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Effects of Flexi bar Training Model to Blood Biochemistry in Overweight Adults

A. Hiruntrakul[1], Y. Phanpheng[2]

[1] *Sports Science program, Faculty of Applied Science and Engineering, Khon Kaen University, Nong Khai Campus, Nong Khai, Thailand*

[2] *Exercise and Sport Sciences Program, Graduate School, Khon Kaen University, Khon Kaen, Thailand*

CORRESPONDING AUTHOR:
Ashira Hiruntrakul
Sports Science program
Faculty of Applied Science and Engineering
Khon Kaen University
Nong Khai Campus
43000 Nong Khai, Thailand
E-mail: hashir@kku.ac.th

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SUMMARY

Background. The purpose of this study was to assess the effects of flexi bar training model and moderate running exercise on blood biochemistry in overweight adults.
Methods. The BMI of Asian people were ranged from 23.00 to 24.99 kg/m2 was considered overweight. The participants had experienced any orthopedic problems in the spine or in the upper and lower extremities in the previous six months. Forty participants were randomly assigned to an experimental (20 participant performing flexi bar training model (FBT) and control (20 participant performing moderate running exercise (MRE) group. The participant in both groups then underwent program training 50 minute/day, 3 times a week, for 12 weeks.
Results. The main outcome measures were blood biochemistry variable. The result showed significant differences between FBT and MRE group ($p<0.05$). After 12 weeks FBT showed improve lipid profile variable but not change complete blood count.
Conclusions. Flexi bar training model can improvement body composition and lipid profile in overweight adults.

KEY WORDS
Flexi bar training; blood biochemistry; overweight; body composition; lipid profile.

BACKGROUND

Overweight or being heavier than standard criteria is generally based on Body Mass Index or BMI. It can be calculated by dividing weight (kilograms) by height^2 (m^2). The normal weight who have BMI ranged from 18.50 to 22.99 kilograms per square meter, Meanwhile, those who have BMI ranged from 25.00 to 29.99 kilograms per square meter were considered overweight and more than 30 kilograms per square meter were considered obesity (1). According to BMI information, WHO conducted the research and found that Asian people have smaller physical sizes than American, European, and African people. It is needed to adjust BMI to be appropriate for Asian physical structures. Therefore, the BMI of Asian people was ranged from 18.50 to 22.99 kilograms per square meter. Meanwhile, those who have BMI ranged from 23.00 to 24.99 kilograms per square meter were considered overweight 25.00 to 29.99 were considered obesity level 1 and more than 30 obesity level 2 (2). In 2017 World Health Organization reported the effects of overweight on chronic disease, stroke, blood pressure, and diabetes type 2 tended to increase for both men and women. To decrease the rate of having health problems in overweight adults, it is focused on promoting appropriate physical behaviors, physical activities, having healthy nutrition, and regular exercises (3).

There are various models of exercises for losing fat such as aerobic dance (4), walking (5,6), running (7,8) and cycling (9). These activities need moving big muscles in different parts together which increase oxygen consumption and basal metabolism rates in overweight adults (10). Vibration exercise an alternative exercising activity to increase lean body mass (11) increasing efficiency of muscle contraction (12,13) increase muscle mass (14,15) and providing positive effects on blood vessels and blood circulatory system (16) since exercising with vibration will stimulate increasing of muscles to correspondingly work as well as increas-

ing of basal metabolism rate (17). Flexi bar exercising is an exercise with vibration equipment and is designed to have low frequency rate at 5 hertz, to vibrate 270 times per minute by using the metronome to control the flexi bar oscillation, with the size of 1.53 meters long, 710 grams, and 9.5 millimeter for circumference (Flexi bar). The experiment was taken place in a laboratory of research and technology, Munich University, Germany and it is certified and tested for the quality of the equipment by National Association of German Back Schools (AGR) that flexi-bar under the brand of Flexisport, Munich is appropriate and safe for exercise (18) because of having been manufactured from high-flexibility fiber glass. While vibrating flexi-bar, the vibration is generated along small amplitude of movement. There is resistance or intensity against vibration along the bar where the weight at both ends were the scale to control the weight of vibration timing. The trainers need to keep the vibration timing rate stable. In this case, the device can maintain stability of force constantly (19). Vibration generated by flexi bar will stimulate core muscle functioning (20,21,22) to generate reaction with the change of cross-sectional area of muscles and increase muscle activate throughout the body (23,24,25). For core muscles in human body, training with flexi bar can help encourage the functioning system of nerve muscles to perform reaction faster (26,27). This condition, body can retrieve energy to be used by burning out energy faster that affects in increasing the rate of more and faster energy expenditure than normal exercises such as brisk walking, running, cycling and *etc.* (28).

