Sport Sciences for Health (2018) 14:265–274
https://doi.org/10.1007/s11332-017-0422-1

ORIGINAL ARTICLE

Body composition and lipid profile of regular recreational table tennis participants: a cross-sectional study of older adult men

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Received: 13 November 2017 / Accepted: 16 December 2017 / Published online: 3 January 2018

Abstract
The aim of the present study was to investigate the effects of regular participation in recreational table tennis training on bone health, body composition and lipid profile of elderly men. 20 regular recreational table tennis players (11.6 ± 3.6 years of experience) and 20 sedentary older adults (age, mass and sex matched of 65–75 years) participated in the study. Serum triglycerides, total cholesterol, HDL-cholesterol, and LDL-cholesterol concentrations were determined after 12 h fasting. Body composition was analyzed using dual-energy X-ray absorptiometry. Regular recreational table tennis participants displayed higher HDL-cholesterol ($p = 0.03$) and lower LDL-cholesterol ($p = 0.04$) and triglycerides ($p = 0.002$) compared to sedentary participants. In the regular recreational table tennis participants compared with sedentary participants, total ($p = 0.001$), sub-regional [lumbar spines ($p = 0.001$), arm ($p = 0.006$), leg ($p < 0.008$)] and site-specific [femoral neck ($p = 0.007$), trochanter ($p = 0.03$), and ward's triangle ($p = 0.001$)] bone mineral densities were higher. Body fat percentage ($p = 0.04$) and total and sub-regional fat mass [arm ($p = 0.004$), leg ($p = 0.02$), and trunk ($p = 0.04$)] were lower. There was no significant difference in the total and sub-regional lean mass between groups ($p > 0.05$). This study offers preliminary evidence to suggest that recreational table tennis training, with the potential for permanent implementation, is associated with beneficial effects on body composition and lipid profile in older adult men. Further research regarding recreational table tennis to be used as a health-promoting activity for older adults is warranted.

Keywords Bone density · Body composition · Recreational sport · Older adults

Introduction

Physical activities (PA), exercises, and sport contribute to physical health through their effects on cardiorespiratory fitness [1], body composition [2], muscular endurance [3], strength, and flexibility. Sedentary behavior and the lack of engagement in sports in general are modifiable risk factor for coronary heart disease (CHD), obesity, type 2 diabetes, hypertension, metabolic syndrome and musculoskeletal diseases (osteoporosis and osteoarthritis) [4, 5].

The importance and benefits of PA and sport as very low cost and the most effective preventive treatment for fighting the increasing worldwide incidence of non-communicated diseases is quite clear for health policymakers and politicians [1, 6]. Despite a lot of evidence supporting the health benefits occurred with increase of PA and sport, many challenges remain related to PA promotion. Some of the main obstacles facing those who try to promote PA includes lack of motivation, attraction and enjoyment, relatively high costs of facilities and transportation as well as difficult availability

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of sports clubs, etc. [7–9]. Accordingly, developing and presenting physical interventions which motivate and attract target groups, require low costs, facilities, and space, and its easy accessibility can be effective on removing challenges of promoting physical activities and consequently enhancing healthy behaviors [10].

Recreational sports, as a potential means to provide opportunities for the public participation in physical activities, have attracted growing attention by government [11]. Although there are a lot of young, older adult, and disabled people all over the world who are regularly involved in recreational sports such as table tennis, soccer, futsal, and badminton in the sports venues, parks and even homes, few studies have been conducted on the beneficial effects of those sports on the health profile of those participants [12–14]. Most studies conducted in relation to physical activities and health have in fact investigated the effects of sports such as walking [15], jogging [16], running [17], cycling [18] and swimming [19] with relatively constant exercise intensity ranging from 30 to 90% of maximal oxygen uptake (VO_{2max}). In this point of view, the Jeans Bangsbo group has published several papers demonstrating that for untrained men [12–14], participation in regular recreational soccer training has significant beneficial effects on health profile and physical capacity, and in some aspects it is superior to frequent moderate-intensity running [14]. The beneficial effects of lifelong football training for muscle oxidative metabolism, and in the DNA repair and senescence suppression pathways are also reported by Mancini et al. [20]. Therefore, studies that investigate the effect of training engagement on recreational sports to improve the health profile and physical capacity are relevant, mainly due to enjoyment of this kind of physical activity which is self-selected by person. Very rare studies appear to have looked at the effects on the health profile of regular training with frequent and marked changes in exercise intensity, as occurs in table tennis training, except for football.

Table tennis is considered an intermittent sport with short-term effort and rest periods [21, 22], which can have very similar nature to the intensity interval training. The phosphagenic energy source (ATP-PCr) and the anaerobic glycolysis system contributes to producing energy during each effort period [22, 23] and aerobic system as principal output energy in full match (~ 96% of overall energy demand) [23], because it is responsible for realizing the fast recovery in rest moments and enables the ideal physical conditions to the next rally [24]. In addition to the effects that table tennis can have over body composition and lipid profile due to its intensity interval features, some studies have been conducted on its effects on bone strength and density [25] and lean mass [26]. The jumping, power and fast movements [27, 28] are dominant factors of table tennis play, which can affect bone strength and density [29]. Thus, table tennis training may serve as an important alternative to training modalities traditionally applied to maintain physical function, health, and longevity in the aging population such as intensity interval training.

