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APPLICATION PROSPECT OF ISOMALTULOSE IN PHYSICAL ACTIVITY

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ABSTRACT

The purpose of this study is to evaluate the effects of different content of carbohydrate and volume (concentration) on glycemic index (GI) of isomaltulose beverage and to provide a reference for the application of solid sports beverage and the development of sports beverage which takes isomaltulose as the raw material. Twenty healthy adult females were selected as research objects. The test was carried out according to the international standard of food GI detection. The objects were given 250 ml (20 g/100 ml), 500 ml (10 g/100 ml), 250 ml (10 g/100 ml) and 250 ml (5 g/100 ml) of isomaltulose beverage which contained 50 g, 50 g, 25 g and 25 g of carbohydrate respectively. Finger blood collected was tested for GI with YSI-1500 glucometer. Totally 1342 blood samples were collected, including the samples used in pre-experiment. GI values of 250 ml (20 g/100 ml), 500 ml (10 g/100 ml), 250 ml (10 g/100 ml) and 250 ml (5 g/100 ml) isomaltulose beverage which contained 50 g, 50 g, 25 g and 25 g of carbohydrate were 33.24 ± 2.15, 32.14 ± 2.47, 38.21 ± 6.14 and 37.55 ± 5.84 respectively; there was no remarkable difference between them. But GI of isomaltulose beverage containing 25 g of carbohydrate was relatively high. It is concluded that, the concentration of carbohydrate has no significant influence on GI. Hence to improve the competitive ability, athletes can select beverage in different concentrations according to their own needs.

1.Introduction

Researches relating to saccharides have attached much attention in sport nutrition field (Bingham et al., 2012; Tomlin et al., 2013). The reasonability of saccharides intake is of great significance to both ordinary people and athletes, especially to those athletes who want to improve competitive levels and abilities (Richards, 2015; Edwards and Casto, 2013; Wang et al., 2013). Glycemic Index (GI) will rise after people eat food containing saccharides. As more and more people, especially patients and their family members, start to detect GI with glucometers, scientific researchers devote more to studying various glucometers (Perard et al., 2014; Ramtoola et al., 2014; Byounghoon et al., 2014). In 2011, Philis-Tsimikas et al. (Athena et al., 2011) explored the preciseness, accuracy and acceptability of OneTouch SelectSimple glucometer. They selected 100 diabetes patients and tested GI with YSI-2300 STAT glucometer and OneTouch SelectSimple glucometer. Health specialist agencies evaluated the results and the users evaluated the operation of OneTouch SelectSimple glucometer and moreover filled questionnaire survey. The statistical results suggested that, OneTouch glucometer was of high preciseness and accuracy and easy to be operated and accepted.

Glycemic index (GI) was proposed by Jenkins (Reyes-Pérez et al., 2013; Jenkins et al., 2012; Vega-López et al., 2009) in 1981 at first. It refers to the response extent of blood glucose two hours after the intake of carbohydrate. GI can definitely reflect the physiological status of body after the intake of carbohydrate and it is also an effective index for measuring blood glucose response induced by food containing carbohydrate (Wolever et al., 2008; Wolever et al., 2013). GI, a relatively new concept in nutriology, is of great reference significance to the energy control and supplementation of athletes. Testing GI of athletes taking sports beverage and developing different sports beverages can provide more choice for athletes and body-building group.

Isomaltulose as a kind of functional disaccharide with special performance has become more and more popular in food industry (Park et al., 2014; Min-Wen et al., 2014). Especially in recent years when people concern more about health, the production and development of isomaltulose arouses much attention. Besides, the advancement of biocatalysis production technology provides a wide prospective prospect for industrial production of isomaltulose (Jördening et al., 2008; Park et al., 2014). Different sports beverages can be produced using different matching methods of saccharides. Due to the different sources of saccharides, GI of different beverages may differ. Hence, GI of isomaltulose which is regarded as the raw material of sports beverage needs to be detected. This study explored the influence of isomaltulose beverage with different carbohydrate content and volume on GI.

2. Materials and methods

2.1. Experimental objects

Twenty female postgraduate students from Beijing Sports University were selected. Written informed consent was obtained from all subjects. The participants conformed to the following conditions: nonsmokers; aged 20 ~ 28 years (average 24.1 ± 1.4 years); normal weight (body mass index BMI = 18±2.1 kg/m^2); no family history of metabolic disease and diabetes; no food allergy or intolerance; normal physiological indexes; completing test according to the requirements; no gastrointestinal disease and upper respiratory infection recently or during experiment; no intake of drugs or nutritional supplement influencing GI. Prior to the test, they were forbidden to eat and drink for more than 10 hours. Sports were not allowed in the morning of the test day.

