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Changes in Blood Bone Metabolism Markers with Oat Bran Consumption and Brisk Walking Exercise in Middle Age Hypercholesterolemic Women

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ABSTRACT

Purpose
To investigate the additional beneficial effects of combined oat bran consumption and brisk walking exercise compared to oat bran consumption alone on bone metabolism markers in 40 to 50-years-old hypercholesterolemic women.

Methods
Thirty-three hypercholesterolemic women participants aged 40 to 50-years-old were recruited and were assigned into three groups, with eleven participants per group (n=11): sedentary without oat bran consumption control (C), oat bran consumption alone (Ob), and combined oat bran consumption and brisk walking exercise (ObEx) groups. Participants in the ObEx group performed brisk walking exercise sessions 30 minutes per session, 3 sessions per week for 6 weeks. Participants in the Ob group and ObEx group consumed 18 g of oat bran powder, 7 days per week for 6 weeks. Participants' anthropometry and blood bone metabolism markers were measured at pre- and post-tests.

Results
There were no significant main effects of time ($p>0.05$) in serum total calcium, serum phosphorus and serum C-terminal telopeptide of type 1 collagen (1CTP) (bone resorption marker) concentrations in all the groups. However, significantly ($p<0.05$) increase in serum alkaline phosphatase (bone formation marker) concentration was observed in Ob group and ObEx group respectively.

Conclusion
The present observations did not show large difference in the beneficial effects of combined oat bran consumption and brisk walking compared to oat bran consumption alone on bone metabolism markers. Future studies with longer duration may be needed to elicit greater effects of combined oat bran consumption and brisk walking than oat bran consumption alone on bone metabolism markers in middle age hypercholesterolemic women.

Keywords
Bone metabolism; Brisk walking; Hypercholesterolemic; Oat bran consumption; Middle age women.

INTRODUCTION

One of the common silence diseases among the elderly is osteoporosis. Osteoporosis becomes a significant public health problem in recent years because of its association with fragility fractures. Exercise is highly recommended to improve bone health. Exercises such as brisk walking, running, jumping, resistance training and other weight-bearing exercises are beneficial to build bones and preserve bone mass.[1]

Besides exercise, bone health also can be affected by the nutritional status of an individual. It is believed that oat bran is one of the beneficial nutritional supplementations for enhancing bone health. It is known as a vital source of B-complex vitamins,

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fat, soluble fiber β-glucan[2] and also contains macronutrients and minerals such as protein, magnesium, zinc, and iron which are important for bone health.[3] Oat bran has total β-glucan and dietary fibre not less than 5.5 and 16.0% respectively with at least one-third of total dietary fiber is soluble fiber.[4] β-glucan in oat plays an important role in improving immunity and prevention against diseases.[5] A previous study carried out by Shin et al[6] reported that Polycan, a β-glucan from Aureobasidium exhibited favourable effect on ovariectomy-induced osteoporosis, and their finding implying that β-glucan may elicit beneficial effect on bone metabolism markers, such as serum calcium, phosphorus and osteocalcin.

Previous studies by Majima et al[7] and Tintut et al[8] examined the relationship between hypercholesterolemia and bone metabolism. Majimaet al[7] reported that lipid and lipoprotein oxidation by-products inhibit osteoblastic differentiation and function although serum bone specific alkaline phosphatase (BAP) was not reduced in patients with hypercholesterolemia. Furthermore, Tintut et al[8] also reported that hypercholesterolemia promotes osteoclastic differentiation and resorptive activity and have suggested that hypercholesterolemia may cause osteoporotic bone loss *via* increased bone resorption. Collectively these previous studies showed that hypercholesterolemia may reduce bone formation and enhance bone resorption.

To date, the effects of oat bran consumption on bone health are lacking. Additionally, information is also lacking on the additional beneficial effects of combined oat bran consumption and brisk walking exercise compared to oat bran consumption alone on bone metabolism markers. Therefore, the present study was proposed to investigate the combined effects of oat bran consumption and brisk walking exercise on bone metabolism markersin 40 to 50-years-old hypercholesterolemic women.

