Journal of Exercise Physiologyonline

Volume 14 Number 4 August 2011

Official Research Journal of the American Society of Exercise Physiologists

ISSN 1097-9751

JEPonline

Exercise and Nutrition More Effective than Exercise Alone for Increasing Lean Weight and Reducing Resting Blood Pressure

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ABSTRACT

Westcott W, Varghese J, DiNubile N, Moynihan N, LaRosa Loud R, Whitehead S, Brothers S, Giordano J, Morse S, Madigan MA, Blum K. Exercise and Nutrition More Effective than Exercise Alone for Increasing Lean Weight and Reducing Resting Blood Pressure. **JEPonline** 2011;14(4):120-133. This study examined the effects of exercise alone and exercise and nutritional supplementation on lumbar spine bone mineral density, lean weight, and resting blood pressure. The subjects (N = 52) were placed into a **Control Group** [no exercise or nutritional supplements], an **Exercise Group** [strength training and aerobic activity; no nutritional supplementation]; and an **Exercise and Nutrition Group** [strength training and aerobic activity; supplementary protein, calcium, and vitamin D]. Changes in lumbar spine bone mineral density did not attain significance. Lean weight increased significantly in the **Exercise and Nutrition Group**. Resting SBP and DBP decreased significantly in the **Exercise and Nutrition Group**. These findings indicate that strength training, aerobic exercise, and nutritional supplements may be more effective than just exercise for increasing lean weight and for reducing resting blood pressure.

Key Words: Exercise, Strength Training, Nutritional Supplementation

INTRODUCTION

According to recent research reported by the National Institutes of Health and Centers for Disease Control and Prevention (61), fewer than 3.5% of adults and 2.5% of older adults [age 60 and above] attain 30 or more minutes of moderate intensity physical activity (3 METs) on a regular basis [i.e., 5 days/week]. In general, lack of physical activity is associated with higher resting blood pressure readings (2), and lack of resistance exercise is associated with lower muscle mass (sarcopenia) and bone mineral density (osteopenia) (31). Osteopenia typically progresses to osteoporosis, which is characterized by low bone mass and bone matrix deterioration (26). According to the U.S. Department of Health and Human services (62), more than 30% of women and 15% of men will experience bone fractures resulting from osteoporosis.

Hurley (31) has reported that bone mineral density is associated with muscle mass and strength, and research clearly confirms these associations (1,6,16,49,54). Although it is tempting to assume a cause and effect relationship between strength training and increased bone mineral density, some studies have supported this premise while others have not. Numerous longitudinal studies have shown significant increases in bone mineral density following 4 to 24 months of resistance exercise (9,17,20,27,34,36-39,41,43,44,46,47,53,56,59,65,67,73). According to a meta-analysis by Wolfe and associates (72), exercise interventions prevented or reversed approximately 1% per year of the bone loss (lumbar spine and femoral neck) in pre and post- menopausal women. A 2009 review by Going and Laudermilk (26) concluded that resistance training increased bone mineral density by about 1 to 3% in pre and postmenopausal women at the lumbar spine and femoral neck sites.

However, a number of other longitudinal studies have not demonstrated significant increases in bone mineral density after 4 to 36 months of resistance exercise (13,25,40,45,51,58,68-70). There are many possible reasons for these inconsistent research results. According to Cussler and colleagues (17), many of the studies on bone mineral density changes resulting from resistance exercise have been limited by small sample size, short intervention period, low completion rate, lack of randomization to exercise, and low training intensity. Other variables include hormone replacement therapy in women (27,34,43), and growth hormone administration in men (73). It is also possible that nutritional factors, such as intake of protein, calcium, and vitamin D may influence skeletal responses to resistance exercise.

Interestingly, a meta-analysis of exercise effects on bone mineral density by Kelley and colleagues (35) showed no significant interactions for calcium and vitamin D intakes. On the other hand, studies have demonstrated a positive association between dietary protein intake and increased bone mineral content (14,29,60). In fact, research with older adults has revealed a positive association between protein intake and change in bone mass density in those with the highest consumption of protein along with calcium and vitamin D supplementation (18). It has also been reported that gene polymorphisms may contribute to varying effects related to resistance exercise and bone density, especially in females (5).

