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Research Article

THE IMPACT OF AEROBIC EXERCISE ON BONE HEALTHINDICATORS

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aerobic training exercise, osteopenic, osteoporosis, calcium, T-score, BAP, BMD

A B S T R A C T

Study objective: the main objective of this study was to investigate the impact of aerobic exercise on bone health through measuring serum trace elements and bone metabolism markers.
Methods and subjects: prospective interventional study was conducted at rheumatoid clinics in Royal Medical Services, Jordan. A total of 117 participants were included of whom 52 participants were males and 65 were females.Participants were assigned into three groups: control group (N=35), osteopenic group (N=45), and osteoporotic group (N=37).A standard aerobic exercise protocol was followed for 12 weeks.Endurance exercise protocol involved three sessions weekly for 60 min each. At basal level and after the experiment, the following parameters were assessed: BMI, BAP, T-score, BMD and calcium. The analysis of data was carried out using SPSS version 21. The difference in means was computed based on T-test. Significance was considered at $p<0.05$.
Results: aerobic training exercise improved the levels of all parameters in all groups for both sexes significantly including BMI, BAP, T-score, BMD, and calcium ($p<0.05$).
Conclusion: Aerobic training exercise improves bone health and restores the hemostasis of bone tissue through restoring bone biomarkers including BAP and calcium.

INTRODUCTION

Osteoporosis is associated with low bone mineral density (BMD), poor bone geometry, and by Harvey, Dennison, and Cooper (2010), it was shown that fractures of hip to be associated with 20% mortality within12 months.

Physical activity (PA) has a therapeutic potential against chronic diseases particularly that associated with ageing (Sallis, 2015). Moderate levels of PAhave been reported to be associated with better outcomes of health (Norton, Norton, and Lewis, 2016; Puciato, Rozpara, and Borysiuk, 2018). The exact mechanisms explaining how PA benefits bone health are not well understood, but it is thought that PA exerts mechanotransduction effects on bone (Tan *et al*., 2014; Wippert *et al*., 2017). The contractions of muscles exert extracellular fluid shear stress within bone matrix leading to bone deformations (Heleen *et al*., 2018). Other studies pointed to the gravitational impacts on the production of bone deformation through fluid shear stresses in addition to mechanotransduction (Amstrup *et al*., 2016; Yavropoulou and Yovos, 2016).

McMillan *et al* (2017) conducted a review study in which the relationship between osteoporosis and physical activity (PA) was investigated in the light of existing literature. Osteoporosis is a disease that depends on age and accompanied by low bone mineral density (BMD) andbone geometry and microarchitecture ending with lowered bone strength. PA is thought to have therapeutic implications in osteoporosis.

Aldahr (2012) conducted a study to investigate the variationsofbone mineral status after training for 6 months between two groups of postmenopausal women: aerobic and resistance exercise. The study included 50 postmenopausal women who were assigned into two groups (N=25); the first group (A) was assigned to receive resistance exercise training, whereas the second group (B) was assigned to receive aerobic exercise training. The results showed that both types of training significantly increased the mean levels of bone mineral density (BMD), serum calcium (Ca) and parathyroid hormone (PTH). Changes in group (A) were significantly more than that in group (B).

Study objectives

The objective of this study was to investigate the impact of aerobic exercise on bone health through measuring serum trace elements and bone metabolism markers on a sample of participants with osteopenia and osteoporosis in comparison with control subjects.

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Methods and subjects

Study design and setting

Prospective interventional study was conducted. The study was conducted at rheumatoid clinics in Royal Medical Services, Jordan.

Study sample

A total of 117 participants were included of whom 52 participants were males and 65 were females.

Study procedure

The study was approved by ethical committee at Royal Medical Services. Participants were assigned into three groups: control group (N=35), osteopenic group (N=45), and osteoporotic group (N=37).

At basal level, body mass index (BMI) was measured as well other physiological parameters such as blood pressure, hip and waist. A blood sample was withdrawn from each participant to test for calcium, and bone specific alkaline phosphatase (BAP). At the end of the experiment, all measurements were repeated.