MATERIALS AND METHODS

Participants

Thirty-three adult women participants were involved in this study. Participants were screened in order to determine the inclusion criteria and they were asked to provide informed consent form. Inclusion criteria of participants were physically healthy volunteers who were free from any chronic diseases, hypercholesterolemia with total cholesterols ranged between 5.2 to 7.0 mmol/L, non-smokers and with age between 40 to 50-years-old. The exclusion criteria were individuals who had the habit of taking oat bran as daily consumption prior to the study period, engaged in any training programme and exercised more than once per week.This study was approved by the human research ethic committee of Universiti Sains Malaysia (JEPeM Code: USM/JEPeM/15100389).

Experimental Design

Participants grouping: Participants were randomly assigned into three groups with 11 participants per group: sedentary without oat bran consumption control group (C), oat bran consumption alone group (Ob) and combined brisk walking exercise with oat bran consumption group (ObEx). Participants in the control group (C) did not perform brisk walking exercise nor having oat bran consumption for 6 weeks. Meanwhile, participants in oat bran consumption alone group (Ob) consumed 18 g of oat bran per day without performing a brisk walking exercise for 6 weeks. Participants in combined oat bran consumption with brisk walking exercise consumed 18 g of oat bran per day for 6 weeks and performed a brisk walking exercise, 30 min per session, 3 sessions per week for 6 weeks.

Brisk walking exercise program: The participants in brisk walking exercise with oat bran consumption (ObEx) group were required to perform a brisk walking exercise with 30 minutes per sessions (from 6.00 p.m. to 6.30 p.m.), three sessions per week for six weeks. In each brisk walking exercise session, all the participants warmed up by performing static stretching activities together for five minutes and then followed by brisk walking for 30 minutes, and ended with cooling down with static stretching activities for five minutes. The estimated walking distance covered was approximately 2.5 km. The exercise intensity during brisk walking was set at 55% to 70% of the participants' age-predicted heart rate maximum (HR_{max}) (HR_{max}=220-age). Heart rate monitors (Polar watch) were worn by participants throughout the brisk walking sessions. In order to ensure that the exercise intensity was maintained within the targeted range, participants were required to record their post-exercise heart rate at the end of the brisk walking session. If the walking pace did not elicit a heart rate within a targeted exercise heart rate, the participants were requested to change their pace during the subsequent walking session. The brisk walking programme was carried out at the jogging track in the Health Campus of Universiti Sains Malaysia and under the supervision of the researcher. The attendance of the participants during each brisk walking session was recorded by the researcher in order to ensure that they have complied with the exercise programme.

Oat bran supplementation: The participants in both Ob and ObEx groups consumed oat bran supplementation with two sachets of oat bran powder (18 g of oat bran powder containing 3.6 g of β-glucan)[9] diluted with plain water per day, 7 days per week for 6 weeks. The participants were required to consume one sachet of oat bran powder before breakfast, and another one sachet of oat bran powder before lunch or dinner. On the exercise days, the participants in the ObEx group were required to consume oat bran one hour before brisk walking exercise.

Measurements of anthropometry: Anthropometric parameters such as body height and body weight were measured during pre- and post-tests. Body height was measured by using a stadiometer (Seca 220, Germany). Body weight was measured by a body composition analyser (Tanita, model TBF-410). Participants were required to be shoeless and wore minimal clothes during these measurements.

Blood sample collection and analysis: Six ml of blood samples were taken immediately before and after the six weeks of experimental period in the morning after a 10 hours overnight fast (drinking plain water was allowed). A blood sample was drawn

from the antecubital vein of the participants. Blood taking sessions for participants in ObEx in post-test were carried out at 8.30 a.m. the next morning after performing a brisk walking exercise, i.e. 14 h post-exercise.

Blood samples were analysed for bone metabolism markers, which were serum total calcium, serum phosphorus, bone formation marker of serum alkaline phosphatase (ALP) and bone resorption markers of serum C-terminal telopeptide of type 1 collagen (1CTP). Serum total calcium, serum phosphorus and serum ALP analysis were performed in an accredited pathology laboratory (BP Clinical Lab, Malaysia). Serum 1CTP concentration was analysed using human 1CTP ELISA kit according to manufacturer's instructions and measured on VersaMax ELISA microplate reader (Molecular Devices, USA) in the laboratory in UniversitiSains Malaysia.