There are research reports studying on the function of the group of core muscles in group of healthy people, however, the benefits gained after training have not been found reported indicated about the use of flexi bar with a group of people with overweight people including the variable of blood biochemistry, in addition, there has not been any report found studying on level of intensity exercise models measured by the rate of energy expenditure during the training period. This can link to the change in the variables in different body composition aspects. Consequently, the researcher hopes that this research will be able to provide advantageous information for health promotion and beneficial as another effective exercise for people with overweight.

MATERIALS AND METHODS

Participants

This study was an action research study; it was approved by the Ethics Committee in Human Research, Khon Kaen University, HE 612319. The research samples were 40 subjects participating in the health promotion project who were staff and students of Loei Rajabhat University, aged 20-45 years old with BMI ranges between 23.00 to 24.99 kg/m^2, BMI is set as the standard for Asian people is considered overweight. The participants were written informed consent has been obtained from each participant. The 40 samples were identified as overweight, using sample random sampling technique. Inclusion criteria consists of without any operation history or having treated with spinal surgery at least 6 months, being healthy without chronic diseases or health problems that possibly reduce readiness to exercise, evaluated from Physical Activity Readiness Questionnaire (PAR–Q) and pass in physical fitness, being healthy and strong without any affective factors obstructing exercise.

Exclusion criteria were as follows having chronic diseases such as high blood pressure, heart disease, diabetes, and coronary artery diseases, etc., less than 80% participation of the flexi bar training sessions and pregnant or breastfeeding volunteers. Other exercises and food consumption were recorded daily.

Experimental training

Data were collected during three periods: the 1st week, the 8th week, and the 12th week of the experiment. The research instruments included twelfth active vibration with flexi bar training model.

The test periods were performed for 12 weeks and included body composition and blood biochemistry variable included lipid profile and complete blood count; CBC. For the 1st - 12th week of the experiment the participants lived their normal lives.

Flexi bar training model

Twelfth active vibration with flexi bar training model has been developed into a model that is suitable for exercise in people who are overweight. Through consideration of the suitability of sports science experts with qualifications through passing the training course of certified personal trainer from American Council on Exercise (ACE) and National Academy of Sports Medicine (NASM). All participants were asked to perform the 12th week training program by doing Flexi bar training model for 50 minutes per time, 3 times a week on Monday, Wednesday and Friday. This program was conducted from 5 pm to 6 pm. The training program was performed at the Sports complex building, Sport and Exercise Sciences program, Loei Rajabhat University.

MEASUREMENT OF OUTCOMES

Blood biochemistry variable

Data were collected during three periods of the experiment. The test periods were performed for 12 weeks were measured blood biochemistry variable included lipid profile for this research study including Total cholesterol (TC), Low density lipoprotein cholesterol (LDL-C), High density lipoprotein cholesterol (HDL-C), and Triglyceride (TG). Measurement using enzymatic color measurement and chemical analysis by BT1000x chemical analyzer. And complete blood count; CBC, There are 6 parameters to be investigated for this research including Hemoglobin (Hb), using SLS Hemoglobin method, Hematocrit (Hct) using Cumulative pulse height detection method, Red blood cells (RBC), Mean cell volume (MCV), Mean Corpuscular Hemoglobin (MCH) using Hydrodynamic focusing direct current method, and Mean Corpuscular Hemoglobin Concentration (MCHC) measurement using fluorescence flow cytometry method using semiconductor laser with automatic analysis device called Sysmex XN-3000. In addition, the assessment of body composition was carried out through the bioelectrical Impedance Analysis (In body 270) measurement of weight, body mass index (BMI), fat percentage (% Fat), fat mass muscle mass and basal metabolic rate (BMR). The participants' height (without shoes) was measured by a standiometre. The BMI was calculated by dividing body mass in kilograms by height in square meters (kg/m^2). The waist girth was measured at the level of the umbilicus horizontally without clothing, Waist hip ratio (WHR) was calculated by dividing the waist girth by the hip girth.

