Research Article

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Effects of aerobic plus explosive power exercises on bone remodeling and bone mineral density in young men
Genç erkeklerde aerobik ve çabuk kuvvet egzersizlerinin kemik yeniden şekillenmesi ve kemik mineral yoğunluğu üzerinde etkileri

Abstract

Objectives: This study aims to examine effects of aerobic jogging and explosive power exercises on body composition, maximal oxygen consumption (MaxVO2), bone mineral density (BMD) and bone turn-over markers: serum bone alkaline phosphatase (BAP), C terminal telopeptide (CTx), Procollagen type I N-terminal propeptide (PINP), in men aged between 20 and 40.

Materials and methods: Thirty seven healthy males were divided into exercise group (EG, n=19) and control group (CG, n=18). EG completed 10 weeks of outdoor aerobic (jogging at 60–70% maximal heart rate reserve starting from 20 min steadily increasing up to 28 min) and explosive power exercises (in 2–3 sets, with maximum repetitions lasting 15 s), 3 times per week. All measurements were taken before and after the exercise program. BMD was measured via dual energy X-ray absorptiometry (DEXA).

Results: Body mass index (p<0.001) significantly decreased; MaxVO2 (p<0.001), femur neck (p=0.036) and total score BMD significantly increased in EG (p=0.034). BAP and vitamin D increased in both groups (p<0.001).

Conclusion: Performing our outdoor exercise program in spring months might have an important role in the significant increase (9 vs. 22 ng/mL) in mean vitamin D level, which reached above the fracture risk level of 20 ng/mL.

Keywords: Aerobic exercises; Explosive power exercises; Bone density; Bone turn-over markers.

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Amaç: Bu çalışma 20–40 yaş arası erkeklerde aerobik koşu ve çabuk kuvvet egzersizlerinin vücut kompozisyonunu, maksimal oksijen tüketimini (MaxVO2), kemik mineral yoğunluğu (KMY) ve kemik döngüsü (turn-over) markerlerinden serum kemik alkalen fosfat (BAP), C terminal telopeptide (CTx), Procollagen tip I N-terminal propeptide (PINP) üzerine etkilerini incelemeyi amaçlamıştır.

Gereç ve Yöntemler: Otuzyedi sağlıklı erkek, egzersiz grubu (EG, n=19) ve kontrol grubu (KG, n=18) olarak ayrıldı. EG 10 hafta, haftada 3 gün, günde 20 dakika ile başlayan 28 dk’ya ulaşan sürelerde aerobik koşu (%60–70 maksimal kalp atm rezervi) ve çabuk kuvvet egzersizleri (2–3 set, 15 saniyelik maksimum tekrarlı) uyguladı. Tüm ölçümler antrenman programından önce ve sonra alındı. KMY, Dual-energy X-ray absorptiometry ile ölçüldü.
Bulgular: EG’nin beden kütle indeksinde \((p<0.001)\) anlamlı azalma; \(\text{MaxVO}_2\) \((p<0.001)\), femur boynu \((p=0.036)\), ve toplam KMY \((p=0.034)\) değerlerinde istatistiksel olarak anlamlı artışlar elde edildi. BAP ve vitamin D her iki grupta da anlamlı olarak arttı \((p<0.001)\).

Sonuç: Ağırlık alan egzersiz programımız ilk bahar aylarında gerçekleştirmek D vitamini düzeylerinin kırık riskini seviyesi olan 20 ng/mL üzerinde çıkacak şekilde artacağı sonda \((9 \text{ ng/mL ye karşın 22 ng/mL})\) önemli bir rol oynamış olabilir.

Anahtar Sözcükler: Aerobik egzersiz; Çubuk kuvvet egzersizleri; Kemik yoğunluğu; Kemik döngüsü markerleri.

Introduction

Osteoporosis is generally considered as a disease affecting women but it is also a health problem for men. Osteoporosis is evidently a gradually increasing risk factor for men. The main reason of osteoporosis, a significant public health issue, is its relation with bone fracture [1]. It is known that physical activity has some significant osteogenic effects and these effects are related to modeling–remodeling courses and mechanical loads [2]. In recent studies based on age and gender three bone markers are discussed: BAP, PINP and CTX [3]. ALP, PINP, and BAP are considered the markers of osteoblastic activity; however, CTX is used as a bone resorption marker [4]. During the production of fibril, while Collagen Type 1 is being processed out of cells, at first amino terminal propeptide containing amino acid and carboxy terminal propeptide containing carbon are formed. These peptides circulate in circulation system and give information about the rate of type 1 collagen synthesis in the body as bone formation precursors. Serum PINP levels have a significant relation with the rate of bone formation, however, non-bone tissues also participate in the serum concentration of these components [5].