STATISTICAL ANALYSIS

Data were analysed using the statistical software in the Statistical Package for Social Science (SPSS) Version 22.0. All data are expressed as means and standard deviation (SD). Repeated measure ANOVA was performed to determine the significance of the difference between and within groups. Statistical significance was accepted at $p<0.05$.

RESULTS

Participant Physical Characteristics

A total of thirty-three participants with mean age: 45.0±4.0 years, mean body weight: 66.2±13.5 kg and mean body height: 153.74 ±5.03 cm completed the study. The mean age of the participants in C, Ob and ObEx group was 44.6±4.1, 45.3±4.7and 45.5±3.5years respectively. Table 1 tabulates the body height and body weight at pre-test and post-test of all the participants according to group. Repeated measures ANOVA showed that there were no significant interactions between time and intervention (df=2, F=3.025, $p=0.064$) on body weight, however there was significant time effect in body weight (df=1, F=7.287, $p=0.011$). There were no significant differences of mean body weight between all the three groups at pre-test ($p=0.133$). After 6 weeks of the study period, participants' body weight was significantly lower at post-test in Ob ($p=0.042$) and ObEx ($p=0.006$) groups compared to pre-test. The average attendance of the participants in the exercise group during training session was 99.1±3.0 %.

Bone Metabolism Markers

Table 2 illustrates the results of serum total calcium and serum phosphorus. Results of the statistical analysis showed that there were no significant interactions between time and intervention (df=2, F=1.916, $p=0.165$), and there was no significant time effect (df=1, F=0.091, $p=0.765$) in serum total calcium. Similarly, results showed that there were no significant interactions between time and intervention (df=2, F=0.237, $p=0.790$), and also no significant time effect in serum phosphorus (df=1, F=0.012, $p=0.915$).

It was found that there were no significant interactions between time and intervention (df=2, F=2.040, $p=0.148$), however there was significant time effect in serum ALP (df=1, F=30.427, $p=0.000$). Further analysis showed that there were no significant differences in serum ALP concentration between pre- and post-tests in C. However, serum ALP increased in post-test compared to pre-test in Ob (+10.27%) and ObEx (+12.98%) groups (Figure 1).

Table 1. *Mean Age, Body Height and Body Weight of the Participants*

Groups	Number of participants per group (n)	Body height (cm) (Mean ± SD)	Body weight (kg) (Mean±SD)		
			Pre-test	Post-test	Percent difference compared to pre-test (%)
C	11	153.5±5.9	59.8±9.3	60.0±9.6	+0.33
Ob	11	153.7±5.4	67.7±14.0	67.0±13.8[a]	-1.03
ObEx	11	154.0±4.1	71.1±15.1	70.1±14.8[a]	-1.41

Values are tabulated in means±standard deviation (SD). [a]significantly different from pre-test ($p<0.05$)

Table 2. *Bone Metabolism Markers of Serum Total Calcium and Serum Phosphorus Concentration*

Groups	Serum total calcium (mmol/L)		Percent difference compared to pre-test (%)	Serum phosphorus (mmol/L)		Percent difference compared to pre-test (%)
	Pre-test	Post- test		Pre-test	Post-test	
C	2.29 ± 0.12	2.33 ± 0.15	+1.75	1.08±0.16	1.10±0.16	+8.33
Ob	2.27 ± 0.08	2.26 ± 0.08	-0.44	1.10±0.09	1.11±0.10	+0.91
ObEx	2.28 ± 0.07	2.27 ± 0.05	-0.44	1.18±0.22	1.16±0.11	-1.69

Values are tabulated in means±standard deviation (SD). Abbreviations: C: sedentary without oat bran consumption control group;Ob: oat bran consumption alone group; ObEx: combined oat bran consumption with brisk walking exercise group.