2.2. Experimental method

2.2.1. Detection method of GI

GI detection was performed according to international standard ISO 26642:2010 (Food, 2010). Food products -- Determination of the glycaemic index (GI) and recommendation for food classification (ISO 26642:2010) is the current international standard for GI determination. As required by the standard, objectives included should not develop good allergy or intolerance and digestive system disease and are forbidden to eat more than 10 hours before test as well as drink and are not allowed to do exercise in the morning of test day, and peripheral blood such as finger blood is suitable to be the blood sample, as it is less likely to mutate compared to venous blood.

The calculation formula for GI was: GI = (increment area under the curve (IAUC) of blood glucose within 2 h after intake of tested food/ IAUC of blood glucose within 2 h after intake of glucose in same quantity) ×100.

The internationally recognized GI detection standard includes the following procedures.

(1)Glucose tolerance test

Participants should be forbidden to eat for at least ten hours prior to test. Fasting blood was collected twice in the morning of next day; there was an interval of 5 min. Blood glucose level was detected in statistic state, and the average value was taken as the baseline value. Then participants were given 50 g of glucose solution for oral administration (20 ml) and it is required to be completed in 12 ~ 15 min.

Timing starts from the time of oral administration. Blood was collected for detecting blood sugar concentration in the 15th, 30th, 45th, 60th, 90th and 120th min.

(2)Food blood glucose response test

Participants who were tested to be qualified in glucose tolerance test received food test after two days at least. Blood was collected twice in the morning of next day; there was an interval of 5 min. Besides, blood glucose level was detected in statistic stage; the average value was taken as the baseline value. Then participants were given food containing 50 g of available carbohydrate and 250 ml water; it is completed in 12 ~15 min. Timing starts from the moment of intake of food. Finger blood was collected for detecting blood glucose level in the 15th, 30th, 45th, 60th, 90th and 120th min.

Heparin anticoagulant capillary tube was used to collect not less than 25 µl of finger blood after the first drop of blood contacts with ACCU-CHEK Performa Tiras Reactivas. Then a 25 µl YSI-1500 glucometer sample injector was used to inject the blood samples into YSI-1500 glucometer.

2.2.2. IAUC of glucose response

Glucose response curve was drawn taking time as horizontal coordinate and blood glucose level at different time points as the vertical coordinate. The following formula was used to calculate IAUC of glucose response (Brouns et al., 2005; Nilsson et al., 2008; Di et al., 2011).

Suppose blood glucose concentration at time point t_0, t_1… t_n (0, 15… 120 min) as G_0, G_1… G_n.

$$\mathrm{IAUC} = \sum_{n}^{x=1} A_x \quad (1)$$

Ax refers to IAUC from time point t_{x-1} to t_x)

In the first period (x=1):

If $G_1 > G_0$, $A_1 = (G_1 - G_0) \times (t_1 - t_0)/2$ otherwise, A_1=0.

In other periods (x > 1):

If $G_x \geq G0$ and $G_{x-1} \geq G0$, then $A_x = ((G_x - G_0)/2 + (G_{x-1} - G_0)/2) \times (t_x - t_{x-1})$;

if $G_x \geq G_0$ and $G_{x-1} < G_0$, then $A_x = ((G_x - G_0)2/(G_x - Gx\text{-}1)) \times (t_x - t_{x-1})/2$;

if $G_x < G_0$ and $G_{x-1} \geq G_0$, then $A_x = ((G_{x-1} - G_0)2/(G_{x-1} - G_x)) \times (t_x - t_{x-1})/2$;

if $G_x < G_0$ and $G_{x-1} < G_0$, $A_x = 0$.

2.2.3. Calculation of GI

Food GI is usually calculated by taking glucose as reference (Edwards and Casto, 2013).

GI = (IAUC of blood glucose within 2 h after intake of tested food/ IAUC of blood glucose within 2 h after intake of glucose in same quantity) ×100.

2.3. Test design

YSI-1500 glucometer was used for testing blood glucose. GI of 250 ml (20 g/100 ml), 500 ml (10 g/100 ml), 250 ml (10 g/100 ml) and 250 ml (5 g/100 ml) isomaltulose beverage which contained 50 g, 50 g, 25 g and 25 g of carbohydrate was detected. Then the GI was compared.

