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ORIGINAL ARTICLE

SUGAR-SWEETENED BEVERAGES CONSUMPTION DURING COVID-19 PANDEMIC AMONG OFFICE WORKERS IN SEMI-URBAN AREA IN SOUTHERN THAILAND: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background. During COVID-19 pandemic, office worker has spent more than 6-8 hours per day sitting for online working following social distancing policy. Considering the popularity of online ordering and home delivery services, sugar-sweetened beverages (SSB) consumption have increased. However, the link between the types SSB consumption and their BMI was less well documented.

Objective. To determine the association of the habitual intake (type, frequency, and volume) of sugar-sweetened beverages (SSB) with body mass index (BMI).

Material and methods. A cross-sectional study, 337 office workers were selected according to probability proportion-to-size and systematic random sampling. Data were collected using face-to-face interviews on the type, frequency, and volume of sugar-sweetened beverage intake. Samples of sugar-containing beverages were analyzed using high-throughput liquid chromatography/mass spectrometry (LC-MS/MS). The chi-square test was used to determine the relationship of SSB consumption with BMI. Unadjusted binary logistic regression analysis was used to assess the associations between BMI and metabolic diseases.

Results. Most respondents (56.1%) were overweight (BMI >23 kg/m^2). The most consumed SSB was milk tea (e.g., Thai tea and green tea), which was significantly related with BMI (p=0.03). LC-MS/MS analysis showed that sucrose and lactose were the major sugars in milk tea (34.7 g/100mL, on average). 70.6% of the respondents consumed >24 g/day of sugar, which is more than the World Health Organization's recommendation.

Conclusions. Health control policies and health education, for example warning labels for the reduction of SSB consumption, may urgently be required to promote health in workplaces and prevent SSB-related metabolic diseases.

Key words: *body mass index, LC-MS/MS, sugar-sweetened beverages, office worker*

INTRODUCTION

Sugar is commonly added to foods and drinks to enhance flavor, especially in the case of sugar-sweetened beverages (SSBs) [1], including freshly prepared iced tea and coffee [2]. SSB consumption has gradually increased from an average of 270.8 mL in 2018 to 278.5 mL in 2019 [3]. The rapid and complete absorption of added sugars (glucose and fructose) stimulates the release of insulin which leads to sugar uptake by the target cells [4]. In adipose tissue, excess glucose is converted to fat (triglycerides) for energy storage [5], whereas in the liver, excess fructose stimulates the synthesis of fatty acids that accumulate in the visceral adipose tissue, leading to weight gain and obesity [1, 4, 6, 7].

Convincing evidence indicates that overweight and obesity remain the major underlying causes of public health issues such as type 2 diabetes, hypertension, and cardiovascular disease, which contributes to premature disability and mortality in both developed and developing countries [8]. In general, overweight

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and obesity are characterized by excessive fat mass accumulation in the body [9], particularly in the abdominal area (abdominal adipose tissue) [10, 11]. Recent studies report that the epidemic of obesity and obesity-related diseases has aggravated simultaneously with the increased consumption of high amounts of added sugars, given the association of added sugars with health issues [12, 13].

As compared to the general population, the prevalence of obesity is higher among office-based workers owing to the extended periods of sedentary behavior (sitting) related to this type of work [14, 15]. Our preliminary data indicated that during the coronavirus disease (COVID-19) pandemic, office workers have spent more than 6–8 hours per day sitting for online working. Considering the popularity of home delivery services, the consumption of SSBs has increased to 500 mL per day [3]. However, there are no studies on the association between the SSB consumption of office workers and their body mass index (BMI) or the presence of obesity-related metabolic diseases during the COVID-19 pandemic.

Therefore, this study was conducted among office workers with the aim of determining the association between patterns of SSB consumption (type, frequency, and amount) and BMI status. The emergence of high-throughput liquid chromatography/mass spectrometry (LC-MS/MS) allows for the simultaneous detection of the sugar profile and amount of sugar in SSBs by means of high quality, quantitative analysis of the specific mass-to-charge ratio (m/z) [16, 17]. Furthermore, obesity-related health outcomes were revealed.

