Effects of habitual aerobic and non-aerobic exercises on traditional CHD risk factors and bone density in middle-aged females

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ABSTRACT

Ten active females aged from 41- to 57-year old, each were recruited from an association of women's volleyball and jogging clubs. All subjects had a history of at least 15 years of participating in their sports. Age matched 10 sedentary females volunteered as controls. Evaluations of the subjects were made to determine if differences existed in the serum levels of total cholesterol, HDL-cholesterol, T-C/HDL-C ratio, or triglycerides between groups with contrasting levels of physical activity habits. The jogging group demonstrated significantly higher HDL-C and lower triglycerides as compared to those of the sedentary controls while the volleyball group which is not considered as a typical aerobic exercise failed to do. A significantly higher value of $V_{O2\,max}$ was shown in the jogging group, and $V_{O2\,max}$ was significantly and positively correlated with HDL-C concentration and negatively associated with T-C/HDL-C ratio, and TG concentration. Isokinetic muscle strengths of the lower limb and bone density on the os calcis were also measured, and the highest values of the two parameters were recorded in the volleyball group while the lowest values were seen in the sedentary group. The bone density was significantly and positively correlated with the values of peak torque of the knee extensors. The results of the present study suggests that habitual jogging which is defined as aerobic is superior to habitual volleyball when an objective of the training is to lower cardiovascular diseases. However, when a purpose of training is to increase bone density, volleyball is more effective.
Epidemiological studies have consistently documented that physical activity is as a risk factor with nearly the same odds ratio as the known risk factors such as hypercholesterolemia and smoking\textsuperscript{(35)}. An inverse relationship between a physically active pattern of living and cardiovascular disease is well established\textsuperscript{(15, 36)}. Since circulating lipids, particularly cholesterol-transporting lipoproteins, are markers for coronary heart disease (CHD)\textsuperscript{(45, 43)}, exercise may confer a measure of protection against CHD through its influence on lipid parameters\textsuperscript{(11, 17, 18)}.

Morris et al.\textsuperscript{(30)} concluded that activities other than vigorous aerobic exercise were not inversely associated with risk for CHD. Though the influence of aerobic exercise on the lipid profile has been intensely studied, less aerobic modalities of exercise on CHD risk factors. Since it is clear that a substantial number of individuals currently choose, whether by necessity or personal preference, a non-aerobic form of exercise such as recreational sports or weight training, it is important to determine whether or not these individuals also obtain a protective effect against CHD from this type of exercise. The literature is equivocal regarding the effects of non-aerobic activity on risk factors associated with CHD.

Besides the problem of cardiovascular diseases, osteoporosis is also major health concern in the senior citizen community of this country, particularly for older women. Numerous reports indicate that physical activity is positively related to bone density and may, therefore, be an important factor in the prevention of osteoporosis. There is some indication that greater bone density may be more related to high intensity endurance types of activities\textsuperscript{(23)}. It is also of concern to whether habitual physical activity as recreation and fitness can contribute to solving bone loss.

The purpose of this study was to evaluate aerobic power, plasma lipids, isokinetic leg muscle strengths, and bone density in middle-aged females whose exclusive mode of regular exercise were jogging (aerobic) and volleyball (non-aerobic). The results are compared to values for sedentary controls.
METHODS AND PROCEDURES

Ten active females each were recruited from the Nagoya City Recreation Volleyball Association, and jogging clubs. All subjects had a history of at least 15 years of participating in their sports. In addition to those subjects, 10 sedentary females volunteered as controls.

The subjects arrived at the medical laboratory in the morning, after at least 12 hr fast and a 10ml blood sample was drawn from an antecubital vein using a disposable syringe with subjects in the seated position. Plasma sample were analysed for lipid and lipoprotein levels. Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) were assessed, while the risk ratio of TC/HDL-C was derived for each subject. Low-density lipoprotein cholesterol (LDL-C) was estimated according to the equations of Friedewald et al. (14).

After the blood tests, the subjects took a light breakfast and moved to the exercise laboratory. At the lab, all assessments except for the treadmill exercise test were conducted on the same day as the blood test. The treadmill walking test was conducted on another day.