Although the effects of regular participation in table tennis on the health profile of professional participants are somewhat clear, effect of recreational table tennis on the heath profile has been underestimated. As such, the present study adds knowledge on how participation to recreational table tennis can be used as an activity to improve body composition and lipid profile in men aged 65–75 years of age. Generally, so far recreational table tennis has not been experientially recommended for different groups of individuals because relatively few studies have investigated its effects on physical health of different groups of population and age groups. Therefore, with regard to limitations of doing research and collecting data, we need more research before claiming suitable effects of table tennis regular practice. Thus, the aim of this cross-sectional study was to investigate the effects of regular participation in recreational table tennis players on bone health, body composition and lipid profile in older adult men. Based on the intensity interval training nature of table tennis training, we hypothesized that regular participation in recreational table tennis can improve body composition and lipid profile in older adult men. Further, it was expected that the extensive use of the upper extremities muscles through largely varied strain stimuli and few strain cycles (repetitions), and lower extremities weight-bearing activities through high/odd impact loading would lead to optimize osteogenesis in older adult men. Thus, we also hypothesized that the regular participation in recreational table tennis can improve bone quality in older adult men.

Methods

Study design

A descriptive cross-sectional study was adopted, and participants were recruited through presentations in the local community from November to May 2016 in the (Shiraz) city.

Participants

A total of 40 older adult men ranged in age from 65 to 75 years (age 69.3 ± 3.27 years, BMI 27.3 ± 1.98 kg/m^2) were enrolled: (1) 20 subjects with regular recreational table tennis participants (age 68.8 ± 4.6 years; BMI 26.9 ± 2.0 kg/m^2) and (2) 20 subjects with age and activity-matched sedentary participants (age 69.5 ± 3.9 years; BMI 27.6 ± 1.9 kg/m^2). Regular recreational table tennis participants had been involved continuously in table tennis for 5–19 years, with training experience of 11.6 ± 3.6 years, and weekly frequency of 3.5 ± 1.05 session (2–5 session), 1.5–3 h per session. The sedentary participants had not participated in a regular exercise schedule for at least 2 years and were less than 150-min moderate-intensity activity and 75-min—intensity activity spread across the week, according to IPAQ-long form score [30].

The inclusion criteria were included: age range from 65 to 75 years; community living (not institutionalized); lack of regular participation in the other physical activities (such as walking, fitness classes); at least 3 h per week table tennis activities [31]; minimum of 8 months table tennis history [32]; and independence in activities of daily living. Participants were excluded if they reported a history of metabolic bone disease and taking of corticosteroids, which are known to have an effect on bone and calcium metabolism; a history of severe musculoskeletal disorders (such as back, knee or hip arthritic diseases) and/or previous arthroplasty surgeries and artificial implants, which can influence the body composition due to muscle wasting; a history of neurological problems/injures (such as Parkinson's disease, stroke, spinal cord injury, and cerebral palsy) which could influence the ambulation function and body composition; a history of endocrine disorders such as hypothyroidism and hyperthyroidism. Other exclusion criteria included taking medication, smoking, alcohol intake, hypertension, diabetes mellitus, liver disease and renal disorders.

All participants were informed of the study procedures and signed a term of informed consent. Before testing, all participants were fully familiarized with the laboratory and testing procedures. This study was approved by the Institution Review Board of (blinded) and met the STROBE study guideline of cross-sectional studies. All procedures were in accordance with the Declaration of Helsinki.

All participants reported in their pre-participation questionnaire that they followed their normal daily routine in regard to sleep, and nutrition and did not further control for these factors prior to each of the testing days.

Pre-participation control

Participants were interviewed to complete a calcium and vitamin D frequency questionnaire including daily amounts of calcium-containing foods [33]. Milligrams of daily calcium intake were calculated from these foods. The data obtained from this interview were used to control the effect of calcium nutrition on dependent research variables especially bone mass.

A face-to-face-guided interview focusing on physical activity using the Iranian version of IPAQ was performed with each participant [34]. Total weekly PA minutes were calculated for the following items: vigorous (heavy lifting, digging, aerobics, or fast bicycling), moderate (e.g., carrying light loads, bicycling at a regular pace, or doubles tennis), and walking within the domains of occupation, transportation, housework/gardening, and leisure-related activities. Participants were considered to have met CDC/ACSM physical activity recommendations if they reported at least 150 min/week of moderate-intensity physical activity or 75 min/week vigorous intensity physical activity or equivalent mix of moderate- and vigorous-intensity physical activity [30]. The data obtained from this assessment were used to physical activity-matched controls of groups (for the table tennis group, other physical activities except table tennis training) to control the effects of other physical activity on dependent research variables.

Arterial blood pressure at rest

Resting blood pressure was measured over the brachial artery using a semi-automated device (DINAMAP™ XL, Critikon, Johnson & Johnson, Tampa, FL, USA). Four consecutive blood pressure measurements were taken, each 2 min apart. The first reading was discarded, and the mean of the next three consecutive readings was used in the study.

Lipid profile measurement

Serum levels of total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDLC), and triglycerides were immediately determined after 12 h fasting by a laboratory technician. The participants were instructed not to perform vigorous exercise for the preceding 24 h and to avoid caffeinated beverages 72 h before collection. The venous blood samples were obtained with consent in the sitting position from the antecubital vein. Measurements were performed according to the standard methods in a specialized laboratory at the University Hospital. Samples were deposited in vacuum tubes with a gel separator without anticoagulant (Becton & Dickinson, Franklin Lakes, NJ, USA) and were centrifuged at − 4 °C for 10 min at 1500×*g* for serum separation. Serum samples from each participant were stored at − 20 °C until analysis. Thereafter, serum concentrations of total cholesterol and triglyceride were specified using commercial assay kits (Pars Azmoon inc., Tehran, Iran).

The LDL-C was calculated using the Friedewald et al. [35] equation, where LDL-C = total cholesterol − (HDL-C + TGL/5). The analyses were carried out using a biochemical autoanalyzer system (Dimension RxL Max—Siemens Dade Behring) according to established methods in the literature consistent with the manufacturer's recommendations [36].

Whole-body composition

Body mass was measured on a digital scale (SECA 760, Vogel & Halke GmbH & Co., Hamburg, Germany) to the nearest 0.1 kg and height was measured to the nearest 0.1 cm. Body mass index (BMI) was calculated using the formula body mass/height^2 (kg/m^2) [37].