Patients were previously diagnosed as osteopenic or osteoporotic. Control subjects were recruited from general population to participate in this study.A standard aerobic exercise protocol was described by the study of Aldahr (2012). We followed this protocol with some modifications. The aerobic exercise was applied for all participants for 12 weeks. Endurance exercise protocol involved three sessions weekly. The time of each session was 60 min. Appropriate music was involved to make a feeling of relaxation. Exercise training protocol involved stretching and warm-up (10-15 minutes), aerobic activities such asstepping and graded walking (35-40 minutes), and cool-down/relaxation (10 minutes).

Statistical analysis

Data were analyzed using SPSS version 21. Descriptive statistical analysis was conducted to describe the general characteristics of participants. Frequency was used to describe categorized variables such as gender. Means were used to describe continuous variables such as age, T-scores, calcium level, and BAP. The differences in means were used to determine using paired T test. Significance was considered at $p< 0.05$.

RESULTS

General characteristics of study participants

As seen in table 1, the study included 117 participants of whom 35 participants as control subjects, 45 osteopenic, and 37 osteoporic. A total of 52 participants were males, the mean age in control group was 43.3 years, osteopenic group 45.7 years, and osteoporotic group 50.5 years. The body mass index level was lowest in control group and significantly increased in osteopenic and osteoporotic groups ($p<0.05$ for both). The calcium level was the highest in control group (91.4 mg/l), and significantly decreased in osteopenic and osteoporotic groups ($p<0.001$ for both). The level of BAP in control group was 17.5 mcg/L and decreased significantly in osteopenic and osteoporotic groups ($p<0.001$ for both).

Table 1 General characteristics ofstudyparticipants

parameters	Normal control (T-score=0 to -0.99)	Osteopenic (T-score=1 to -2.49)	Osteoporotic (T-score ≤ -2.5)
N	35	45	37
Male/Female	15/20	22/23	15/22
Age(years)	43.3	45.7	50.5
BMI(kg/m^2)	25.4	26.8*	29.2*
Calcium (mg/L)	91.4	66.7**	59.2**
BAP	17.5	11.3**	10.1**

*p<0.05 (osteopenic or osteoporotic vs control), **p<0.001(osteopenic or osteoporotic vs control)

The impact of aerobic exercise on female trace elements and bone metabolism markers

The results showed that in control group, there were significant relationshipsfor all variables listed in table 2 due to the aerobic exercise ($p<0.05$ for all variables). In both groups, osteopenic and osteoporotic groups, there were strong impacts of aerobic exercise on the outcome of all listed variables ($p<0.001$).

Table 2 Comparison of serum trace element (mg/L) and the bone metabolism markers for female subject (N=65) before and after 12-week aerobic exercise taining (mean ± SD)

parameters	Normal control (N=20) (T-score=0 to -0.99)		Osteopenic (N=23) (T-score=1 to -2.49)		Osteoporotic (N=22) (T-score ≤ -2.5)	
	Pre	Post	Pre	Post	Pre	Post
BMI(kg/m^2)	25.6	25*	27.3	26.4*	29.4	28.5*
BAP	17.4	24.5*	11.1	23.3**	9.9	17.1**
T-score	-0.61	-0.4*	-1.6	-1.1**	-3	-2.2**
BMD hip (g/cm^2)	0.85 ± 0.1	0.95*	0.81	0.92**	0.7	0.94**
BMD spine (g/cm^2)	0.86± 0.1	0.96*	0.99	1.4**	0.91	1.7**
Calcium (mg/L)	91.1	120*	66.5	101**	58.4	110.6**

*p<0.05 (pretest VS posttest of each group), **p<0.001 (pretest VS posttest of each group)

The impact of aerobic exercise on male trace elements and bone metabolism markers

The results showed that in control group, there were significant relationships for all variables listed in table 3 due to the aerobic exercise ($p<0.05$ for all variables). In both groups, osteopenic and osteoporotic groups, there were strong impacts of aerobic exercise on the outcome of all listed variables ($p<0.001$).