Procedures

Twenty overweight adult subject's active vibration with flexi bar training model (FBT). The exercise sessions were divided into three sessions; at 10 minutes warm up session performing static stretch following dynamic warm up with flexi bar. At 35 minutes workout session performing the other 12 positions, chest, balance abductor, waist, oblique, triceps, biceps, core muscle, deep back extensor, shoulder, hips, lower back and abdominals. The Flexi-Bar (FLEXI-BAR®; Flexi-Sports, Germany) used in this experiment is an exercise tool having weights at the both ends of a glass fiber elastic bar of weight 719 g and length 1.53 m. at the center part, a grip of 17.9 cm, whereas the ends consist of weighty rubber. So the hands and arms holding the middle handle and shaking the flexi bar, by using the metronome to control the flexi bar oscillation rhythm 270 times per minute. In which the speed of 270 vibrations per minute will produce a vibrating response equal to 5 hertz, the subject held the Flexi-Bar with both hands while standing and performed vibration exercise, each position performed its exercise for 30 seconds and rested for 30 seconds, continue to practice with 3 sets of each pose following with a 5 minute cool down and static stretching of major muscle groups. The control group, twenty overweight subjects using moderate running exercise (MRE) were divided into three sessions;

Table I. Flexi bar training model protocol.

Day	Unit of training	Active vibration with flexi bar training model position	Duration of training
Monday Wednesday Friday	Warm up	Static stretching of major muscle groups and dynamic warm up with flexi bar.	10 minutes
	Work out	1. Chest 2. Balance abductor 3. Waist 4. Oblique 5. Triceps 6. Biceps 7. Core muscle 8. Deep back extensor 9. Shoulder 10. Hips 11. Lower back 12. Abdominals	35 minutes - 30 second active vibration - 30 rest in set - 3 sets each position
	Cool down and stretching	Static stretching.	5 minutes

at 10 minutes warm up session performing static stretch following dynamic warm up. At 35 minutes workout session performing moderate running exercise (MRE) with treadmills (T5, Life fitness, America). Manual setting program with control speed and heart rate 60-75% of maximum heart rate. Following with at 5 minutes cool down and static stretching. Both groups used the same duration of training with continue 50 minutes (**table I**).

Intensity control and energy expenditure

Both groups control intensity 65-75% of maximum heart rate throughout the duration of each exercise. Intensity and energy expenditure while training with flexi bar and moderate running exercise. All participants put on heart rate monitor (Polar Team Pro) in which the signal was connected to the receiver (Apple I-pad). Throughout the training period, each subject will show displayed on the screen at the real time for control heart rate. And final results were report training session on the screen while training including Heart Rate (bpm.), Percent of Average Heart Rate (%AVG^{HR}), Percent of Maximum Heart Rate (% AVG^{HRmax}) and Energy Expenditure of Exercise in Kilocalories (Kcal).

STATISTICAL ANALYSES

The data analysis, the statistical package SPSS Version 17 software was used. Data were presented as mean ± SD, changes within group and within-group variance of baseline data and after-training data. Kolmogorov-Smirnov Test used to normality distribution of the data in both groups before the experiments. The baseline data were the data before week 1st, week 8th, and week 12th. The paired samples t-test was used to compare pre training and post training variables in each group (FBT or MRE). The independent samples t-test was used to compare basal variables between groups (FBT vs. MRE). Research using two ways ANOVA for analysis with statistical significance level of 0 .05.

RESULTS

The participant group was no baseline differences in demographic and clinical findings between the experimental and control groups. At week 12th, the FBT and MRE group were significantly different ($p<0.05$) from baseline in body composition variable. For example, for body composition, the weight, percentage of fat decreasing while muscle mass and BMR increase significantly ($p<0.05$) (**table II**).