Total and regional body composition was measured using a dual-energy X-ray absorptiometry (DXA) scan (GE, Lunar Prodigy, USA), as previously reported [25]. Prior to scanning, participants were instructed to remove all objects containing metal. Scans were performed with the participants lying in the supine position along the table's longitudinal centerline axis. Participants remained motionless during the entire scanning procedure. The procedure lasted 10–15 min for each individual and was conducted by a skilled laboratory technician who had calibrated the device using a lumbar spine phantom and according to the manufacturer's recommendations as well. The enCore 2003 Version 7.0 software generated standard lines that set apart the limbs from the trunk and head. These lines were adjusted by the same technician using specific anatomical points determined by standardized segmentation protocol that is described elsewhere [38].

Lean mass (kg), fat mass (kg), and BMC (kg) were calculated from total analysis of the whole body scan. BMD (g/cm^2) was calculated using the formula BMD = BMC area^1. The body fat percent (%BF) was calculated by dividing fat mass by the total scanned mass.

Additionally, total body scan sub-regions were reported. The sub-regional analysis was performed as described elsewhere [39]. Lean mass was assumed to be equivalent to the muscle mass, but only in the limbs [40]. The arm region (including the anatomical arm, forearm, and hand) was separated from the trunk by an inclined line crossing the scapulo-humeral joint, such that the humeral head was located in the arm region. The leg region (including the upper leg and the lower and foot) was separated from the trunk by an inclined line passing just below the pelvis.

Special assessment was conducted to measure bone mass in the lumbar vertebra regions L_1–L_4 and left complete proximal femur including the femur neck, trochanter intertrochanter region, and Ward's triangle.

In our laboratory, the coefficients of variation were 0.6% for whole body BMC, 0.9% for whole body BMD, lower 1.4% for femoral regions BMD, 0.9% for lumbar spine BMD, 1.9% for whole body fat mass, and 1.6% for whole body LM.

Statistical analyses

The data were analyzed using the SPSS 18.0 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were provided for all variables in this study, and also to participant characteristics. The results are presented as mean ± standard deviation (SD) and lower/upper 95% confidence interval (95% CI). The Shapiro–Wilk and Lilliefors (used for variables with less than 50 samples) tests were used for normality analyses. Because the normality was not rejected, independent *t* test was used to study the differences between the two groups. For all statistical procedures, the significance level was set at $p < 0.05$. The effect size Cohen's *d* (ES) was calculated for all variables between groups. Thresholds for small, moderate, and large effects were 0.20, 0.50, and 0.80, respectively [41].

Results

Pre-participation control

Daily amounts of calcium intake and vitamin D intake were not significant differences between the two groups $p = 0.63$ and $p = 0.73$, respectively). About weekly PA minutes, there were no significant differences in vigorous-intensity PA ($p = 0.41$), moderate-intensity PA ($p = 0.13$), and walking ($p = 0.07$) among the groups, but sitting time was significantly higher in the sedentary participants compared to the regular recreational table tennis participants ($p < 0.01$) (Table 1).

Demographic characteristics

Table 2 shows the demographic characteristics of participants according to groups. There were no significant differences in age, body weight, height and BMI among the groups. Body fat percentage in the regular recreational table tennis participants group was significantly lower than that in the sedentary participants ($p = 0.04$).

Lipid profile

The total cholesterol level was not different between the two groups ($p = 0.06$), whereas LDL-C level ($p = 0.04$), triglycerides level($p < 0.01$), and total cholesterol/HDL-C ratio ($p = 0.04$) in the sedentary participants were significantly higher than the regular recreational table tennis participants, whereas HDL-C level and HDL/LDL ratio in sedentary participants were significantly lower than the regular recreational table tennis participants ($p = 0.03$ and $p = 0.03$, respectively) (Table 3).

Body composition

Total fat mass ($p < 0.01$) and sub-regions fat mass including arm ($p < 0.01$), leg ($p = 0.02$), and trunk ($p = 0.04$)

Table 1 Daily calcium and vitamin D intake and self-reported minutes per day spent in each different intensity physical activity of study participants

Demographic characteristics	Regular recreational table tennis participants (n = 20) Mean ± SD	Sedentary participants (n = 20) Mean ± SD	Between group difference Mean (95% CI)	p
Calcium (mg/day)	1057.7 ± 289.1	1015.3 ± 269.2	42.4 (–136.5 to 221.2)	0.63
Vitamin D (IU/day)	144.9 ± 62.7	138.3 ± 58.7	6.6 (− 32.3 to 45.5)	0.73
Sitting (h/day)	8.4 ± 0.72	10.7 ± 1.1	− 2.4 (− 2.9 to − 1.8)	0.001*
Walking (min/week)	87.5 ± 14.8	97.2 ± 15.9	− 9.75 (− 19.6 to 0.09)	0.07
Moderate activity (min/week)	58.5 ± 10.8	65.0 ± 15.2	− 6.5 (− 14.9 to 1.97)	0.13
Vigorous activity (min/week)	9.1 ± 18.9	15.1 ± 24.2	− 6.0 (− 19.9 to 7.9)	0.41