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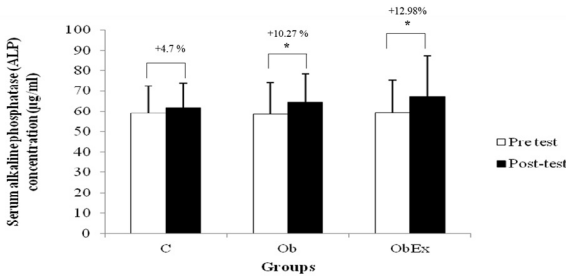
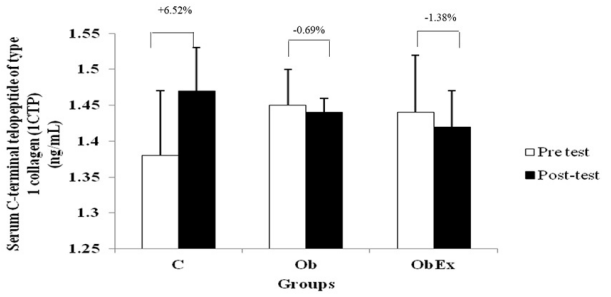
Figure 1. *Serum Alkaline Phosphatase (ALP) Concentration*



**, denotes p<0.05 significantly different from pre-test Abbreviations: C: sedentary without oat bran consumption control group;Ob: oat bran consumption alone group; ObEx: combined oat bran consumption with brisk walking exercise group.*

Regarding serum 1CTP, it was found that there were no significant interactions between time and intervention (df=2, F=0.570, p=0.572), and there was no significant time effect in this measured parameter (df=1, F=1.618, p=0.214). The results of serum 1CTP are exhibited in Figure 2.

Figure 2. *Serum C-terminal telopeptide of type I collagen (ICTP) concentration*



Abbreviations: C: sedentary without oat bran consumption control group; Ob: oat bran consumption alone group; ObEx: combined oat bran consumption with brisk walking exercise group.

DISCUSSION

Bone metabolism markers are specific biochemical markers which can estimate the bone metabolic process. These markers have been established as useful parameters in assessing changes in bone turnover.[10] In other words, bone metabolism changes can be detected indirectly *via* blood markers of bone metabolism.In this present study, serum alkaline phosphatase was measured as bone formation marker and serum C-terminal telopeptide of type 1 collagen (1CTP) was measured as a bone resorption marker. Additionally, serum total calcium and serum phosphorus were measured to reflect bone related metabolic changes.

The main finding of the present study was that there were significant increases in serum alkaline phosphatase (ALP) in oat bran alone (Ob) group and combined oat bran with exercise (ObEx) group. This finding reflects that Ob and ObEx groups could increase the level of bone formation marker and implying that both Ob alone and ObEx may elicit a beneficial effect on bone health by stimulating bone formation. Nevertheless there was no large difference in the percentage increase in serum ALP in ObEx (+12.98%) and Ob (+10.27%).

Regarding the relationship between bone formation marker and nutritional supplement, 6 weeks of daily oat bran consumption alone could increase bone formation marker, i.e. alkaline phosphatase of the present study finding has supported our hypothesis that the β-glucan, macronutrient and minerals such as protein, magnesium, zinc, and iron contained in oat bran[3] may be beneficial for enhancing bone health.[6,11-13] Similarly, a previous study also found positive effect of mineral supplemented wheat flours with magnesium, iron and zinc on increasing bone mineral density in rats.[14]

The present observation of increased alkaline phosphatase with 6 weeks oat bran consumption alone in 40 to 50-years-old women was similar with a previous study by Ooi et al,[15] which also reported an increase in alkaline phosphatase with 6 weeks honey supplementation alone in 18 to 25-years-old young females. Both the present study and study of Ooi et al[15] findings imply that 6 weeks nutritional consumption of oat bran alone or honey alone could increase bone formation marker in the female population with different age. It is speculated that both oat bran and honey contain magnesium, zinc and iron which are beneficial for enhancing bone health.[3,15,16] Therefore, the positive effects of these nutritional supplementation on bone formation marker were observed.

The present finding of combining brisk walking with oat bran did not show vast difference in percentage increase (+12.98%) in ALP than oat bran alone (+10.27%), implies that combined exercise and nutritional consumption may elicit similar beneficial effect than nutritional consumption alone. The finding of increased in serum ALP as a result of combined oat bran with walking exercise in the present study was in agreement with another combined nutritional supplementation and exercise animal study, i.e. Mosavat et al,[16] which found that serum ALP was significantly increased in 80 jumps per day combined with 5 days per week daily honey supplemented rats after 8 weeks. Similarly, a previous human study by Ooi et al[15] also reported significantly increased of serum ALP in combined honey and aerobic dance exercise group after 6 weeks experimental period compared to the pre-test value in young females.

