SD	M± SD				
Age (years)	61.7 ± 1.97	62.1 ± 2.04	-0.4	-0.62	0.53	**NS**
Weight (kg)	100.5 ± 6.52	99 ± 7.01	1.5	0.7	0.48	**NS**
Height (cm)	160.95 ± 2.28	161.25 ± 3.5	-0.3	-0.32	0.75	**NS**
BMI (kg/m²)	38.8 ± 2.43	38.05 ± 2.05	0.75	1.04	0.3	**NS**

M: Mean.	**SD: Standard deviation.**	**MD: Mean difference.**
t value: Unpaired t-value.	**p-value: Probability value.**	**NS: Non-significant.**

As shown in table (2), At the beginning of the study there was statistically non- significant difference between both groups pretreatment while after the study arterial stiffness showed statisticallysignificant decrease in group (A)in brachial ankle Pwv from 14.1± 0.3m/sec to 12.7±1.4 m/sec. While there was non significant change in control group (B) in brachial ankle Pwv from 14.0±0.3 to 13.9 ±0.2 m/sec.

The mean ± SD PwV of the Leg Pwv post treatment of group A was significantly decreased form 9.9 ± 0.3 m/sec to become 9.4±0.2 m/sec.

While there was non-significant change in Leg Pwv in control group B from 9.8 ± 0.2 m/sec to become 9.8± 0.3 m/sec post study.

***Table 2**. Comparison of post treatment mean values of brachial ankle PWV and leg PWVbetween the study and control groups*

		Study Group(n= 20)	**Control Group (n= 20)**	**t-value**	**P- value**
Brachial ankle PWV (m\sec)	**Pre- treatment**	14.1(0.3)	14.0(0.3)	0.4	0.69(NS)
	Post-treatment	12.7(1.4)	13.9(0.2)	4.4	0.0001(S)
	t- value	4.4	1.7		
	p-value	0.0003(S)	0.09(NS)		
Leg PWV (m\sec)	**Pre- treatment**	9.9 (0.3)	9.8 (0.2)	1.2	0.2 (NS)
	Post- treatment	9.4 (0.2)	9.8 (0.3)	4.4	0.001 (S)
	t- value	6.3	0.4		
	p-value	0.0001(S)	0.7 (NS)		

p-value: Probability value. S: Significant. NS: Non-Significant.

Discussion

The present study was designed to study the effect of WBVT on arterial stiffness in obese postmenopausal women diagnosed with arterial stiffness. The results of this study revealed that arterial stiffness showed statistically significant decrease in group (A) with non significant change in group (B)

The results of our study came in accordance with **Alvarez-Alvarado(18)** et al, in which they revealed that after 6 weeks of WBVT, there was a significant reduction of carotid-femoral PWV (aortic stiffness, P<0.05), femoral-ankle (leg arterial stiffness, P<0.01) and baPWV (systemic arterial stiffness, P<0.01) compared with controls . They came into conclusion that WBVT led to reductions in arterial stiffness, central BP and wave reflection in young obese women.

A study implemented by **Figueroa et al(19)** proved that WBV exercise training for 12 weeks improved systemic and leg arterial stiffness, BP,and leg muscle strength in postmenopausal women with pre hypertension or hypertension. They postulated that WBV exercise training may decrease cardiovascular and disability risks in postmenopausal women by reducing leg PWV and increasing leg muscle strength.

Another study by **Figueroa et al (20)**, concluded that WBV training decreases ankle SBP in postmenopausal women with high ankle SBP. WBV training reduces aortic SBP, legPWV, and baPWV, but not carotid-femoral PWV, in postmenopausal women independently of ankle SBP. Therefore, reductions in peripheral and central SBP induced by WBV training are explained by a reduction in peripheral PWV.

These results also proved by **Miyaki et al (21)** where they came to a conclusion that addition of WBV training to a lifestyle-modification program in overweight and obese women thus decreased arterial stiffness

Watanabe et al (22) found a significant decrease in PWV and a significant increase in VO2max levels in WBV training group, suggesting that regular short-term aerobic exercise combined with WBV training might more effectively reduce arterial stiffness and improve cardiorespiratory fitness than aerobic training alone.

Also, the results of this study came in accordance with **Rubin et al.,(23)**who found that WBV mechanically stimulates abdominal and leg arteries, which may reduce arterial tone and decrease arterial stiffness via mechanical stimuli to arteries.

Otsuki et al (24) stated that mechanical stimuli to artery, such as compression, elicit vasodilation and acutely decrease arterial stiffness. As whole-body vibration(WBV)-induced oscillation is propagated at least to lumbar spine.

The results of this study agreed with (**Yamada et al.,(25)**who found that blood volume in the vastus lateralis acutely increased after a WBV session. It may be possible that WBV is beneficial not only to the skeletal system and musculature but also to the cardiovascular system.