*Statistically significant difference

Table 2 Demographic characteristics of study participants

Demographic characteristics	Regular recreational table tennis participants (n = 20) Mean ± SD	Sedentary participants (n = 20) Mean ± SD	Between group difference Mean (95% CI)	p
Age (years)	68.8 ± 4.6	69.5 ± 3.9	0.6 (− 3.4 to 2.1)	0.25
Height (cm)	170.7 ± 8.69	171.4 ± 3.5	0.7 (− 3.4 to 2.1)	0.91
Mass (kg)	78.4 ± 6.8	81.1 ± 5.1	2.7 (− 6.6 to 1.6)	0.67
BMI (kg/m^2)	26.9 ± 2.0	27.6 ± 1.9	0.8 (− 2.0 to 0.5)	0.31
Percent body fat (%)	30.3 ± 4.7	32.9 ± 2.0	− 2.6 (− 5.04 to − 0.1)	0.04*
BMC (kg)	2.76 ± 0.6	2.48 ± 0.4	0.28 (− 0.58 to 0.62)	0.12
Systolic BP (mmHg)	136.5 ± 15.7	144.6 ± 12.8	− 8.1 (− 17.2 to 1.11)	0.08
Diastolic BP (mmHg)	82.2 ± 3.9	85.1 ± 5.6	− 2.8 (− 5.9 to 0.3)	0.07

BMI body mass index, *BMC* bone mineral content, *BP* blood pressure

*Statistically significant difference

Table 3 Lipid profile of study participants

Lipid variables	Regular recreational table tennis participants (n = 20) Mean ± SD	Sedentary participants (n = 20) Mean ± SD	Between group difference Mean (95% CI)	p	d
TC (mg/dL)	188.4 ± 10.7	195.5 ± 8.6	− 6.11 (− 12.3 to 0.11)	0.06	0.73
TG (mg/dL)	113.3 ± 8.9	122.6 ± 8.6	− 9.3 (− 14.9 to − 3.7)	0.002*	1.06
HDL-C (mg/dL)	56.4 ± 15.5	46.7 ± 11.37	9.7 (1.0 to 18.4)	0.03*	0.71
LDL-C (mg/dL)	109.3 ± 23.7	123.3 ± 18.3	− 13.9 (− 27.5 to − 0.4)	0.04*	0.66
HDL/LDL (ratio)	0.57 ± 0.28	0.41 ± 0.16	0.16 (0.02 to 0.32)	0.03*	0.72
TC/HDL (ratio)	3.6 ± 1.2	4.4 ± 1.2	− 0.8 (− 1.6 to − 0.03)	0.04*	0.67

TC total cholesterol, *TG* triglycerides, *TC/HDL* total to high-density lipoprotein cholesterol ratio

*Statistically significant difference

were significantly higher in sedentary participants than the regular recreational table tennis participants (Table 4).

Regarding lean mass, there was no significant differences in total ($p = 0.39$) and sub-regions (arm ($p = 0.12$), leg ($p = 0.32$), and trunk ($p = 0.43$) between the groups (Table 4).

Total body BMD in the sedentary participants was significantly lower ($p < 0.01$) compared to the regular recreational table tennis participants. Sub-regions of the lumbar spines ($p < 0.01$), arm ($p < 0.01$), leg ($p < 0.01$) were significantly lower in the sedentary participants compared to the regular recreational table tennis participants, but thoracic

Table 4 Body composition of study participants

Body composition variables	Regular recreational table tennis participants ($n = 20$) Mean ± SD	Sedentary participants ($n = 20$) Mean ± SD	Between group difference Mean (95% CI)	p	d
Lean mass (kg)					
Total	55.1 ± 8.1	53.1 ± 5.2	1.9 (− 2.4 to 6.31)	0.39	0.25
Arm	7.1 ± 0.9	6.6 ± 0.9	0.4 (− 0.15 to 1.01)	0.12	0.44
Leg	17.8 ± 2.5	17.1 ± 1.8	0.7 (− 0.74 to 2.04)	0.32	0.32
Trunk	30.8 ± 6.4	29.2 ± 5.4	1.5 (− 2.3 to 5.3)	0.43	0.25
Fat mass (kg)					
Total	23.8 ± 2.9	26.9 ± 2.8	− 3.1 (− 4.9 to − 1.3)	0.001*	1.09
Arm	2.5 ± 0.5	3.1 ± 0.6	− 0.54 (− 0.9 to − 0.18)	0.004*	0.98
Leg	8.3 ± 1.6	9.4 ± 1.1	− 1.1 (− 1.9 to − 0.19)	0.02*	0.79
Trunk	12.9 ± 2.6	14.6 ± 2.8	− 1.8 (− 3.5 to − 0.1)	0.04*	0.67
BMD (g/cm^2)					
Total	1.27 ± 0.13	1.1 ± 0.11	0.17 (0.09 to 0.25)	0.001*	1.4
Arm	0.81 ± 0.07	0.76 ± 0.04	0.05 (0.02 to 0.09)	0.006*	0.9
Thoracic spine	0.91 ± 0.04	0.88 ± 0.06	0.03 (0.002 to 0.07)	0.13	0.6
Lumbar spine	1.25 ± 0.11	1.24 ± 0.09	0.11 (0.05 to 0.17)	0.001*	1.1
Leg	1.25 ± 0.14	1.15 ± 0.06	0.09 (0.03 to 0.16)	0.008*	0.9
Femoral neck	0.98 ± 0.06	0.94 ± 0.05	0.05 (0.002 to 0.07)	0.007*	0.9
Trochanter	0.83 ± 0.07	0.79 ± 0.05	0.04 (0.09 to 0.25)	0.03*	0.67
Ward's triangle	0.91 ± 0.05	0.84 ± 0.04	0.07 (0.04 to 0.1)	0.001*	1.5

%BF body fat percentage, *BMC* bone mineral content, *BMD* bone mineral density

*Statistically significant difference

spine BMD was not significantly different among the groups ($p = 0.13$). Site-specific BMD showed to be significantly different among the groups for femoral neck ($p < 0.01$), trochanter ($p = 0.03$), and ward's triangle ($p < 0.01$) (Table 4).

Discussion

The current study is the first to investigate the effects of regular participation in recreational table tennis players on bone health, body composition and lipid profile of older adult men. The present study shows that the lipid profile in the regular recreational table tennis participants was better than those in sedentary older adults. Total fat mass and sub-regions fat mass in the regular recreational table tennis participants were lower than those in sedentary older adults, but total, sub-regions, and site-specific BMD were better than those in sedentary older adults. These results suggest that regular participation in recreational table tennis may have a positive effect in the prevention of lifestyle-related diseases in older adults.