2.4. Statistical processing

Data were expressed as mean ± standard error (SE). SPSS for Windows 16.0 was used for statistical analysis.

GI of beverage with different content of carbohydrate and volume was tested by double-factor variance analysis. When there was obvious difference, difference of data was tested with Post Hoc Tests using Tukey HSD test method by taking the content of carbohydrate and volume as processing factors. $\alpha = 0.05$ was considered as the significant level.

3. Results and discussions

3.1. Glucose response of glucose beverages with different content of carbohydrate and volume

Glucose response of females drinking beverages with different content of carbohydrate and volume was detected at different time points. The significant difference of blood glucose level concentrated on time points of 60th, 90th and 120th min. Blood glucose concentration of females taking beverage containing 50 g and 20 g of carbohydrate had remarkable difference (table 1). Results suggested that, IAUC of glucose was in a correlation to the intake of glucose (50 g or 25g), *i.e.*, IAUC of blood glucose of beverage containing 50g of glucose (500 ml or 250 ml) was much larger than IAUC of blood glucose of beverage containing 25g of glucose (500 ml or 250 ml); IAUC of blood glucose of glucose had no relationship with the intake of liquid (500 ml or 250 ml), *i.e.*, IAUC of blood glucose of the intake of 50g or 25g of glucose had no significant difference, no matter the volume of beverage taken was 500 ml or 250 ml. Details are shown in Figures 1 ~ 6.

Table 1: Glucose response of females drinking glucose beverage detected with YSI-1500 glucometer (mmol/l)

Volume of beverage	**250ml**		**500ml**	
Content of glucose	25g	50g	25g	50g
0min	4.17±0.12	4.41±0.05	4.11±0.14	4.14±0.15
15min	6.44±0.32	7.19±0.41	7.01±0.29	7.29±0.46
30min	7.93±0.36	8.31±0.31	8.14±0.32	8.71±0.38
45min	7.02±0.31	8.24±0.54	7.28±0.19	7.33±0.59
60min	5.33±0.29^*	7.23±0.51	5.71±0.25^*	6.42±0.41
90min	3.99±0.24^*	5.98±0.36	4.02±0.15^*	6.35±0.21
120min	4.02±0.15^*	4.76±0.21	3.51±0.14^*	5.42±0.27^

^: $p < 0.05$ compared to 50 g (250 ml); *: $p < 0.05$, compared to 50 g (500ml)

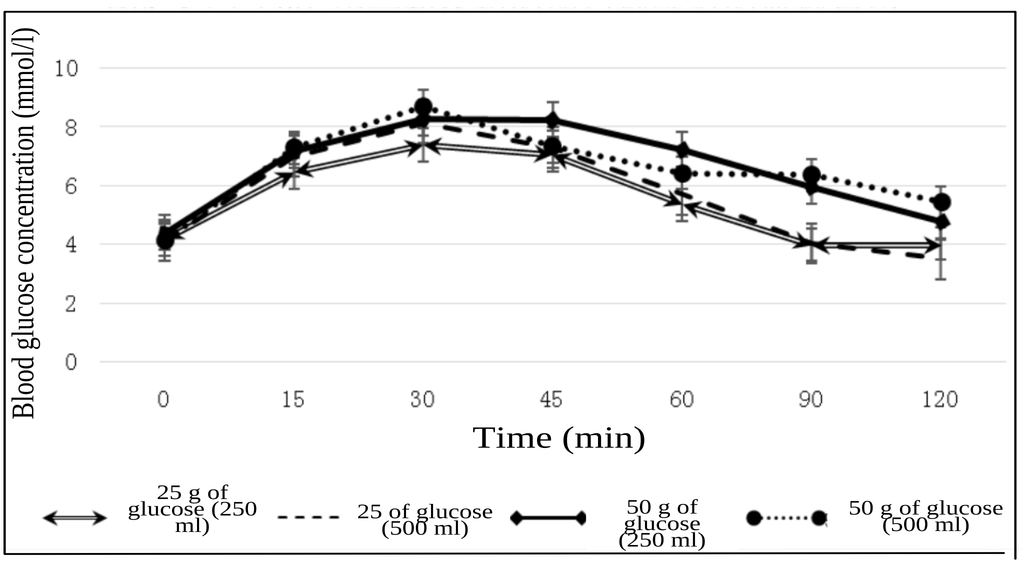

Figure 1. Glucose response of glucose beverage with different content of carbohydrate and volume