BAP is an enzyme secreted by osteoblasts and increased serum level of it indicates an increase in osteoblast activities. Moreover, it is also the result of bone resorption [3]. More than 90% of organic bone matrix consists of type 1 collagen which is synthesized within bone. In physiologically and pathologically increased bone resorptions type 1 collagen increasingly breaks down and there is a proportional increase in the levels of collagen fragments in blood. The specific related collagen type 1 fragments are C terminal telopeptide (CTX). Aspartic acid found in C terminal telopeptide turns into the form of aspartic acid (CTX) with age. These isomerized telopeptides are specific for break down of type 1 collagen domination in bone [6]. Vitamin D has an important role on bone metabolism for its effects on calcium homeostasis and bone mineralization process. Studies show that sufficient vitamin D level with exercises is necessary to increase and grow bone mass [2].

There is evidence that mechanical loading applied to bone affects bone formation and bone remodeling process [7]. Research has proven that resistance training is useful in increasing bone mineral density (BMD) [8–10]. Some researchers determined positive effects of aerobic exercises on bone mass [11]. In addition, the results of combined exercise programs indicated more positive results on increasing and maintaining bone mass [12–14]. However, literature about the pure effects of physical exercises carried out using body weight against gravity in a relatively short time on BMD and bone turn-over related markers in young males without taking any medical supplements is limited. Therefore; this study aims to examine the pure effects of aerobic jogging and explosive power exercises on body composition, maximal oxygen consumption \((\text{MaxVO}_2)\), BMD and bone turn-over markers such as BAP, CTx and PINP in 20–40 year-old men.

Materials and methods

Subject selection

In this study, 37 males aged 20–40 and living in Manisa participated voluntarily. Participants were chosen by face to face interview or leaflets and their written consent was taken. Those having chronic diseases, being under regular medical treatment, having vitamin D or calcium supplements, and having musculoskeletal diseases were discarded. In order to determine the number of participants in groups, 80% effect size, 80% power and 95% confidence interval were taken 11 participants for each group were calculated. We planned to include 18 subjects to each group thinking that effect size could not be provided for all the biochemical markers. Therefore, 19 healthy males participated in EG, and 18 healthy males participated in CG without randomization in order to increase their participation in the study.

Before starting the study, all participants had health control. They filled out ‘the nutritional habits section’ of the ‘health-profile lifestyle profile’ survey developed by Walker et al. [15]. There were no statistically significant differences on nutritional habits between two groups.

The ethical council of Celal Bayar University Faculty of Medicine approved the study. The study was conducted in accordance with the principles of Helsinki Declaration.
Study design

This study was an intervention study conducted with exercise. Before the study began, the participants were made to take a pre-training course for 2 weeks in order to adapt the exercise modes. All blood samples were taken and tests were carried out at the same hours to control the circadian variation in performance. Body composition analyses of the participants were performed using bioelectrical impedance analysis method (Tanita 300 MA, Tanita C.O, Tokyo-Japan). Body mass index (BMI) was calculated as body weight/height² (kg/m²). MaxVO₂ was estimated by 2 km walking test [16]. In this test, participants were asked to walk 2 km on a 400 m outdoor track as fast as possible. The test was performed on a 400 m out door track by completing five tours. At the end of the test heart rates (HR) and finishing times were recorded by exercise experts. There was emergency staff in case of emergency health cases. The following predictive equation developed for men was then used to estimate MaxVO₂ from the heart rate, age, BMI and the duration:

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184.9 - 4.65 \times \text{duration (min)} - 0.22 \times \text{HR} - 0.26 \times \text{age} - 1.05 \times \text{BMI}
\]

Subjects were told to avoid any physical activity within 48 h preceding the assessment day.

Exercise program

The exercise group carried out aerobic jogging on an outdoor track (400 m) and explosive power exercises, three times a week under the supervision of exercise experts. However, the control group continued their daily routine and did not do any exercises for 10 weeks. The exercise program was designed to be carried out securely and easily by all exercise group participants. The exercise program was planned according to the principles of the American College of Sport Medicine recommendations [17]. The exercise intensity was prescribed based on target heart rates (THR) and finishing times were recorded by exercise experts. Before beginning the aerobic exercises all the participants were ensured to run at the target heart rate by Polar Vantage NV (Polar, Kempele, Finland) pulse meter. Participants’ heart rates were measured three times in equal intervals in each running session. Then, the individual training heart rates were calculated by taking the mean of the three measurements. Rate of perceived exertion (RPE) was determined by The Borg Scale.