According to **Schindl et al,(26)** a few minutes lasting stance on a vibrating platform leads to an increase in the relative moving blood volume of quadriceps and gastrocnemius muscles. Mean blood flow in the popliteal artery was also increased and its resistive index decreased. According to the authors' opinion, trying to attenuate the imposed vibration on the body evokes rhythmic muscle contractions.

Another study **Lai et al(27)** by found that 3 months 30 Hz and 3.2 g horizontal WBV training had a positive effect on arterial stiffness in middle-aged and older adults and could therefore be regarded as a supplementary exercise scale. They showed that after 3 months of WBV training, the bilateral baPWV were significantly reduced (P=0.014 and P=0.041). However, compared with the control group, there was no significant difference; meanwhile, the two groups had no significant changes in bilateral blood pressure or heart rate

These findings indicate that WBV exercise training decrease arterial stiffness in obese postmenopausal women, WBV exercise training may decrease cardiovascular and disability risks in obese postmenopausal women.

Conclusion

Whole body vibration exercise training has positive effects on arterial stiffness in obese postmenopausal women. As, this study demonstrated the possibility of WBV as an adjunctive to exercise training. It may be worthwhile to further investigate WBV for humans who cannot sufficiently perform aerobic exercise training.

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Declaration of Competing Interest

The authors declare that there is no conflict of interest associated with this manuscript.

References

1- O'Rourke MF, Staessen JA, Vlachopoulos C, Duprez D, Plante GE (2002): Clinical applications of arterial stiffness; definitions and reference values. Am J Hypertension 15:426-444.

2-Liao D, Arnett DK, Tyroler HA, Riley WA, Chambless LE, Szklo M, Heiss G (2000): Arterial stiffness and the development of hypertension: the ARIC study. Hypertension,34:201–206.

3--Assmann G, Cullen P, Evers T,Petzinna D, Schulte H: Importance of arterial pulse pressure as predictor of coronary heart disease risk in PROCAM Eur Heart J 26:2120-2126, 2005.

4-Tomiyama H, Yamashina A, Arai T, Hirose K, Koji Y, Chikamori T, et al: Influences of age and gender on resultsof noninvasive brachial-ankle pulse wave velocity measurement – a survey of 12,517 subjects. Atherosclerosis 2003; 166: 303–309.

5- Rajkumar C, Kingwell BA, Cameron JD, Waddell T, Mehra R, Christophidis N, et al: Hormonal therapy increases arterial compliance in postmenopausal women. J Am CollCardiol 1997; 30: 350–356.

6-.Zaydun, G. *et al*. Menopause is an independent factor augmenting the age–related increase in arterial stiffness in the early postmenopausal phase. *Atherosclerosis.*184, 137–42 (2006).

7-Natoli, A. K. *et al*. Sex steroids modulate human aortic smooth muscle cell matrix protein deposition and matrix metalloproteinase expression. *Hypertension.*46, 1129–34 (2005).

8- Munakata, M. Brachial–Ankle Pulse Wave Velocity: Background, Method, and Clinical Evidence. *Pulse (Basel).*3, 195–204 (2016).

9- Hollander M, Bots ML, Del Sol AI, Koudstaal PJ, Witteman JC, GrobbeeDE,Hofman A, Breteler MM. Carotid plaques increase the risk of stroke and subtypes of `1 cerebral infarction in asymptomatic elderly: the Rot- terdam Study. Circulation.2002;105:2872–2877

10-Boutouyrie P, Tropeano AI, Asmar R, Gautier I, Benetos A, Lacolley P, Laurent S (2002): Aortic stiffness is an independent predictor of primary coronary events in hypertensive patients: a longitudinal study. Hypertension 39:10-15.

(11)MunakataM .Brachial-ankle pulse wave velocity in the measurement of arterial stiffness: recent evidence and clinical applications. *CurrHypertens Rev* 2014; 10: 49–57.

12- Lebrun, Corinne EI[a,b]; van der Schouw, Yvonne T[a]; Bak, Annette AA[a]; de Jong, Frank H[b]; Pols, HuibertAP[b]; Grobbee, DiederickE[a]; Lamberts, Steven WJ[b]; Bots, Michiel L[a] Arterial stiffness in postmenopausal women: determinants of pulse wave velocity .Journal of Hypertension: November 2002 - Volume 20 - Issue 11 - p 2165-2172

13-Roos CM, Zhang B, Palmer AK, Ogrodnik MB, Pirtskhalava T, Thalji NM, Hagler M, Jurk D, Smith LA, Casaclang-Verzosa G, Zhu Y, Schafer MJ, Tchkonia T, Kirkland JL, Miller JD (2016). "Chronic senolytic treatment alleviates established vasomotor dysfunction in aged or atherosclerotic mice" .Aging Cell. doi:10.1111/acel.12458 .PMID 26864908 .Retrieved 2016-02-15.