MATERIAL AND METHODS

Study design, sample, and study setting

This cross-sectional study was conducted in Tha Sala district of Nakhon Si Thammarat province, Thailand (Latitude: 8° 38' 42.2'' N; Longitude: 99° 53' 47.6'' E). Nakhon Si Thammarat is the most working aged province in the southern part of the country where 16.5% of southern Thai working aged population residing in. We purposively selected one university where the biggest campus has been implemented because it would be more feasible and flexible for this university to implement campaigns on awareness raising and reduction of SSB consumption in the future. The participants comprised 337 office workers who were recruited from 51 departments at a university. The sample size was calculated using the Taro Yamane formula (N=2,118, e=0.05) and probability proportional to size and systematic random sampling. Written informed consent was obtained from all participants prior to data collection. The inclusion criteria were as follows: i) working for 6–8 hours per day, ii) excess BMI and waist circumference, and iii) consumption of SSBs on a daily basis. The exclusion criteria were the inability to answer questions owing to physical, mental, or cognitive handicaps, and stopping the participants. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Human Research Ethics Committee of Walailak University (Approval Number: WUEC-20-185-01).

Data collection

Anthropometric measurements including weight and height were obtained to the nearest 0.1 kg and 0.1 m, respectively. Standardized equipment was used and the BMI was subsequently calculated as the weight divided by the square of the height (kg/m^2), as per the World Health Organization guidelines. Waist circumference was measured, to the nearest 0.1 m, at the level of the iliac crest while the subject was standing in the upright position and at minimal respiration. All measurements were performed by researchers who received standardized training in anthropometric measurements.

The data were collected by means of face-to-face interviews using a beverage intake questionnaire which was conducted as per *Hedrick* et al., with slight modification [18]. Modifications included the addition of an open-ended question to cover all types of SSBs consumed by the participants, as well as a question on the presence of metabolic syndrome as diagnosed by a medical professional. The questionnaire consisted of two main sections: (i) socio-demographic data (e.g., age, sex, educational background, marital status, and the presence of metabolic syndromes), and (ii) behavioral patterns related to SSB consumption. We determined the type, frequency, and volume of SSB consumption using a 24-hour dietary recall as an intensive method, capturing consumption data from midnight to midnight of the previous day. The frequency of SSB consumption was categorized into the following groups: none, 1–2 servings/week, 3–4 servings/week, and 5–7 servings/week, while the volume per serving was divided into 360 mL, 480 mL, 540 mL, 600 mL, and 660 mL groups.

Sugar determination (LC-MS/MS)

Freshly prepared iced tea samples were subjected to an ultrasonic bath and centrifuged at 12000 rpm (30 min at 4°C). After passing through a membrane filter (0.22 μm, PVDF, Millex, Ireland), all samples were diluted with ultrapure water (1:100) and 10 μL was subsequently injected into the LC-MS/MS system. The standards for fructose, glucose, sucrose, and lactose were obtained from Sigma-Aldrich (Darmstadt, Germany). The LC-MS/MS method [17] was performed using a triple quadrupole mass spectrometer with negative ion mode electrospray ionization equipped with an ultra-performance liquid chromatography system (Agilent Technologies, Santa Clara, CA). The sucrose, lactose, fructose, and glucose standards and freshly prepared iced tea samples were separated using the Asahipak NH2P-50 column (4.6 µm, 250 mm; Showa Denko America, Inc., New York, NY). A mobile phase consisting of 80% 10 mM ammonium acetate and 20% acetonitrile at a flow rate of 0.2 mL/min was used. The column temperature was maintained at 28°C and the volume of injection was 10 µL. The mass spectrometer detector conditions were set as follows: the capillary voltage was maintained at 4500 V, the nebulizer was set to 2 bar, the drying heater to 200°C, and the drying gas flow to 8 L/min.

Statistical analysis

Data were analyzed using R version 3.0.2 in RStudio GUI version 1.3.959 (R Foundation for Statistical Computing, Vienna, Austria). The Chi-square test was employed to determine the relationship of SSB consumption and the amount of sugar in SSBs with BMI status. Unadjusted binary logistic regression analysis was used to examine the associations between BMI classification and metabolic diseases. Differences were considered statistically significant at $p<0.05$.