Regarding body composition variable there were significant changes ($p<0.05$) from baseline at week 8th, FBT group showed increase Basal metabolic rate (BMR) found significant difference between group in week 12th, In addition after exercise at 12th week FBT group changes different ($p<0.05$) in weight, %fat and muscle mass from baseline at week 12th. Also MRE group were showed significantly decreased from baseline in weight, %fat ($p<0.05$) at 12th week. While blood biochemistry variable there were significant changes ($p<0.05$) from baseline at week 8th, FBT group showed increase high density lipoprotein (HDL-C) found significant difference between group in week 12th, In addition after 12 week, FBT group showed decreased from baseline different ($p<0.05$) in triglycerides (TG) and low density lipoprotein (LDL-C). Also MRE group were changes different ($p<0.05$) in triglycerides (TG), low density lipo-

Table II. Differences of body composition variable.

Body composition Pre test		**Moderate Running Exercise (MRE = 20)**				
		12 week	**Pre test**	**8 week**	**12 week**	
Body composition variable						
Age (years)	22.70±1.26	22.70±1.26	22.70±1.26	22.40 ±1.04	22.40 ±1.04	22.40 ±1.04
Weight (kg)	67.74±5.86	67.10±5.40	66.60±5.26*	66.64 ± 6.53	66.40± 6.67	65.72±6.37*
BMI (kg./m.^{2})	24.09±0.55	23.95±0.82	23.80±0.74	24.08 ± 0.58	23.98±0.56	23.94±0.52
Fat % (percent)	20.74±2.29	20.43±2.37	19.92±2.46*	20.07±1.27	19.89±1.19	19.69±1.02*
Fat mass(kg)	15.04±2.33	14.78±2.39	14.66±2.31	15.19±2.09	14.86±1.98	14.81±1.94
Muscle mass (kg)	40.56±15.08	40.95±15.39	41.35±15.41*	40.59±10.91	39.85±10.48	39.40±10.10
WHR (inch)	0.85±0.53	0.85±0.52	0.85±0.52	0.85±0.23	0.85±0.52	0.85±0.52
BMR (Kcal)	1682±71.32	1690±88.60*	1693±86.37*^{t}	1687±68.25	1694±66.60	1683±68.22

The data are presented by means ± SD; *statistically significant difference when compared within group, mean scores at point comparisons from baseline: *$p<0.05$ and *^{t} $p < 0.05$ when comparing the difference between experimental groups

protein (LDL-C) and high density lipoprotein (HDL-C) after exercise at week 12th.

DISCUSSION

This study was aimed to investigate the effect of flexi bar training (FBT) on blood biochemistry variable in overweight adults compared to the moderate running exercise (MRE). There have been studies conducted a study in a passive method using full body vibration exercise equipment, while this study used a flexi-bar to apply active vibration exercise. There were three phases of this study; the pre-training, the 8 week, and 12 week of the experiment. This study showed that flexi bar training significantly improved body composition (**table II**) and blood biochemistry (**table III**). The variables improvements were persisted at 12th week.

According to anatomical and mechanical properties, the exposure of vibration to the skeletal muscular system causes a tonic vibration reflex (TVR) (29). The application of vibration to the tendon or muscle results in a TVR response, as reported previously (30,31). The TVR was initially considered to be a result of frequency stimulation applied directly to a muscle or tendon for a short period. The application of local vibration to the tendon or muscle also improves muscle function (32,33). From this it can be surmised that the increased effectiveness of the training also influences muscular strength and muscular endurance, additional data include we exercise with flexi bar can activation of the core muscle and increase transvers abdominals thickness (21,22,34). Moreover, active vibration with flexi bar training can improve oxygen building muscle and yield a relevant increase energy expenditure better general exercise in the same amount of time (28).

The active vibration with flexi bar training and moderate running exercise groups provided better body composition outcomes in terms of weight, body mass index (BMI) and fat percentage after training period. The changes in body composition were as follows; the body weight of the participants reduced significantly at the 12th week of training. Because the active vibration with flexi bar training continuously allowed metabolic processes to burn fat cells in the normal weight, overweight and obese people more efficiently. According to principle of aerobic exercise, the active vibration with flexi bar training is a one type of aero-

Table III. Differences of blood biochemistry variable measurements.