Based on the National Health Service (NHS) recommendations, 30% of regular recreational table tennis participants compared to 60% of sedentary participants have higher LDL-C, whereas 10% of regular recreational table tennis participants compared to 35% of sedentary participants have lower HDL-C [42]. Generally, fasting LDL-C was 8.3% lower and HDL-C was 17.37% higher in the regular recreational table tennis participants compared to the sedentary participants which show a considerable importance, since increase of LDL-C and decrease of HDL-C, HDL-C/LDL-C ratio and total cholesterol/HDL-C ratio are important predictors of CHD, diabetes, hypertension and kidney diseases, they are of the leading causes of death worldwide [43, 44]. In addition, more than 200 risk factors for CHD have now been identified; the single most powerful predictor of CHD risk is abnormal lipid profile [45]. Another highly considerable point is that more than half of cardiovascular diseases (CVD) are attributed to lipid abnormalities [45]. In accordance with the present results, previous studies have also demonstrated positive effects of sports such as recreational football [14, 46], rowing [47], swimming [19] and recreational tennis [48] on the lipid profile in the youth and older adult people. However, this is the first study regarding the recreational table tennis as a popular and amusing sport. In a recent study review, it is shown that regular physical activities lead to the increase of HDL-C level, control of LDL-C and they theoretically prevent the offsetting increases of triglyceride [49]. It has been shown that increasing the energy expenditure related to aerobic exercise (by increasing the exercise intensity or duration) positively affects the lipoprotein lipase (LPL) activity, HDL-C levels and lipid profile [50], consistently during the resistance training. The increase of movements volume (by the number of sets and/or repeating) compared to exercise intensity (e.g. by high weight low repetition) has more impact on the lipid profile [51, 52]. It seems that recreational table tennis, due to its intermittent activities that dominantly depends on ~ 96% of aerobic energy [23], could also increase the ability of skeletal muscles to use the carbohydrates and fats, leading to decreasing the plasma lipids. Recreational table tennis possibly decreases LDL-C and increases HDL-C and HDL-C/LDL-C ratio due to removing plasma LDL-C and fat oxidation by increasing the activities of lipolytic, LPL and hepatic lipase enzymes [49, 53]. Furthermore, recreational table tennis participants may be a consequence of increased formation of HDL from increased functionality of RCT process through enhanced capacity of plasma to promote cholesterol efflux, increased concentration of preβ1-HDL, and increased activity of Lecithin cholesterol acyl transferase (LCAT) [54]. Increased plasma HDL-cholesterol levels are one of the multiple anti-atherogenic and antithrombotic mechanisms by which physical exercise reduces the risk of primary and secondary events. The available data in this study verify the positive effect of regular participation in recreational table tennis on the lipid profile of the older adult people. Such knowledge can be used in preventing and managing dyslipidemia, while decreasing the risks of CHD, type 2 diabetes hypertension and metabolic syndrome. Physicians and physical trainers can encourage their patients to physical activities such as recreational table tennis as much as possible to achieve the optimal benefits, by considering their basic conditions.

In regular recreational table tennis participants, fat mass and BF% were 3.35 kg and 2.58% lower than the sedentary participants, respectively, for which the major cause of difference was due to the difference of fat in the trunk area. In accordance with the present results, Laforest et al. [55] showed that regular participation in recreational tennis decreases the body fat. In this study, the fat mass difference for the regular recreational table tennis participants and the sedentary participants was more prominent compared to the studies which had used football [46], aerobic running [56] and swimming [19] as the intervention. The lower body fat in regular recreational table tennis participants compared to the sedentary participants is an important finding, because obesity has become a global epidemic with more than 1.9 billion overweighed adults (BMI > 25) and at least 600 million people with clinical obesity (BMI > 30) [57]. Lean mass in the regular recreational table tennis participants was 1.7 kg higher than the sedentary participants, which was not statistically meaningful. Unlike the results of the current study, Kondrič et al. [58] showed that recreational football leads to meaningful increase of lean mass and a major part of this increase is due to the lean mass of lower limbs. This is probably due to the necessity of this attribute in the lower limbs for football [59]; however, this is not necessary for success in table tennis [58].

In our study, BMD was 5.7% higher for the regular recreational table tennis participants than the sedentary participants. In a retrospective study, it is observed that the athletes who participate in odd-impact sports such as football and squash have 20% thicker cortex around the femur neck compared to healthy sedentary individuals [60]. Moreover, the findings of the current study are consistent with the studies which have demonstrated the effect of football as a bone health intervention in healthy older adult men [61]. Carrasco et al. [62] have also shown that there is a meaningful relationship between the weekly PA hours and BMD in both healthy people and those who suffer from osteoporosis. The studies have shown that high-impact and weight-bearing exercises are primarily important for increasing the bone mass. Another factor that could be effective in increasing BMD is the muscle power output during the exercise and increase of muscle strength over time [63, 64]. This could be due to the fact that the force exerted by the muscle on the bone could stimulate the bone formation and increase of BMD. Most of the bone formation activities are those which put small amount and high-frequency strain on the bone. Usually, such strains are obtained by weight-bearing impact loadings and high-intensity progressive resistance trainings (HIRT) or power trainings. This finding supports the exercise advice provided by the American College of Sports Medicine (ACSM) regarding physical activities and bone health which has suggested 20–40 min of weight-bearing endurance activities such as tennis, at least three times a week for increasing the bone minerals in children and teenagers and 30–60 min of these activities at least three times a week for maintaining the bone health in adults [65].