RESULTS

The socio-demographic characteristics of the participants are presented in Table 1. There were 114 males (33.8 %) and 223 females (66.2%) participants aged 20–59 years. Most of the participants were 30–39 (n=122, 36.2%) or 40–49 (n=109, 32.3%) years old and had obtained a bachelor (n=127, 37.7%) or master or doctoral degree (n=108, 32.1%). There was a 1.5-fold higher proportion (n=189, 56.1%) of individuals who were overweight (BMI: 23–30 kg/m^2) and obese (BMI: >30 kg/m^2) than those with a normal weight (BMI: 18.5–22.9 kg/m^2; n=148, 43.9%). Approximately 30% of both male and female participants had a normal waist circumference, indicating that more than 60% of participants were at risk of abdominal obesity. Moreover, we observed a history of metabolic diseases including type 2 diabetes (n=9, 2.7%), hypertension (n=6, 1.8%), and dyslipidemia (n=4, 1.2%).

Among the 19 types of SSBs, the participants most often consumed milk and freshly prepared iced milk tea (both: n=136, 40.4%), Carbonated drinks (n=135, 40.1%), cocoa drinks (n=133, 39.5%), fermented milk (n=130, 38.6%), and juice packs (n=118, 35.0%), with an average volume of 110–151 mL/day during the prior month (Table 2). The consumption of freshly prepared iced milk tea beverages (e.g., iced matcha green tea latte, iced Thai milk tea, and iced bubble tea; p=0.03) and iced lemon tea (p=0.01) was significantly associated with BMI status (Table 3), indicating that a high consumption of freshly prepared iced milk tea might be one of the risk factors associated with weight status. This result prompted us to further examine the amount of sugar and the sugar profile in freshly prepared iced milk tea and iced lemon tea. According to the LC-MS/MS multiple reaction monitoring analysis, the standards of sucrose (m/z 341→179), lactose (m/z 341→179), fructose (m/z 179→161), and glucose (m/z 179→161) were eluted at retention time

Table 1. Sociodemographic characteristics of the study participants

Sociodemographic characteristic	Number of subjects (%)
Age (years)	
20–29	72 (21.4)
30–39	122 (36.2)
40–49	109 (32.3)
50–59	34 (10.1)
Gender	
Male	114 (33.8)
Female	223 (66.2)
Education	
Primary level	24 (7.1)
Secondary level	78 (23.2)
Undergraduate	127 (37.7)
Graduated	108 (32.1)
Monthly income (Thai bath)	
5,000–10,000	76 (22.6)
10,001–15,000	26 (7.7)
15,001–20,000	45 (13.4)
20,001–25,000	46 (13.6)
25,001–30,000	44 (13.1)
>30,000	100 (29.7)
Body mass index (kg/m^2)	
<18.5	25 (7.4)
18.5–22.9	123 (36.5)
23.0–24.9	65 (19.3)
25.0–29.9	91 (27.0)
≥30.0	33 (9.8)
Waist circumference (cm)	
Males	
<90	84 (73.7)
>90	30 (26.3)
Females	
<85	136 (61.0)
>85	87 (39.0)
Metabolic diseases	
Type 2 diabetes	9 (2.7)
Hypertension	6 (1.8)
Dyslipidemia	4 (1.2)

Table 2. Type and volume of sugar-sweetened beverage consumption by the study participants

Type of sugar-sweetened beverage	Number of subjects (%)	Volume (mL/day)	
		Mean	SD
Milk	136 (40.4)	151.5	109.4
Freshly prepared iced milk tea	136 (40.4)	146.8	109.6
Carbonated drink	135 (40.0)	110.5	90.7
Cocoa drink	133 (39.5)	140.7	107.7
Fermented milk	130 (38.6)	113.7	79.1
Juice pack	118 (35.0)	117.6	103.1
Freshly prepared iced Americano	92 (27.3)	226.1	135.2
3-in-1 instant coffee mix	73 (21.7)	163.1	93.4
Herbal drink	66 (19.6)	135.0	124.9
Freshly prepared iced lemon tea	63 (18.7)	121.7	99.1
Low fat milk	46 (13.7)	110.1	62.4
Freshly prepared iced espresso	40 (11.9)	186.0	118.5
Freshly prepared iced cappuccino	35 (10.4)	191.9	152.1
Energy drink	34 (10.1)	93.1	57.7
Freshly prepared iced latte	33 (9.8)	171.9	135.1
Sugar green tea (bottle)	32 (9.5)	111.4	79.1
Freshly prepared iced black tea	29 (8.6)	123.1	106.9
Skim milk	26 (7.7)	129.1	95.3
Freshly prepared iced mocha	20 (5.9)	138.9	86.5

Table 3. Association between sugar-sweetened beverage consumption and body mass index