Assuming a close relationship between muscle loss (sarcopenia) and bone loss (osteopenia), research showing a positive association between resistance exercise with supplemental protein and muscle development may also have application for bone development. Numerous studies have demonstrated that a post-exercise protein – carbohydrate supplement enhances muscle development in men and women of all ages (4,15,21,22,30,32,33,48,50). In a previous study using a standard program of resistance exercise and aerobic activity performed according to recommended training protocols (3), with or without post-exercise protein/carbohydrate supplementation, a strong trend was found towards greater lean weight gain in the subjects who consumed the supplemental nutrition (71).

Based on the findings and the related research literature, the present study was designed to determine whether exercise and nutrition positively effects bone mineral density, lean weight, and resting blood pressure. More specifically, this study compared the effects of exercise alone (i.e., resistance training and aerobic activity) with the same exercise program and supplemental protein, calcium, and vitamin D on lumbar spine bone mineral density, lean weight, resting systolic blood pressure, and resting diastolic blood pressure.

METHODS

Subjects

This study was approved by the Quincy College Institutional Review Board [IRB]. It was conducted in compliance with the IRB guidelines. Fifty-two participants (48 women and 4 men) ranging in age from 39 to 82 yrs (mean age = 59 yrs) completed a 9-month research program in 1 of 3 study groups: (a) **Control Group** that did not exercise or take nutritional supplements (n = 9); (b) an **Exercise Group** that performed strength and aerobic training, but did not take nutritional supplements (n = 18); and (c) an **Exercise and Nutrition Group** that performed strength and aerobic training while taking nutritional supplements (n = 25). Subject characteristics are presented in Table 1.

Table 1. Characteristics for subjects in the control, exercise and exercise and nutrition groups.

Groups	Age (yrs) M ± SD	Height (in) M ± SD
Control (n = 9)	55.6 ± 11.0	63.7 ± 3.1
Exercise (n =18)	60.8 ± 12.7	65.5 ± 3.2
Exercise and Nutrition (n = 25)	59.0 ± 8.0	63.6 ± 4.2

Procedures

Subjects in both the Exercise Group and the Exercise and Nutrition Group participated in 1 hr physical activity classes that trained according to recommended protocols (3) in the college fitness research facility for a period of 36 weeks. Each class consisted of approximately 8 participants supervised by 2 nationally certified fitness professionals. The training program included approximately 25 min of resistance exercise and 25 min of aerobic activity, as presented below.

Strength workout

Participants performed 1 set of 8 to 12 repetitions on 12 Nautilus One-Line resistance machines: 1) leg extension; 2) leg curl; 3) hip abduction/adduction; 4) leg press; 5) chest press; 6) seated row; 7) shoulder press; 8) lat pulldown; 9) low back; 10) abdominal; 11) rotary torso; and 12) neck flexion/extension. Resistance was increased by approximately 5% whenever 12 repetitions were completed with proper form, which included controlled movement speed (approximately 6 secs /repetition) and complete (pain free) movement range.

Aerobic workout

Participants completed about 25 min of recumbent cycling performed in an interval training manner, with 5 higher-effort intervals (2 min each) alternated with 5 lower-effort intervals (2 min each), in addition to a 2-min warm-up and 2-min cool-down. Heart rate (HR) responses were at the lower end of the age-adjusted target HR range during the lower-effort intervals and at the higher end of the age-adjusted target HR range during the higher-effort intervals. Resistance was increased when the peak

HRs dropped to the middle of the age-adjusted HR range, and when rating of perceived exertion fell to the "moderate effort" level (7).

In addition to performing the strength and aerobic workouts, the Exercise and Nutrition Group drank a protein and carbohydrate shake immediately after each training session. The shake provided approximately 24 grams of protein and 36 grams of carbohydrate and was fortified with free l-leucine. Participants in this group also took a daily vitamin/mineral complex that contained 500 mg of calcium and 1200 IU of vitamin D throughout the course of the study. All nutritional shakes and supplements were provided by Shaklee Corporation (Pleasanton, CA, USA).