Blood biochemistry variable	Flexi Bar Training (FBT = 20)			Moderate Running Exercise (MRE = 20)		
	Pre test	8 week	12 week	Pre test	8 week	12 week
Lipid profile						
Total Cholesterol ; TC (mg/dL)	174.47±18.21	173.65±18.10	173.37±17.72	172.21±16.12	171.61±15.80	171.92±15.52
Triglycerides ; TG (mg/dL)	91.31±7.31	89.62±7.16	88.58±6.32*	91.58±5.70	90.90±5.62	90.14±5.40*
High Density Lipoprotein ; HDL-C (mg/dL)	53.75±10.37	55.10±10.38*	57.65±10.58*t	52.85±9.43	53.70±9.25	54.05±9.16*
Low Density Lipoprotein; LDL-C (mg/dL)	123.08±10.92	122.11±10.46	120.73±10.81*	124.63±8.81	122.78±8.75	121.03±8.65*
Complete blood count ; CBC						
Red Blood Cell; RBC (fL)	5.55±0.47	5.53±0.43	5.60±0.49	5.58±0.54	5.50±0.54	5.58±0.57
Hemoglobin; Hb (g/dL)	14.75±1.10	14.75±1.14	14.76±1.18	14.76±1.00	14.76±1.07	14.76±1.08
Hematocrit; Htc (%)	44.77±3.80	44.97±3.63	44.97±3.65	44.73±3.22	44.77±3.08	44.68±3.13
Mean Corpuscular Volume; MCV (fL)	82.76±7.88	82.62±7.32	82.45±7.09	81.85±7.12	81.80±8.19	81.83±8.45
Mean Corpuscular Hemoglobin; MCH (pg)	27.16±1.50	27.12±1.49	27.16±1.47	27.18±1.45	27.22±1.42	27.23±1.44
Mean Corpuscular Hemoglobin Con centration; MCHC (g/dL)	32.74±1.10	32.85±1.16	32.85±1.15	32.72±0.88	32.79±0.94	32.75±0.87

The data are presented by means ± SD; *statistically significant difference when compared within group, mean scores at point comparisons from baseline: *p<0.05 and *t p < 0.05 when comparing the difference between experimental groups.

bic exercises. Felix *et al.* (35) suggested that resistance from vibration will help stimulate more blood circulatory transported for muscle and nerve cell nourishment. Moreover, repeating training postures frequently links between nerves and muscles to work together better. To a targeted training program with the active vibration with flexi bar training yields a relevant increase in energy expenditure as a determining factor of weight and fat loss. Moreover, the activation of large muscle groups with moderately high intensity within a given time span as part of a classical flexi bar training module should at least directly correlate with distinct increases in active metabolic rate.

Aerobic exercise helped increase efficiency of heart muscles. Previous studies, aerobic exercise has a positive effect on blood lipids. This is consistent with this study that, after 8 week of training it was found that lipid profile; High density lipoprotein, (HDL-C) and difference statistical significance level 0.05 between groups in 12 weeks. While in both group exercises there were found as follows; Triglycerides (TG), Low Density Lipoprotein (LDL-C) decreased with statistical significance when comparing to before the experiment. However, additionally, not found Total Cholesterol (TC) difference in both groups when comparing to before and after training. Decreasing of lipid profile variable may be resulted from increasing of energy expenditure during exercise with flexi bar in which higher energy is consumed while exercise than moderate running exercise. This activity will stimulate the muscles to use lower energy than constant intensity. According to the assessment of energy expenditure while exercising, comparing between two groups, it can be seen that the group of flexi bar training had higher energy expenditure than running group. Combination of various aerobic energy systems will provide positive effect on energy consumption from body fat and affecting fatty molecules which is lipid transported to parts of body (36). Previous researches showed that different kinds of aerobic exercise activities with continuity and appropriate time will affect the level of lipid profile such as level of Triglyceride, level of low density lipoprotein and increasing of high density lipoprotein (37, 38). Generally, High density lipoprotein (HDL-C) will transport cholesterol along with other kinds of fats totaling 30% in blood, therefore increasing of HDL-C will reduce waste of fat accumulated along blood vessels. This also helps reduce risk factor of Atherosclerosis (39). This is consistent to the finding in this research that the stimulation of muscles to contract by periods of low intensity vibration from flexi bar continuously, approximately 5 Hertz will stimulate muscles to carry out energy for burning fat or fat metabolism. Similarly, Di Loreto A. *et a.l* (17) conducted the study to investigate the effects of aerobic exercise with vibration device. The finding showed that after continuous exercise, it provides positive effects for physical fitness and triglyceride, low density lipoprotein decreased. Moreover, Thorsten *et al.* (4) found that aerobic exercise with use of resistant exercise is beneficial for overweight and fat adults. This exercise helps improve physical fitness and any factors regarding to lipid profile better because muscles need more food substance especially free-fatty acid when doing exercise, blood circulatory along with triglyceride delivered to muscles also increase and turn to be free fatty acid which is a source of energy for muscles. When more triglyceride is oxidized, the level of triglyceride decreases. Moreover, exercise helps stimulate performance of lipoprotein in blood that can also cause in reducing triglyceride as well (40,41). However, change of total cholesterol was not fond in this research when comparing with before training. Stein *et al.* (42) suggested about the intensity of aerobic exercise that training the level of 85% of maximal heart rate will affect the decreasing of total cholesterol.