It was mentioned in Ooi et al[17] that different exercise modes can elicit different mechanical impact on bone physically and its metabolism. Even though the type of exercise in the present study, i.e. walking was different from jumping exercise in the rats by Mosavatet al[16] and aerobic dance in young females by Ooi et al,[15] similar positive effects on bone formation were observed.

Regarding the result of bone resorption marker in the present study, it was found that there were no significant differences in serum 1CTP, a bone resorption marker after six weeks of the study period in C (+6.52%), Ob (-0.69%) and ObEx (-1.38%). In a previous study involving patients with hypercholesterolemia by Majima et al,[7] serum bone-specific alkaline phosphatase (BAP)

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of the patients was significantly higher than that of the controls in women. Serum N-terminal telopeptide of type I collagen (NTx), a bone resorption marker of the patients was significantly higher than that of the controls in both men and women. These results indicate increased bone turnover in hypercholesterolemic or dyslipidemic patients regardless of gender. Findings of an animal model study also demonstrated that bone mineral density (BMD) was reduced in dyslipidemic mice.[18] These findings suggest that hypercholesterolemia may be a risk factor in affecting bone metabolism or turnover markers in hypercholesterolemia subjects.

Ooi et al[19] reported that there was no significant difference in serum 1CTP with Eurycoma longifolia Jack consumption alone after 8 weeks of intervention period compared to pre-test in adult men. Similarly, a significant reduction in 1CTP was not observed in oat bran alone group in the present study. The absence of significant change in serum 1CTP was also reported by Ooi et al,[15] which showed that there was no significant difference in 1CTP between pre- and post-tests in aerobic dance exercise combined with honey consumption groups in young females. Similarly, a previous study by Rahim et al[20] also reported that after 8 weeks of the experimental period, serum 1CTP level did not change significantly in post-test compared to pre-test value in honey combined with aerobic dance in adult women. In a previous animal study done by Tavafzadehet al,[21] lower level of serum 1CTP was observed in combined jumping exercise with honey group compared to other experimental groups in young female rats. Comparison between the present study finding with the human study of Ooi et al[15] and Rahim et al[20] showed that significant changes in serum 1CTP were not observed with neither oat bran nor honey when combined with exercise in young females and adult women. Nevertheless, the comparison between the present study with Tavafzadehet al[21] showed that significant reduction in serum 1CTP could be observed in animals, however not in human with nutritional supplementation combined with exercise.

The present study found that serum total calcium and serum phosphorus were not affected by oat bran consumption alone and the combination of oat bran and brisk walking exercise. Rahim et al[20] found that there was significantly greater serum total calcium in post-test compared to pre-test in honey consumption alone group after 8 weeks of the study period in adult women. Their finding was not consistent with the present finding, in which oat bran consumption alone did not show any significant increase of serum total calcium in the Ob group. Comparison between Rahim et al[20] and the present study showed that honey drink may have greater potential in increasing serum total calcium than oat bran consumption in adult women. Regarding serum phosphorus, the absence of significant changes in serum phosphorus as a result of combined honey supplementation and jumping exercise in rats was reported by Mosavatet al.[16] Similarly, the present study also did not find significant change with combined oat bran and brisk walking exercise in women.

In the present study, brisk walking exercise was prescribed for middle age hypercholesterolemic women. It was mentioned by Krall et al[22] that walking is frequently recommended as a way to help to protect against loss of bone density. Brisk walking improved bone quality in elderly women.[23] Compared to other types of exercises, it is the most appropriate and safest activity for a wide spectrum of the population including the older population. Dynamic exercises can develop bone tissue better than static exercise.[24] This is because dynamic loading can create higher hydrostatic pressure gradients within bone tissue compared to a static load. Walking is a type of dynamic exercise. It was expected to observe a much greater beneficial effect of brisk walking combined with oat bran than oat bran alone on bone metabolism markers in this study. However, our observation did not show vast difference in the beneficial effects of the combination of brisk walking and oat bran compared to oat bran alone on bone metabolism markers. A future study with longer duration may be needed to elicit greater effects of combined brisk walking and oat bran than oat bran alone on bone metabolism markers.

