

A Short Review of Honey Supplementation on Bone Metabolism Markers and Sports Performance

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ABSTRACT Bee product such as honey has been used thousands of years ago as a healthy supplement among human being. Honey is a nutritious supplement and contains fructose, glucose amino acids and multivitamins-minerals. It is well documented that honey has antioxidant, anti-inflammatory, antimicrobial and anti-mutagenic properties. An antioxidant agent is proven able to prevent several acute and chronic disorders such as inflammatory, osteoporosis, osteoarthritis, cardiovascular and cancer. It is believed that honey is beneficial on bone health and sports performance but it is lacking solid scientific evidences to prove its efficacy. This article summarizes current evidences on the effects of honey supplementation on bone metabolism markers and sports performance.

KEYWORDS: Honey; Exercise; Bone metabolism markers; Antioxidant; Sports performance.

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INTRODUCTION

Honey is a popular natural supplement and frequently used by athletes to enhance health status. Honey contains monosaccharide carbohydrate such as fructose, glucose, essential amino acids and multivitamins-minerals (Bogdanov *et al.*, 2008). It is well documented that honey has antioxidant (Nagai *et al.*, 2001; Al-Waili, 2003; Aljadi *et al.*, 2004; Erejuwa *et al.*, 2012; Tartibian *et al.*, 2012; Ahmed *et al.*, 2018; Nayaka *et al.*, 2020; Seung *et al.*, 2020), anti-bacterial (Cooper *et al.*, 2001; Lusby *et al.*, 2005; Sherlock *et al.*, 2010; Abouda *et al.*, 2011; Zaharil *et al.*, 2011; Schneider *et al.*, 2013; Nayaka *et al.*, 2020; Seung *et al.*, 2020) and anti-mutagenic properties (Wang *et al.*, 2002; Swellam *et al.*, 2003; Yang *et al.*, 2007; Aryappalli *et al.*, 2019; Tomasin *et al.*, 2020). Honey contains natural vitamin C, phenolic and flavonoid compounds as an antioxidant agent (Ferrerres *et al.*, 1992; Al-Mamary *et al.*, 2002). Ingestion of honey at dosage 1.2g per kg of body weight increased antioxidant agents such as beta-carotene, vitamin C and glutathione reductase in human (Al-Waili, 2003).

Previous studies indicated that oxidative stresses are the major causes of osteoporosis (Zhou *et al.*, 2016; Domazetovic *et al.*, 2017), osteoarthritis (Zahan *et al.*, 2020) and cardiovascular diseases (Hertog *et al.*, 1993; Rakha *et al.*, 2008). Reactive oxygen species (ROS) and reactive nitrogen species (RNS) were found able to damage DNA in cells which cause inflammation and disease (Orrenius *et al.*, 2007). Antioxidants are able to reduce oxidative stress and scavenge free radical from damaging the cell. Antioxidant properties of honey can protect bone primarily through its polyphenol content that acts upon several signalling pathways which leading to bone anabolic and anti-resorptive effects (Kamaruzzaman *et al.*, 2019). In the review article by Nadia *et al.* (2012) summarize that supplementation of honey was able to reduced osteoclastogenic activity and can be used as an alternative treatment of postmenopausal osteoporosis.

Reactive oxygen species and reactive nitrogen species are related to the muscle damage and cause inflammation in the active skeletal muscle (Sen, 1995). The increased intensity of exercise will augment the free radicals production during and after exercise. Exercise is postulated to produce free radicals and cause muscular fatigue (Dekkers *et al.*, 1996). Antioxidant properties of honey are able to reduce

free radicals production during and after exercise which it is beneficial on sports performance. To date, there is limited information of clinical studies of honey supplementation on bone metabolism markers and sports performance. There are only a few related studies of honey supplementation on bone metabolism markers (Ariefdjohan *et al.*, 2008; Chepulis & Starkey, 2008; Ooi *et al.*, 2011; Tavafzadeh *et al.*, 2011; Mosavat *et al.*, 2014) and sports performance (Earnest *et al.*, 2004; Abbey & Rankin, 2009; Shukri *et al.*, 2011; Ahmad *et al.*, 2015; Hajizadeh *et al.*, 2016; Aly *et al.*, 2019). This article summarizes current findings and evidences on the effects of honey supplementation on bone metabolism markers and sports performance.

