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The Acute Effects of the Different Total Body Resistance Exercise (TRX) Postures on Flow-Mediated Dilatation in Elderly Subjects

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ABSTRACT

Boonsit S, Peepathum P, Mitranun W. The Acute Effects of the Different Total Body Resistance Exercise (TRX) Postures on Flow-Mediated Dilatation in Elderly Subjects. **JEPonline** 2017;20(4):24-35. The purpose of this study was to examine and compare the acute effects of the different total body resistance exercise (TRX) postures on flow-mediated dilatation (FMD) in elderly subjects. The subjects consisted of 45 elderly women 60 to 80 yrs of age of which they were divided into 2 age groups: (a) 60 to 70 yrs of age; and (b) 71 to 80 yrs of age. Then, they were randomly divided into 3 groups with 15 people in each group. The first group trained with the TRX Mid Row workout, the second group did the TRX Squat workout, and the third group did the TRX Chest Press workout. Heart rate, systolic blood pressure, diastolic blood pressure, mean blood pressure, baseline brachial diameter, peak brachial diameter, shear rate, blood flow, and flow-mediated dilatation (FMD) were determined before the test and 5 min after the test. One-way analysis of variance, the Bonferroni method, and the pair *t*-test were used to analyze the data. Statistical significance was set at $P \leq 0.05$. The findings indicate that: (a) the TRX Squat and the TRX Chest workouts significantly increased systolic blood pressure; (b) the TRX Mid Row and the TRX Chest Press workouts significantly increased diastolic blood pressure and blood flow; and (c) the TRX Mid Row, the TRX Squat, and the TRX Chest Press significantly increased mean blood pressure and shear rate ($P<0.05$). Since FMD did not decrease, the three workouts can be used to train muscle strength in elderly women without any negative effects on the blood vessels.

Key Words: Elderly Subjects, Flow-Mediated Dilatation, Resistance Exercises, TRX

INTRODUCTION

The number of older people in Thailand has dramatically increased and most seniors have more health problems than people in other age groups. The most common diseases in the elderly are hypertension, diabetes mellitus, and heart disease (20,33). In particular, the elderly experience vascular diseases, which are caused by decreased vascular elasticity, increased thickness, narrowing lumen diameter, and increased hardening of blood vessels (2,23,34).

In general, the functional evaluation of the blood vessels is divided into 2 methods: (a) an invasive method (17) that involves the puncturing or the insertion of a medical instrument into the body; and (b) a non-invasive method (16,24) that is the measurement at the level of the skin and does not require venipuncture. An example of the latter is flow-mediated dilatation (FMD), which is the measurement of changes in the arterial diameter from stimuli such as post-occlusive reactive hyperemia (PORH) by cuff inflation from a blood pressure monitor. The value of FMD represents the change in the diameter of the brachial artery from increasing shear stress. Of particular importance is the awareness of a reduction in FMD that precedes development of arterial stenosis, arteritis, atherosclerosis, and hypertension (2,23,34).

When compared with young adults, older adults have decreased FMD due to decreased vascular endothelial function. The production of nitric oxide decreases, while the production of Endothelin-1 (ET-1) and the Endothelium Depolarization Factor (EDF) increases (1,35). The most common cofactors that decrease FMD are cigarette smoking, radiation therapy, obesity or being overweight, hypertension, hyperlipidemia, diabetes, medication (25), stress, genetics, and exercise (27,28,34). Conversely, aside from the physiologic benefits of a healthy lifestyle, older adults should also engage in regular aerobic exercise and/or long-term resistance exercise to increase FMD (19,31,36).

Yet, in regards to resistance exercise, interestingly, Bertovic et al. (2) and Miyachi et al. (23) reported that consistent resistance exercise training increased arterial stiffness in middle-aged adults. In 2015, Mitranun and Phongsri (21) and then in 2016, Mitranun (22) reported that resistance training in the form of a 30-second plank and side crunch training did not produce a change in the subjects' FMD, while 60-second plank training and leg raise training acutely decreased FMD. Hence, the different types of resistance training might contribute to the difference in the change in FMD.