Suitable level of exercise will provide positive effect to blood biochemistry and in this research there is no change regarding Complete Blood Count (CBC) among both groups of overweight adults throughout the period of 12 weeks. Possibly, since the stimulation of flexi bar is at 5 Hertz, as it is low intensity, it doesn't provide effect to change of complete blood count in a short period. This result is consistent with the previous study of Kodama, S *et al.* (43) that there was no statistically significant difference regarding the use of vibration for training in terms of red blood cells, white blood cells, lymphocytes, monocytes, granulocytes, hemoglobin and hematocrit. Additionally, Dorota *et al.* (44) found that after a 12 weeks aerobic exercise, cholesterol in blood of participants reduced while the amount of complete blood counts didn't change. Johannsen *et al.* (45) suggested that after 6 months of aerobic exercise, there was change regarding complete blood counts. Based on the previous research studies, there are supportive results to identify that low flexi bar training with low intensity vibration is a limitation for stimulating blood production process as well as other blood biochemistry components. Limitation of time which is not enough for training cannot provide any change regarding complete blood counts as well as the appropriate level of intensity for exercise in this research study.

Limitation of the study

This study uses samples with body mass index for Asian people only. And training postures, most of which are static training, there should be applies to the training styles for various movements for the effectiveness of the training program.

Suggestions for further research study

The patterns of flexi bar training should be appropriately adjusted for different groups of people such as children, elderly, and patients with chronic diseases.