The current study has some limitations. First, this study adopted a cross-sectional design, and we enrolled only healthy elderly men in the community. Participants may have engaged in other lifestyle behaviors that may affect the outcomes of interest. Although we attempted to control effects of other lifestyle activities using self-report interview, we recommend that these variables be considered in future investigations. Since the research subjects only consist of senior 65–75 years-old men, the generalization of the results to other age groups and sex is limited. In addition, not investigating the pre-inflammatory and anti-inflammatory markers could be another limitation of the current study. On the other hand, to our knowledge, our study is the first study which has investigated the effect of recreational table tennis on the body composition and lipid profiles in older men and as a result, it has a significant contribution to the current body of literature. Randomized controlled trial (RTC) studies in the future by collecting physiological, psychological and sociological data could provide valuable information regarding the effect of recreational table tennis practices for the young male and female, adults and senior participants with the risk of lifestyle diseases.

Conclusions

It was suggested that recreational table tennis is an appropriate type of exercise that could be used as a health-promoting activity with a potential for constant implementation without changing the participant's diet. Therefore, we can conclude that participation in regular recreational table tennis training can attenuate risk factors of CHD and metabolic syndrome and loss of BMD and lean mass. Our results suggest that regular recreational table tennis exercise may have a positive effect in the prevention of lifestyle-related diseases in older men.

Acknowledgements The authors would like to thank the participants for their enthusiastic participation.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest regarding the publication of this article.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Lillo N, Palomo-Vélez G, Fuentes E, Palomo I (2015) Role of physical activity in cardiovascular disease prevention in older adults. Sport Sci Health 11(3):227–233
2. Vissers D, Hens W, Taeymans J, Baeyens J-P, Poortmans J, Van Gaal L (2013) The effect of exercise on visceral adipose tissue in overweight adults: a systematic review and meta-analysis. PLoS One 8(2):e56415. https://doi.org/10.1371/journal.pone.0056415
3. Warburton DER, Nicol CW, Bredin SSD (2006) Health benefits of physical activity: the evidence. Can Med Assoc J 174(6):801–809. https://doi.org/10.1503/cmaj.051351
4. de Rezende LFM, Rey-López JP, Matsudo VKR, do Carmo Luiz O (2014) Sedentary behavior and health outcomes among older adults: a systematic review. BMC Public Health 14(1):333. https://doi.org/10.1186/1471-2458-14-333
5. Organization WH (2013) Physical activity and older adults. http://www.who.int/dietphysicalactivity/factsheet_olderadults/en/. Accessed 25 Nov 2016
6. Pedersen BK, Saltin B (2006) Evidence for prescribing exercise as therapy in chronic disease. Scand J Med Sci Sports 16(S1):3–63. https://doi.org/10.1111/j.1600-0838.2006.00520.x
7. Nicholson S, Sniehotta FF, Wijck F, Greig CA, Johnston M, McMurdo MET, Dennis M, Mead GE (2013) A systematic review of perceived barriers and motivators to physical activity after stroke. Int J Stroke 8(5):357–364. https://doi.org/10.1111/j.1747-4949.2012.00880.x
8. Reichert FF, Barros AJD, Domingues MR, Hallal PC (2007) The role of perceived personal barriers to engagement in leisure-time physical activity. Am J Public Health 97(3):515–519. https://doi.org/10.2105/AJPH.2005.070144
9. Schutzer KA, Graves BS (2004) Barriers and motivations to exercise in older adults. Prev Med 39(5):1056–1061. https://doi.org/10.1016/j.ypmed.2004.04.003
10. Mackintosh C (2013) An evaluation of the outdoor table tennis initiative pilot programme in London: 'ping pong in the fresh air how does that work?'. Manag Leisure 18(3):226–238. https://doi.org/10.1080/13606719.2013.796176
11. Parnell D, Cope E, Bailey R, Krustrup P, Curran K (2016) Football and physical health: what do we know? Sport Soc. https://doi.org/10.1080/17430437.2016.1207787
12. Bangsbo J, Hansen PR, Dvorak J, Krustrup P (2015) Recreational football for disease prevention and treatment in untrained men: a narrative review examining cardiovascular health, lipid profile, body composition, muscle strength and functional capacity. Br J Sports Med 49(9):568–576
13. Krustrup P, Dvorak J, Bangsbo J (2016) Small-sided football in schools and leisure-time sport clubs improves physical fitness, health profile, well-being and learning in children. BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine, Cardiff
14. Krustrup P, Nielsen JJ, Krustrup BR, Christensen JF, Pedersen H, Randers MB, Aagaard P, Petersen A-M, Nybo L, Bangsbo J (2009) Recreational soccer is an effective health-promoting activity for untrained men. Br J Sports Med 43(11):825–831
15. Lee I-M, Buchner DM (2008) The importance of walking to public health. Med Sci Sports Exerc 40(7 Suppl):S512–S518. https://doi.org/10.1249/MSS.0b013e31817c65d0
16. Schnohr P, O'Keefe JH, Marott JL (2015) Intensive jogging confers less longevity benefit than light jogging. J Am Coll Cardiol 65(5):411–419. https://doi.org/10.1016/j.jacc.2014.11.023
17. Wolf ID, Wohlfart T (2014) Walking, hiking and running in parks: a multidisciplinary assessment of health and well-being benefits. Landsc Urban Plan 130:89–103. https://doi.org/10.1016/j.landurbplan.2014.06.006
18. Oja P, Titze S, Bauman A, de Geus B, Krenn P, Reger-Nash B, Kohlberger T (2011) Health benefits of cycling: a systematic review. Scand J Med Sci Sports 21(4):496–509
19. Sideravičiūtė S, Gailiūniene A, Visagurskiene K, Vizbaraite D (2006) The effect of long-term swimming program on body composition, aerobic capacity and blood lipids in 14–19-year aged healthy girls and girls with type 1 diabetes mellitus. Medicina (kaunas) 42(8):661–666
20. Mancini A, Vitucci D, Labruna G, Imperlini E, Randers M, Schmidt J, Hagman M, Andersen T, Russo R, Orrù S (2017) Effect of lifelong football training on the expression of muscle molecular markers involved in healthy longevity. Eur J Appl Physiol 117(4):721–730
21. Zagatto AM, Morel EA, Gobatto CA (2010) Physiological responses and characteristics of table tennis matches determined in official tournaments. J Strength Cond Res 24(4):942–949. https://doi.org/10.1519/JSC.0b013e3181cb7003
22. Zagatto AM, Kondric M, Knechtle B, Nikolaidis PT, Sperlich B (2017) Energetic demand and physical conditioning of table tennis players. A study review. J Sports Sci 36(7):724–731. https://doi.org/10.1080/02640414.2017.1335957
23. Zagatto A, Leite J, Papoti M, Beneke R (2016) Energetics of table tennis and table tennis-specific exercise testing. Int J Sports