After each running session, EG performed explosive power exercises. These exercises consisted of push-ups, sit ups, hyperextension, prone cobra, jump squat, lateral leg raises (at 90° waiting for 3 s) and were performed at the highest speed at a maximum number in 15-s periods. Each exercise was performed in two sets during the first 4 weeks and three sets during the last 6 weeks. The resting period between the sets was 1.5 min and was 5 min between the series. There were 8–10-min warm-up sessions at the beginning of the exercises and 3–5-min stretching sessions in the end. The exercise program was based on the gradual loading and individual loading principles.

Blood analyses and bone mineral density measurements

Following a 12 h overnight fast, venous blood samples were collected from an antecubital vein (20 mL) in the sitting position after a 20-min rest between 8:00 and 9:00 a.m. The items and the devices used for measurements are as follows: BAP, calcium, and phosphorus tests in advia 1800 device; 25-hidroksi vitamin D in Cobas device (Roche Diagnostics GmbH, D-68298, Mannheim, Germany) with kits by spectrofotometric method in autoanalyzer. Daily inner quality tests and monthly outerquality tests were done regularly by the lab experts. CTx was assessed by an electrochemiluminescence immunoassay on Roche E170 immunoassay analyzer (Roche Diagnostics GmbH., Mannheim, Germany). The inter and intraassay coefficient of variation (CV) for CTx at level 0.45 ng/mL were 4.2 and 2.0%, respectively. Human (PINP) levels in blood samples were examined by Elisa method with commercial kits (SunRed Bio, Shanghai, China). The intra-assay coefficient variation (CV) values of the kit were calculated as <10%. The human BAP levels in serum samples were examined by Elisa method with commercial kit (immunodiagnostic systems limited, UK). The intra-assay coefficient variation (CV) values of the kit were calculated as <6.5%. Inter-assay CV values were calculated as <5.8%. Serum was separated by centrifugation, and samples were stored at −80°C until assays were performed (within 1 month) in all samples. Total and regional BMD were assessed non-invasively using dual energy X-ray absorptiometry (model DPX-L, Lunar Radiation Corp., Madison, WI, USA).
**Statistical analysis**

In order to analyze whether the pre-test values of the parameters distributed normally, Shapiro-Wilk test was used for both EG and CG. In the descriptive statistics of data, mean ± SD was used when parametric conditions were provided. If nonparametric conditions were provided they were presented as median (min–max). In the analytic evaluations, both time effect (pre-post intervention) and between-group effect and the interaction of these two factors were analyzed using multivariate ANOVA F test (two way ANOVA) when parametric conditions were provided. Significant results were checked from the model for within group and between group effects. Statistical analyses were carried out in EG and CG separately when interactions were determined. If the parametric conditions were provided, paired t-test was used and Wilcoxon test was used when parametric conditions were not provided. In statistical hypothesis testing, significance was p < 0.05 for all comparisons and SPSS 23.0 software program was used for statistical evaluation of the dataset.

**Results**

EG members who aimed to run at 60–70% HRRmax had an average heart rate of ~147.28 ± 2.73 beat·min⁻¹ (corresponding to ~64% of HRRmax) during the training. Mean walking speed for the whole program for EG was ~8.54 ± 0.67 km/h. The RPE reported by EG was 14.17 ± 1.17. Total distance run was 138495 ± 5124 m. Pre-study characteristics of the subjects were not significantly different except for MaxVO₂ (Table 1).

Baseline characteristics of the participants were given as mean ± SD in Table 1. Physical and physiological pre- and post-intervention descriptive statistics and comparisons of the two groups were given in Table 2.

Upon analyzing body fat percentage change by time together with the group effect in the model, no statistical significance was determined (p: 0.099). In the evaluation of BMI by time, BMI was found to be significantly decreased in EG (p < 0.001); but the reduction in CG was not significant (p: 0.177). The change of VO₂max by time was evaluated a significant reduction was observed in EG (p < 0.001); however, no significant change was observed in CG (p: 0.180).

