

## **BONE PROPERTIES AND BLOOD BONE METABOLISM MARKERS IN RESPONSE TO EXERCISES AND NUTRITIONAL SUPPLEMENTATION**

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The recognition of osteoporosis as a major health problem among the growing number of elderly people around the world has resulted in widespread efforts to determine the etiology of the disease and how it might be delayed or prevented. One strategy is to increase bone mass during the formative years of life and then subsequently either try to maintain the gain or reduce the rate of bone loss. These could be achieved through adequate nutritional intake and regular weight bearing exercises.

It has been suggested that weight-bearing exercises such as walking, running, dancing, and jumping are particularly necessary to help develop and maintain strong bones. Besides regular weight-bearing exercises, nutrition also plays an important role in enhancing and maintaining bone health. Honey contains carbohydrates such as glucose, fructose, sucrose and raffinose, enzymes, flavonoids, antioxidants, minerals, organic acids, proteins, phenolic acids, and vitamins such as vitamin C and vitamin E (Aljadi *et al.*, 2004), and some of these components are believed to be important for enhancing bone health. It was reported previously that taking honey appeared to enhance calcium absorption in rats, and could therefore play a role in boosting bone health (Ariefdjohan *et al.*, 2008). Additionally, in another study, it was found that in a group of young Sprague Dawley rats fed with honey for 52 weeks, their bone mineral density were significantly greater than the sugar free diet-fed controls (Chepulins & Starkey, 2008), this again indicates that honey may enhance bone health in animals.

Since the combined effect of honey and exercise in animal has not been confirmed, thus the present research team has conducted a study to investigate the effect of this combination on bone in rats. We found that that there were beneficial bone effects elicited by combined jumping exercise and honey supplementation with increases bone mineral density, geometry, mechanical properties, and bone metabolism in female rats (Tavafzadeh *et al.*, 2011; Ooi *et al.*, 2014).

As an extension work of the animal study mentioned above, the present research team has carried out a study for determining the effect of 6 weeks of combined aerobic dance exercise and honey supplementation on bone metabolism markers in young females (Ooi *et al.*, 2011). The measurable changes in bone mineral density by using bone densitometry such as Dual Energy X-ray Absorptionmetry scanning are expected not be able to be observed in a short duration of 6 weeks, therefore this study focused on changes in blood parameters, where changes in blood bone turnover markers such as serum alkaline phosphatase as bone formation marker, and serum C-terminal telopeptide of type 1collagen (1CTP) as bone resorption marker were observed.

In this previous human study involving young females, it was found that six weeks of aerobic dance exercise at three times per week, one hour per session combined with daily consumption of 20g of honey diluted in 300 ml of plain water elicited more beneficial effects on bone health by increasing blood bone formation marker in 19 to 29 years old young females compared to honey supplementation alone or exercise alone.

It was speculated that bone response varies with age, thus bone metabolism may be different in older population compared to young females with the combination of exercise and honey supplementation. Therefore an extension work of the above mentioned study was carried out for determining the effectiveness of combination of aerobic dance exercise and honey supplementation on bone metabolism markers in adult women with age ranging from 25 to 40 years old (Rahim *et al.*, 2016).

This previous study which involved adult females found that honey supplementation alone could significantly elevate serum total calcium level, whereas aerobic dance sessions alone could significantly elevate bone resorption. It was also found that combination of aerobic dance exercise and honey supplementation may elicit beneficial effects on reducing bone resorption induced by exercise in sedentary adult women.

It is well known that mechanical loading has an effective role in increasing bone health, in which an adequate exercise program can promote bone development and protect bone against age-related bone loss (Berard *et al.*, 1997). Evidences show that osteogenic effects of mechanical loading are dependent on the type, magnitude and rate of the applied load (Maimoun *et al.*, 2006). Dynamic and high magnitude loading such as jumping exercise which elicits great ground reaction force could elicit beneficial effects on bone health (Umemura *et al.*, 1997; Ooi *et al.*, 2009; Tavafzadeh *et al.*, 2011). Nevertheless, strenuous exercise is believed may elicit negative effects on bone properties (Matsuda *et al.*, 1986; Hou *et al.*, 1990; Li *et al.*, 1991; Maynard *et al.*, 1995).

It was mentioned by Mastorakos *et al.* (2005) that strenuous exercise is related with a decreased hypothalamic-pituitary-adrenal secretion. The stress of exercise can stop the gonadal function, by the production of glucocorticoids and catecholamines with activation of the corticotrophin releasing hormone neurons. Additionally, it was mentioned by Warren & Perlroth (2001) that low caloric input and high caloric expenditure can result in endocrine abnormalities, and this could be a factor which affects gonadotropin-releasing hormone suppression that manifests as menstrual disturbances with strenuous training. The consequence effects of strenuous exercise on female menstrual dysfunction consist of amenorrhea, infertility and osteoporosis.