Total Body Resistance Exercise (TRX) is an exercise that uses body weight as a resistance force. Using TRX suspension training, Gaedtke and Morat (9) found that a 12-wk whole-body sling training program restored the physical abilities of healthy older adults. Research by Fong et al. (8) investigated core muscle activation during TRX training in adults with chronic low back pain. Dawes and Melrose (6) evaluated the percentages of body mass resistance experienced by users of the TRX™ suspension training system (STS) at different angles and distances from the hanging point. Gaedtke and Morat (9) developed and evaluated the feasibility of a TRX suspension training program for healthy older adults.

But, there appears to be no studies regarding the acute effects of different workouts of TRX resistance exercise on FMD. Therefore, in this study, we studied three workouts of TRX resistance exercise: (a) the TRX Mid Row workout that focused primarily on chest muscle training; (b) the TRX Squat workout that trained primarily the leg muscles; and (c) the TRX Chest Press workout that worked predominantly for back muscles. Each workout emphasized the large muscles of the body and what the acute effects may be in the elderly women. The results from the study should allow for a recommendation as to the appropriate workout of TRX resistance exercises in older subjects.

METHODS

Subjects

The subjects consisted of 45 elderly women 60 to 80 yrs of age who were selected from a senior club of Ratchawarin Temple, Bukkhalo Sub-district, Thon Buri District, Bangkok. They had not participated in a systemic exercise training program during the 6 months prior to this study getting underway. Each subject achieved a passing score of 10 to 20 on the Barthel Activities of Daily Living questionnaire and a passing score of 40 to 48 on the Oxford Knee Score questionnaire. The subjects were willing to participate in the research of which each subject agreed to sign a consent form to participate. The subjects were divided into 2 age groups: (a) 60 to 70 yrs of age; and (b) 71 to 80 yrs of age. After that, they were randomly divided into 3 groups with 15 subjects in each group. The first group trained with the TRX Mid Row workout, the second group did the TRX Squat workout, and the third group did the TRX Chest Press workout. The size of the target group was determined by G*Power software with a power analysis of 0.8 and an effect size of 0.5. This study received approval for human subjects' research from the Human Research Ethics Committee, the Strategic Wisdom and Research Institute, Srinakharinwirot University with the code number SWUEC-358/59E.

Procedures

Exercise

The exercise started with a warm-up. The subjects were told to walk fast for 10 min. Then, stretching exercises were done for 5 min to increase the flexibility of joints and muscles. TRX resistance exercise is an exercise workout that focuses on large muscles, including the chest, back, and leg muscles, such as: (a) the TRX Chest Press workout; (b) the TRX Mid Row workout; and (c) the TRX Squat workout, respectively.

TRX Chest Press

The subjects were told to drop to their knees (using a yoga mat to support the knees) at the anchor point. Grab with both hands the suspended bands. Place the knees shoulder-width apart. Take a breath and lean forwards until the thighs are at a 45° angle to the floor with the arms stretching straight. This is the starting position. Breathe out. Slowly move the chest down and bend the elbows at a 90° angle. Keep both hands at the chest level for 3 sec. Then, stretch the arms out and pull the body up to return to the starting position. Perform 3 sets. The subjects' number of repetitions was determined to be 60% of their maximum repetition (the number of times) and, then they rested for 1 min between sets. After that, the 3 target groups underwent training of their own group's workout. Before the training, each subject found out the number of repetitions at 100% of the maximum repetition, and before the real training for 72 hrs. Then, the number of repetitions was determined to be 60% of the maximum repetition. The subjects' performed 3 sets and rested for 1 min between sets. Afterward, the muscles were relaxed by a cool down for 1 min.

TRX Mid Row

The subjects were told to stand straight at the anchor point as both hands grabbed the handles of the suspended bands. Place the feet shoulder-width apart. Then, take a breath and lean backwards until the body is at a 45° angle to the floor with the arms stretching straight. This is the starting position. Breathe out and slowly pull the body upwards. Keep the arms close to the sides for 3 sec. After that, stretch the arms out and return to the starting position. Perform 3 sets. The number of repetitions was determined to be 60% of the maximum repetition. The subjects' performed 3 sets and rested for 1 min between sets.

TRX Squat

The subjects were told to stand 80 cm from the anchor point. Grab the suspended bands with both hands. Extend both arms forwards so that both arms are stretched straight. Bend both knees and drop the hip backwards. Bear the weight on the thighs and buttocks until the thighs are parallel with the floor (try to keep your shin vertical), and the knees do not move beyond the tips of the toes. Then, lean backwards very slightly. This is the starting position. Take a breath and slowly pull the hips back by tensing the legs. Keep the arms close to the sides for 3 sec. Breathe out and slowly bend the knees to return to the starting position. Perform 3 sets. The number of repetitions was determined to be 60% of the maximum repetition. The subjects' performed 3 sets and rested for 1 min between sets.