Ultrasound of the os calcis was measured with an Achilles densitometer (Lunar Corp). With this densitometer, the foot is placed in a waterbath for approximately 3 min. Measurements of the speed of sound (SOS) and the broadband ultrasound attenuation (BUA) are obtained through a trabecular region on the os calcis approximately 2.5 cm in diameter. The “Stiffness index” (calculated by a computer program provided by the manufacturer from the combined data of SOS and BUA) was also recorded.

Body fat percentage was estimated from skinfold at 4 sites (triceps, anterior thigh, abdomen, and suprailiac), based on body density (21).

Isokinetic muscle strength of the quadriceps muscle was assessed for the dominant leg with a CYBEX 330 Extremity System (Division of Lumex, Inc., Ronkonkoma, NY). The back rest of the seat was
adjusted to 15° to the vertical. Restraining Velcro strapping was placed around the chest and hips, and a kneebrace for maximum stabilization clamped over the distal third of the quadriceps. The subjects grasped handles on the sides of seat and leg extension was initiated from a relaxed position at approximately 90° of knee flexion. Isokinetic muscle strength was evaluated during knee extension at angular velocity of 120 s⁻¹. Gravity effect torque was corrected for all subjects as indicated by the manufacturer.

The subjects were allowed to extend the knee 4 times as practice prior to each test. Three maximal voluntary muscular torque contractions were required. The total work was registered as the work produced by the three repetitions at the speed of 120° s⁻¹ as well.

Maximal graded exercise was conducted using a modified Balke-Were protocol. The treadmill (Quinton Q4000) test started with a workload of 3.3 mph and 0% grade for the first one min. For the second one min, the treadmill was elevated by 2%, and then 1% increments every minute thereafter. Metabolic measurements of expired gas were determined with Mijnhardt Oxycon System (Oxycon Sigma) calibrated with standardized gases. Criteria for \( V_{O2 \text{max}} \) included achieving two of the following three: 1) within 10 beats of age-predicted maximum heart rate, 2) RER greater than 1.15, or 3) the subject’s inability to continue despite urging by testing staff.

Heart rate was monitored throughout the test using chest electrodes in the CM5position using an electrocardiograph, ML1200 (Fukuda Electronics Co., Tokyo).

Statistical analyses of data were performed using analysis of variance (ANOVA) with repeated measures. When significant differences occurred among the means, a Scheffe post-hoc analysis was utilized to determin which groups were different.

RESULTS

Physical characteristics of the subjects are presented in Table 1. All subjects were similar in age and height, but the sedentary subjects were significantly greater than the joggers in body mass (\( P < 0.05 \)).
the body fat expressed as %body mass (%BF), the sedentary group also demonstrated a significantly higher value than both the joggers and volleyballers (P<0.05). The volleyball players tended to be heavier than joggers, but no significant difference was observed between the two groups. Resting heart rates (RHR) of the joggers were significantly lower than those of the volleyballers (P<0.05) and sedentary women (P<0.001) while no difference was found in both resting systolic (BP_s) and diastolic (BP_d) blood pressure among the groups.

Maximal oxygen uptake($\dot{V}_{O2\text{max}}$) for the three groups is shown in Fig. 1. Mean value (SD) for the jogging, volleyball, and sedentary groups was 44.3 (7.6), 31.3 (3.0), and 27.2 (8.8) ml kg$^{-1}$ min$^{-1}$, respectively. The value of the jogging group was significantly higher than those of the sedentary (P<0.001) and volleyball (P<0.05) groups.

The knee extension peak torque and total work are depicted in Fig. 2. The volleyball group demonstrated the highest values for both peak torque and total work indicating 79.3 (17.1) newton-meters and 64.4 (16.1) jules at angular velocity of 120 s$^{-1}$, respectively. Corresponding values for the jogging group were 74.6 (9.6) and 59.4

Table 1. Physical characteristics of fitness athletes and sedentary controls [mean [SD]]