To date, information is lacking on the effects of combined higher intensity of jumping exercise with honey on bone health and gonadotropins compared to combination of lower intensity of jumping exercise with honey in female rats. Moreover, we hypothesize that honey as a source of energy and its antioxidant properties may protect against adverse effects induced by exercise on gonadotropin hormones. Therefore, the present research team has carried out a study to investigate the effects of different jumping exercise intensities, i.e. low and high intensities combined with honey supplementation on bone parameters and gonadotropins in female rats. (Mosavat *et al.*, 2014). This study found that high intensity jumping exercise combined with honey supplementation resulted more discernable effects on bone mass and blood bone metabolism markers. Meanwhile, honey may protect against the adverse effects induced by jumping exercise on gonadotropins in female rats.

In summary, our human studies showed that supplementation of honey drink with 20g of honey diluted in 300ml of plain water combined with 3 days per week of aerobic dance exercise has potential to be proposed for formulating guidelines in planning exercise and nutrition promotion programs to elicit beneficial effects on bone metabolism compared to exercise or honey supplementation alone in female population with different age, i.e. both young and adult females. Meanwhile, our animal study showed that high intensity jumping exercise combined with honey elicited great beneficial effects on bone mass and bone metabolism markers. In addition, honey could elicit protective effects on disturbance of reproductive hormone levels induced by high and low intensities of jumping exercise. Therefore, honey may be able to be recommended to female athletes for maintaining their bone health and normal reproductive functions.

## References:

1. Aljadi AM, Kamaruddin MY (2004) Evaluation of the phenolic contents and antioxidant capacities of two Malaysian floral honeys. *Food Chem J* 85:513-518.
2. Ariefdjohan MW, Martin BR, Lachcik PJ, Weaver CM (2008) Acute and chronic effects of honey and its carbohydrate constituents on calcium absorption in rats. *J Agric Food Chem* 56: 2649-54.
3. Berard A, Bravo G, Gauthier P (1997) Meta-analysis of the effectiveness of physical activity for the prevention of bone loss in postmenopausal women. *Osteoporosis Int* 7: 331-337.
4. Chepulis L, Starkey N. (2008) The long-term effects of feeding honey compared with sucrose and a sugar-free diet on weight gain, lipid profiles, and DEXA measurements in rats. *J Food Sci* 73: H1-7.
5. Hou CH, Salem GJ, Zernicke RF, Barnard RJ (1990) Structural and mechanical adaptations of immature trabecular bone to strenuous exercise. *J Appl Physio* 69: 1309-1314.
6. Li KC, Zernicke RF, Barnard RJ, Li AF (1991) Differential response of rat limb bones to strenuous exercise. *J Appl Physio* 70: 554-560.
7. Maimoun L, Manetta J, Couret I, Dupuy A, Mariano-Goulart D, Micallef, J., Peruchon E, Rossi, M (2006) The intensity level of physical exercise and the bone metabolism response. *Int J Sports Med* 27: 105-111.
8. Mastorakos G, Pavlatou M, Diamanti-Kandarakis E, Chrousos GP (2005) Exercise and the stress system. *Hormones* 4: 73-89.
9. Matsuda JJ, Zernicke RF, Vailas AC, Pedrini VA, Pedrini-Mille A, Maynard JA (1986) Structural and mechanical adaptation of immature bone to strenuous exercise. *J Appl Physiol* 60: 2028-2034.

10. Maynard JA, Pedrini-Mille A, Pedrini VA, Vailas AC (1995) Morphological and biochemical effects of strenuous exercise on immature long bones. *Iowa Ortho J* 15: 162-167.
11. Mosavat M, Ooi FK, Mohamed M (2014) 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* 14:1-8.
12. Ooi FK, Ismail N, Abdullah MY (2011) Effects of combined aerobic dance exercise and honey supplementation on bone turnover markers in young females. *Asian J Exerc Sport Sci* 8:1-11.
13. Ooi FK, Singh R, Singh HJ, Umemura Y (2009) Minimum level of jumping exercise required to maintain exercise-induced bone gains in female rats. *Osteoporosis Int* 20: 963-972.
14. Ooi FK, Tavafzadeh SSH, Hung LK, Hung WY, He YX (2014) Tibial bone mineral density, geometry and mechanical properties in response to high impact exercise and honey supplementation in rats. *Asian J Exerc Sport Sci* 11:12-24.
15. Rahim, M, Ooi FK , Hamid WZWA (2016) Changes of bone metabolism markers and muscular performance with combined aerobic dance exercise and honey supplementation in adult women. *Sport Exerc Med Open J*. 1(6): 186-197.
16. Tavafzadeh SSH, Ooi FK, Oleksandr K, Siti Amrah S (2011) Effect of a combination of jumping exercise and honey supplementation on the mass, strength and physical dimensions of bones in young female rats. *J Api/Product ApiMed Sci* 3:26-32.
17. Umemura Y, Ishiko T, Yamauchi T, Kurono M, Mashiko S (1997). Five jumps per day increase bone mass and breaking force in rats. *J Bone Miner Res* 12: 1480-1485.
18. Warren MP, Perlroth NE (2001) The effects of intense exercise on the female reproductive system. *J Endocrinol* 170: 3-11.