EFFECTS OF HONEY SUPPLEMENTATION ON BONE METABOLISM MARKERS

Bone metabolism or bone remodelling is a process of bone formation or bone resorption in human. Bone resorption is referring to the mature bone tissue being removed from the skeleton, while bone formation is referring to new bone tissue being formed. Remodelling responds also have functional demands on the mechanical loading. To date, several studies related to bee product, i.e. honey supplementation combined with jumping exercise in animals (Tavafzadeh *et al.*, 2011; Mosavat *et al.*, 2014); honey supplementation combined with aerobic dance in humans (Ooi *et al.*, 2011) and honey supplementation alone in animals (Ariefdjohan *et al.*, 2008; Chepulis & Starkey 2008) were beneficial for enhancing bone metabolism markers.

Chepulis and Starkey (2008) reported that honey feeding alone for 52 weeks increased bone mineral density in rats in comparison with sucrose and sugar free diet feeding. Ariefdjohan *et al.* (2008) reported that ingestion of honey for 8 weeks increases calcium absorption after acute feeding in growing rats. It is reported higher calcium retention and calcium absorption in the group of rats given 10% of honey than 5% of honey and control group. However, there were no significant differences in femur density and femur bone mineral between the groups. In an animal study done by Tavafzadeh *et al.* (2011), forty eight of 12-week old female rats were divided into four groups: control group, honey supplementation group, jumping exercise group without supplementation group, and combined jumping exercise and honey supplementation group. Oral honey supplementation was given to the rats at dosage of 1 g/kg of body weight/day for 8 weeks. Jumping exercise consisted of 40 jumps per day for 5 days per week at the height of 40 cm. This study found that combination of jumping exercise and honey supplementation may elicit beneficial effects on lower extremity bone properties and bone metabolism when compared to either jumping exercise or honey supplementation alone or control group in young female rats.

In a human study by Ooi *et al.* (2011), it was found that combination of aerobic dance exercise and honey supplementation i.e. 20 g of honey diluted in 300 mL of plain water for 8 weeks elicited more beneficial effects on bone turnover markers generally compared to aerobic dance exercise or honey supplementation alone in sedentary young female. A study by Mosavat *et al.* (2014) investigated honey supplementation combined with different jumping exercise intensities on bone mass and serum bone metabolism markers. This study indicated that supplementation of honey with 80 jumps per day, 5 days per week for 8 weeks elicited greatest beneficial effects on tibial and femoral mass, bone metabolism markers such as serum total calcium and alkaline phosphatase concentrations. This study concluded that high intensity jumping exercise combined with honey supplementation has more discernable beneficial effects on bone mass and bone metabolism.

EFFECTS OF HONEY SUPPLEMENTATION ON SPORTS PERFORMANCE

To date, there is scanty data on effect of honey supplementation on sports performance. It only has several studies showed ergogenic beneficial effects of pre-exercise supplementation (Earnest *et al.*, 2004; Shukri *et al.*, 2011; Aly *et al.*, 2019) and post-exercise supplementation (Ahmad *et al.*, 2015) of honey on sports performance will be summarised in this article. There have two studies by (Abbey & Rankin, 2009; Hajizadeh *et al.*, 2016) reported that honey supplementation did not show ergogenic effect on sports performance will be excluded for summarizing in this article. Table 1 summarizes current published research areas related to the honey supplementation on sports performance.

Table 1. Research areas related to the honey supplementation on sports performance.

