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The Effect of Resveratrol Administration on Element Metabolism in Bone Tissue of Acute Swimming Exercised Rats

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Abstract

BACKGROUND/AIMS: In this study, we investigated how acute exercise affects bone element levels in resveratrol supplemented rats.

MATERIAL AND METHODS: The rats used in the study were divided into 4 groups with equal numbers (7 animals in each group). Control (group 1), swimming control (group 2), resveratrol (group 3), resveratrol + swimming (group 4). At the end of the four-week application, the animals were sacrificed under general anesthesia and bone tissue samples were removed. Zinc, magnesium, copper, iron, lead, cobalt, molybdenum, chromium, manganese, phosphorus, calcium and selenium levels were determined in bone tissue samples taken.

RESULTS: The bone zinc, iron, calcium, phosphorus, magnesium and boron levels of group 3 who received resveratrol supplementation were higher than all other groups ($p<0.05$). The lowest magnesium, calcium, and phosphorus values were obtained in the swimming groups (groups 2 and 4) ($p<0.05$). The levels of other measured elements did not differ between the groups.

CONCLUSION: According to the findings of this study: 1) Both resveratrol supplementation and acute swimming exercise cause changes in bone element metabolism. 2) Resveratrol supplementation changes bone element levels independent of exercise. 3) Resveratrol supplementation has a protective and/or regulating effect on bone element metabolism.

Keywords: Resveratrol supplementation, acute exercise, bone tissue, elements, rat

INTRODUCTION

Along with nutritional behaviors, sports and physical activity are considered as an important component in maintaining a healthy lifestyle.[1] Many studies have shown that moderate exercise may be beneficial for primary and secondary diseases, especially heart diseases,[2] disorders in carbohydrate metabolism, especially diabetes,[3] metabolic syndrome[4] and diseases such as Alzheimer's[5,6] caused by hippocampal degeneration.

Hormesis is a concept that has been proposed to explain the ability to maintain life at low concentrations of toxic agents and the adaptive cases developed against these agents.[7] The adaptation mechanism exhibited by metabolism against physical exercise can also be evaluated within the context of this concept. Sports and exercise are recommended to maintain a healthy lifestyle. However, it has also been shown that sports and physical exercise can cause oxidative stress and thus tissue damage.[7] Therefore, intensive efforts are made to develop dietary strategies for tissue damage caused by sports and exercise.[7] In recent year, ability of resveratrol in modulation of physical performance and prevention of oxidative damage has been studied.[7] Resveratrol administration in elderly mice has been shown to prevent lipid peroxidation.[8] Similar findings have been demonstrated by Dolinsky et

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al.[9] In a study on 14 athletes, resveratrol administration was reported to prevented lipid peroxidation caused by exercise.[10] It is mentioned that resveratrol supplement may delay aging by improving health and quality of life in the aging process, in addition to its performance enhancing effect in athletes and physically active individuals.[11,12] Consistently, it was demonstrated in elderly mice model that resveratrol increases strength in exercise[8] and may prolong lifetime.[13,14] In the mentioned events it is obvious that muscular function is likely to be largely activated by resveratrol therapy.[15] The above reports of researchers on the subject show that resveratrol administration is beneficial in rodents with suppressed physical performance. But it is also noteworthy that resveratrol supplementation increased exercise capacity and physical performance not only in experimental animals with chronic health problems but also in healthy young adult mice and rats.[16,17] Similarly, it has been demonstrated that resveratrol increased muscle strength and functions in experimental animals specially raised for exercise types requiring endurance.[18] More importantly, in addition to the positive effects of resveratrol on exercise,[19] its important effects on cardiac tissue have also been shown in two different rodent models. In conclusion, administration of resveratrol with regular exercise[17] has sustainable positive effects not only on cardiovascular functions but also on the muscle activity.

Contrary to the mentioned effects of resveratrol, studies on its effects on element metabolism in exercise are scarce in the literature. Therefore, the aim of this study how acute exercise affects bone element levels in resveratrol-supplemented rats.

MATERIAL AND METHODS

Experimental Design

Adult male rats (Wistar) used in this study were obtained from Necmettin Erbakan University Kombassan Experimental Medicine Research and Application Center. This study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the Experimental Animals Ethics Board of Necmettin Erbakan University's Kombassan Experimental Medicine Research and Application Center (approval number: 2013-183).

The rats used in the study were divided into 4 groups with equal numbers (7 animals in each group). Control (group 1), swimming control (group 2), resveratrol (group 3), resveratrol + swimming (group 4).