Another notable finding in the present study was that both Ob and ObEx groups had significantly decreased values of body weight at post-test compared to pre-test. Oat bran is a type of high fiber diet that can be consumed to reduce body weight. Decker et al[25] mentioned that oats are uniquely nutritious food as they contain high amounts of soluble fiber. According to Turner et al,[26] high fiber intake diets may increase satiation and reduce hunger. Based on the finding of this previous study, we can speculate that participants may reduce the intake of daily diets after consumed oat bran supplementation during six weeks of experimental study. This finding suggests that oat bran consumption alone or combined brisk walking and oat bran consumption can be prescribed to reduce the body weight of the participants. ObEx group has higher percentage difference compared to pre-test in the reduction of body weight compared to the Ob group. Based on this evidence, though oat bran alone can elicit beneficial effect to reduce body weight, the combination of brisk walking and oat bran consumption may have potential in eliciting greater beneficial effects in reducing the body weight of the participants.

In general, the discrepancy of the finding of the measured parameters between the present study and previous studies may be due to differences in the type of exercise and duration of exercise prescribed, the age range of the participants and particularly the time of blood withdrawal after exercise. It is suggested that future studies with different exercise intensity, longer intervention period and repeated blood withdrawing after exercise are needed. The presence of exercise alone group is also needed to be included as one of the study group in future studies to determine the effect of exercise alone on bone metabolism.

CONCLUSION

In conclusion, the present study did not indicate large difference in the beneficial effects of combined daily consumption of oat bran and brisk walking exercise performed for 3 days per week, compared to oat bran consumption alone on bone metabolism markers. Therefore, future studies with longer duration may be warranted to elicit greater effects of combined oat bran consumption and brisk walking than oat bran consumption alone on bone

metabolism markers in middle age hypercholesterolemic women.

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CONFLICTS OF INTEREST

None of the authors have any conflicts of interest.

REFERENCES

1. Aloia JF, Vaswani AN, Yeh JK, Cohn SH. Premenopausal bone mass is related to physical activity. *Arch Intern Med*. 1988; 148(1): 121-123. doi: 10.1001/archinte.1988.00380010123012

2. Butt MS, Tahir-Nadeem M, Khan MK, Shabir R, Butt MS. Oat: Unique among the cereals. *Eur J Nutr*. 2008; 47(2): 68-79. doi: 10.1007/s00394-008-0698-7

3. Biogrow Company. Oat BG22 Oat Bran Powder. Web site. http://biogrow.com.my/index.php/catalogue/oat-bg22-bran-powder. Accessed October 5, 2015.

4. American Association for Clinical Chemistry. AACC committee adopts oat bran definition. *Cereal Foods World*. 1989; 34: 1033-1034.

5. Daou C, Zhang H. Oat beta-glucan: Its role in health promotion and prevention of diseases. *Compr Rev Food Sci Food Saf*. 2012; 11(4): 355-365. doi: 10.1111/j.1541-4337.2012.00189.x

6. Shin HD, Yang KJ, Park BR, Son, CW, Jang HJ, Ku SK. Anti-osteoporotic effect of Polycan, β-glucan from Aureobasidium, in ovariectomized osteoporotic mice. *Nutrition*. 2007; 23(11-12): 853-860. doi: 10.1016/j.nut.2007.08.011

7. Majima T, Shimatsu A, Komatsu Y, et al. Increased bone turnover in patients with hypercholesterolemia. *Endocr J*. 2008; 55(1): 143-151. doi: 10.1507/endocrj.K07E-004

8. Tintut Y, Morony S, Demer LL. Hyperlipidemia promotes osteoclastic potential of bone marrow cells ex vivo. *Arterioscler Thromb Vasc Biol*. 2004; 24(2): 6-10. doi: 10.1161/01.ATV.0000112023.62695.7f

9. Sahrir NA, Ooi FK, Chen CK, Kyi WM, Osman JM. Bone metabolism in response to oat bran consumption and jogging exercise in young males. *Sport Sci Health*. 2018; 14(1): 135-142. doi: 10.1007/s11332-017-0416-z

10. Christenson RH. Biochemical markers of bone metabolism: An overview. Clin Biochem. 1997; 30(8): 573-593. doi: 10.1016/S0009-9120(97)00113-6

11. Angus RM, Sambrook PN, Pocock NA, Eisman JA. Dietary intake and bone mineral density. *Bone Miner*. 1988; 4(3): 265-277.