Table 3 Comparison of serum trace element (mg/L) and the bone metabolism markers for female subject (N=52) before and after 12-week aerobic exercise training (mean ± SD)

parameters	Normal control (N=15) (T-score=0 to -0.99)		Osteopenic (N=22) (T-score=1 to -2.49)		Osteoporotic (N=15) (T-score ≤ -2.5)	
	Pre	Post	Pre	Post	Pre	Post
BMI(kg/m^2)	25.1	24.7*	26.3	25.1**	28.9	28.1*
BAP	17.6	24.4*	13.2	24**	10.4	20.5**
T-score	-0.5	-0.3*	-1.8	-1.2**	-2.8	-1.9**
BMD hip (g/cm^2)	0.84	0.99*	0.82	0.9**	0.71	0.8**
BMD spine (g/cm^2)	0.83	0.89*	1.1	1.5**	0.92	0.99**
Calcium (mg/L)	91.8	121*	66.9	102**	60.4	115**

*p<0.05 (pretest VS posttest of each group), **p<0.001 (pretest VS posttest of each group)

DISCUSSION

The data of the present study showed that aerobic exercise for 12 weeks had positive impacts on bone health among three groups involved in this study: control group, osteopenic group, and osteoporotic group for males and females ($p<0.05$ for all variables). These findings agree with other studies that showed positive impacts of aerobic exercise on bone health (Aldahr, 2012;Norton, Norton, and Lewis, 2016;McMillan *et al*., 2017;Puciato, Rozpara, and Borysiuk, 2018). Due to the nature of aerobic exercise training protocols involved in this study such as stretching and warm-up, stepping and graded walking, and cool-down/relaxation, it is plausible to think of improved bone health to due to such mechanisms involving mechanotransduction effects on bone (Tan *et al*., 2014; Wippert *et al*., 2017), and extracellular fluid shear stress within bone matrix (Heleen *et al*., 2018).

BMI levels were significantly lowered in all groups ($p<0.05$). This means that applying aerobic exercise protocol for 12 weeks was effective in lowering weight as reflected by lowered BMI. This finding is in line with other studies (Aldahr, 2012; Langsetmo *et al*., 2012).The results of this study showed that aerobic exercise training protocols significantly increased the levels of BAP in all groups. Actually, this finding indicated that aerobic training for 12 weeks improved bone formation leading to better outcomes of bone health. These findings are consistent with previous studies that reported similar results (Maimoun *et al*., 2004; Gonzalez-Aguero *et al*., 2012; Alghadir, Aly, and Gabr, 2014).

The results of the present study showed significant improvement of T- scores and BMD due to aerobic exercise in all study groups ($p<0.05$). These findings revealed that aerobic training protocol we applied was efficient and helped restoring the structure and function of bone tissue in all groups, particularly in osteopenic and osteoporotic groups. These results are in agreement with other studies that reported significant improvement of T-score and BMD as a result of moderate aerobic training exercise (Trivitayaratana W and Trivitayaratana P, 2005;Aldahr, 2012;Alghadir, Aly, and Gabr, 2014; Alghadir *et al*., 2016).

The results of the present study showed that the levels of calcium at basal level were significantly lowered in ostoepenic and osteoporotic groups than control group ($p<0.001$). Aerobic exercise improved the calcium levels significantly in all study groups ($p<0.05$). These results suggested that aerobic exercise can restore the hemostasis of calcium which is crucial for numerous biological mechanisms such as bone metabolism (Narattaphol, 2007). These finding agree with other studies that revealed the improvement of calcium levels due to exercise training (Aldahr, 2012; Alghadir, Aly, and Gabr, 2014; Alghadir *et al*., 2016). It is plausible to explain the increased levels of calcium as a consequence of aerobic training exercise through stimulation of parathyroid glands to produce and release more parathyroid hormone which, in turn, leads to mobilization of calcium from its stores into blood (Kelly, Eisman, and Sambrook, 1990; Kara, 2011; Alghadir *et al*., 2016). The results of this study showed the effects of aerobic exercise on improving the bone health as previously mentioned in both sexes, and this finding agrees with the study of Alghadir *et al* (2016).

CONCLUSION

Aerobic training exercise improves bone health and restores the hemostasis of bone tissue through restoring bone biomarkers including BAP and calcium. Aerobic training protocol helps in lowering the risk of osteoporosis in both sexes.

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