Rats in group 1 and 2 were fed standard rat chow. The rats in groups 3 and 4 received resveratrol "Sigma R5010" (10 mg/kg/day) supplementation in drinking water for 4 weeks in addition to the standard diet. The rats in groups 2 and 4 were given 30 min of acute swimming exercise at the end of the 4 weeks of practice.

The rats in the study groups were fed standard rat chow not less than ten grams per hundred grams of their body weight. The food of the experimental animals was obtained from the center where the study was conducted as normal rat food (as pellets). All animals were maintained at the same room temperature (21±1 °C) and on the same light/dark cycle (12 h light and 12 h dark cycle) throughout the study.

Swimming Exercise

Swimming exercises in rats were performed in an 80 cm long and 50 cm wide swimming pool made of heat-resistant polyethylene. To minimize stress factors in animals, acute swimming exercises were performed as 30-minute swimming exercises in a single session. It is accepted that swimming exercises between 30 and 60 min cause moderate stress in rats.[20]

Informed Consent

Following the four-week applications, 30-minute acute swimming exercises were applied to the animals in a single session. All animals were sacrificed 24 h after the acute swimming exercise and bone tissue samples were taken. General anesthesia was administered to all animals (with intramuscular administration of a combination of Ketalar, Parke-Davis and xylazine "Rompun, Bayer") to avoid animal suffering.

Elemental Analysis in Bone Tissue

At the end of the four-week practice, the animals were sacrificed under general anesthesia 24 h after 30 min of acute swimming exercise, and bone tissue samples were taken. Analysis of Zn, Pb, Co, Mo, Mg, Mn, P, Cu, Fe, Ca, Se and B elements in bone tissue samples was performed by the anomical emission method (inductively coupled plasma atomic-emission spectrometer). Results were calculated as µg/gram tissue. All elemental analysis in bone tissue were performed following the National Institute of Standards and Technology 1547 procedure.[21]

Statistical Analysis

Statistical evaluation of the data obtained was carried out using SPSS v. 21.0 package software, and the arithmetic mean and standard deviation of all parameters were calculated. Data were determined to show a normal distribution with Shapiro-Wilk test. One-Way variance analysis was used to determine differences between the groups, and the least significant difference test was used to find the group causing difference. $P<0.05$ values were considered statistically significant.

RESULTS

The highest bone zinc level was obtained in group 3, independent of swimming exercise, who received resveratrol supplementation ($p<0.05$). Acute swimming exercise led to the suppression of bone zinc levels in swimming groups (group 2 and group 4) with and without resveratrol supplementation ($p<0.05$). The lowest iron values in bone tissue were obtained in the swimming groups (groups 2 and 4) ($p<0.05$). There was no difference between the groups in terms of copper and selenium values (Table 1).

Table 1. Zn, Fe, Cu and Se levels in bone tissue of experimental animals (µg/gram tissue)

Groups	Zn	Fe	Cu	Se
G1 (control)	38.08±6.05[b]	18.10±8.30[a]	0.42±0.10	1.66±0.48
G2 (swimming control)	23.37±2.52[c]	8.78±3.76[b]	0.64±0.40	2.17±1.84
G3 (resveratrol)	53.22±12.52[a]	17.72±7.99[a]	0.44±0.19	2.23±0.50
G4 (resveratrol + swimming)	17.82±2.88[c]	8.86±2.65[b]	0.42±0.33	1.77±0.37

*Means with different superscripted letters in the same column are statistically significant a<b<c ($p<0.05$).

Resveratrol supplementation (group 3) increased bone calcium, phosphorus, and magnesium levels independent of swimming exercise ($p<0.05$). When compared with the control group, acute exercise led to a significant suppression of calcium, phosphorus, and magnesium levels in the bone in the swimming groups (groups 2 and 4) with and without resveratrol supplementation ($p<0.05$). There was no difference between the groups in terms of lead values in bone tissue (Table 2).

Resveratrol supplementation increased bone boron levels in group 3 ($p<0.05$). There was no difference between the groups in terms of Co, Cd, and Mo values in bone tissue (Table 3).