Descriptive and comparative results of blood pre and post intervention values according to groups were given in Table 3. Models, by which between groups interventions of repeated measured values of Calcium, phosphor and PINP were controlled, were found not to be statistically significant (p values 0.447, 0.929, 0.085, respectively). Vitamin D levels of both groups were increased (p < 0.001), however, this increase was more remarkable in EG and its vitamin D level is significantly higher (p: 0.020). The repeated measures of Bone ALP values were found to be significant in both groups (p < 0.001), but between group difference was not significant (p: 0.512).

Pre and post-intervention BMD descriptive and comparative statistics of both groups were given in Table 4. Neck and total BMD repeated measures (within group) were found statistically significant (p: 0.036, 0.034, respectively); this increase was more remarkable in EG; neck and total BMD scores of EG were significantly higher (p < 0.001, p: 0.005, respectively). Pre- and post-intervention total BMD scores of the groups are given in Figure 1.

L1–L2, L2–L3, L2–L4, wards, trochanter, and shaft BMD measures were evaluated but no significant changes were found.

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**Table 1:** General characteristics and comparisons of participants at baseline (mean ± SD).

| Parameters          | EG (n=19) Mean ± SD | CG (n=18) Mean ± SD | EG (n=19) p-Value | CG (n=18) p-Value | EG vs. CG p-Value |
|---------------------|---------------------|---------------------|-------------------|-------------------|------------------|
| Age (years)         | 33.26 ± 6.67        | 36.66 ± 3.89        | 0.028             | 0.022             | 0.123            |
| Height (cm)         | 175.84 ± 4.91       | 175.05 ± 7.36       | 0.099             | 0.617             | 0.707            |
| Body weight (kg)    | 85.25 ± 9.16        | 81.22 ± 10.47       | 0.923             | 0.568             | 0.220            |
| BMI (kg/m²)         | 27.23 ± 2.83        | 26.46 ± 2.81        | 0.989             | 0.183             | 0.416            |
| Percent body fat (%)| 20.58 ± 5.73        | 22.45 ± 6.04        | 0.002             | 0.007             | 0.167            |
| VO₂max (mL·kg⁻¹·min⁻¹) | 45.57 ± 9.35     | 38.73 ± 5.03        | 0.001             | 0.001             | 0.054            |

EG, Exercise group; CG, control group. *p < 0.05; †p < 0.01. Shapiro-Wilk test was used to determine whether the groups are distributed normally or not. To compare pre-test values, Independent t-test or Mann Whitney U-test was used according to distribution of the groups.
Discussion

In the present study we investigated the effect of 10-weeks jogging plus explosive power exercise programs on bone turn-over-related markers and bone mineral density in men aged 20–40 years. The program had positive effects on cardiorespiratory function and some physical characteristics of the exercise group members. However, the most outstanding result of the study is the increase determined in the femoral neck, shaft, and total score BMD values, together with the significant increase in the bone formation marker BAP. Another remarkable finding is the increase in vitamin D, which has a positive effect on bone remodeling process.

According to Wolff’s law, stress or mechanical loading applied to the bone via the muscle and tendons...
has a direct effect on bone formation and remodeling [7]. There is evidence that resistance training has beneficial effects on bone mineral density (BMD) [8–10]. However, the results of some studies revealed no increase in BMD after resistance training [18, 19]. Aerobic exercise also increases bone mass by using body weight as the resistance. Walking and running are great ways to increase or maintain bone mass while increasing cardiovascular fitness [11]. However, studies investigating the effects of aerobic training on BMD are quite scarce and have contradictory results. While low intensity walking exercise resulted in no significant change in bone mineral density [20], a 24-week program of aerobic high-impact loading exercise was found to increase the BMD of the L2–L4 and the femoral neck [12]. The researchers concluded that aerobics combined with high-impact exercise at a moderate intensity is effective in offsetting the decline in BMD in osteopenic postmenopausal women. Parallel to the aforementioned results, our 10-week aerobic jogging program combined with explosive power exercises resulted in significant increases in femoral neck, shaft and total score; therefore, more site-specific exercises should be