All of the study assessments were conducted at the beginning and end of the 36-week training period lumbar spine bone mineral density was assessed by DEXA scans (Lunar Prodigy Pro™) at the local hospital. Lean weight was assessed by means of computerized ultrasound technology (SomaTech). Resting blood pressure was measured using an automatic blood pressure machine (Dinamap™ Critikon Vital Signs Monitor 1846SX).

Statistical Analyses

Data are presented as mean (M) ± standard deviation (SD). Analysis of variance (2 x 3 mixed ANOVA with Pre and Post as the repeated measure and treatment condition as the between factor) was applied to determine statistically significant changes in bone mineral density, body weight, lean weight, resting systolic blood pressure, and resting diastolic blood pressure within and among the three study groups. The alpha level for statistically significant differences was set at $P \leq 0.05$. For all analyses with significant interactions, pair-wise comparisons between levels of the within-subjects factor were conducted. All data analyses were performed using SYSTAT 13 statistical software. A power analysis was not determined prior to the study due to certain limitations for recruitment parameters governed by the Quincy College IRB Committee.

RESULTS

Means ± standard deviations for beginning and ending values of lumbar spine bone mineral density, body weight, lean weight, resting systolic blood pressure, and resting diastolic blood pressure are presented in Table 2. Lumbar spine bone mineral density did not change significantly in any of the groups. However, the Control Group experienced a 1% decrease in bone mineral density (1.178 – 1.164 g/cm^2), the Exercise Group had essentially no change in bone mineral density (1.163 – 1.159 g/cm^2), and the Exercise and Nutrition Group experienced a 1% increase in bone mineral density (1.071 – 1.083 g/cm^2) (refer to Figure 1).

Across all subjects there was a significant main effect for body weight ($F\{1, 48\} = 4.28$, $P = 0.04$), with a reduction of 1.2 lbs (152.7 – 151.5 lbs). There was no significant interaction among the treatment groups ($F\{2, 48\} = 1.57$, $P = 0.22$). With respect to lean weight, there was a significant main effect ($F\{1, 48\} = 19.05$, $P \leq 0.001$), with significant interaction among groups ($F\{2, 48\} = 13.63$, $P \leq 0.001$). Only the Exercise and Nutrition Group, which added 5.2 lbs of lean weight (110.7 – 115.9 lbs), attained a significant increase in this measure (95% CI, 2.62 – 4.59) (Figure 2).

Resting systolic blood pressure did not show a significant main effect ($F\{1, 46\} = 2.65$, $P = 0.11$). There was a significant interaction among groups ($F\{2, 46\} = 3.79$, $P = 0.03$). Only the Exercise and Nutrition Group, which experienced a 10.0 mmHg reduction in resting systolic blood pressure (118.0 – 108.0 mmHg), attained a significant decrease in this measure (95% CI, 1.48 – 8.85) (Figure 3).

Table 2. Changes in lumbar spine bone mineral density, body weight, lean weight, resting blood pressure for the Groups over a 9-month period (n=52; M ± SD **). ***Statistically significant (P≤0.05)

Assessment	Control Group		Exercise Group		Exercise and Nutrition Group	
	Pre	Post	Pre	Post	Pre	Post
	M ± SD		M ± SD		M ± SD	
BM Density (g/cm²)		-1.0%		0%		+1.0 %
	1.178±0.197	1.164±0.191	1.163±0.196	1.159±0.202	1.071±0.159	1.083±0.170
Body Weight (lbs)		-1.9		-2.4		-0.1
	132.4±29.6	130.5±30.1	161.9±35.6	159.9±34.5	152.6±35.9	152.5±34.8
Lean Weight (lbs)		-2.1 lbs		+3.9 lbs		+5.2 lbs*
	99.4±18.2	97.3±19.2	113.4±26.1	117.3±26.2	110.7±27.6	115.9±29.3
Systolic BP (mmHg)		+2.9		-2.5		-10.0*
	117.1±9.5	120.0±12.1	124.3±16.8	121.8±19.0	118.0±11.5	108.0±11.2
Diastolic BP (mmHg)		+6.0		+1.7		-4.8*
	68.0± 6.8	74.0±6.9	68.6±6.4	70.3±7.2	70.5±7.9	65.7±7.9