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Mass (Kg)</th>
<th>Body fat (%BF)</th>
<th>RHR (bpm)</th>
<th>BP_s (mmHg)</th>
<th>BP_d (mmHg)</th>
<th>Grip (Kg)</th>
<th>R</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joggers (J)</td>
<td>50.0</td>
<td>154.4</td>
<td>50.1</td>
<td>23.7</td>
<td>66</td>
<td>117</td>
<td>79</td>
<td>31.2</td>
<td>28.1</td>
<td></td>
</tr>
<tr>
<td>(n=10)</td>
<td>(7.2)</td>
<td>(2.9)</td>
<td>(3.2)</td>
<td>(4.0)</td>
<td>(6)</td>
<td>(14)</td>
<td>(7)</td>
<td>(6.2)</td>
<td>(5.4)</td>
<td></td>
</tr>
<tr>
<td>Volleyball (V)</td>
<td>49.2</td>
<td>152.7</td>
<td>55.3</td>
<td>28.2</td>
<td>74</td>
<td>119</td>
<td>79</td>
<td>27.5</td>
<td>25.1</td>
<td></td>
</tr>
<tr>
<td>Players (n=10)</td>
<td>(2.2)</td>
<td>(2.2)</td>
<td>(3.3)</td>
<td>(3.1)</td>
<td>(8)</td>
<td>(8)</td>
<td>(7)</td>
<td>(3.4)</td>
<td>(3.4)</td>
<td></td>
</tr>
<tr>
<td>Sedentary (S)</td>
<td>49.8</td>
<td>154.2</td>
<td>58.3</td>
<td>33.1</td>
<td>77</td>
<td>124</td>
<td>84</td>
<td>24.8</td>
<td>22.1</td>
<td></td>
</tr>
<tr>
<td>Controls (n=10)</td>
<td>(2.7)</td>
<td>(2.7)</td>
<td>(7.4)</td>
<td>(3.3)</td>
<td>(6)</td>
<td>(17)</td>
<td>(4)</td>
<td>(3.2)</td>
<td>(2.7)</td>
<td></td>
</tr>
</tbody>
</table>

ANOVA J vs S*   J vs S***  J vs S***  V vs S*  J vs V*  J vs V*

Significant difference: *P<0.05, **P<0.01, ***P<0.001
Variables: PHR = resting heart rate; BP_s = systolic blood pressure;
BP_d = diastolic blood pressure;
Fig. 1. Maximal oxygen uptake ($\dot{V}O_2\text{max}$) in groups with different exercise habits. Values are mean±SD. *** $P<0.001$. JOG denotes jogging, VOL volleyball, and SED sedentary groups.

Fig. 2. Knee extension peak torque and total work in groups with different exercise habits. Values are mean±SD. *$P<0.05$, **$P<0.01$, ***$P<0.001$. Definitions as in Figure 1.
**Fig. 3.** Bone stiffness on the os calcis in groups with different exercise habits. Values are mean±SD. *P<0.05, **P<0.01, ***P<0.001. Definitions as in Figure 1.

**Fig. 4.** Relationship between bone stiffness on the os calcis and level of peak torque of the knee extensors.
Table 2 Serum total lipids, lipoprotein lipid, and glucose in fitness athletes and sedentary controls [mean (SD)]

<table>
<thead>
<tr>
<th></th>
<th>Total cholesterol (mg/dl)</th>
<th>HDL cholesterol (mg/dl)</th>
<th>LDL cholesterol (mg/dl)</th>
<th>T-C/HDL</th>
<th>Triglyceride (mg/dl)</th>
<th>Glucose (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joggers (J)</td>
<td>228.0</td>
<td>78.4</td>
<td>136.0</td>
<td>2.9</td>
<td>70.1</td>
<td>84.7</td>
</tr>
<tr>
<td>(n=10)</td>
<td>(30.5)</td>
<td>(14.9)</td>
<td>(32.0)</td>
<td>(0.9)</td>
<td>(1.8)</td>
<td>(6.3)</td>
</tr>
<tr>
<td>Volleyball (V)</td>
<td>214.4</td>
<td>65.8</td>
<td>127.8</td>
<td>3.3</td>
<td>104.0</td>
<td>92.7</td>
</tr>
<tr>
<td>Players (n=10)</td>
<td>(28.2)</td>
<td>(14.6)</td>
<td>(30.4)</td>
<td>(0.8)</td>
<td>(38.4)</td>
<td>(10.3)</td>
</tr>
<tr>
<td>Sedentary (S)</td>
<td>196.6</td>
<td>56.7</td>
<td>116.4</td>
<td>3.5</td>
<td>117.3</td>
<td>101.1</td>
</tr>
<tr>
<td>Controls (n=10)</td>
<td>(19.6)</td>
<td>(16.6)</td>
<td>(20.9)</td>
<td>(1.0)</td>
<td>(31.5)</td>
<td>(10.0)</td>
</tr>
</tbody>
</table>