|          | Pre-intervention | Post-intervention | Multivariate F test | Within group | Between group |
|----------|------------------|-------------------|---------------------|--------------|--------------|
| L1–L2 (g/cm²) |                  |                   |                     |              |              |
| EG (mean ± SD) | 1.06 ± 1.3       | 1.09 ± 1.5        | F = 1.678           | NA           | NA           |
| CG (mean ± SD) | −0.33 ± 1.5      | −0.26 ± 1.2       | p = 0.204           |              |              |
| L2–L3 (g/cm²) |                  |                   |                     |              |              |
| EG (mean ± SD) | 1.24 ± 1.6       | 1.22 ± 1.6        | F = 0.478           | NA           | NA           |
| CG (mean ± SD) | −0.29 ± 1.3      | −0.17 ± 1.3       | p = 0.494           |              |              |
| L2–L4 (g/cm²) |                  |                   |                     |              |              |
| EG (mean ± SD) | 1.03 ± 1.6       | 1.08 ± 1.6        | F = 2.382           | NA           | NA           |
| CG (mean ± SD) | −0.35 ± 1.3      | 0.05 ± 1.5        | p = 0.132           |              |              |
| Femoral neck (g/cm²) |              |                   |                     |              |              |
| EG (mean ± SD) | 1.25 ± 0.2       | 1.27 ± 0.2        | F = 4.768           | F = 4.768    | F = 14.419   |
| CG (mean ± SD) | 1.1 ± 0.1        | 1.1 ± 0.1         | p = 0.036*          | p = 0.036*   | p < 0.001b   |
| Ward's (g/cm²) |                |                   |                     |              |              |
| EG (mean ± SD) | 1.1 ± 0.2        | 1.2 ± 0.2         | F = 0.001           | NA           | NA           |
| CG (mean ± SD) | 0.9 ± 0.2        | 0.9 ± 0.1         | p = 0.974           |              |              |
| Trochanter (g/cm²) |             |                   |                     |              |              |
| EG (mean ± SD) | 1.0 ± 0.1        | 1.0 ± 0.1         | F = 3.971           | NA           | NA           |
| CG (mean ± SD) | 0.9 ± 0.1        | 0.9 ± 0.1         | p = 0.054           |              |              |
| Shaft (g/cm²) |                 |                   |                     |              |              |
| EG (mean ± SD) | 1.4 ± 0.2        | 1.4 ± 0.2         | F = 2.597           | NA           | NA           |
| CG (mean ± SD) | 1.3 ± 0.2        | 1.3 ± 0.2         | p = 0.116           |              |              |
| Total score (g/cm²) |           |                   |                     |              |              |
| EG (mean ± SD) | 1.2 ± 0.14       | 1.26 ± 0.16       | F = 4.889           | F = 4.889    | F = 8.771    |
| CG (mean ± SD) | 1.1 ± 0.15       | 1.10 ± 0.14       | p = 0.034*          | p = 0.034*   | p = 0.005b   |

F: in nonexistence of group & time interaction, in parametric conditions, two-way ANOVA F test. NA, Non-available. *p < 0.05; p < 0.01.
In recent years, Dual energy X-ray absorptiometry (DEXA) is frequently used to quantify BMD and to diagnose osteoporosis or osteopenia; however, it may not be so effective in monitoring the efficacy of a medical or exercise therapy in a few months. For this purpose, bone turnover markers are used in clinical practice. Biochemical markers of bone remodeling, a dynamic process of breakdown and renewal of bone in order to maintain mechanical integrity of skeleton, provide a dynamic measurement of skeletal status [24]. In our study we analyzed the following markers: BAP, PINP and CTX. BAP is a tetrameric glycoprotein found on the membrane of the osteoblast cell. Although the function of BAP is not fully understood, BAP levels are considered to reflect osteoblastic activity and can therefore be used as a marker of bone formation [25]. Increases in the bone formation marker PINP indicate increased osteoblast activity during bone metabolism. Serum CTX is a marker of osteoclast activity and is used to assess the level of bone resorption [26]. However, the results of the studies on the effects of exercise on these markers are conflicting. The EPIDOS study has determined the relevance of elevated CTX levels in predicting severe clinical events, such as hip fractures [6]. Herrmann and Herrmann stated that the elite endurance athletes exhibited significantly higher levels of CTX than controls and they suggested that elevated levels of CTX concentrations could be used to identify athletes at risk of osteoporosis and future fractures [27]. Kitareewan et al. [28] studied the effects of 3-month (30 min; 3 times/week) moderate intensity (50% of HRRmax) walking exercises on PINP and CTX in menopausal and menstrual participants (30–70 years). CTX levels decreased in both groups at the 1st, 2nd and 3rd months; serum PINP did not significantly change except in the menstrual group in the 3rd month. Elhabashy et al. [29], compared type1 diabetes mellitus and osteopeny patients to 38 healthy controls using aerobic exercises 3 times/week for 3 months. They found PINP and BMD significantly raised in type 1 diabetes mellitus patients. Another investigation revealed significant increases in serum Bone ALP in the training group following 4 months resistance training [30]. In our study we determined no significant changes in the assayed bone turn-over markers except for the increase in BAP levels in EG. The lack of significant changes between the exercising and control groups apart from MaxVO2, body weight, and BMI makes the results we obtained on the positive effects of jogging plus explosive power exercises on bone turnover status difficult to interpret. Moreover, the relatively short intervention period of our study (10 weeks) may not have been long enough to allow completion of bone remodeling so that we could detect changes in all measured parameters. Although the physical activity may positively influence the bone remodeling, the biochemical process responsible by such effect and the exact reasons of these conflicting results remain unclear and speculative, but possible factors contributing to this inconsistent variability might be: type of assay kits used, the subjects’ different initial activity level, nutrition, gender, and seasonal variation, as well as the exercise duration, exercise intensity, exercise type, and the characteristics of the participants.