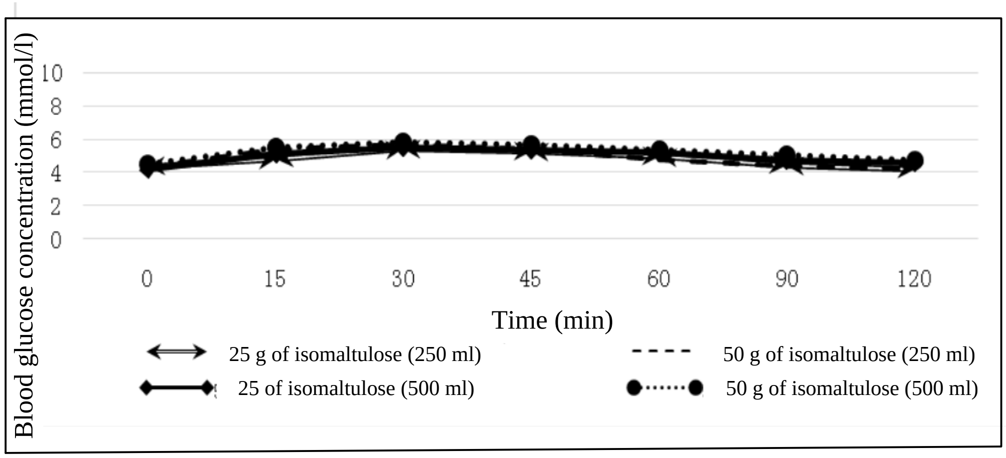

Figure 2. Glucose response of isomaltulose with different content of carbohydrate and volume

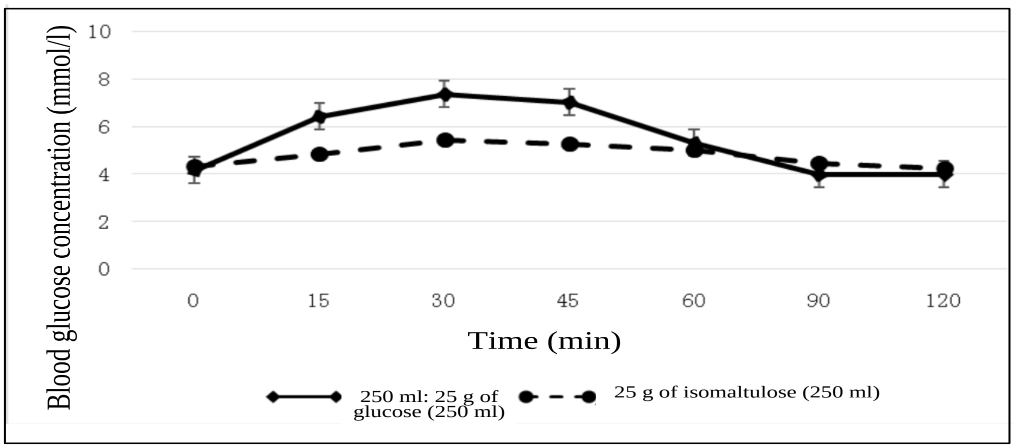

Figure 3. Glucose responses of 25 g of glucose and isomaltulose (250 ml)