14-Couillard C, Despres JP, Lamarche B, et al. Effects of endurance exercise training on plasma HDL cholesterol levels depend on levels of triglycerides: evidence from men of the Health, Risk Factors, Exercise Training and Genetics (HERITAGE) Family Study. ArteriosclerThrombVasc Biol. 2001; 21: 1226–1232.

15-Tanaka H, Dinenno FA, Monahan KD, Clevenger CM, Desouza CA, Seals DR. Aging, habitual exercise, and dynamic arterial compliance. Circulation.2000; 102: 1270–1275.

16-Sorichter, S; Koller A; Haid C; Wicke K; Judmaier W; Werner P; Raas E. (2007). "Light concentric exercise and heavy eccentric muscle loading: effects on CK, MRI and markers of inflammation" . Int J Sports Med. 16 (5): 288–292.doi:10.1055.

17-Albasini, Alfio; Krause, Martin; and Rembitzki, Ingo. (2010). Using Whole Body Vibration in Physical Therapy and Sport: Clinical Practice and Treatment Exercises

18-Alvarez-Alvarado S, Jaime SJ, Ormsbee MJ, Campbell JC[1], Post J[1], Pacilio J[1], Figueroa A[1]. Hypertens Res. Benefits of whole-body vibration training on arterial function and muscle strength in young overweight/obese women. 2017 May;40(5):487-492. doi: 10.1038/hr.2016.178. Epub 2017 Jan 12.

19- Figuero , Arturo a MD, PhD, Roy Kalfon, BS, Takudzwa A. Madzima, BS, and Alexei Wong, MS Whole-body vibration exercise training reduces arterial stiffness
in postmenopausal women with prehypertension and hypertension Menopause: The Journal of The North American Menopause Society
Vol. 21, No. 2, pp. 131/136

20-Figueroa, Arturo MD, PhD[1]; Kalfon, Roy MS[1]; Wong, Alexei PhD[1,2]Whole-body vibration training decreases ankle systolic blood pressure and leg arterial stiffness in obese postmenopausal women with high blood pressure. Menopause: April 2015 - Volume 22 - Issue 4 - p 423-427

21-Asako Miyaki, Seiji Maeda, Youngju Choi, Nobuhiko Akazawa, Yoko Tanabe, Rina
So, Kiyoji Tanaka, RyuichiAjisakThe addition of whole-body vibration to a lifestyle modification on arterial stiffness in overweight and obese women (2012) Artery Research
ISSN (Online): 1876-4401 ISSN (Print): 1872-9312

22- Watanabe T, Yabumoto T, Shin S, Shi B, Matsuoka T
Effect of Short-Term Whole-Body Vibration Training on Metabolic RiskFactors, Inflammatory Markers, and Arterial

Stiffness. *Advances in Bioscience and Biotechnology*, 5, 438-445.Advances in Bioscience and Biotechnology, 2014, 5, 438-445

23-Rubin, C., Pope, M., Fritton, J.C., Magnusson, M., Hansson,T. & McLeod, K. 2003. Transmissibility of 15-hertz to 35-hertz vibrations to the human hip and lumbar spine:determining the physiologic feasibility of delivering low-level anabolic mechanical stimuli to skeletal regions at greatest risk of fracture because of osteoporosis. Spine 28,2621–2627

24- T. Otsuki,1,2 Y. Takanami,3 W. Aoi,3 Y. Kawai,3 H. Ichikawa2,4 and T. Yoshikawa2,3

Arterial stiffness acutely decreases after whole-bodyvibration in humans .ActaPhysiol 2008

25-Yamada, E., Kusaka, T., Miyamoto, K., Tanaka, S., Morita, S., Tanaka, S., Tsuji, S., Mori, S., Norimatsu, H. & Itoh, S. (2005). Vastus lateralis oxygenation and blood volume measured by near-infrared spectroscopy during whole body vibration. ClinPhysiolFunct Imaging 25,203–208.

26-K. Kerschan-Schindl , S. Grampp , C. Henk, H. Resch ,E. Preisinger, V. Fialka-Moser,H. Imhof Whole-body vibration exercise leads to alterations in muscle blood volume

First published: 28 June 2008Clinical Physiology

27-Chung-Liang Lai,[1,2] Han-Yu Chen,[3] Shiuan-Yu Tseng,[1,2] Wan-Chun Liao,[2] Bing-Tang Liu,[2] Meng-Chih Lee,[1,4,*] and Hsin-Shui Chen[5,]Effect of whole-body vibration for 3 months on arterial stiffness in the middle-aged and elderly .ClinInterv Aging. 2014; 9: 821–828