Type of sugar-sweetened beverage		Body mass index (kg/m^2)					P-value
		≥30	25–29.9	23–24.9	18.5–22.9	<18.5	
Freshly prepared iced milk tea	Consumption, n (%)	19 (14.0)	28 (20.6)	24 (17.6)	51 (37.5)	14 (10.3)	0.03*
	Non-consumption, n (%)	14 (7.0)	63 (31.1)	41 (20.4)	72 (35.8)	11 (5.5)	
Freshly prepared iced lemon tea	Consumption, n (%)	7 (11.1)	9 (14.3)	9 (14.3)	32 (50.8)	6 (9.5)	0.01*
	Non-consumption, n (%)	26 (9.5)	82 (29.9)	56 (20.4)	91 (33.2)	19 (6.9)	

*p<0.05 is considered a statistically significant difference (chi-square test)

5.2, 5.7, 3.2, and 4.2 minutes, respectively (Figure 1). The sugar concentration of iced milk tea and iced lemon tea was calculated by comparison with standard curves; the results are presented in Table 4. Most of the free sugar in all the samples was sucrose, with an average concentration of 35.9+5.2 g/100 mL for iced lemon tea, 32.7±2.8 g/100 mL for Thai milk tea, 31.9±1.9 g/100 mL for milk green tea, and 30.8±6.6 g/100 mL for bubble tea. However, lactose, the sugar found in milk, was observed in only 5 among 12 milk tea samples (range: 2.4–4.7 g/100 mL), suggesting that the milk tea assessed in this study might have contained non-dairy creamer instead of milk (Figure 2).

The daily consumption of sugar for all the participants was calculated based on the LC/MS-MS analysis as well as the information found on nutrition facts labels. Approximately 60% of the participants consumed more than 24 g of added sugar from SSBs per day and this trend was significantly associated with an increased BMI (p=0.01). As presented in Table 5, approximately 78.8% of individuals with obesity (BMI >30 kg/m^2) consumed more than 24 g of added sugar from SSBs per day. As shown in the Figure 3, the waist circumference of the participants gradually increased by 0.30 cm for every 1-unit increase in BMI. Furthermore, Table 6 shows that, when compared to a normal BMI, a BMI >30 kg/m^2 was associated with a higher risk of type 2 diabetes (OR 15.1, p=0.02, 95% CI 1.51–150.13).