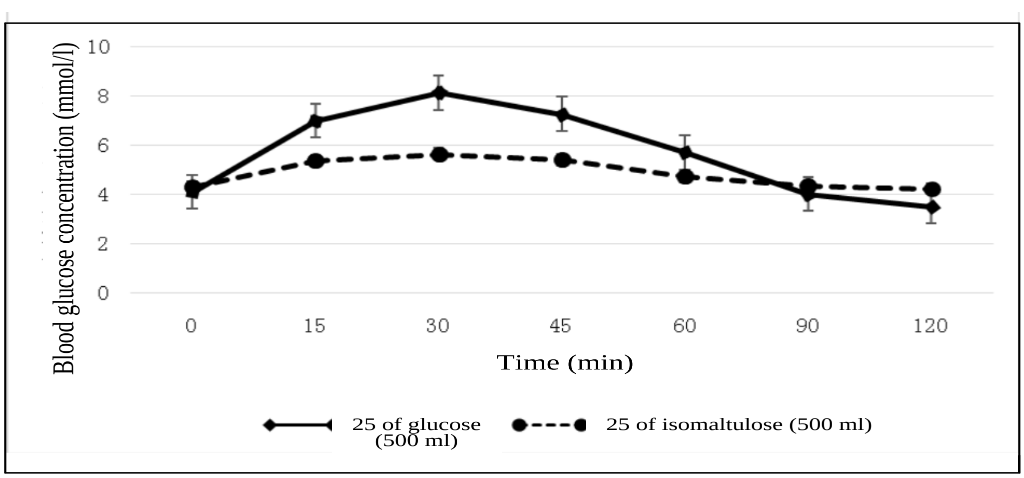

Figure 4. Glucose responses of 25 g of glucose and isomaltulose (500 ml)

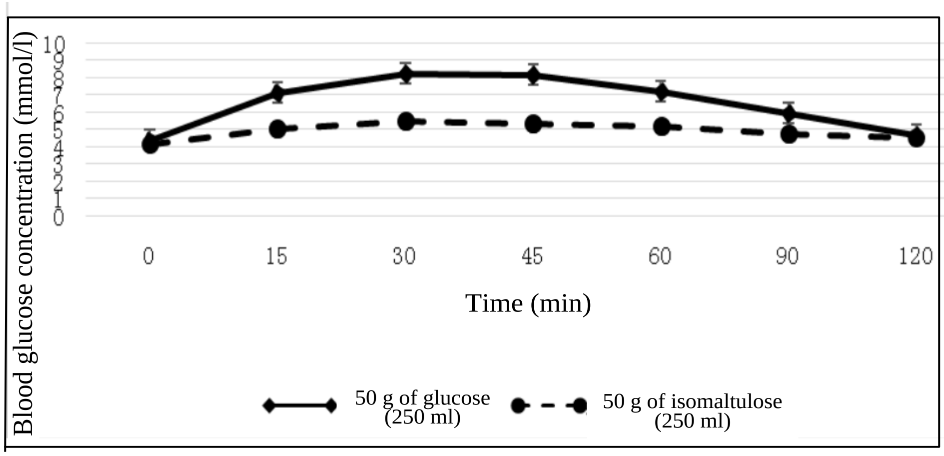

Figure 5. Glucose responses of 50 g of glucose and isomaltulose (250 ml)

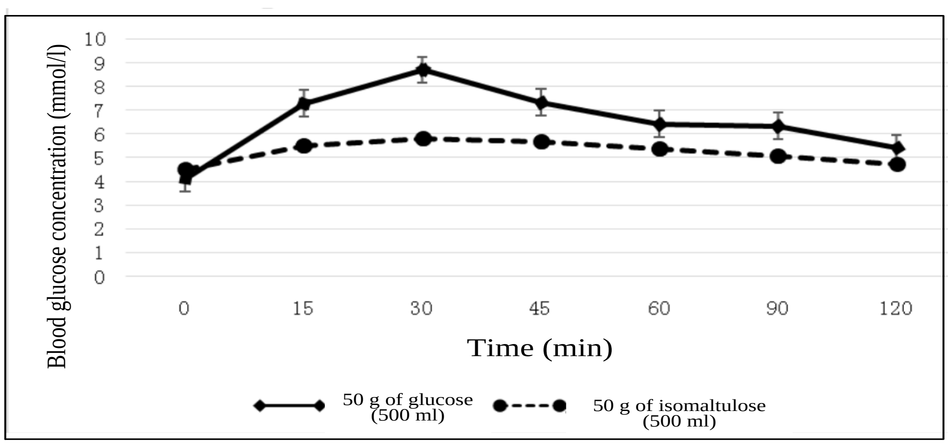

Figure 6. Glucose responses of 50 g of glucose and isomaltulose (500 ml)

3.2. Glucose response of isomaltulose beverage with different content of carbohydrate and volume

The difference of blood glucose level mainly reflected on time points of 60th min, 90th min and 120 min (table 2). IAUC of blood glucose of isomaltulose was much smaller than that of glucose in the same conditions. IAUC of blood glucose of 50 g of isomaltulose was slightly higher than IAUC of blood glucose of 25 g of isomaltulose, but there was no remarkable difference. Similar to glucose, the volume of beverage taken had no influence on IAUC of blood glucose of isomaltulose.