Physiol Perform 11(8):1012–1017. https://doi.org/10.1123/ijspp.2015-0746
24. Zagatto AM, Papoti M, Gobatto CA (2008) Validity of critical frequency test for measuring table tennis aerobic endurance through specific protocol. J Sports Sci Med 7(4):461–466
25. Sanchis-Moysi J, Dorado C, Olmedillas H, Serrano-Sanchez JA, Calbet JA (2010) Bone and lean mass inter-arm asymmetries in young male tennis players depend on training frequency. Eur J Appl Physiol 110(1):83–90. https://doi.org/10.1007/s00421-010-1470-2
26. Zagatto AM, Milioni F, Freitas IF, Arcangelo SA, Padulo J (2016) Body composition of table tennis players: comparison between performance level and gender. Sport Sci Health 12(1):49–54. https://doi.org/10.1007/s11332-015-0252-y
27. Padulo J, Di Giminiani R, Iacono AD, Zagatto AM, Migliaccio GM, Grgantov Z, Ardigò LP (2016) Lower arm muscle activation during indirect-localized vibration: the influence of skill levels when applying different acceleration loads. Front Physiol 7:242. https://doi.org/10.3389/fphys.2016.00242
28. Padulo J, Pizzolato F, Tosi Rodrigues S, Migliaccio GM, Attene G, Curcio R, Zagatto AM (2016) Task complexity reveals expertise of table tennis players. J Sports Med Phys Fit 56(1–2):149–156
29. Kovacs M (2007) Tennis physiology: training the competitive athlete. Sports Med 37(3):189. https://doi.org/10.2165/00007256-200737030-00001
30. Sparling PB, Howard BJ, Dunstan DW, Owen N (2015) Recommendations for physical activity in older adults. BMJ Br Med J (Online) 350:h100. https://doi.org/10.1136/bmj.h100
31. Ara I, Vicente-Rodriguez G, Jimenez-Ramirez J, Dorado C, Serrano-Sanchez J, Calbet J (2004) Regular participation in sports is associated with enhanced physical fitness and lower fat mass in prepubertal boys. Int J Obes 28(12):1585
32. Ferry B, Lespessailles E, Rochcongar P, Duclos M, Courteix D (2013) Bone health during late adolescence: effects of an 8-month training program on bone geometry in female athletes. Jt Bone Spine 80(1):57–63
33. Taylor C, Lamparello B, Kruczek K, Anderson EJ, Hubbard J, Misra M (2009) Validation of a food frequency questionnaire for determining calcium and vitamin D intake by adolescent girls with anorexia nervosa. J Am Diet Assoc 109(3):479–485 **(e473)**
34. Moghaddam MB, Aghdam FB, Jafarabadi MA, Allahverdipour H, Nikookheslat SD, Safarpour S (2012) The Iranian Version of International Physical Activity Questionnaire (IPAQ) in Iran: content and construct validity, factor structure, internal consistency and stability. World Appl Sci 18(8):1073–1080
35. Friedewald WT, Levy RI, Fredrickson DS (1972) Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 18(6):499–502
36. Tomeleri CM, Ribeiro AS, Souza MF, Schiavoni D, Schoenfeld BJ, Venturini D, Barbosa DS, Landucci K, Sardinha LB, Cyrino ES (2016) Resistance training improves inflammatory level, lipid and glycemic profiles in obese older women: a randomized controlled trial. Exp Gerontol 84:80–87
37. Prevention CfDCa (2016) Defining adult overweight and obesity. https://www.cdc.gov/obesity/adult/defining.html. Accessed 16 June 2016
38. Scafoglieri A, Tresignie J, Provyn S, Marfell-Jones M, Reilly T, Bautmans I, Clarys JP (2012) Prediction of segmental lean mass using anthropometric variables in young adults. J Sports Sci 30(8):777–785. https://doi.org/10.1080/02640414.2012.670716
39. Calbet JA, Dorado C, Diaz-Herrera P, Rodriguez-Rodriguez L (2001) High femoral bone mineral content and density in male football (soccer) players. Med Sci Sports Exerc 33(10):1682–1687
40. Perez-Gomez J, Olmedillas H, Delgado-Guerra S, Royo IA, Vicente-Rodriguez G, Ortiz RA, Chavarren J, Calbet JA (2008) Effects of weight lifting training combined with plyometric exercises on physical fitness, body composition, and knee extension velocity during kicking in football. Appl Physiol Nutr Metab 33(3):501–510
41. Cohen J (1992) Statistical power analysis. Curr Dir Psychol Sci 1(3):98–101
42. National Heart L, and Blood Institute (2017) High cholesterol—diagnosis. https://www.nhlbi.nih.gov/health/health-topics/topics/hbc/diagnosis. Accessed 27 Feb 2017
43. Rubins HB, Robins SJ, Collins D, Fye CL, Anderson JW, Elam MB, Faas FH, Linares E, Schaefer EJ, Schectman G (1999) Gemfibrozil for the secondary prevention of coronary heart disease in men with low levels of high-density lipoprotein cholesterol. N Engl J Med 341(6):410–418. https://doi.org/10.1056/NEJM199908053410604
44. Sahadevan M, Kasiske BL (2002) Hyperlipidemia in kidney disease: causes and consequences. Curr Opin Nephrol Hypertens 11(3):323–329
45. Hobbs FR (2003) Cardiovascular disease and lipids: issues and evidence for the management of dyslipidaemia in primary care. Eur J Gen Pract 9(1):16–24
46. Sousa M, Fukui R, Krustrup P, Pereira R, Silva P, Rodrigues A, Andrade J, Hernandez A, Silva M (2014) Positive effects of football on fitness, lipid profile, and insulin resistance in Brazilian patients with type 2 diabetes. Scand J Med Sci Sports 24(S1):57–65. https://doi.org/10.1111/sms.12258
47. Sanada K, Miyachi M, Tabata I, Suzuki K, Yamamoto K, Kawano H, Usui C, Higuchi M (2009) Differences in body composition and risk of lifestyle-related diseases between young and older male rowers and sedentary controls. J Sports Sci 27(10):1027–1034. https://doi.org/10.1080/02640410903081852
48. Ferrauti A, Weber K, Strüder HK (1997) Effects of tennis training on lipid metabolism and lipoproteins in recreational players. Br J Sports Med 31(4):322–327. https://doi.org/10.1136/bjsm.31.4.322
49. Mann S, Beedie C, Jimenez A (2014) Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. Sports Med 44(2):211–221. https://doi.org/10.1007/s40279-013-0110-5
50. Kraus WE, Houmard JA, Duscha BD, Knetzger KJ, Wharton MB, McCartney JS, Bales CW, Henes S, Samsa GP, Otvos JD (2002) Effects of the amount and intensity of exercise on plasma lipoproteins. N Engl J Med 347(19):1483–1492. https://doi.org/10.1056/NEJMoa020194
51. Fett CA, Fett WCR, Marchini JS (2009) Circuit weight training vs jogging in metabolic risk factors of overweight/obese women. Arq Bras Cardiol 93(5):519–525. https://doi.org/10.1590/S0066-782X2009001100013
52. Lira FS, Yamashita AS, Uchida MC, Zanchi NE, Gualano B, Martins E, Caperuto EC, Seelaender M (2010) Low and moderate, rather than high intensity strength exercise induces benefit regarding plasma lipid profile. Diabetol Metab Syndr 2(1):31. https://doi.org/10.1186/1758-5996-2-31
53. Diniz TA, Inoue DS, Rossi FE, Panissa VLG, Monteiro PA, Lira FS (2016) Order effects of high-intensity intermittent and strength exercise on lipoprotein profile. Sport Sci Health 12(3):353–359
54. Leaf DA (2003) The effect of physical exercise on reverse cholesterol transport. Metabolism 52(8):950–957
55. Laforest S, St-Pierre DM, Cyr J, Gayton D (1990) Effects of age and regular exercise on muscle strength and endurance. Eur J Appl Physiol 60(2):104–111. https://doi.org/10.1007/BF00846029
56. Kraemer WJ, Volek JS, Clark KL, Gordon SE, Puhl SM, Koziris LP, McBRIDE JM, Triplett-McBride NT, Putukian M, Newton RU (1999) Influence of exercise training on physiological and performance changes with weight loss in men. Med Sci Sports