12. Palacios C. The role of nutrients in bone health, from A to Z. *Crit Rev Food Sci Nutr*. 2006; 46(8): 621-628. doi: 10.1080/10408390500466174

13. International osteoporosis foundation. Good nutrition for healthy bones. https://www.iofbonehealth.org/sites/default/files/PDFs/ good_nutrition_for_healthy_bones.pdf. 2006. Accessed November 19, 2015.

14. Coudray C, Levrat-Verny MA, Tressol JC, et al. Mineral supplementation of white wheat flour is necessary to maintain adequate mineral status and bone characteristics in rats. *J Trace Elem Med Biol*. 2001; 15(2-3): 131-137. doi: 10.1016/S0946-672X(01)80056-0

15. Ooi FK, Ismail N, Abdullah MY. Effects of combined aerobic dance exercise and honey supplementation on bone turnover markers in young females. *Asian J Exer Sport Sci*. 2011; 8(1): 1-11.

16. Mosavat M, Ooi FK, Mohamed M. Effects of honey supplementation combined with different jumping exercise intensities on bone mass, serum bone metabolism markers and gonadotropins in female rats. *BMC Complement Altern Med*. 2014; 14(1): 126. doi: 10.1186/1472-6882-14-126

17. Ooi FK, Sahrir NA. Physical activity, bone remodelling and bone metabolism markers. *Journal of Exercise, Sports & Orthopedics*. 2018; 5(2): 1-4. doi: 10.15226/2374-6904/5/2/00171

18. Parhami F, Tintut Y, Beamer WG, Gharavi N, Goodman W, Demer LL. Atherogenic high-fat diet reduces bone mineralization in mice. *J Bone Miner Res*. 2001; 16(1): 182-188. doi: 10.1359/jbmr.2001.16.1.182

19. Ooi FK, Mohamed HA, Chen CK, Asari MA. Combined effects of Eurycomalongifolia Jack supplementation and a circuit training programme on bone metabolism markers, muscular strength and power, and immune functions in adult men. *Int J Eng Res Sports Sci*. 2015; 2(3): 1-10.

20. Rahim M, Ooi FK, Hamid WZ. Changes of bone metabolism markers and muscular performance with combined aerobic dance exercise and honey supplementation in adult women. *Sport Exerc Med Open J*. 2016; 1(6): 186-197. doi: 10.17140/SEMOJ-1-129

21. Tavafzadeh SS, Ooi FK, Chen CK, Sulaiman SA. Changes in bone metabolism and antioxidant status with combined exercise and honey supplementation in young female rats. *J Exerc Sport Ortho*. 2015; 2(2): 1-8. doi: 10.15226/2374-6904/2/2/00127

22. Krall EA, Dawson-Hughes B. Walking is related to bone density and rates of bone loss. *Am J Med*. 1994; 96(1): 20-26. doi:

10.1016/0002-9343(94)90111-2

23. Brooke-Wavell K, Jones PR, Hardman AE. Influence of brisk walking on bone quality of healthy elderly women. *Bone*. 1996; 1(18): 110-111. doi: 10.1016/S8756-3282(96)80019-6

24. Turner CH, Robling AG. Designing exercise regimens to increase bone strength. *Exerc Sport Sci Rev*. 2003; 31(1): 45-50. doi: 10.1097/00003677-200301000-00009

25. Decker EA, Rose DJ, Stewart D. Processing of oats and the impact of processing operations on nutrition and health benefits. *Br J Nutr*. 2014; 112(S2): S58-64. doi: 10.1017/S000711451400227X

26. Turner TF, Nance LM, Strickland WD, Malcolm RJ, Pechon S, O'Neil PM. Dietary adherence and satisfaction with a bean-based high-fiber weight loss diet: A pilot study. *ISRN Obes*. 2013; 2013: 915415. doi: 10.1155/2013/915415