Author	Research areas
Earnest <i>et al.</i> (2004)	Low versus high glycemic index carbohydrate gel ingestion during stimulated 64 km cycling time trial performance
Shukri <i>et al.</i> (2011)	Effects of acacia honey drink supplementation compared to sports drink on blood glucose and running performance in the heat
Ahmad <i>et al.</i> (2015)	Effects of post-exercise honey drink ingestion on blood glucose and subsequent running performance in the heat
Aly <i>et al.</i> (2019)	The effect of honey supplementation formula on delaying some fatigue markers on 1500 meters runners

Earnest *et al.* (2004) investigated effect of honey supplementation or placebo feedings during a simulated 64-km cycling time trial. In this study, nine subjects consumed 15 g of honey or placebo every 16 km during cycling time trial. This study found that time to complete 64 km cycling time trial for honey trial was significantly shorter in comparison with placebo trial. This finding reflected that supplementation of 15 g of honey at every 16 km cycling was able act as ergogenic aid for cyclists compared to the placebo. Shukri *et al.* (2011) investigated the effects of honey supplementation and sports drink pre-exercise on endurance running performance. Subjects run at 60% VO_{2max} for 60 minutes and immediately followed by 20 minutes time trial performance on a motorized treadmill. Subjects consumed 500 ml of honey drink or sports drinks one hour before trial. Subjects also consumed 3ml per kg of body weight of cool honey or sports drink every 20 minutes during the running trial in a randomized controlled trial. This study discovered that there was no significant difference in distance covered in the 20 minutes time trial performance between the two trials. This finding reflected that honey drink can replace sports drink as an ergogenic drink to improve endurance running performance in the hot and humid condition (31°C & 70% relative humidity).

Ahmad *et al.* (2015) conducted a research to investigate effects of honey drink supplementation during rehydration post exercise on subsequent endurance performance. Ten athletes were recruited in this study. During exercise test, subject was required to run on a motorized treadmill at 65% VO_{2max} intensity for 60 minutes. During two hours recovery, subjects were given honey drink or placebo with equivalent to 150% of body weight lost in a randomized controlled trial. After recovery, subjects performed 20 minutes running time trial performance. This study discovered there was a longer distance covered in the running time trial performance in the honey trial compared to the placebo trial. Blood glucose concentration in the honey trial was significant higher in comparison with the placebo trial. High blood glucose concentration during recovery and running will be used as energy and augment endurance running performance. This study showed that honey supplementation contributed more ergogenic effects than placebo on subsequent running performance after two hours recovery.

There was a field test conducted by Aly *et al.* (2019) investigated effects of honey supplementation on 1500 meters run. Fifty subjects were voluntarily participated in this study. The experimental design of this study was divided into experimental group and control group. Subjects in the experimental group consumed honey drink for one week before and after running while the subjects in the control group was running without using the honey drink. Subjects in the experimental group were given honey drink that contains 50g of honey + 0.5g of royal jelly + 0.5g bee-pollen. This study found that experimental group was faster to complete 1500 meter run in comparison with control group. The blood glucose concentration was reported higher in the experimental group compared to the control group. Blood glucose will be used as adenosine triphosphate that provides energy for enhancing sports performance. This finding indicated that honey supplementation was more beneficial on 1,500 meter run compared to the placebo.

CONCLUSION

The evidences from the above-mentioned previous studies indicating the ergogenic beneficial effects of honey supplementation on bone metabolism markers and sports performance are due to the natural antioxidant properties and nutritious content of honey. Further studies are still warranted to investigate effects of honey supplementation on sports performance at different types, intensity and duration of exercise. Additional clinical studies are also required to investigate long term supplementation of honey on bone health among athletes. The findings will be beneficial for those athletes who want to enhance their sports performance and bone health. As a conclusion, honey is a natural ergogenic aid supplement that should be used by athletes to enhance their bone health and sports performance.

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