Researchers generally found BMD positively affected if the participants underwent a combined exercise program. For example, Lester et al. [13] reported that the combined (resistance and aerobic training) and the resistance training groups had significant increases in serum concentrations of bone ALP (15.8 and 16.6%, respectively) following 8 weeks of training [13]. In another study, resting levels of serum BAP increased following KAATSU-walk training. The researchers suggested that low-intensity exercise combined with KAATSU can influence bone metabolic markers [14]. A relatively low-intensity aerobic jogging was empowered by explosive power exercises in our program. Thus, the positive change in BAP may be attributed to the contribution of these exercises.

In literature, there are a few studies investigating the effects of different types of exercises on BMD related turn-over markers in both males and females in a mixed group [9] and making comparisons between genders [10]. Some researchers have focused on the effects of exercise programs on BMD values of females since osteoporosis is believed to be a disease specific to the female [8, 12, 13, 18, 19, 23, 27, 28]. However, osteoporosis is also a health problem for men. Even so, fewer researchers have studied exercise-bound effects in male population [4, 14, 20–22, 30]. In our study, we intended to highlight the pure effects of an exercise program without using any medication on BMD-related turn-over markers in young males.

Vitamin D plays an important role in bone metabolism and the normal functioning of the muscular system. The most important causes of decreased levels of vitamin D in the body include insufficient exposure to sunlight and insufficient dietary supply of this vitamin [31]. Athletes in various disciplines may have vitamin D
deficiency or insufficiency depending on the sports discipline, study period and geographic location [32–35]. Performing our outdoor exercise program in spring months might have an important role in the significant increase (9 vs. 22 ng/mL) in mean vitamin D level, which reached above the fracture risk level of 20 ng/mL. Therefore, such an exercise regimen is advisable to young adults to increase their vitamin D levels without a dietary supplement.

Despite the significant changes obtained in some bone remodeling parameters, we are aware that solid conclusions may not be drawn from this present investigation because of some limitations. First of all, the number of participants is relatively small. We could not include more participants because we had strict inclusion criteria. Besides, our exercise program required a careful monitoring, it would be impossible for the present exercise experts to control a more crowded group so closely.

Comparing the results of our study to the other trials has posed some difficulty because the majority of the interventions have been carried out with female population. In addition, quite a lot of studies included vitamin D or calcium supplementation in their research design; however, we excluded such volunteers since our main purpose was to highlight the pure exercise-bound effects on the measured parameters in 20–40 year-old males. Moreover, most of the research is on the effects of resistance exercises on bone remodeling process. Thus we had difficulty in finding research conducted with aerobic exercises to discuss our study results.

Maintaining peak bone mass until the older ages is vitally important. The role of strenuous training programs is very well documented in literature. However, following such programs may not be possible as the people get older. Therefore, having an exercise habit that can be the part of everyday life of anybody is crucial. Thus, exercising for 30–50 min per day, at least 3 days a week at moderate intensity provides health-related benefits. In this sense, young males may be advised to follow the exercise program we applied in this study to prevent themselves from osteoporosis.

Conclusion

Despite some limitations, the beneficial results as a result of jogging plus explosive power exercises, regarding increases in MaxVO$_2$, and reductions in BMI can be accepted as the benefits of this program to prevent participants against cardiovascular diseases. More importantly, the significant increases in femoral neck and total score; and the significant increases in BAP and vitamin D indicate the beneficial effect of a 30–50 min/day program performed 3 days per week, at moderate intensity on bone remodeling process. However, the role of aerobic jogging plus explosive power exercises, on all bone remodeling process remains to be investigated in more crowded groups from different ages and sexes. In order to have higher impacts of this program, it has to be performed in longer periods of intervention.

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