Flow-Mediated Dilatation Measures (FMD)

Measures of blood vessels variables were done using an ultrasound device (Ultrasound Echo Ge; Vivid-I model from the United States of America). Before the measures were done, the subjects laid down to rest for 20 min. Then, blood pressure and the FMD of the brachial artery were measured by using the cuff of a blood pressure monitor to wrap around the right forearm during the entire test. An image of the brachial artery at the antecubital fossa was recorded in a longitudinal plane. The recording of an image and a video was done 1 min before cuff inflation. After inflating the cuff until the pressure was 50 mmHg higher than the systolic blood pressure of each subject (21,26), the cuff was inflated to remain at that pressure for 5 min. An image and a video were recorded throughout the cuff inflation. Accordingly, the cuff was deflated rapidly, likewise, an image and a video were continuously recorded after deflation for 5 min (3,16,21,22). The recording of the image and video of the size of blood vessels were done by using B-mode.

Mean blood velocity during the data collection from the ultrasound device was analyzed in doppler mode. Moreover, in order to reduce bias of the researcher in the analysis of images and videos, the Brachial Analyzer program was used to analyze the changes of brachial artery diameter. Shear stress was calculated by performing [blood velocity ÷ brachial diameter]. Flow-mediated dilatation (FMD) was calculated by performing [Peak brachial diameter – baseline brachial diameter] x 100 ÷ baseline brachial diameter (21).

Biological Variables

The subjects' age, weight, and height were measured using a spring scale and height measurement scale (Health Meter). Body mass index was calculated while heart rate at rest, diastolic blood pressure, systolic blood pressure were determined using a digital blood pressure monitor (MO701i model from the United States of America) before and after the training. Mean blood pressure was calculated by using the following formula: mean blood pressure = 1/3 x [systolic blood pressure – diastolic blood pressure] + diastolic blood pressure. In addition, TRX resistance training was conducted by using the TRX Pro3 model (from the United States of America).

Questionnaire Measurements

All subjects were requested to fill out the Barthel Activities of Daily Living questionnaire and the Oxford Knee questionnaire. The variables of blood vessels and blood pressure were measured before training and, then repeated within 5 min after training.

Statistical Analyses

Frequency, percentage, means ± SD of the target group were analyzed and compared before and after training by using paired-*t* test. The difference between means before and acutely after the training was tested by one-way analysis of variance using Bonferroni's test with the statistical significance set at $P \leq 0.05$.

RESULTS

Table 1 presents the subjects' baseline values before doing the TRX resistance training in each of the 3 training groups: (a) the TRX Mid Row workout; (b) the TRX Squat workout; and (c) the TRX Chest Press. Baseline variables included the number of elderly people, age, height, body weight, body mass index, heart rate at rest, systolic blood pressure, diastolic blood pressure, mean blood pressure, and the maximum repetitions before training. The baseline variables before the training of the subjects in each group did not differ significantly. However, baseline values of the subjects' maximum repetitions when doing an exercise was significantly different.

Table 1. Baseline Data of Subject Characteristics.

	TRX Mid Row	TRX Squat	TRX Chest Press
Number (n)	15	15	15
Age (yrs)	68.25 ± 5.22	69.58 ± 7.65	69.25 ± 7.10
Height (cm)	152.33 ± 1.38	151.00 ± 1.88	154.83 ± 1.38
Body Mass (kg)	57.48 ± 2.49	52.74 ± 3.02	56.71 ± 2.70
Body Mass Index ($kg \cdot m^{-2}$)	24.76 ± 0.97	23.11 ± 1.25	23.65 ± 1.13
Heart Rate at Rest (mmHg)	73.25 ± 1.34	75.42 ± 2.38	74.00 ± 3.55
Systolic Blood Pressure (mmHg)	131.00 ± 4.60	129.92 ± 3.63	136.92 ± 4.89
Diastolic Blood Pressure (mmHg)	77.50 ± 2.89	81.00 ± 2.87	79.00 ± 2.56
Mean Arterial Pressure (mmHg)	95.33 ± 3.13	97.31 ± 2.85	98.31 ± 3.15
Maximum Repetitions (reps)	43.25 ± 3.01	40.08 ± 2.52*	24.83 ± 1.70*