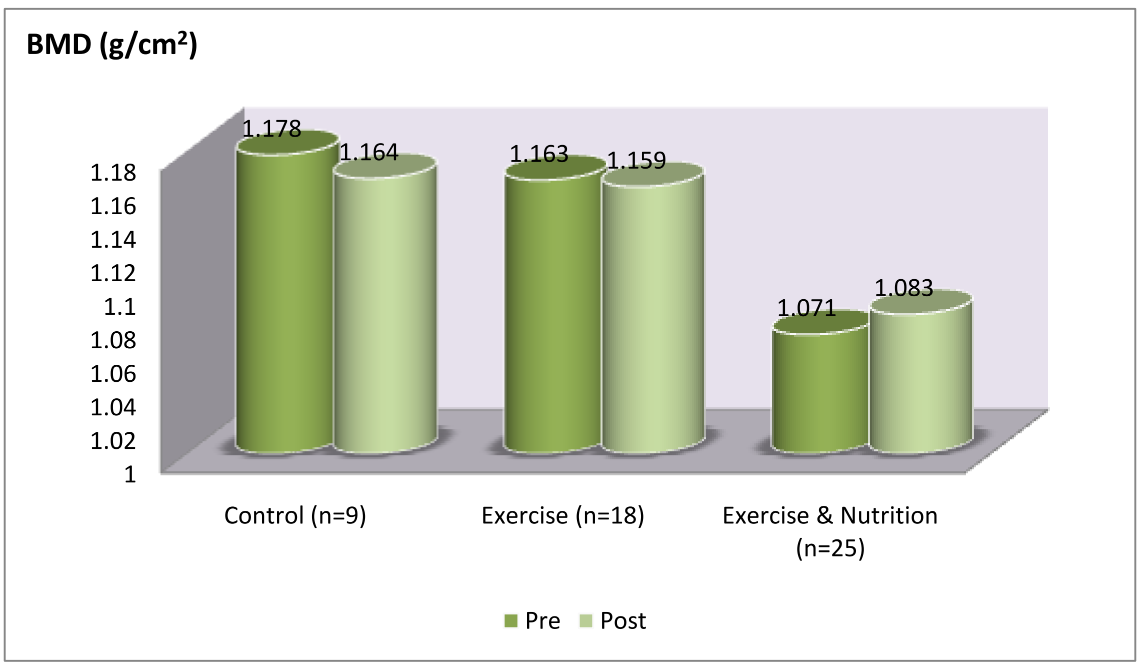

Figure 1. Mineral Bone Density (g/cm²)