DISCUSSION

The highest levels of zinc, magnesium, calcium and phosphorus were obtained from the resveratrol only group, and the lowest levels of zinc, magnesium, calcium and phosphorus were obtained from the swimming groups and resveratrol + swimming group. Regular and long-term moderate exercise increase mineral content, and in conclusion this type of exercise is beneficial for bone mineralization.[22,23] On the other hand, many researchers have shown that exhausting exercises or the exercises performed until exhaustion negatively affect element metabolism in bone tissues.[24-26] In their study, Nielsen[26] pointed out that loss of bone minerals, especially zinc, occurred in rats that were subjected to tiring and exhausting exercise, and that especially loss of zinc in the bone tissue may cause osteopenia. Again, a single swimming exercise performed until exhaustion was reported to increase the loss of both magnesium and iron in the bone tissue.[24,25] In the present study, our finding of decreased magnesium, calcium, zinc and iron levels (in swimming control and resveratrol + swimming groups) is consistent with the results of above mentioned studies. Interestingly, in this study we found that levels of zinc, magnesium and calcium that were decreased in the swimming groups (swimming control and resveratrol + swimming groups) were increased in resveratrol alone group, and there was no change in bone iron levels. This finding is important in terms of indicating that resveratrol administration with a dose of 10 mg/kg for 4 weeks may lead to an increase in the mineral content of bones. In the present study, boron levels in bone tissue were higher in the resveratrol alone group compared to all other groups. Boron administration was reported to decrease calcium excretion, increase estrogen levels, and prevent bone loss in women in the menopausal period.[27-29] In a study, 3 mg/day boron was given to postmenopausal women, and it was found that urinary spillage of Mg, Ca, and P was decreased with boron supplementation, with these decreases being more prominent in the Mg diet.[29] Researchers state that magnesium and boron are essential for optimal calcium metabolism and elderly men and postmenopausal women need these minerals in order to be protected against losses in bone mass.[30,31] In our study, high boron levels in the bone tissue obtained in the resveratrol alone group are an important finding given the effects of boron element on bone metabolism. It was proposed that resveratrol has a bone tissue protecting effect, which occurs by stimulation of osteoblastic activity, and that resveratrol administration is critical to the prevention of age-related bone losses.[32] Similar finding was also reported by Wu et al.[32] Zhao et al.[33] Demonstrated that resveratrol administration has a protective effect on bone loss in osteoporosis. Increased levels of magnesium, calcium, zinc, and boron values that we obtained in resveratrol administration alone seem as a very crucial finding, emerge as an important result which will provide original and interesting information especially in the relationship between bone metabolism and resveratrol.

CONCLUSION

When the results of this study are examined as a whole; 1) Resveratrol administration changed element levels in the bone tissue independently of exercise. 2) It should be underlined that resveratrol administration has a protective and/or regulatory effect on bone metabolism independent of exercise.

MAIN POINTS

- Resveratrol administration changes element levels in the bone tissue independently of exercise.
- It should be underlined that resveratrol administration has a protective and/or regulatory effect on bone metabolism independent of exercise.
- In future studies, it can be suggested that the relationship between resveratrol administration and bone metabolism should be examined not only in terms of element metabolism but also in terms of histological changes.

Table 2. Ca, P, Mg and Pb levels in bone tissue of experimental animals (µg/gram tissue)

Groups	Ca	P	Mg	Pb
G1 (control)	53.05±12.9^{b}	30.50±5.16^{b}	11.50±2.41^{b}	0.10±0.03
G2 (swimming control)	33.91±7.93^{c}	14.76±1.30^{c}	7.84±1.97^{c}	0.34±0.12
G3 (resveratrol)	83.91±24.14^{a}	42.92±15.30^{a}	15.22±5.35^{a}	0.37±0.20
G4 (resveratrol + swimming)	31.53±17.82^{c}	15.18±2.15^{c}	5.70±1.87^{c}	0.16±0.07

*Means with different superscripted letters in the same column are statistically significant a<b<c ($p<0.05$).

Table 3. Co, Cd, Mo and B levels in bone tissue of experimental animals (µg/gram tissue)

Groups	Co	Cd	Mo	B
G1 (control)	0.048±0.03	0.011±0.01	0.06±0.03	0.15±0.01^{b}
G2 (swimming control)	0.021±0.01	0.020±0.03	0.08±0.04	0.19±0.03^{b}
G3 (resveratrol)	0.053±0.02	0.010±0.01	0.10±0.02	0.83±0.18^{a}
G4 (resveratrol + swimming)	0.020±0.01	0.011±0.02	0.05±0.02	0.29±0.05^{b}

*Means with different superscripted letters in the same column are statistically significant a<b ($p<0.05$).

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ETHICS

Ethics Committee Approval: The study protocol was approved by the Experimental Animals Ethics Board of Necmettin Erbakan University's Kombassan Experimental Medicine Research and Application Center (approval number: 2013-183).

Informed Consent: Patient approval has not been obtained as it is performed on animals.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: D.A., S.B.B., Ö.Ü., Design: D.A., S.B.B., Ö.Ü., Data Collection and/or Processing: D.A., S.B.B., Ö.Ü., Analysis and/or Interpretation: D.A., S.B.B., Ö.Ü., Literature Search: S.B.B., Ö.Ü., Writing: S.B.B., Ö.Ü.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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