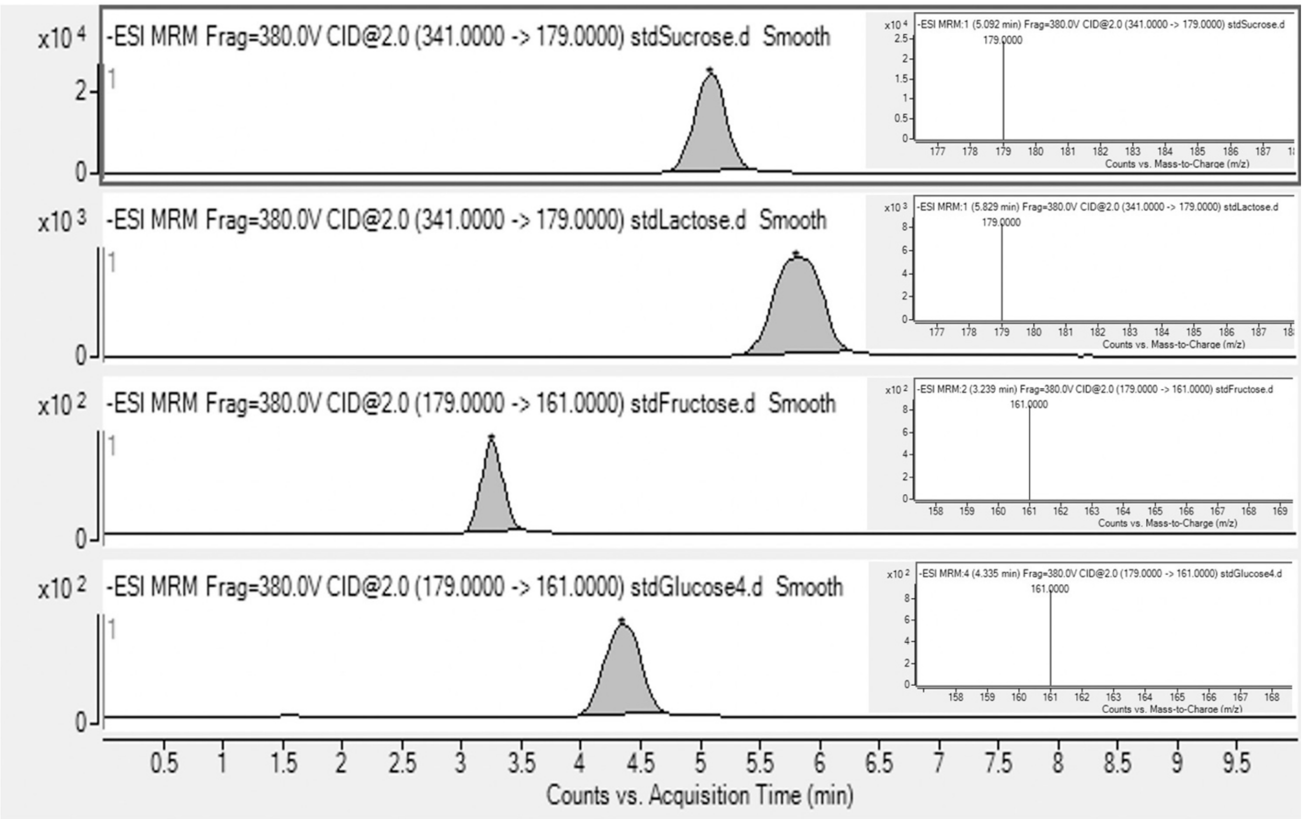

Figure 1. Standards of sucrose, lactose, fructose, and glucose were separated using the Asahipak NH2P-50 column (4.6 µm, 250 mm) with an isocratic mobile phase consisting of 80% 10 mM ammonium acetate and 20% acetonitrile. Standards of sucrose, lactose, fructose, and glucose were eluted at retention time 5.2, 5.7, 3.2, and 4.2 minutes, respectively.

Table 4. Sugar profile and amount of sugar in freshly prepared iced beverage samples

Freshly prepared iced beverage	Sucrose (g/100 mL)	Lactose (g/100 mL)	Fructose (g/100 mL)	Glucose (g/100 mL)	Total sugar (g/100 mL)
Milk green tea					
Sample 1	30.0	n.d.	n.d.	n.d.	30.0
Sample 2	34.4	3.00	n.d.	n.d.	37.4
Sample 3	32.2	n.d.	2.8	1.6	36.6
Sample 4	30.8	2.8	1.8	2.7	38.1
Average	31.9	2.9	2.3	1.85	34.6
SD	1.9	-[a]	-[a]	-[a]	3.9
Thai milk tea					
Sample 1	32.2	n.d.	n.d.	n.d.	32.2
Sample 2	29.0	4.7	2.9	3.4	39.9
Sample 3	35.7	n.d.	n.d.	n.d.	35.7
Sample 4	33.8	n.d.	0.1	0.8	34.8
Average	32.7	4.7	1.5	2.1	35.6
SD	2.8	-[a]	-[a]	-[a]	3.2
Bubble milk tea					
Sample 1	23.1	4.2	0.1	0.58	27.9
Sample 2	39.0	n.d.	n.d.	n.d.	38.9
Sample 3	32.2	n.d.	0.1	1.04	33.4
Sample 4	29.0	2.4	1.8	2.69	35.8
Average	30.8	3.3	0.7	1.4	34.0
SD	6.6	-[a]	0.9	1.2	4.7

Lemon tea					
Sample 1	28.2	-	0.9	1.1	30.2
Sample 2	37.9	-	0.9	1.3	40.0
Sample 3	39.3	-	0.4	1.4	41.1
Sample 4	38.3	-	0.5	0.7	39.4
Average	35.9	-	0.7	1.1	37.7
SD	5.2	-[a]	0.3	0.3	5.0

n.d. : Non detected

-[a] : Not available

All samples were purchased from different shops depending on the frequency of participants selected. Data were analyzed using LC-MS/MS methods and the amount of sugar was calculated by comparison with standard curves for sucrose, lactose, fructose, and glucose.

