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Effect of Honey on Measurable Sport

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***Abstract*—For more than 5000 years, people have used honey to improve the physical attributes of the musculoskeletal system as well as for health reasons. Honey is mainly composed of carbohydrate (CHO), minerals, and vitamins which are properties that are proved to be able to improve sports performance and general health. Honey has the potential to improve aerobic exercise performance. Meanwhile, honey in combination with exercise improves bone health, boosts the immune system, and improves performance in sports. It is believed that Carbohydrate (CHO) and honey constituents play an important role during training in providing the benefits of improving sports performance on cycling, and running. Honey is a source of carbohydrates that contain flavonoid compounds which act as antioxidants and have ergogenic properties. The natural nutrition and biochemical properties of honey make it an energy food status. Carbohydrate (CHO) make up the largest portion of honey's nutritional composition (95-99%) with the glycemic index (GI) varying from 32 to 87, in the average water content range of 13.6% to 19.2%. Other important compositions of honey include vitamins and minerals. Its composition is highly dependent on the type of flower extracted by bees, as well as regional and climatic conditions. This paper presents to elaborate the findings about the effect of honey on measured sport performance as well as the combined effect of honey and exercise on health-related outcomes. Trainers and athletes should know the positive effects of using honey and how to use it so, that the results are felt more leverage in sports performance.**

Keywords: carbohydrate, honey, cycling, running, performance

I. INTRODUCTION

The natural nutritional and biochemical properties of honey make it obtain an energy food status. Carbohydrates (CHO) make up the largest portion of honey's nutritional composition (95-99%) with a glycemic index (GI) varying from 32 to 87 [1-3], in the average water content range 13, 6 to 19.2%. Other important compositions of honey include vitamins and minerals. Its composition is highly dependent on the type of flower extracted by bees, as well as regional and climatic conditions [4]. Nutritional supplements have been widely studied as prevention of exercise disorders and the risk of infection [5]. Among various supplements, honey and honey-derived products are newer supplements used which have been shown to have immunomodulatory, anti-inflammatory, antibacterial, antiviral, and antioxidant properties [6]. The effects of the supplementation of honey and honey products on the athlete's immune response during the exercise program have been investigated.

Fructose and glucose are the most abundant CHO found, but other glucose polymers such as saccharose, maltose, trehalose, and elizitose are also present. Depending on the sugars, ratio of fructose to glucose, honey is absorbed at different rates, where fructose, a low GI CHO is absorbed more slowly and evenly than glucose, which is ideal for endurance sports as pre-exercise nourishment. Meanwhile, glucose, a high GI CHO enters the bloodstreams more rapidly. A study showed that both high and low GI CHO (dextrose and honey respectively) had shorter finishing time than placebo during a 64-km simulated cycling time trial (TT), however in the last 16-km dextrose group performed better than placebo [7].

This shows that in the final portion of a TT maintenance of glucose concentration plays a role in preventing fatigue. Another study, it also showed that honey supplementation improved the distance covered in a 20 min TT following an exhaustive exercise compared to water [7]. These findings suggest that the CHO content of honey plays a comparable role in prolonged exercise. Studies have shown that exercise-induced oxidative stress and inflammatory-responsive cytokines [8,9]. It can be attenuated by nutritional supplementations. A study by Morillas, found that protein carbonyl, an oxidative stress marker decreased significantly following a 90-min cycling test when participants were supplemented with polyphenolic antioxidants [10]. Honey contains phenolic and flavonoid compounds that are shown to exert antioxidant properties [11]. Besides, other anti-inflammatory and antioxidants such as diastase (amylase), invertase (glucosidase), phosphatase and catalase are also present. Honey also contains minerals such as copper, calcium, iron, manganese, magnesium, potassium, phosphorus, sodium, and zinc [12]. Other compounds found in honey are vitamins B6, niacin, thiamine, pantothenic acid, and riboflavin. These compounds have been shown to be important in enhancing bone health [13].

Studies reporting the effect of honey consumption on exercise performance per se are few. However, there are relatively more studies that investigated the effect of honey along with exercise on: bone health, inflammatory responses, oxidative stress, and reproductive hormones production. Unfortunately, no consensus can be reached due to issues such as research designs, time of feeding either pre-, mid-, or post-

exercise, dosage prescribed and exercise measures tested in previous studies.