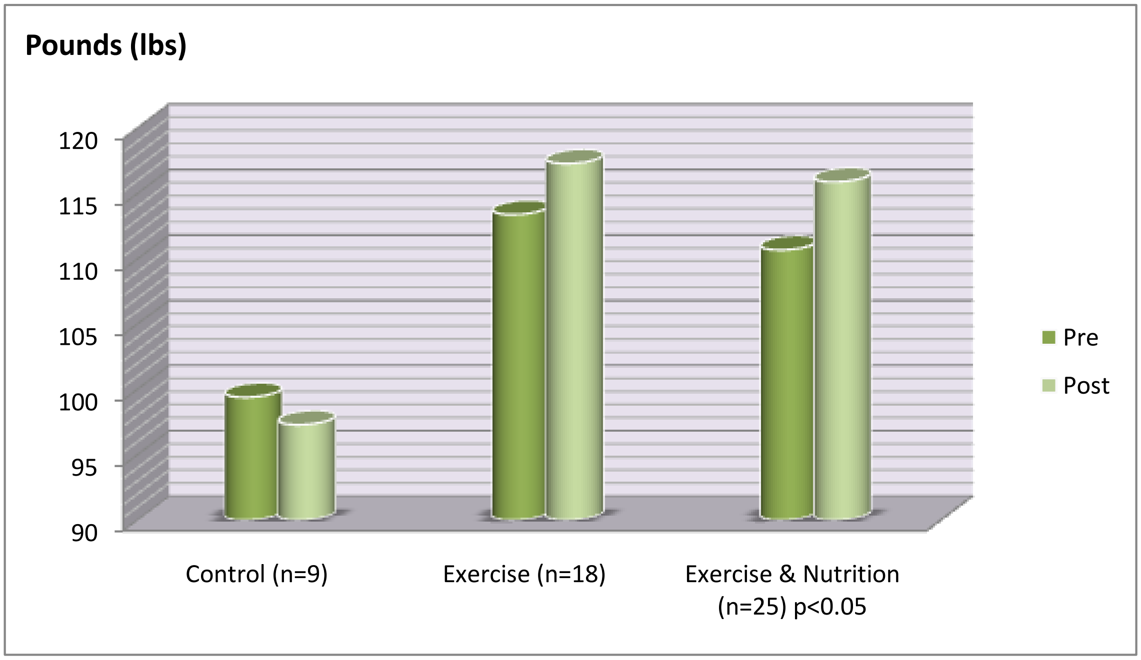

Figure 2. Lean Body Weight (lbs)

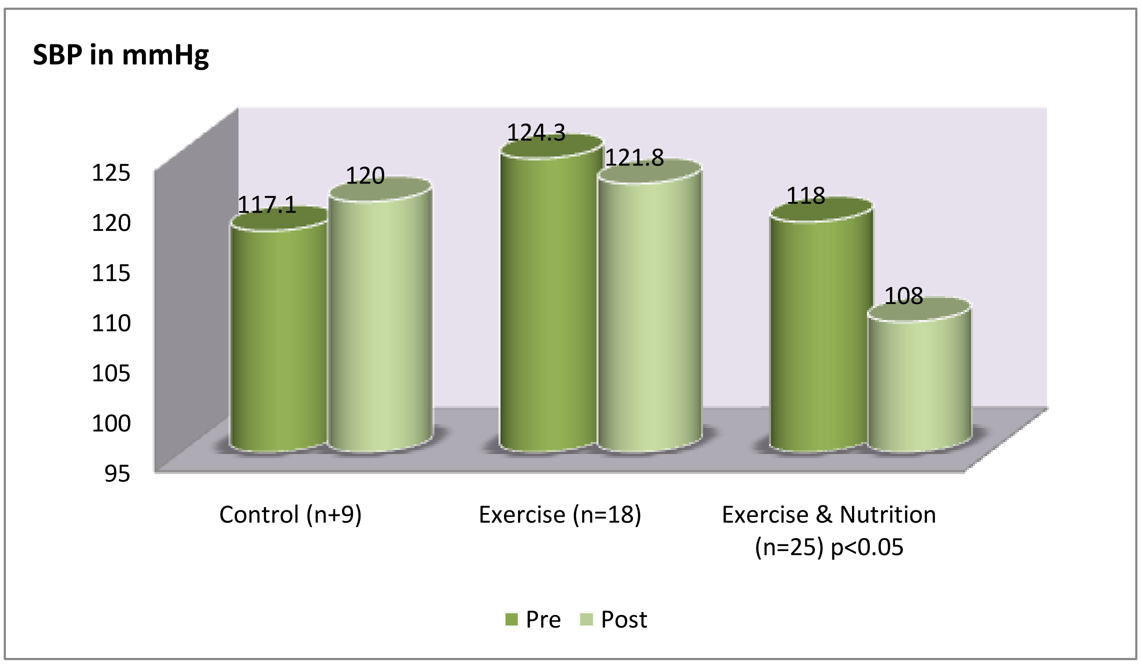

Figure 3. Resting Diastolic BP (mmHg)

Resting diastolic blood pressure did not demonstrate a significant main effect (F {1, 46} = 1.19, P = 0.28). There was a significant interaction among groups (F {2, 46} = 12.68, P≤0.001). Only the Exercise and Nutrition Group, which realized a 4.8 mmHg reduction in resting diastolic blood pressure (70.5 – 65.7 mmHg), achieved a significant decrease in this measure (95% CI, 1.09 – 2.32) (refer to Figure 4).