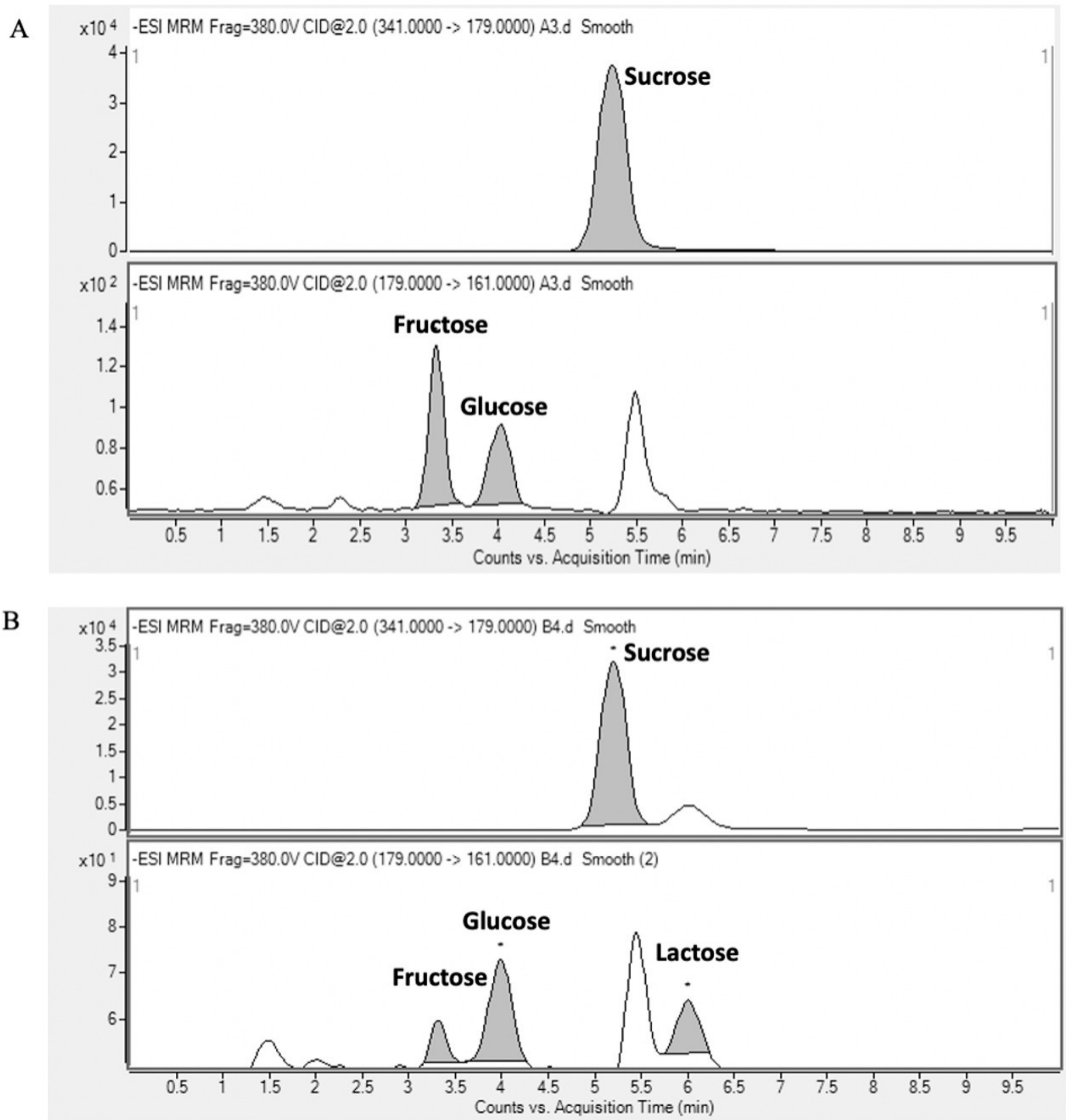

Figure 2. The sugar profile of freshly prepared iced milk green tea (A) Sample 3 and (B) Sample 4. Lactose (milk sugar) was not detected in Sample 3, whereas it was detected in Sample 4.

Table 5. Relationship between sugar consumption and body mass index

Amount of added sugar consumed	n (%)	Body mass index (kg/m²)					P-value
		≥30	25–29.9	23–24.9	18.5–22.9	<18.5	
>24 g/day	238 (70.6)	26 (10.9)	53 (22.3)	44 (18.5)	93 (39.1)	22 (9.2)	0.01*
<24 g/day	99 (29.4)	7 (7.1)	38 (38.4)	21 (21.2)	30 (30.3)	3 (3.0)	

*p<0.05 is considered a statistically significant difference (Chi-square test)

