A Comparison between the Effects of Aerobic Dance Training on Mini-Trampoline and Hard Wooden Surface on Bone Resorption, Health-Related Physical Fitness, Balance, and Foot Plantar Pressure in Thai Working Women

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Objective: *To compare the effects of aerobic dance training on mini-trampoline and hard wooden surface on bone resorption, health-related physical fitness, balance, and foot plantar pressure in Thai working women.*
Material and Method: *Sixty-three volunteered females aged 35-45 years old participated in the study and were divided into 3 groups: A) aerobic dance on mini-trampoline (21 females), B) aerobic dance on hard wooden surface (21 females), and C) control group (21 females). All subjects in the aerobic dance groups wore heart rate monitors during exercise. Aerobic dance worked out 3 times a week, 40 minutes a day for 12 weeks. The intensity was set at 60-80% of the maximum heart rate. The control group engaged in routine physical activity. The collected data were bone formation (N-terminal propeptine of procollagen type I: P1NP) bone resorption (Telopeptide cross linked: β-CrossLaps) health-related physical fitness, balance, and foot plantar pressure. The obtained data from pre- and post trainings were compared and analyzed by paired samples t-test and one way analysis of covariance. The significant difference was at 0.05 level.*
Results: *After the 12-week training, the biochemical bone markers of both mini-trampoline and hard wooden surface aerobic dance training subjects decreased in bone resorption (β-CrossLaps) but increased in bone formation (P1NP). Health-related physical fitness, balance, and foot plantar pressure were not only better when comparing to the pre-test result but also significantly different when comparing to the control group ($p<0.05$). The aerobic dance on mini-trampoline showed that leg muscular strength, balance and foot plantar pressure were significantly better than the aerobic dance on hard wooden surface ($p<0.05$).*
Conclusion: *The aerobic dance on mini-trampoline and hard wooden surface had positive effects on biochemical bone markers. However, the aerobic dance on mini-trampoline had more leg muscular strength and balance including less foot plantar pressure. It is considered to be an appropriate exercise programs in working women.*

Keywords: *Aerobic dance on mini-trampoline, Aerobic dance on hard wooden surface, Bone resorption (Telopeptide cross linked: β-CrossLaps or CTx), Balance, Health-related physical fitness, Foot plantar pressure*

J Med Assoc Thai 2015; 98 (Suppl. 8): S58-S64
Full text. e-Journal: *http://www.jmatonline.com*

"Osteoporosis" is a bone disease with decreasing bone mass and micro-architectural deterioration that makes bones fragile and increases risk of fractures. The accumulation of bone mass will stop when an individual is between 25-30 years old. Between 35-45 years old, bone mass begins to drop 0.5-1.0 percent per year in both females and males; however, females tend to manifest a higher rate of decrease in bone mass up to 3-5 percent per year more than their male counterparts[1,2]. World Health Organization[3] defines osteoporosis as having bone mineral density of 2.5 standard deviations or more below peak bone mass and factors that may contribute to osteoporosis are genetics, nutrition, calcium deficiency, vitamin D deficiency, loss hormone, not much exercise, drugs and certain diseases[4,5].

Several methods for prevention and treatment of osteoporosis exist. Exercise has shown to be an effective method in preventing osteoporosis; in addition, it is safe and economical. Weight bearing exercises such as walking, jogging, running, yoga, and aerobic dance are the alternative ways for prevention osteoporosis. They are forms of weight bearing exercise

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that affect bone mass, balance, and health-related physical fitness.

The exercise on mini-trampoline may require high demands of the muscles of the lower extremities[6,7]. Heitkamp et al[7] found that a balance training circuit with the mini-trampoline station improved balance, strength and equalization of muscular imbalance between the two limbs, i.e. left and right. During trampoline training, participants are forced to respond continuously to a constant change of gravity that provides deep proprioception as other sensory inputs. Therefore, mini-trampoline exercise consists of a multiple component approach which affects many other physical factors than strength, such as body stability, muscle coordinative responses, joint movement amplitude and spatial integration[8].

The previous study[9] investigated the effects of outdoor mini-trampoline aerobic dance training on bone resorption and vitamin D in working women. Thirty-seven volunteers females aged between 35-45 were divided into 2 groups as follows: 17 females in the outdoor mini-trampoline aerobic dance and 20 females in the control group engaging in routine physical activity. The training intensity was 60-80% of the maximum heart rate for 12 weeks with three times per week and 40 minutes per session at 7.20-8.00 AM. This study showed that outdoor mini-trampoline aerobic dance subjects were significantly lower in β-CrossLaps but P1NP had no significant difference when compared with the control group ($p<0.05$). Besides, the 25 (OH) D in the outdoor mini-trampoline aerobic dance group after the training intervention was significantly higher than the control group ($p<0.05$).