ANOVA

J vs S*
J vs S**
J vs S*
J vs V*

Significant difference: *P<0.05, **P<0.01, ***P<0.001
Variables: T-C=total cholesterol; HDL=high density lipoprotein;
LDL=low density lipoprotein

(9.4), respectively. The lowest values were recorded by the sedentary group indicating 56.1 (10.1) and 46.2 (4.9), respectively. The value of peak torque in the sedentary group was significantly lower than in the volleyball group (P<0.001) and in the jogging group (P<0.05) while the significant difference in total work was found only between the volleyball and sedentary groups (P<0.01). The correlation coefficients for the peak torque to total work relationship was r=0.68.

Results of the bone density (stiffness) measurements are presented in Fig. 2. The highest value for stiffness was seen in the volleyball group (93.2 and 6.9SD) followed by the jogging (88.4 and 12.4SD), and sedentary (75.9 and 5.8SD) groups. ANOVA revealed significant differences between the volleyball and sedentary (P<0.001) and between the jogging and sedentary groups (P<0.05).

Relation of bone stiffness and muscle strength is presented in Fig. 4. Bone stiffness was positively correlated with the peak torque of the knee extensors (r=0.63, P<0.01). The regression equation was: bone stiffness = 54.55 + 0.45 (peak torque) at test speed of 120° s⁻¹.

Values for serum lipoprotein variables and glucose are shown in Table 2. For all subjects, although mean values of HDL-C in the active
groups were higher than that in the control group, a significant difference was only found between the jogging and sedentary groups (P<0.05).

TG of the jogging group was significantly lower than the values of any other groups. As compared with the sedentary subjects, the values of plasma glucose were also significantly lower in the jogging group (P<0.05). All plasma variables measured in this study were within clinical normal limits for all groups.

DISCUSSION

Several epidemiological studies have found that HDL-C is a strong, negative, independent predictor of coronary heart disease in women; and an increase of 0.26mmol/L is as associated with 42–50% decrease in risk\(^{(22)}\). One positive influence on HDL-C may be physical activity as endurance trained women are reported to have concentrations which are nearly 30% higher than in comparable sedentary women\(^{(29)}\). In the present study the jogging group demonstrated similar values being 28% higher than the levels of their inactive counterparts. The difference in HDL-C between the jogging and the volleyball groups was not significant although the difference was 16%. No significant difference was also found in HDL-C levels between the volleyball and sedentary groups (65.8 vs 56.7mg/dl; 14% difference). However, the level of the volleyball group can be classified as “Excellent” while the sedentary group as “Fair” in fitness category according to the norm proposed by Cooper\(^{(9)}\). Therefore, the results of the present study suggests that a certain level of elevation of HDL-C can be expected if the exercise have been performed vigorously as habitual levels for years. This observation may be supported by a study\(^{(16)}\) in which more favorable blood lipid profiles were found in women who are physically active, although not endurance trained, as compared to sedentary women. Furthermore, though the HDL-C difference between the volleyball and sedentary groups was not statistically significant, a difference of this magnitude is biologically meaningful since the relatively higher HDL-C
concentrations found in the volleyball subjects would place these individuals in a lower CAD risk quartile according to data from the Framingham sample reported by Castelli et al.\(^6\).

In general, an exercise modality which is less aerobic and strength training programs have not been shown to be as effective as running programs in the development of maximum aerobic power. These conclusions were substantiated by the results of the present study. The \(\bar{V}_{O_2 \max}\) was significantly elevated in the jogging individuals while the volleyball and sedentary individuals did not differ from each other in maximal aerobic capacity. In the subject population as a whole, \(\bar{V}_{O_2 \max}\) was significantly and positively correlated with HDL-C concentration (\(r=0.63\)) and negatively associated with the TC/HDL-C ratio, the LDL-C/HDL-C ratio, and TG concentration (\(r=-0.56, -0.45,\) and \(-0.52\), respectively, \(P<0.01\)). These findings are consistent with those reported by Wood et al.\(^{46}\) and indicate that individuals with a higher aerobic capacity tend to be at an advantage with regard to lipid derived from CHD risk. The T-C/HDL-C ratio, an important predictor of CHD\(^{35}\), in the jogging group was significantly lower (\(P<0.05\)) than the ratio in the sedentary group. With improved aerobic capacity, the variation in this calculated cardiovascular risk ratio of HDL-C to T-C decreases, and ratios in the pathological range of \(<0.2\) to \(>5.0\), respectively\(^{1,2}\), are found less frequently in endurance trained individuals\(^4\).