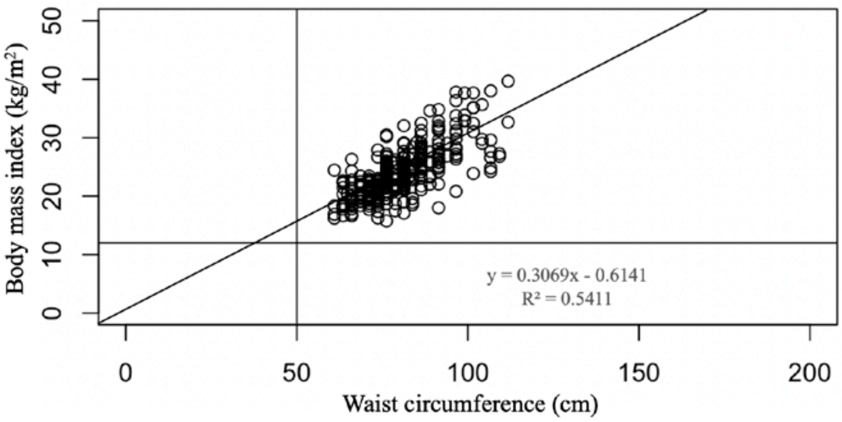

Figure 3. The association of body mass index and waist circumference determined using linear regression analysis

Table 6. Odds ratios of metabolic syndrome according to body mass index

Body mass index (kg/m²)	Disease	Non-disease	P-value	OR	95% CI	
					Lower	Upper
Type 2 diabetes mellitus						
≥30	3 (33.3)	30 (9.1)	0.02*	15.10	1.51	150.13
25–29.9	4 (44.4)	85 (25.9)	0.08	7.10	0.78	64.60
23–24.9	1 (11.1)	62 (18.9)	0.53	2.43	0.15	39.55
<22.9	1 (11.1)	151 (46.1)	Ref.			
Hypertension						
≥30	1 (16.6)	32 (10.5)	0.492	2.34	0.2	26.63
25–29.9	2 (33.3)	87 (25.8)	0.589	1.72	0.23	12.45
23–24.9	1 (16.6)	62 (18.7)	0.877	1.21	0.1	13.58
<22.9	2 (33.3)	150 (44.5)	Ref.			
Hyperlipidemia						
≥30	1 (25.0)	35 (10.5)	0.277	4.31	0.28	77.43
25–29.9	1 (25.0)	85 (26.3)	0.704	1.77	0.10	27.77
23–24.9	1 (25.0)	62 (18.6)	0.531	2.43	0.15	39.55
<22.9	1 (25.0)	151(45.3)	Ref.			

OR: odds ratio, CI: confidence interval

DISCUSSION

This study was to determine the association between the habitual intake of SSBs (type, frequency, volume, and total amount of free sugar) and BMI among office workers during the COVID-19 pandemic (March to December 2020). Our findings demonstrated that 56.1% of participants were overweight or obese, which is consistent with results from a previous report by *Sakboonyarat* et al [19]. Among 19 types of SSBs, freshly prepared iced milk tea (e.g., milk green tea, Thai milk tea, and bubble tea) and iced lemon tea were the most consumed, and were found to be associated with an increased BMI. This result is consistent with that of *Phulkerd* et al. [3], who found that the consumption of freshly prepared milk tea increased by approximately 3% from 2018 (270 mL) to 2019 (278 mL). The increasing trend of consuming tea-based beverages may be due to the price of SSBs, which are non-taxable items. This is consistent with *Bleich* et al. [20], who reported a decrease in the consumption of SSBs after the implementation of SSB tax [20-22]. Moreover, tea-based beverages contain caffeine (an addictive substance), leading to their continuous intake, and the experience of tea-related traditional Thai medicine may also incentivize the consumption of these beverages and popularize them among young people and the working population [23].