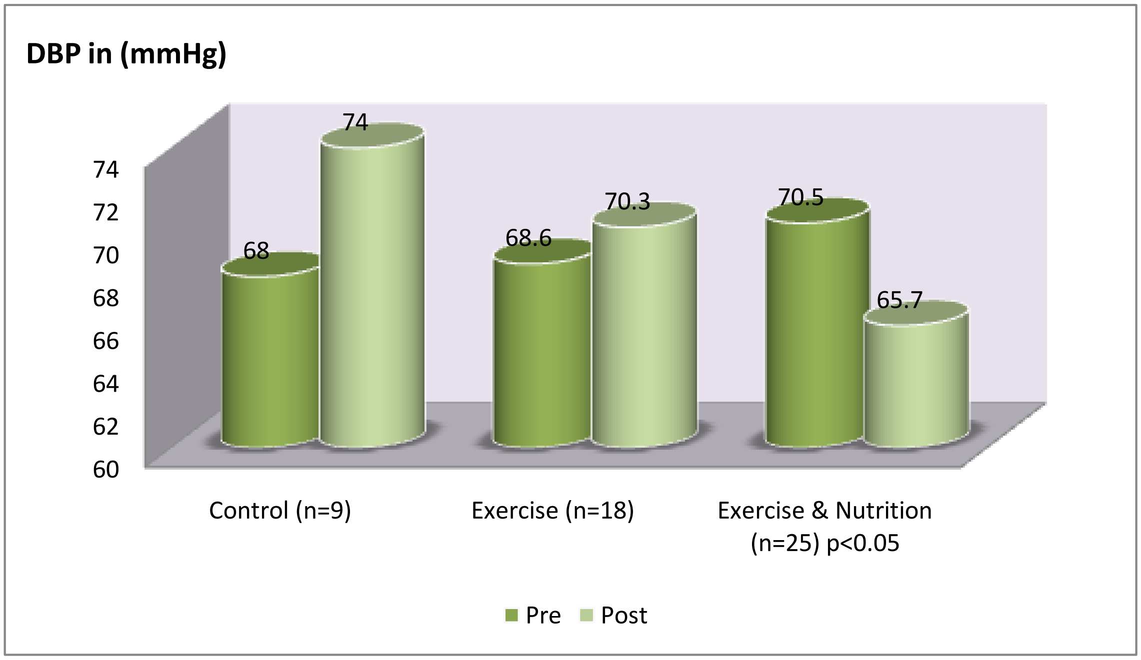

Figure 4. Resting Diastolic BP (mmHg)

DISCUSSION

Although both exercise groups added lean weight, only the Exercise and Nutrition Group attained a significant increase in lean weight. This finding is consistent with numerous studies that have demonstrated significantly greater gains in lean weight when resistance training is coupled with post-exercise protein/carbohydrate supplementation (15,21,22,30,32,33,48,50,71). Based on our findings and previous research results, it would appear that ingesting a protein/carbohydrate snack shortly after each strength training session may enhance lean weight gain and muscle development.

With respect to resting blood pressure, only the Exercise and Nutrition Group experienced significant decreases in systolic and diastolic readings. While the reasons for these changes are not fully understood, the fact that this group made significant improvements in lean weight may have played a role in the blood pressure reductions.

A primary purpose of the present study was to determine if resistance exercise or resistance exercise plus supplemental protein, calcium, and vitamin D could prevent or reverse the loss of bone that accompanies inactive aging. With respect to bone mineral density, the results are consistent with previous research studies. For example, the meta-analysis by Wolfe and associates (72) indicated that exercise interventions prevented a 1% per year bone loss in the lumbar spine, and that is essentially what was found between the Control Group and the Exercise Group. After 9 months, the inactive control subjects experienced a 1% lumbar spine bone loss, whereas the exercise subjects essentially maintained their lumbar spine bone mineral density. The recent literature review by Going and Laudermilk (26) revealed that exercise produced a 1 to 3% increase in lumbar spine bone mineral density, which is inclusive of the 1% increase attained by Exercise and Nutrition Group. Although the group differences did not reach statistical significance, it is speculated that a longer training period (e.g., 12 months) may produced significant findings. Based on the pattern of percentage changes in bone mineral density observed in this study, it would appear advisable to provide a combined program of exercise and nutritional supplementation for enhanced bone-building benefits.