In agreement with previously reported findings\(^{12,19}\), the \%BF of the jogging group was significantly lower (\(P<0.05\)) than that of the sedentary group (23.7% vs 33.1%, respectively) while the \%BF of the volleyball group (28.2%) was about midway between the two. However, the difference between the volleyball and sedentary groups was significant (\(P<0.05\)). In addition, \%BF was signifiantly associated with both the HDL-C level and T-C/HDL-C ratio (\(r=-0.57\) and 0.62, respectively; \(P<0.01\)), which could be interpreted to mean that altered lipid profiles which result from exercise may not be independent of changes in body composition. However, it has been shown that exercise and weight loss can separately and independently influence lipid and lipoprotein metabolism resulting in
beneficial changes in blood concentrations of these variables\(^{(42)}\).

Low plasma TG concentrations, as compared to those for the general population, have been reported for long-distance runners\(^{(27, 47)}\), and tennis players\(^{(45)}\). The values of plasma TG levels of those are typically below 100mg/dl. In the present study, our jogging group also showed a value (70.1mg/dl) less than 100mg/dl, being significantly lower than the other two groups (\(P<0.05-0.01\)), while no significant difference was found between the two groups.

Other measurements of cardiovascular fitness include RHR and resting blood pressure. It has long been established that aerobically trained individuals exhibit a slower RHR compared to untrained persons matched for age and sex\(^{(3)}\). In this study the volleyball group failed to demonstrate slower mean RHR as compared to that of the sedentary group although they have played the games and practices for years (Table 1). It has been well documented that an increase in blood glucose suggests an increased tendency for diabetes mellitus, a recognized cardiovascular disease risk factor. The better glucose tolerance in the jogging group than in the sedentary group in the present study (Table 2) might be in part due to their lower body weight in addition to the aerobic exercise of the joggers.

The Achilles densitometer used in this study has been shown to provide good precision (<2%) in adults\(^{(13, 25, 38)}\). The bone stiffness for our subjects who have participated in sports for years tended to be higher (\(P<0.05-0.001\)) than that for the sedentary controls (Fig. 3). This result was in agreement with a number of previous studies concerning effects of exercises on bone mineral density\(^{(8, 10, 37, 44)}\). Especially, two studies\(^{(7, 20)}\) selected the calcaneus for bone mineral measurements. One of them\(^{(20)}\) using a single energy X-ray densitometer, reported a 12% higher value in a high load group than a low load group in 26- to 51-year old men. Another study by Cheng et al.\(^{(7)}\) found an 8% higher bone mineral density in vigorously exercising women (50-60 years old) than less active women. Our results which were 14 to 18% higher in the active groups than the sedentary group may be comparable to those reported above.

Nilsson\(^{(31)}\) reported that within athlete groups, sports activities
involving a heavy load on the lower limb were associated with higher bone density at the distal end of the femur. The swimmers did not differ significantly from the non-athletes when both exercising and non-exercising controls were included in the comparison. In the present investigation measured at the calcaneus, the highest value of bone stiffness was found in the volleyball group followed by the jogging group (Fig. 3). The results of this study support the concept that the dominant factor in daily physical activity relating to bone mineral density is the participation in site specific high load activities, i.e., high calcaneus load in this case. The higher values of bone stiffness in the volleyball and jogging groups than the sedentary group might be related to their daily activities that impose great forces placed on the calcaneus region. When the force imposed on the lower limb is expressed as ground reaction forces (GRFz), GRFz supported by one leg of jogging range from 2 to 3 times body weight (28) and are somewhere between 5 and 7 times body weight at impact of landing from a jump(24) in volleyball.