CONCLUSIONS

To design this Flexi bar training model, the researcher combined exercise and the use of flexi bar which is a pattern of exercise designed by the researcher and proved for appropriateness by the experts based on the principles of sport science and exercise. The model can promote various kinds of body composition and blood biochemistry including lipid profile, complete blood count. This is safe for physical structure and doesn't cause vertical force. Therefore, flexi bar training is an alternative exercise for those who want to lose weight, strengthen physical fitness and increase effectiveness of blood vessel functioning. Consequently, it should be widely promoted and future applied for enhancing healthiness.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. American College of Sports Medicine [ACSM]. Guidelines for Exercise Testing and Prescription. 6th ed. Philadelphia: Lippincott Williams and Wilkins 2006.
2. World Health Organization [WHO]. Strategy for oral health in South-East Asia, 2013-2020. India: Indraprastha Estate, Mahatma Gandhi Marg 2016.
3. American College of Sports Medicine [ACSM]. ACSM's Resources for Clinical Exercise Physiology. 2th ed. Philadelphia: Lippincott Williams and Wilkins 2009.
4. Thorsten S, Stefanie S, Billy S. Aerobic dance: health and fitness effects on middle-aged premenopausal women. J Exerc Physiol 2008; 11(4): 25-33.
5. Takeshima N, Iyoji T, Fumio K, Takemasa W, Akashi K**.** Effects of aerobic exercise conditioning at intensitiescorresponding to lactate threshold in the elderly. Eur J Appl Physio 1993; 67: 138-143.
6. McArdle WD, Katch FI, Katch VL. Exercise Physiology Energy, Nutrition, and Human Performance. 6th ed. Philadelphia: Lippincott Williams & Wilkins 2007.
7. Shaw I, Shaw BS, Krasilshchikov O. Comparison of aerobic and combined aerobic and Resistance training on low-density lipoprotein cholesterol concentrations in men. Cardiovasc J Afr 2009; 20(5): 174-189.
8. Nybo L, Sundstrup E, Jakobsen MD, Mohr M, Hornstrup T, Simonsen L. High-Intensity Training Vs. Traditional exercise interventions for promoting health. Med Sci Sports Exerc 2010; 74: 225-236.
9. Bergström I, Lombardo C, Brinck J. Physical training decrease waist circumference in the postmenopausal borderline overweight women. Acta Obstet Gynecol Scand 2009; 88: 308-313
10. Bell JM, Bassey EJ. A compareison of the relation between oxygen uptake and heart rate during different styles of aerobic dance and a traditional step test in women. Department of physiology and pharmacology, Medical school, Queen's medical centre, Notingham, England 1993.
11. Olson PT, Donald RD, Arthur SL, Kathryn HS**.** Moderate resistance training and vascular health in overweight women. Med Sci Sports Exerc 2006; 38(9): 1558-1564.
12. Roelants M, Delecluse C, Goris M, Verschueren S. Effects of 24 weeks of whole body vibration training on body composition and muscle strength in untrained females. Int. J. Sports Med 2004; 25: 1-5.
13. Cochrane DJ. The potential neural mechanisms of acute indirect vibration. J Sci Med Sport 2011; 10: 19-30.
14. Delecluse C, Roelants M, Verschueren S. Strength increase after whole-body vibration compared with resistance training. Med Sci Sports Exerc 2003; 35(6): 1033-41.
15. Verschueren SM, Roelants M, Delecluse C, Swinnen S, Vanderschueren D, Boonen S. Effect of 6-month whole body vibration training on hip density, muscle strength, and postural control in postmenopausal women: a randomized controlled pilot study. J Bone Miner Res 2004; 19(3): 352-9.
16. Kerschan S, Grampp C, Henk H, Resch E, Preisinger V, Fialka-Moser H. Whole-body vibration exercise leads to alterations in muscle blood volume. Clinical Physiology 2001; 21(3): 377-382.
17. Di Loreto A, Ranchelli P, Lucidi G, Murdolo N, Parlanti A, De Cicco O, Tsarpela G, Annino C, Bosco F. Effects of whole-body vibration exercise on the endocrine system of healthy men. J Endocrinol Invest 2004; 27(4): 323–327.
18. Markus D, Gunsch F. Deep penetrating 3 D training with the flexi bar: Expert advice concerning the Flexi-Bar performance. Switzerland: Official Training and Therapy Center of the PGA of Germany 2009.
19. Masoud A, Mohammad N, Sajad A, Mohsen A, Mohamad P, Kinda K. A model for flexi-bar to evaluate intervertebral disc and muscle forces in exercises. Med Eng Phys 2016; 38: 1076-1082.
20. Jung HK, Ki HS, Yu RB, Byoung HL. A Comparison of Flexi-bar and General Lumbar Stabilizing Exercise Effects on Muscle Activity and Fatigue. J Phys Ther Sci 2014; 26: 125-136.