According to the 2004 report by the Surgeon General (62), an estimated 10 million Americans have osteoporosis, and this number is predicted to increase almost 40% by the year 2020 (26). It is therefore essential to identify successful strategies for preventing the insidious series of degenerative processes starting with sarcopenia, leading to osteopenia, and progressing to osteoporosis. Numerous studies have shown that the most productive means for increasing muscle mass is resistance training coupled with a post-exercise protein and carbohydrate snack (15,21,22,30,32,33,48,50,71). Consuming additional protein, especially after exercise, may be particularly important for older adults, as research indicates that people over age 50 need more protein than younger adults (12,22-24,55). In fact, according to leading nutritionists, exercisers over 50 years of age need 50% more protein than the recommended daily allowance (RDA) in order to add muscle tissue (55).

Because there is a positive relationship between muscle mass/strength and bone mineral density (11,17,26,46) resistance training coupled with a post-exercise protein/carbohydrate snack would seem to be an effective means for increasing bone mineral density. Based on recent research and the pattern of bone mineral density changes observed in the present study, it would also appear appropriate for adults and older adults to complement their exercise program and post-training protein/carbohydrate snack with supplemental calcium and vitamin D for enhanced musculoskeletal health (8,18,42,60,64,66).

While it is well known that exercise reduces resting blood pressure, the finding of a decrease of resting blood pressure only in those subjects who combined exercise with soy protein supplementation was not completely surprising. Meta-regression analyses have revealed a significant inverse association between pre-treatment blood pressure readings and the level of blood pressure reductions in humans consuming soy protein (19). Soy protein intake, compared with a control diet, has been shown to significantly reduce both systolic blood pressure and diastolic blood pressure. Interestingly, related to the specific findings in the present study, the blood pressure reductions are related to pre-treatment BP levels of subjects and the type of control diet used as comparison (19). In addition, individual genetics may have a profound influence on blood pressure homeostasis. Most importantly, it is known that high protein diets can increase dopaminergic tone (10). In terms of dopamine genetics it is well established that specific polymorphisms of the dopamine D2 receptor gene causing dopamine D2 receptor deficiency results in hypertension in animal models (63) and in humans (52). Moreover, there is adequate evidence that agonists of both the dopamine transporter and dopamine D2 receptor genes have been shown to decrease blood pressure in experimental animals and hypertensive patients (28). Finally, studies suggest that DNA sequence variation in the DRD2 gene is associated with physical activity levels among White women (30). Specifically, carriers of the same polymorphisms observed in hypertensive patients, TT homozygote White women had 29-38% lower sports index ($F=4.09$, $P=.023$) and 27-33% lower work index ($F=6.23$, $P=.004$) than the CC homozygotes and CT heterozygotes. In future experiments, it will be important to further correlate exercise, nutrition and dopaminergic genes especially in White women.

Recommendations

Assuming physician approval, a reasonable exercise and nutrition program for previously inactive men and women may include the following guidelines: 1) perform 1 set of 12 basic resistance exercises that cumulatively address all of the major muscle groups, 2 or 3 non-consecutive days per week; 2) perform about 25 min of aerobic activity using an interval training protocol, 2 or 3 days per week; 3) consume a protein/carbohydrate shake/snack (e.g., 24 grams protein and 36 grams carbohydrate) immediately after each exercise session; and 4) take daily calcium supplementation [e.g., 500 mg] and daily vitamin D supplementation (e.g., 1200 IU).

CONCLUSIONS

Based on the research literature and the results of this study, we suggest that the combination of regular exercise (i.e., strength training and aerobic activity) and supplemental nutrition (post-exercise protein/carbohydrate snack, daily calcium, daily vitamin D,soy) represents a relatively comprehensive and productive approach for enhancing musculoskeletal fitness by increasing lean weight and bone mineral density, and for reducing cardiovascular risk factors (i.e., decreasing resting systolic blood pressure and resting diastolic blood pressure) in adults and older adults. In short, this study determined that exercise and nutritional supplementation may be more effective than exercise alone for increasing lean weight and for reducing resting blood pressure.

ACKNOWLEDGMENTS

The authors thank Jamie McManus, MD and Les Wong, BS, and the Shaklee Corporation for supporting this research study. The authors also acknowledge Maggie Faretra, Joanne D'Andrea, Michael Frontino, John Fachey, and Hank Pilot for providing instructional leadership to the study participants, and Susan Stoddard for her assistance with the manuscript.

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