Data are means ± SD. *P<0.05 vs. TRX Mid Row

Table 2 presents the physiological changes in the subjects' variables after training. Systolic blood pressure increased in the TRX Squat and TRX Chest Press workouts. On the other hand, diastolic blood pressure and blood velocity increased in TRX Mid Row and TRX Chest

Press workouts ($P<0.05$). Mean blood pressure and shear stress increased in all 3 workouts ($P<0.05$). There was no statistically significant change in the baseline and peak brachial diameter in all 3 workouts.

Table 2. Brachial Characteristics and Blood Pressure Data.

	TRX Mid Row		**TRX Squat**		**TRX Chest Press**	
	Baseline	After Training	Baseline	After Training	Baseline	After Training
Baseline Brachial Diameter (mm)	4.45±0.15	4.45±0.15	4.28±0.12	4.28±0.12	4.39±0.16	4.39±0.16
Peak Brachial Diameter (mm)	4.51±0.18	4.55±0.17	4.66±0.15	4.59±0.13	4.75±0.25	4.85±0.24
Shear Rate (s^{-1})	20.21±4.24	25.01±4.47*	20.44±3.59	25.84±4.50*	20.86±3.38	25.52±4.31*
Blood Flow ($ml\cdot min^{-1}$)	253.39±42.84	308.48±48.44*	224.63±40.78	258.64±46.12	258.07±32.85	320.82±48.39*
Systolic Blood Pressure (mmHg)	131.00±4.60	137.50±6.79	129.92±3.63	137.17±4.19*	136.92±4.89	148.92±5.47*
Diastolic Blood Pressure (mmHg)	77.50±2.89	83.83±2.71*	81.00±2.87	83.25±2.81	79.00±2.56	86.42±2.00*
Mean Arterial Pressure (mmHg)	95.33±3.13	101.72±3.54*	97.31±2.85	101.22±2.96*	98.31±3.15	107.25±2.76*
Heart Rate ($beat\cdot min^{-1}$)	73.25±1.34	75.83±2.29	75.41±2.38	79.00±2.72*	74.00±3.55	78.42±3.45*

Data are mean ± SD. *$P<0.05$ vs. Baseline

Figure 1 compares flow-mediated dilatation (FMD) within each group before and after the training, as well as between the groups. In this study, FMD did not change in the 3 training groups and between the training groups.

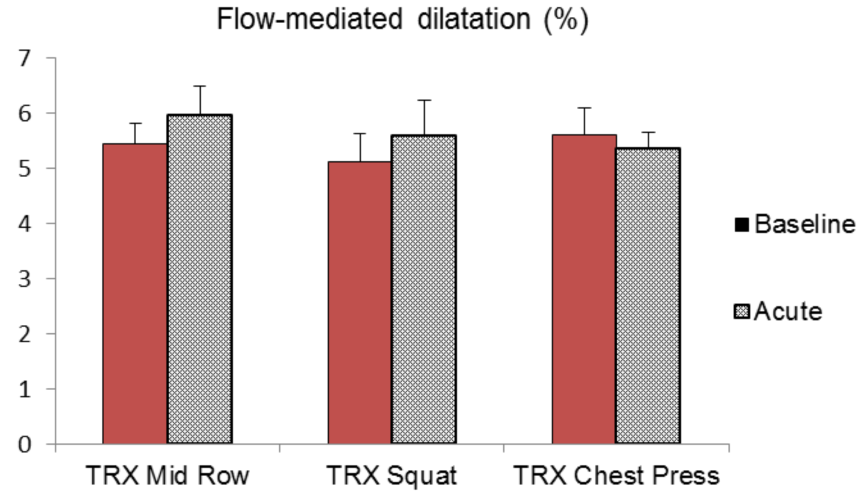

Figure 2. Flow-Mediated Dilatation in the 3 Training Groups and Between the Training Groups.