3.3. GI of isomaltulose beverage with different content of carbohydrate and volume No remarkable difference was observed in GI of isomaltulose beverage with different content of carbohydrate and volume (Table3).

Table 2: Glucose response of isomaltulose beverage detected by YSI-1500 glucometer

Volume of beverage	250ml		500ml	
Isomaltulose	**25g**	**50g**	**25g**	**50g**
0min	4.35±0.09	4.25±0.08	4.31±0.09*	4.51±0.09
15min	4.85±0.12	5.14±0.16	5.39±0.24	5.52±0.24
30min	5.45±0.15	5.53±0.16	5.66±0.18	5.81±0.18
45min	5.29±0.20	5.39±0.15	5.42±0.13	5.69±0.20
60min	5.02±0.15	5.26±0.14	4.74±0.12*	5.39±0.16
90min	4.45±0.15*	4.79±0.18	4.36±0.10*	5.10±0.18
120min	4.26±0.12*	4.58±0.16	4.24±0.16*	4.73±0.18

^: $p < 0.05$, compared to 50 g (250 ml); *: $p < 0.05$, compared to 50 g (500 ml).

Table 3: GI and IAUC of blood glucose of glucose and isomaltulose beverage with different content of carbohydrate and volume

Volume of beverage – carbohydrate content	IAUC of blood glucose		GI
	Glucose	**Isomaltulose**	
250ml-25g	161.11±13.87*ab	60.14±13.78^	38.21±6.14
250ml-50g	282.56±28.77*cd	91.36±11.68^	33.24±2.15
500ml-25g	190.32±12.87*ab	69.47±13.48^	37.55±5.84
500ml-50g	301.22±16.87*cd	93.74±9.56^	32.14±2.47

^: $p < 0.05$, compared to IAUC of blood glucose of glucose;
*: $p < 0.05$, compared to IAUC of blood glucose of isomaltulose;
a: $p < 0.05$, compared to 50g-250 ml;
b: $p < 0.05$, compared to 50g-500 ml;
c: $p < 0.05$, compared to 25g-250ml;
d: $p < 0.05$, compared to 25g-500ml.

4. Conclusions

We carried out the experiment according to the international standard ISO 26642:2010(E). In the experiment, we compared differences of glucose, IAUC of blood glucose and GI as well as the effects of glucose and isomaltulose with different content of carbohydrate and volume on them. Detection of glucose response IAUC of glucose and isomaltulose suggested that blood glucose IAUC of glucose was in a correlation to the intake of glucose (50 g or 25 g), i.e., IAUC of blood glucose of 500 ml or 250 ml isomaltulose beverage containing 50 g of glucose was much larger than IAUC of blood glucose of 500 ml or 250 ml isomaltulose beverage containing 25 g of glucose; IAUC of blood glucose of glucose had no relationship with the intake of liquid (500 ml or 250 ml), i.e., IAUC of blood glucose of beverage containing 50 g or 25 g of glucose had no significant difference, no matter the volume of beverage taken was 500 ml or 250 ml. Besides, GI of isomaltulose beverage with different content of carbohydrate and volume had no significant difference.

The internationally used GI detection method is to add 250 ml of water into 50 g of carbohydrate (20%) (Wong et al., 2009; Donaldson et al., 2010; Luscombe et al., 1999). In this study, we used the above method and finally obtained results consistent with the international GI table.

Usually, the concentration of carbohydrate of most liquid sports beverages ranges from 5% to 10%. GI of the beverage which was prepared by adding 50 g of carbohydrate into 500 ml of water (10%) and that of the beverage which was prepared by adding 50 g of carbohydrate into 250 ml of water (20%) had no remarkable difference. If the concentration of beverage is set as 5% and moreover intake of 50 g of carbohydrate is required, then intake of 1000 ml of liquid is necessary. However, intake of such a large quantity of liquid seems to be difficult for some participants. In such a condition, intake of 25 g of carbohydrate is easy to be accepted. It was found that, detection result of GI of 25 g of carbohydrate was a little higher than GI, but there was no remarkable difference.

The purpose of the experiment is to observe effects of different content of carbohydrate and volume on GI of isomaltulose beverage. Experimental results suggested that, GI of isomaltulose beverage with four different contents of carbohydrate and volumes had no significant difference. Hence, it is considered that, concentration has no obvious impact on GI. Athletes can select sports beverage in different concentrations according to their needs, thus to improve competitive ability.

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