21. Jun SC, Seol P, Ji YK, Ji WP. Effects of flexi-bar and non-flexi-bar exercises on trunk muscles activity in different postures in healthy adults. J Phys Ther Sci 2015; 27:2275-2278.
22. Sin HC, Young YY, Hyung JL, Sang HS. Effects of stabilization exercise using flexi-bar on functional disability and transverse abdominis thickness in patients with chronic low back pain J Phys Ther Sci 2018; 30:400-404.
23. Seong JL, Yong NK, Dong KL. The effect of flexi-bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties. J Phys Ther Sci 2016; 28:1298-1302.
24. Woon SC, Chi BP, Jae HL. The Effect of Trunk Strengthening Exercise using Oscillation on Trunk Muscle Thickness and Balance. J Korean Med Sci 2017;12(2): 91-101.
25. Dong KL, Yong NK, Chi BP. The effect of actively induced vibration using shoulder joint on pain and dysfunction in patients with low back pain. J Phys Ther Sci 2018; 30:23-26.
26. Torvinen S, Kannus P, Sievanen H, Jarvinen TA, Pasanen M, Kontulainen, S. Effect of a vibration exposure on muscular performance and body balance. Randomized cross-over study. Clin Physiol Funct Imaging 2002; 22:145-152.
27. Martin BJ, Park H. Analysis of the tonic vibration reflex: influence of vibration variables on motor unit synchronization and fatigue. Eur JAppl Physiol 1997; 75:504–511.
28. Dippert T, Moeller K, Stengel S, Kemmler W. Energy expenditure during a 30-minute exercise unit with the "FLEXI-BAR®" Pilot Study. Nuremberg, Germany: Institute of Medical Physics Friedrich-Alexander-University of Erlangen 2010.
29. Trans T, Aaboe J, Henriksen M, Christensen R, Bliddal H, Lund H**.** Effect of whole body vibration exercise on muscle strength and propri-oception in females with knee osteoarthritis. Knee 2009; 16:256–261.
30. Bernard J. Martin SP. Analysis of the tonic vibration reflex: influence of vibration variables on motor unit synchronization and fatigue. Eur J Appl Physiol Occup Physiol 1997;75(6):504–511.
31. Couto BP, Silva HR, Filho AG, Da Silveira SR. Acute Effects of Resistance Training with Local Vibration. Int J Sports Med 2013;34(9):814-819.
32. Iodice P, Bellomo RG, Gialluca G, Fanò G, Saggini R. Acute and cumu-lative effects of focused high-frequency vibrations on the endocrinesystem and muscle strength. Eur J Appl Physiol 2011; 111:897–904.
33. Mischi M, Cardinale M. The Effects of a 28-Hz Vibration on Arm Muscle Activity during Isometric Exercise. Med Sci Sports Exerc 2009;41(3):645-53.
34. Kim YM, Park JH. The effect of whole-body vibration exercise on balance, muscle strength and falls efficacy in the elderly. J Korean Soc Phys Med 2017;12(4):61-71.
35. Felix G, Daniel D, Carina G, Ralf B, Thomas V, Tilmann K. Oscillatory whole-body vibration improves exercise capacity and physical performance in pulmonary arterial hypertension: a randomised clinical study. Heart 2017; 103: 592-598.
36. Alberga AS, Prud'homme D, Sigal RJ. Effects of aerobic training, resistance training or both on cardiorespiratory and musculoskeletal fitness in adolescents with obesity: the HEARTY trial. Appl Physiol Nutr Metab 2016; 2: 514–521.
37. Escalante Y, Saavedra JM, García HA. Improvement of the lipid profile with exercise in obese children: a systematic review. Prev. Med 2012; 54: 293-301.
38. Yating W, Danyan X. Effects of aerobic exercise on lipids and lipoproteins. Lipids in Health and Disease. J Phys Ther Sci 2017; 3: 116-132.
39. Stefan B, Yevhen P, Cédric E, Celestine NC, Julia K, Stefan A. Solution structure of discoidal high density lipoprotein particles with a shortened apolipoprotein A-I. Nat. Struct. Mol. Biol 2017; 24: 187-193.
40. Noble JB. Physiology of exercise and sport. St. Louis: Time Mirror/Mosby 1986.
41. Tambalis K, Demosthenes BP, Stavros AK, Labros SS. Responses of Blood Lipids to Aerobic, Resistance, and Combined Aerobic With Resistance Exercise Training: A Systematic Review of Current Evidence. Angiology 2009; 60(5): 614-632.
42. Stein RA, Michielli DW, Glantz MD, Sardy H, Cohen A, Goldberg N, Brown CD. Effects of different exercise training intensities on lipoprotein cholesterol fractions in healthy middle-aged men. Am Heart J 1990; 119: 277-83.
43. Kodama S, Tanaka S, Saito K, Shu M, Sone Y, Onitake F. Effects of aerobic exercise training on serum level of high-density lipoprotein cholesterol: a meta-analysis. Clin J Sport Med 2008; 10: 999-1008.
44. Dorota KN, Robert NZ, Jastrzebski B, Aleksandra Z, Marta B, Izabela D. Effect of 12-week-long aerobic training programme on body composition, aerobic capacity, complete blood count and blood lipid profile among young women. Biochemia Medica 2015; 25(1): 103-113.
45. Johannsen NM, Swift DL, Johnson WD, Dixit VD, Earnest CP, Blair SN. Effect of different doses of aerobic exercise on total white blood cell (WBC) and WBC subfraction number in postmenopausal women: results from DREW. PlosOne 2012. 7(2): e31319.
46. Padulo J, Oliva F, Frizziero A, Maffulli N. Muscles, Ligaments and Tendons Journal - Basic principles and recommendations in clinical and field Science Research: 2018 update. MLTJ 2018; 8(3): 305 – 307.