Exerc 31(9):1320–1329. https://doi.org/10.1097/00005768-199909000-00014
57. Organization WH (2016) Obesity and overweight. http://www.who.int/mediacentre/factsheets/fs311/en/. Accessed June 2016
58. Kondrič M, Zagatto AM, Sekulić D (2013) The physiological demands of table tennis: a review. J Sports Sci Med 12(3):362
59. Morgans R, Orme P, Anderson L, Drust B (2014) Principles and practices of training for soccer. J Sport Health Sci 3(4):251–257. https://doi.org/10.1016/j.jshs.2014.07.002
60. Nikander R, Kannus P, Dastidar P, Hannula M, Harrison L, Cervinka T, Narra NG, Aktour R, Arola T, Eskola H (2009) Targeted exercises against hip fragility. Osteoporos Int 20(8):1321–1328. https://doi.org/10.1007/s00198-008-0785-x
61. Helge EW, Andersen TR, Schmidt JF, Jørgensen NR, Hornstrup T, Krustrup P, Bangsbo J (2014) Recreational football improves bone mineral density and bone turnover marker profile in elderly men. Scand J Med Sci Sports 24(S1):98–104. https://doi.org/10.1111/sms.12239
62. Carrasco M, Martínez I, Navarro MD (2015) Daily physical activity and bone mineral density in older women. Revista brasileira de medicina do esporte 21(1):22–26. https://doi.org/10.1590/1517-86922015210101638
63. de Regil-González P, de León AO-G, Chávez-Arias DD, Nava-Bringas TI, Macías-Hernández SI, Cruz-Medina E, Lara-Vázquez BI, Coronado-Zarco R (2015) Appraisal of exercise recommendations for osteoporosis treatment of current guidelines: a systematic review. Acta Univ 25(5):28–35. https://doi.org/10.15174/au.2015.767
64. Moreira LDF, Oliveira MLd, Lirani-Galvão AP, Marin-Mio RV, Santos RNd, Lazaretti-Castro M (2014) Physical exercise and osteoporosis: effects of different types of exercises on bone and physical function of postmenopausal women. Arq Bras Endocrinol Metab 58(5):514–522. https://doi.org/10.1590/0004-2730000003374
65. Bloomfield SA, Little KD, Nelson ME, Yingling VR (2004) American College of Sports Medicine position stand: physical activity and bone health. Med Sci Sports Exerc 195(9131/04):3611