II. METHOD

A. Honey Improve Exercise Performance

Three studies investigated the effect of honey on exercise performance: 64-km cycling TT, 20-min running TT, and high-intensity run [7,11], all three studies showed acute consumption of honey improved exercise performance. In the 64-km TT study, low GI honey (0.97 g/kg BW) was compared with high GI CHO (dextrose), the findings showed that both improved performance. Generally, GI refers to the degree of how quickly blood glucose rises after consumption of a food relative to a reference food (eg. white bread or glucose solution), by quantifying the amount (in grams) of available CHO in the food that raises the blood glucose level. Ahmad also prescribed low GI honey drink (1.9 g/kg BW), and found that the distance covered in 20 min TT was significantly further in the honey group compared to placebo. It should be noted how-ever that typically a higher amount of CHO is prescribed aspire-exercise supplementations, with amount ranging from 1.3 [14], to 2.67 g/kg BW [15]. The improvement in the time-trials despite relatively low amount of CHO in honey might be attributed to the combination of glucose and fructose found in honey, which has been shown to improve total CHO oxidation rate compared to glucose alone [16]. In a related study, low GI CHO is shown to improve along duration event (20 minutes longer) rather than short burst high-intensity exercise [17].

This could be achieved by sustaining the blood glucose level [18], and preventing glycemic rebound phenomenon which reduces fat oxidation [19]. Slow-release of glucose provides a continuous supply during prolonged exercise and delays muscle glycogen depletion [20]. In short, a low GI meal reduces CHO oxidation and favors fat oxidation compared to intermediate or high GI [21], which could optimally be beneficial during prolonged exercise [22,23]. In agreement with that, the ingestion of inter-mediate GI honey showed lack of performance improvement as shown by Abbey, where honey was pre-scribed at two intervals (30 min before soccer match and at half time). The observation was attributed to low frequency of CHO ingestion which failed to maintain the blood glucose level especially in the second half of match play where hypoglycemia sets in and glycogenolysis was favoured overfat oxidation [21]. It was postulated that higher frequency feeding would provide sufficient energy source for the activity. Interestingly, a later study which pre-scribed a higher frequency feeding of CHO (every 15 min) did not observed an improvement in performance [24]. It seems that not only the feeding rate but also GI level of the CHO fed should be considered for such performance. Related to the CHO content of honey during prolonged exercise, consuming honey will prevent hypoglycemia, promote high rates of CHO oxidation, and improve endurance capacity. Few studies have shown that taking relatively small amounts of CHO (20 g/h) were adequate to exert beneficial changes in performance [25,26]. Maughan showed that consuming 16 g/h of glucose improved endurance capacity by 14% compared to control [26]. In contrast, consuming excessive amounts of exogenous CHO has been shown to have no benefits on endurance performance. In the review by Jeukendrup, they recommended an upper limit of 60 g/h of CHO intake during exercise before reaching saturation in CHO oxidation [27]. Different types of carbohydrates when ingested during exercise are metabolized at different rates and the rate of exogenous CHO oxidation during exercise is limited to 60 g/h [28,27]. This rate is regulated by intestinal absorption of CHO (using SGLT1 transporter), interestingly, when glucose was ingested simultaneously with another CHO, oxidation rates rise above 60 g/h [29].

Many studies support that multiple transportable CHO produced higher oxidation rates (as high as 75%) than glucose that use SGLT1 only [30,28]. Glucose and fructose are the most abundant CHO in honey and several studies have shown that exogenous CHO oxidation rates observed with multiple transportable CHO are able to delay fatigue and improve exercise performance. In a study that prescribed 90 g/h glucose-fructose drink during a 5-cycling exercise, and it was shown that the subjects' ratings of perceived exertion were lower, and maintained better cadence towards the end of the exercise with the mixture of glucose and fructose compared to glucose [31]. Other researchers also support the findings that improvements in performance (exercise lasting for 2 h or more) are related to exogenous supply of glucose-fructose solution, [32,33]. Meanwhile for exercise at higher intensity and shorter duration (75% of maximal oxygen uptake; VO2 max for 1 h), consuming honey is believed not to have many beneficial effects. It was shown that even when CHO was intravenously infused into the systemic circulation, rapid uptake of glucose was reported, however, no performance effect was found [34].

B. Measurable Sports

1) Cycling: Contemporary research findings suggest that cyclists ingest carbohydrate (CHO) during prolonged exercise as a means of improving performance.

However, CHO ingestion may not be necessary for all events, depending on the length and intensity of the event in question. For example, CHO use during cycling time trial (TT) studies has produced equivocal results. Some authors suggest that CHO ingestion during shorter events might influence performance via a placebo effect. A distinction not often addressed is that the times necessary to complete a TT are often separated by small differences. This is especially true for accomplished riders, where small differences can make a very real difference between winning and losing. This scenario can be demonstrated by examining the top five riders' performances during the longest TT of the 2001 Tour de France. During this 61-km race, the difference between the top five riders was only 1.8–3.1%. The difference between 1st and 2nd was only 1.8%. As another example, the separation between 1st (Jan Ullrich) and 4th (no medal) during the 2001 World TT Championships (40 km) was only 25 seconds. Thus, an examination of these subtle performance differences and any factors affecting them are important, as recent mathematical modelling studies suggest that CHO and electrolyte solutions may improve 40-km TT performance by 32 to 42 seconds depending on the ability of the rider. The length and time of the event needs to be considered when comparing TT studies; shorter TT events lasting 20–40 km

(30–60 minutes) may be affected differently than longer TT efforts (90–120 minutes). In this regard, three common themes emerge from the literature regarding CHO use. These are (a) the glycemic index of the CHO, (b) the rate of gastric emptying of the CHO alone or when combined with other macronutrient sources and (c) the maintenance of blood glucose concentration during a TT event.