DISCUSSION

Total Body Resistance Exercise (TRX) is an exercise training program in which the individual using his or her body weight as the resistant force. Two nylon straps are hung on a pole or a wall and then used in different types of exercises (i.e., workouts). The training weight can be increased by adjusting the length of a strap or by changing the angle of the workout. The TRX training program with straps can increase the strength of the muscles of the arms, legs, and core (4,8,10,30). It can increase strength in adults with hypertension, diabetes mellitus, rheumatoid arthritis, scoliosis, herniated disc, and hypercholesterolemia (9). TRX training is also helpful in increasing balance in elderly adults (10) and promoting mental health and well-being among seniors (9). However, to our understanding, there are no studies that have examined the acute effects of a TRX training program on blood vessels.

Flow-mediated dilatation (FMD) is the measurement of changes in blood vessel diameter by stimulation with Post-Occlusive Reactive Hyperemia (PORH) through cuff inflation from a blood pressure monitor. This method reflects endothelial function. The vascular endothelium controls the changes in the blood vessel diameter and blood flow. It also responds to stimuli produced and secreted from blood vessels including vasodilators, such as Nitric Oxide (NO), Prostacyclin, Endothelium Derived Hyperpolarizing Factors (EDHF), and vasoconstrictors, such as Endothelin-1, Angiotensin II, Thromboxane A2, and Prostaglandin H2 (35). Low FMD increases the risk of hypertension, hyperlipidemia, diabetes mellitus, and stress (27,28,34).

Most elderly people have decreased FMD, when compared with other age groups because of decreasing vascular endothelial function. The production of nitric oxide decreases, while the production of Endothelin-1 (ET-1), Endothelium Depolarization Factor (EDF), and Endothelins increase (1). FMD of older people can be increased by exercise. From previous studies, FMD of seniors who do aerobic exercise consistently can be increased by 47%. Moreover, it can improve the function of the heart and blood vessels (7). However, the effects of resistance exercise on FMD are still controversial. Previous research reports include increasing results

(21,22), decreasing results (13,15), and no change (15,21). For example, 60-sec plank training (22) and leg raise training acutely decreased FMD (21); whereas, 30-sec plank training (22) and side crunch training had no effect on FMD (21). It is possible that different workouts may affect the changes of FMD.

However, the difference of physical abilities might impact the different changes of FMD as well. The decrease in FMD after acute resistance training in people who regularly do resistance exercise is less than that of people who have not engaged in resistance exercise (15,26,29,32). Doing regular resistance exercise can help prevent an acute decrease of FMD (14,15,26,32). According to the results in the present study, TRX resistance exercise does not negatively affect the FMD of elderly women, although seniors have lower physical abilities and never exercise.

Resistance exercise increases blood pressure more than aerobic exercise. The former increases blood pressure and decreases FMD (5,18). Thus, blood pressure is the major factor affecting FMD. This research finds that systolic blood pressure increases in the TRX Squat and the TRX Chest Press workouts. There was no change in the TRX Mid Row workout. Diastolic pressure increased only in the TRX Mid Row and the TRX Chest Press workouts, while there was no change in the TRX Squat workout. However, we may discuss the changes of blood pressure by using mean blood pressure, which is calculated by using variables including systolic blood pressure and diastolic blood pressure. The results indicate that mean blood pressures during the 3 workouts was significantly increased. In the present study, blood pressure did not impact the change in FMD.

Shear rate is one factor that affects FMD (12). Shear rate is an indicator of shear stress of training. During exercise, the increase in blood flow contributes to an increase in shear stress (11) and the stimulation of vasoactive substances, such as nitric oxide (29). Previous research illustrates that after training shear rate increases and causes FMD to increase (29). The present research found that shear rate increased during the 3 workouts, but the increase in shear rate did not affect FMD.

The findings in this study reveal that there are changes, including shear rate and blood pressure. However, there was no change in the subjects' FMD. Generally, the mechanism that impacts FMD comes from changes related to vasodilation and vasoconstriction. An increase in shear rate comes from a mechanism related to vasodilatation, while an increase in blood pressure is a mechanism related to vasoconstriction. Therefore, the combination of both leads to no change in FMD. The research results show that TRX resistance training does not cause a negative effect on FMD in elderly women. This is in accordance with previous work that proposed a concept of choosing a workout that does not have a negative effect on FMD (i.e., it does not decrease FMD) (21).

CONCLUSIONS

The findings indicate that the 3 TRX resistance exercise workouts did not decrease FMD in the elderly women. Therefore, the TRX Mid Row, the TRX Squat, and the TRX Chest Press workouts can be used to train muscle strength in elderly women without any negative effects on blood vessels.

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