The aerobic dancing floor is the most poorly understood factors of dance injury and prevention. According to Roan and Writer[10], the podiatrists found the highest incidence of injuries occur on carpet-over concrete surface (50 percent), tile over concrete (47 percent), the surface padded carpeted floor (36 percent) and hardwood floors over airspace (35 percent). Therefore, aerobic dancing required a good floor that provided shock absorbency and resiliency. A study by Schoor et al[11] compared the force attenuation capacity of 10 different hip protectors: both hard and soft hip protection. Using weight impact testing with a 25 kg. weight by dropping it from a height of 8 cm caused a force of almost 7806 N on the bare femur. The study showed that the hard hip protection was superior to the soft, but the soft tissue thickness increased. This meant the soft hip protection was capable of reducing the impact. The previous study[12] found that rubber floor tile that could reduce the best impact was made from smoked rubber sheets which was able to fill in the blowing agent 15 phr (part per hundred of rubber). The amount of rubber foam was 80% mold resulting in at 39% reduction in impact when compared to the force occurred at the femoral bone (6370 N) in case of no rubber floor tiles. In addition, the aerobic dance on mini-trampoline can also provide positive effects and more safety[8,9]. Currently, there is no research that compares the effects of aerobic dance training on different surface.

Material and Method

Purpose of the study

The aim of this study was to compare the effects of aerobic dance on mini-trampoline and on hard wooden surface on bone resorption, health-related physical fitness, balance, and foot plantar pressure in Thai working women aged 35-45.

Subjects' selection and criterion

The participants were sixty-three volunteer working women who were verified and approved by committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University. The inclusion criteria were as follows: healthy women at the age of 35-45, able to participate in aerobic dance exercise, not smoking or consuming any alcoholic beverages, not taking hormone replacement therapy (HRT), consuming tea or coffee of not more than 2 standard cups per day (250 cc/cup), exercise not more than twice per week, not being diagnosed with osteoporosis (BMD not less than -2.5 SD), BMI being less than 24.9 kg/m^2, no liver diseases, no osteoarthritis and heart diseases. The subjects were assigned into three groups: a) aerobic dance on mini-trampoline (21 females), b) aerobic dance on hard wooden surface (21 females) and c) control group (21 females).

Instrument and data collection

Questionnaires to assess general health were distributed and the SAHARA® BMD was used to measure the heel bone mineral density (BMD).

The two experimental groups performed aerobic dance exercise that consisted of 40-minute exercise, 3 times a week for 12 weeks. The intensity of exercise was controlled by Polar heart rate monitor (M53) in order to achieve 60-80% of maximum heart rate. The two groups exercised simultaneously and the control group performed their usual activity of daily

life.

The health-related physical fitness testing were performed as follow: a body composition using the bioelectrical-impedance analysis (220, Inbody), peak oxygen uptake using modified Balke treadmill test, flexibility using sit and reach test, legs muscular strength and endurance using 1-minute chair sit to stand test, and balance using time up and go test. The testing instruments for bone formation and bone resorption were Elecsys 2010 "Hitachi" from Japan, β-Crosslaps and P1NP biochemical testing of Roche Diagnostics (Thailand) Co. Ltd.

The foot plantar pressure was tested using F-scan system (F-scan Datalongger-New) from USA by putting insole F-scan in sneakers of the two aerobic dance groups on mini-trampoline and hard wooden surface. The 4 positions measured were marching, easy walking, hopping, and bouncing. All participants wore the same type and brand of sneakers.

Methods

Before the experiment, the biochemical bone markers were tested by analyzing the blood for β-CrossLaps (ng/ml) and P1NP (ng/ml) value. The aerobic dance exercise program's validity was verified by 5 experts and its reliability was verified by checking the heart rate of those who were within the criteria. Prior to the experiment, all groups underwent the pre-test by using the research instruments. After taking the pre-test, the control group continued their daily activity routine while the other two experimental groups underwent the aerobic dance program. The aerobic dance exercise of the two groups consisted of 10-minute warm up, 20-minute aerobic dance exercise, and 10-minute after exercise cool down. The total of exercise was 40 minutes at the intensity of 60-80% of a maximal heart rate. The exercise of both experimental groups was held at the same place (indoor), the same exercise time at 17:20-18:00. Both aerobic dance exercise groups were performed simultaneously at the same frequency of 3 times a week for 12 weeks (Fig. 1, 2). After three weeks of the exercise program, both experimental groups' foot plantar pressure was tested by using F-scan system assesssing 4 postures: marching, easy walk, hopping and bouncing.