According to the LC-MS/MS analysis, university staff members consumed an average of 50.25 g (12.56 teaspoons) and 39.18 g (9.75 teaspoons) of added sugar per serving of milk tea and lemon tea, respectively; these values are approximately 2-fold higher than the World Health Organization's recommendations. Moreover, we found that 70.6% of the participants consumed more than 24 g of total sugar per day from SSB, where sucrose was the most prevalent added sugar. In previous reports, high sucrose consumption was found to be associated with an increase in abdominal or visceral fat given its association with metabolic diseases (e.g., type 2 diabetes) [1,6, 7, 24, 25]. This can be explained by sucrose, which is further digested into glucose and fructose, being completely and rapidly absorbed by the body. Fructose is subsequently converted to fat (triglycerides), resulting in lipid deposition in the visceral adipose tissue and reduced insulin sensitivity [26, 27, 28, 29]; therefore, sucrose has a harmful effect on type 2 diabetes. Surprisingly, our results demonstrated that some milk tea samples were supplemented with non-dairy creamer instead of milk as a tea whitener. In experimental animal models fed non-dairy creamer (an enriched high-fat diet), an increased triglyceride concentration and visceral fat accumulation were observed [30]. Therefore, the consumption of iced milk tea may lead to a high calorie intake owing to the inclusion of ingredients containing both sugar and fat, leading to an increased waist circumference and BMI, and adverse health outcomes. Our results imply that the excess consumption of freshly prepared iced tea containing high amounts of sucrose may contribute to overweight and obesity, in particular increased fat storage in the abdominal area (visceral and subcutaneous adipose tissue).

According to the binary logistic regression analysis, the relationship between BMI and metabolic diseases (diabetes, hypertension, and hyperlipidemia) revealed that participants who have obesity (BMI >30 kg/m^2) were 15 times more likely to develop type 2 diabetes than those with a normal weight (BMI 18–23 kg/m^2). This is consistent with a previous report that excess visceral adipose tissue accumulation is associated with type 2 diabetes [24]. Moreover, we found that an increased BMI was associated with an increased waist circumference, indicating that abdominal fat may play a role in the development of type 2 diabetes. The possible mechanism may be explained by a previous study by *Lin* et al. that found that the excess consumption of SSBs may elevate the c-reactive protein concentration, which causes individuals with obesity to experience chronic low-grade inflammation [31]. In the case of adipose tissue inflammation, the remodeling of fat cells plays a crucial role in the development of insulin resistance and diabetes [31, 32, 33, 34]. It is possible that the consumption of SSBs may contribute to weight gain and the development of type 2 diabetes; however, information on SSB consumption prior to the development of type 2 diabetes is lacking. Therefore, the relationship between SSB consumption and the change in visceral adipose tissue need to be further elucidated through longitudinal studies.

Limitations

Many factors contribute to the development of overweight and obesity, such as dietary intake, individual metabolic rate, genetic factors, and SSB consumption; however, this study only focused on the pattern of SSB consumption, leading to uncontrolled confounding. Therefore, a regression analysis for the estimation of the relationship between SSB consumption and overweight/obesity that is adjusted for potentially confounding variables is required to further elucidate this issue. Moreover, the use of a 24-hour dietary recall to record the consumption frequency of SSBs may lead to recall bias. Repeating the 24-hour dietary recall by using an electronic questionnaire, which is a low-burden method, may reduce recall bias.

Implications and future research

Our findings provide evidence-based information on the sugar profile and amount of sugar in freshly prepared iced milk tea beverages, of which the consumption has increased among university staff during the COVID-19 pandemic. Sugar (sucrose) consumption exceeding 24 g/day may be associated with overweight and obesity owing to increasing waist circumference, leading to type 2 diabetes. Further research is necessary to determine the relationship between a) SSB consumption and the change in visceral fat deposition over time, to elucidate the effect of sugar intake on long-term health outcomes, and b) the amount of sucrose obtained via the consumption of SSBs and insulin sensitivity, to facilitate a reduction in sugar content per serving.

CONCLUSIONS

Our study finding found that among 19 types of SSBs consumption during COVID-19 pandemic, the consumption of sugar-containing tea-based beverages, especially freshly prepared milk tea and lemon tea without nutrition facts labels were associated with BMI status. Total sugar content and sugar profile of freshly prepared milk tea and lemon tea were determined using direct method LC-MS/MS. This is due to these beverages containing large amounts of sucrose (approximately 35 g/100 mL) which is further metabolized to synthesize triglycerides, resulting in visceral fat accumulation and adverse health outcomes (Type II diabetes). To minimize the risks related to SSBs, a warning label policy should be implemented on relevant products and in the shops that sell these products.

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Authors' contributions
J.P, L.C, and P. Pouyfung performed the study, analyzed the data, conducted the data interpretation, and drafted the manuscript. A.S, P.K, T.D, and P. Pornpitayalaud performed the study. J.P, and P. Pouyfung designed the study and reviewed the manuscript. All authors proofread and approved the final manuscript.

Declaration of competing interest
The authors declare that they have no conflict of interest.

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