*2) Running performance:*Carbohydrate can be ingested in a bolus feeding or dispersed in intervals. It has been mentioned that intake of CHO in the first 2 hours after exercise allows fast rate of glycogen synthesis and fluid should be consumed directly proportional or close to sweat loss to maintain important physiological functions.

Additionally, if water is consumed, the volume ingested needs to exceed the fluid deficit by approximately 150% to compensate for the urinary loss that occurs with water ingestion. Honey is one of the carbohydrate sources. To date, the possible role of carbohydrate contained in honey during recovery i.e. after exercise is still unclear. Thus, the present study was proposed. Acacia honey used in the present study was obtained from the Johor region, Malaysia, and it was produced by Apis mellifera bees. Based on the laboratory analysis done in department of Molecular Medicine, Universiti Malaysia, Malaysia, it was reported that Acacia honey contains 31.2% of fructose, 22.9% of glucose, 3.3% of maltose, and 9.9% of sucrose, it also contains 13 mg of sodium per 100 g of serving and 75 g of CHO per 100 g of serving. It was speculated that honey consists of different types of carbohydrates, and these multiple transportable carbohydrates may lead to high carbohydrate oxidation rates and result in better performance during exercise. This speculation was based on a recent previous study which showed that a mixture of glucose and fructose ingestion resulted in approximately 55% higher exogenous carbohydrate oxidation rates compared to the ingestion of an isocaloric amount of glucose during prolonged cycling exercise. Additionally, in another previous study, it was found that a mixture of glucose, sucrose and fructose ingestion resulted in higher exogenous carbohydrate oxidation rates compared with glucose ingestion alone during 150 min cycling (9).

The beneficial effects of glucose and fructose supplementation on endurance performance was also shown in a meta-analysis done by Vandenbogaerde and Hopkins, in which it was found that the best supplement inferred from the analysis consisted of a ~3-10% carbohydrate-plus-protein drink providing ~0.7g/kg/h glucose polymers, ~0.2 g/kg/h fructose and ~0.2g/kg/h protein. According to Ivy, fructose contained in honey is beneficial for the replenishment of liver glycogen. Consumption of fructose or sucrose during recovery may increase the supply of glycogen substrate to the liver and thus increase the relative proportion of whole-body glycogen resynthesis occurring within the liver. Moreover, ingestion of CHO drink can maintain a higher osmolality of blood effectively compared to plain water. It was mentioned that fructose ingestion may produce deleterious effects on the cardiovascular system, such as the increase in blood pressure and also elicit adverse metabolic effects, for example, insulin resistance and hypertriglyceridemia. However, fructose which is contained in natural sources such as honey may produce beneficial effects on human health. Besides, that fructose intake at normal population levels but not hyper dosing does not cause biochemical outcomes substantially different from other dietary sugars. To date, the sports drinks available in the market are mostly carbonated drinks which may cause gastric discomfort. Acacia honey drink which will be prescribed to the subjects in the present study is not a carbonated drink. It is believed that this noncarbonated honey drink may not cause gastric discomfort, while it is ingested by subjects after exercise.

III. CONCLUSIONS

Only three randomized-controlled studies that investigated the effect of honey on exercise performance were identified in this review. Meanwhile, five studies reported changes in bone health after consuming honey alongside some jumping exercises or aerobic dance. Additionally, one of the studies also reported that stress and reproductive hormones were positively regulated. The remaining five studies reported an improvement in immune response after ingesting honey together with intense resistance or aerobic exercises. All studies showed benefits of honey alone or together with exercise. It is believed that the carbohydrates content of honey plays an important role in sustaining endurance exercises, while other active properties in combination with exercise stimulus may exert a positive influence on bone health, immune system, reproductive hormones, and inflammatory responses.

We believe that the reader must consider several observations associated with this trial. These include consistent statistically significant within CHO treatment findings suggesting an improvement in performance with continual CHO feedings during a 64-km TT effort. However, the small subtleties associated with overall time differences may not be fully elucidated because of the small sample size used in this trial. We, therefore, recommend that similar investigations be performed with larger samples and that particular attention be given to the latter stages of the TT, because some riders may increase power output during the final portions of this type of event. It further appears that honey can serve as an effective mixed CHO gel source.

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