Data analysis and Results

The data from the pre- and post trainings were computer-analyzed for the mean scores, standard deviation, paired samples t-test and ANCOVA. The significant difference was at 0.05 level.

The characteristic data of the 42 subjects in the two experimental groups and 21 in the control group were presented. There were no significant differences

Fig. 1 Mini-trampoline compound: diameter of 1.22 m, stand all steel 8 pieces and height of ground 21.5 cm, pick weight 100 kg and spring 44 pieces.

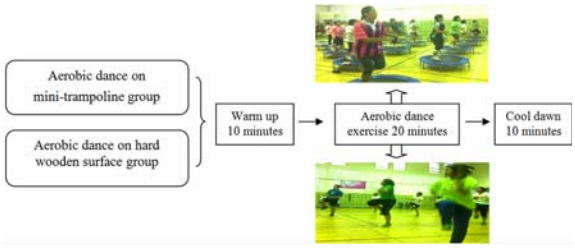

Fig. 2 Aerobic dance exercise.

Table 1. Subject characteristics (mean ± SD)

Variable	Group			F	Sig
	Aerobic dance on mini-trampoline (T_1: n = 21)	Aerobic dance on hard wooden surface (T_2: n = 21)	Control (C: n = 21)		
Age (year)	40.0±3.6	39.5±3.8	41.1±4.0	0.929	0.40
Height (cm)	158.1±6.4	157.7±4.8	158.1±5.5	0.037	0.96
T-score (BMD of the left)	0.4±0.2	0.4±0.1	0.5±0.1	2.889	0.06

Table 2. Before and after 12 weeks responses of the biochemical bone markers, physiological, health-related physical fitness and balance (mean ± SD)

Variable	Group					
	Aerobic dance on mini-trampoline (T_1: n = 21)		Aerobic dance on hard wooden surface (T_2: n = 21)		Control (C: n = 21)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Biochemical bone markers						
P1NP (ng/ml)	31.51±9.23	42.96±9.28*#	34.62±9.41	41.98±12.83*#	32.11±11.27	27.51±9.73*
β-CrossLaps, bCTx (ng/ml)	0.27±0.12	0.19±0.79*#	0.28±0.15	0.19±0.08*#	0.26±0.16	0.28±0.15
Physiological data						
BMI (kg/m^2)	23.05±2.41	22.24±1.82	23.37±1.86	22.54±2.13	22.24±1.83	22.42±2.02
Heart rate resting (bpm)	78.71±10.50	66.28±6.01*#	78.57±10.48	70.90±8.53*#	78.85±8.58	77.09±7.47
Systolic blood pressure (mmHg)	124.52±15.10	108.47±8.39*#	118.90±10.62	110.04±14.34*#	118.61±12.97	121.40±13.31
Diastolic blood pressure (mmHg)	79.52±9.24	68.90±10.05*#	74.90±6.72	66.42±7.67*#	74.80±8.09	77.57±8.69
Flexibility						
Sit and reach (cm)	5.85±6.29	9.65±5.24*#	7.52±8.57	11.23±6.61*#	4.28±6.45	2.38±7.41*
Balance						
Time up and go test (sec)	6.20±0.65	4.52±0.32*#$^{\alpha}$	6.33±1.04	5.21±0.56*#$^{\alpha}$	6.16±0.79	6.16±0.73
Muscle strength and endurance (times/min)						
Chair sit to stand	39.85±7.50	54.95±8.90*#$^{\alpha}$	37.19±4.94	45.61±6.71*#$^{\alpha}$	38.38±4.80	37.19±4.93
Oxygen peak uptake						
VO_2 peak (ml/kg/min)	24.31±4.67	36.19±4.67*#	22.61±2.59	34.14±2.52*#	22.76±3.95	22.35±2.91

* Difference from the pre-test is significant at the 0.05 level; # Difference from the control group is significant at the 0.05 level; $^{\alpha}$ Aerobic dance two groups are significantly different at the 0.05 level

in the mean age, height, and T score of BMD (Table 1). The results of this study were as follow: after the 12-week training, the biochemical bone markers on mini-trampoline and hard wooden surface aerobic dance training subjects decreased in bone resorption (β-CrossLaps) and increased in bone formation (P1NP), health-related physical fitness, and balance were significantly different at 0.05 level when comparing to the control group. The aerobic dance on mini-trampoline showed significantly better leg muscular strength and balance than aerobic dance on hard wooden surface at 0.05 level (Table 2). The results of the left and right foot plantar pressure from the two aerobic dance exercise groups measured in 4 positions were significantly different at 0.05 level (Table 3).