Another factor which has an effect on increasing bone density is types of muscle activities. Muscle strength has been found to correlate positively with bone density(5,33,34). Furthermore, several studies(31,39) have reported that greater bone mineral content may be more related to high intensity, weight-resistance types of activities than to lower intensity endurance types. The finding that muscle stress suffices to stress bone, without a requirement for weight bearing, was reported by Orwoll et al.(32). Our results confirm the correlations between muscle strength and bone mineral density reported by those studies. The highest value of mean isokinetic muscle strength was associated with the highest value of mean isokinetic muscle strengths measured as knee extension (Figs. 2 and 3). Furthermore, a significant positive correlation was found between the bone stiffness of the os calcis and the knee extensor peak torque at an angular velocity of 120 s⁻¹ (r = 0.63, P<0.01) as shown in Fig. 4. Such positive correlation in this study was in agreement with the studies which had reported a significant positive correlation between bone mineral content of the midradius and the power grip of the non-dominant extremity(41), and
between bone mineral density of the spine and back muscle strength in postmenopausal women\(^{(40)}\). Muscle strengths of the lower limb may characterise physical activity related to overall physical activity such as walking, jogging, volleyball, soccer, etc. Therefore, decline of muscle strength caused by disuse may be pronounced in the lower limb and be less pronounced in the upper limb. Results of grip strength measurements (Table 1), which showed no significant difference between the active groups and the sedentary control, reflect this speculation. Consequently, because of less use of the lower limb the bone stiffness on the os. calcis for the controls was significantly lower than those for the active subjects of volleyball and jogging.

In summary, the results of the present study suggests that joggers who have engaged in jogging for years as their habitual exercise is superior to those who have also engaged in volleyball as habitual basis when an objective of the training program is to increase circulating HDL-C concentration and, thereby, lower cardiovascular diseases. This is due to a significant enhancement of jogger's aerobic capacity expressed as maximal oxygen uptake. However, when a purpose of the training program is to increase bone density, volleyball activity is sufficient to enhance bone health. This is due to a significant enhancement of muscle strengths and frequent mechanical stress on the bone through volleyball activity.

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15年以上活発にジョギングとバレーボールの運動習慣を有する41 - 57歳の女性各10名と同様の年齢にある運動習慣を持たない女性10名、合計30名の中年女性が被検者として本研究に参加した。典型的な有酸性運動のジョギングと有酸性に欠けるとみなされているバレーボールおよび座業習慣者によるライフスタイルの違いが冠動脈心疾患危険因子の軽減と骨密度（強度）に及ぼす影響についての検討がなされた。冠動脈心疾患因子に関連するパラメーターとして血清総コレステロール（T-C）、高比重リポ蛋白コレステロール（HDL-C）、動脈硬化度指数（T-C／HDL-C比）、中性脂肪（TG）が求められた。他方、超音波骨密度計（アキレス）により著骨の骨密度がSTIFFNESS INDEXとして測定され、さらに膝伸展筋群の等速性筋力がサイベックス筋力測定装置モデル350によって計測された。

その結果、有酸素性パワー（V₀₂max）が最も高いジョギング群のHDL-C値は非運動習慣群より有意に高く、非運動習慣群との間にV₀₂maxに有意差が見られなかったバレーボール群のHDL-C値は非運動群より高い値を示したが両群間には有意差は見られなかった。また、ジョギングのTG値は他の二群に比べて有意に低い値となった。

全体として、V₀₂maxとHDL-Cには有意で正の相関が、動脈硬化度指数のT-C／HDL-C比及びTGには有意で負の相関が観察された。

膝伸展筋群の等速性筋力では、運動習慣群は非運動習慣群より有意に大きく、バレーボール群が最大値を示した。著骨のBONE STIFFNESSレベルは膝伸展筋力に応じて観察された（r=0.63, P<0.01）。これは骨密度はその部位の筋力と骨への機械的加負の大きさに影響されることを示しておりパレーボールがそれらの要素に貢献するものであると思われる。

以上の結果、有酸素性運動実践習慣群は冠動脈心疾患リスクの低い血性状を保有し、体重を支える動作を持続させることで高い骨密度を保有しているといえよう。他方、有酸素性運動様式に欠けるバレーボールでは、長期に亘る運動習慣をしなえても、冠動脈心疾患の予防上の効果はジョギング群より低い。しかし、そのスポーツ動作による比較的大きな地面反力と形成される大きな脚筋力から、バレーボール習慣群は非運動習慣群に比べて著しく高い骨密度を形成している。

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