Discussion

After 12 weeks, the two groups of aerobic dance exercise increased in P1NP and decreased in β-CrossLaps when compared to the control group. As the aerobic dance exercise is weight bearing, the bones and joints continuously response to the stress being imposed on them which in turns caused changes to bone mineral density. Similarly, the research conducted by Kohrt et al[4] showed the positive effects of ground reaction force on bone mineral density. Including, Namboolu et al[9] studied the effects of outdoor mini-trampoline aerobic dance training on bone resorption and vitamin D in working women resulted in lower β-CrossLaps which presented similar results to Phoosuwan et al[13].

The flexibility and the VO_2 peak of the two aerobic dance groups increased significantly when comparing them to the control group. These may be due to the fact that the two exercise groups received proper instructions on how to perform correct exercise techniques and they were also led by the instructor during each exercise session thereby enhancing their physical performance[14]. The two aerobic dance groups showed better leg's muscular strength, muscular endurance, and balance than the control group. Furthermore, when comparing them between the two aerobic groups, the aerobic dance on mini-trampoline performed better than the aerobic dance on hard wooden surface because the aerobic dance on mini-trampoline required the subjects to balance themselves while exercising which in turns recruited more motor unit to stimulate the lower extremities. High motor unit recruitment will increase strength[15]. The previous study[9] showed that exercise on mini-trampoline increased muscular strength body stability, muscle coordinative responses, joint movement and spatial integration[8]. Also, challenging the motor system by exercising on a volatile surface will improve individual's balance ability[16].

After three weeks of the exercise program, the comparison of the insole F-scan sneaker measurement between left and right foot plantar pressure on mini-trampoline and hard wooden surface was done. Both groups exercised in 4-posture, aerobic dances: marching, easy walk, hopping, and bouncing. The mean of 4 postures showed that the left and right foot plantar pressure of the aerobic dance group performed on mini-trampoline was less than the group on hard wooden surface because mini-trampoline having springs adsorbed occurring impact force more than hard wooden surface. The hard wooden surface had higher impact force. In brief, soft material adsorbed impact force better than hard material, which can decrease the risk of joint injuries at high impact[11].

Table 3. Foot pressure aerobic dance exercise two groups measure by 4 positions (mean ± SD)

Variable (newton) (4 positions)	Group (left foot pressure)		Group (right foot pressure)	
	Aerobic dance on mini-trampoline (T_1: n = 21)	Aerobic dance on hard wooden surface (T_2: n = 21)	Aerobic dance on mini-trampoline (T_1: n = 21)	Aerobic dance on hard wooden surface (T_2: n = 21)
Marching	559.41±208.54	778.80±103.02*	569.59±216.34	748.39±161.10*
Easy walk	574.30±221.59	815.66±243.39*	547.43±213.46	777.01±184.66*
Bouncing	342.92±129.50	450.75±155.23*	331.75±125.68	435.80±110.18*
Hopping	1,254.40±430.32	1,591.93±582.61*	1,176.86±389.59	1,525.43±477.00*

* Difference from the aerobic dance on mini-trampoline left foot plantar pressure and difference from the aerobic dance on mini-right foot plantar pressure are significant at the 0.05 level

Conclusion

After the 12-week exercise program 3 times a week, the study found the aerobic dance on mini-trampoline and hard wooden surface had the positive effects on biochemical bone markers, health-related physical fitness, and balance. However, the aerobic dance on mini-trampoline showed better leg muscular strength and balance. The left and right foot plantar pressure in the aerobic dance group on mini-trampoline was less than the group on hard wooden surface.

Acknowledgement

This research was funded by Graduate School and Faculty of Sports Science, Chulalongkorn University. The authors would like to thank you the subjects who volunteered for this study and the staff at the Testing Research Center for Sports Material and Equipment, Faculty of Sports Science, Chulalongkorn University.

Potential conflict of interest

None.

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การเปรียบเทียบผลการฝึกเต้นแอโรบิกบนมินิแทรมโพลีนกับผลบนพื้นแข็งต่อการสลายมวลกระดูก, สุขสมรรถนะ การทรงตัว และแรงกดใต้ฝ่าเท้าในหญิงไทยวัยทำงาน

วิทวัส สุขแก้ว, ณรงค์ บุณยะรัตเวช, ณนอมวงศ์ กฤษณ์เพ็ชร์

วัตถุประสงค์: เพื่อเปรียบเทียบผลของการฝึกเต้นแอโรบิกบนมินิแทรมโพลีนและบนพื้นแข็งต่อการสลายมวลกระดูก, สุขสมรรถนะ, การทรงตัว และแรงกดใต้ฝ่าเท้าในหญิงไทยวัยทำงาน

วัสดุและวิธีการ: อาสาสมัครหญิงวัยทำงานที่มีอายุระหว่าง 35-45 ปี จำนวน 63 คน โดยเข้ากลุ่มตามความสมัครใจแบ่งออกเป็น 3 กลุ่ม คือ กลุ่มฝึกเต้นแอโรบิกบนมินิแทรมโพลีน 21 คน กลุ่มฝึกเต้นแอโรบิกบนพื้นแข็ง 21 คน และกลุ่ม ควบคุม 21 คน กลุ่มที่ฝึกเต้นแอโรบิกจะทำการฝึกเต้นพร้อมกับคาดเครื่องวัดอัตราการเต้นของหัวใจ (Heart rate monitor) ความหนักของ การออกกำลังกายคือ 60-80% ของอัตราการเต้นหัวใจสูงสุด ครั้งละ 40 นาที (อบอุ่นร่างกาย 10 นาที เต้นแอโรบิก 20 นาที และคลายอุ่นร่างกาย 10 นาที) 3 วันต่อสัปดาห์ เป็นระยะเวลา 12 สัปดาห์ และกลุ่มควบคุม ใช้ชีวิตประกอบกับกิจกรรมทางกายตามปกติ เก็บข้อมูลทั้งก่อนและหลังการทดลอง ได้แก่ ทดสอบข้อมูลพื้นฐานทางสรีรวิทยา การสร้างมวลกระดูก (P1NP) การสลายมวลกระดูก (β-CrossLaps) สุขสมรรถนะ การทรงตัว และแรงกดใต้ฝ่าเท้า นำผลที่ได้จากการทดลองทั้งก่อนและหลังการทดลองมาวิเคราะห์หาความแตกต่างภายในกลุ่มโดยทดสอบค่าที แบบรายคู่ (Paired t-test) และเปรียบเทียบระหว่างกลุ่มด้วยการวิเคราะห์ความแปรปรวนร่วม (Analysis of Covariance) ระดับความมีนัยสำคัญทางสถิติที่ 0.05

ผลการศึกษา: หลังการทดลอง 12 สัปดาห์ พบว่ากลุ่มที่ออกกำลังทั้ง 2 กลุ่ม มีค่าการสลายมวลกระดูก (β-CrossLaps) ลดลงและค่าการสร้างมวลกระดูก (P1NP) เพิ่มขึ้นรวมทั้งสุขสมรรถนะและการทรงตัวดีขึ้น เมื่อเทียบกับก่อนการทดลองและกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 แต่กลุ่มที่เต้นแอโรบิกบนมินิแทรมโพรลีนเมื่อเปรียบกับกลุ่มที่เต้นแอโรบิกบนพื้นแข็งพบว่า ความแข็งแรงและความอดทนของกล้ามเนื้อขาและการทรงตัวดีกว่า และยังพบแรงกดใต้ฝ่าเท้าบนมินิแทรมโพลีนมีน้อยกว่าอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05

สรุป: การเต้นแอโรบิกบนมินิแทรมโพลีนและบนพื้นแข็งมีผลต่อสารชีวเคมีของกระดูก สุขสมรรถนะการทรงตัว และแรงกดใต้ฝ่าเท้า แต่ในการเต้นแอโรบิกบนมินิแทรมโพลีนจะช่วยให้ความแข็งแรงและความอดทนของกล้ามเนื้อขาและการทรงตัวดีกว่า และลดการบาดเจ็บของข้อต่อจากแรงกดใต้ฝ่าเท้าได้ดี ซึ่งจะเป็นการออกกำลังกายทางเลือกใหม่ของหญิงวัยทำงานทั่วไปได้