MALAYSIAN JOURNAL OF

NUTRITION

VOL. 29 NO. 1 APRIL 2023

PP18053/02/2013 (033331)

ISSN 1394-035X

Official Publication of the
PERSATUAN PEMAKANAN MALAYSIA
NUTRITION SOCIETY OF MALAYSIA

Malaysian Journal of Nutrition is abstracted/indexed by Google Scholar, the WHO Western Pacific Region Index Medicus, Elsevier databases of the Scopus, EBiology and Ecare, ASEAN Citation Index (ACI), CABI Global Health database and Asian Digital Library (ADL)

MALAYSIAN JOURNAL OF NUTRITION

Peer-reviewed Journal of the Nutrition Society of Malaysia
(http//www.nutriweb.org.my)

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Malaysian Journal of Nutrition
Vol. 29 No. 1, 2023

Contents

Mal J Nutr 29(1): 001-015, 2023

Growth patterns of urban Malaysian children under 24 months of age in Selangor, Malaysia

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ABSTRACT

Introduction: To identify the growth patterns of young children during the first two years of life according to gestational age, birth weight, and growth status at 24 months of age. **Methods:** This was a retrospective cohort study of 4,570 young children in Selangor. Data were extracted from children's health records in government health clinics. Growth data were analysed using the Anthro Plus software that utilises the World Health Organization growth standards. **Results:** Generally, wasting prevalence was the highest at birth and 24 months, but stunting was more predominant from 1 to 21 months. Weight-for-age z-scores (WAZ), length-for-age z-scores (LAZ), and weight-for-length z-scores (WLZ) from birth to 24 months were within -3.00 to 0.00 standard deviation (*SD*) for pre-term low birth weight children, –1.50 to 0.00 *SD* for pre-term normal birth weight children, and –2.50 to 0.50 *SD* for full-term low birth weight children. While WAZ, LAZ, and WLZ from birth to 24 months for underweight/stunted/wasted children were within –2.50 to 0.50 *SD*, the values for overweight/obese (OV/OB) children were within –1.00 to 2.00 *SD*. For normal children, WAZ, LAZ, and WLZ exhibited comparable trends, with values within –1.00 to 0.00 *SD* from birth to 24 months. **Conclusion:** While stunting and wasting persisted as the most common forms of malnutrition in this sample of young children, the prevalence of OV/OB increased by 24 months. Interventions to promote child growth should focus not only on the prevention of undernutrition, but also on OV/OB.

Keywords: Malaysia, malnutrition, obesity, overweight, retrospective studies

INTRODUCTION

Worldwide, the prevalences of stunting, wasting, and underweight among children under five years have been reported to be 21.3%, 14.0%, and 13.0%, respectively; with the highest prevalence in Asia and Africa (WHO, 2020). In Asia, the number of stunted children has decreased from 134 to 87 million, a 35% reduction in 16 years (WHO, 2020). Although the number of stunted children under five years in South Asia has also declined from 90.1 million to 56.1 million between 2000 and 2019, South Asia still has the highest prevalence of stunting in the world. In Malaysia, the prevalence

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doi: https://doi.org/10.31246/mjn-2021-0103

of stunting (21.8%) remains the most prevalent form of undernutrition among children under five years in 2019, followed by underweight (14.1%) and wasting (9.4%) (IPH, 2020).

Approximately 45% of all deaths among children under five years of age are attributed, directly or indirectly, to undernutrition (WHO, 2020). These deaths often occur in the same countries where the rates of childhood obesity are rising. Worldwide, there are 38.3 million children under five years (5.9%) who are overweight; with Southeast Asia and Northern America being the only sub-regions that had a substantial rise in the number of overweight children from 2000 to 2019. In Malaysia, the prevalence of overweight and obesity (BAZ>+2 standard deviation, *SD*) in 2019 among children under five years was 5.6%, and it was more prevalent in the urban than rural areas (6.0% vs 4.4%), and among the bottom 40% (B40 – < RM 4,850) than middle 40% (M40 – RM 4,850 to RM 10,959) and top 20% of household income categories (T20 – > RM 10,959) (6.0% vs 5.6% vs 4.2%) (IPH, 2020).

The first two years of life are often referred to as a critical period, during which there is a higher energy and nutrient demand to support a child's growth and development needs (Arnold *et al.*, 2009). A poor diet together with frequent infections may contribute to infant growth retardation (Goulet, 2010). Evidence indicates that growth faltering often occurs among infants of low- and middle-income households at some point during the first two years of life, and it commonly starts between four and six months of age (Victora *et al.*, 2010). In developing countries, weight faltering in infants often occurs around four months of age, while faltering of height occurs around three months of age (Victora *et al.*, 2010).

Poor growth in early life is associated with many adverse health consequences, ranging from cognitive deficits to the risk of chronic diseases in later childhood and adulthood (Singhal, 2017). Child growth monitoring is therefore a crucial step to understand the patterns and timing of growth faltering in both weight and height of infants. In addition, children with different birth status (e.g., pre-term delivery, low birth weight) may have different patterns of growth due to substantial neonatal growth restriction and the need for intensive care in most pre-term and low birth weight infants. The insight on the growth patterns and timing of growth faltering in children under 24 months of age could be the starting point for developing strategies to prevent early childhood growth retardation. Thus, this study aimed to examine the growth patterns of young children during the first two years of life, specifically according to gestational age, birth weight, and growth status at 24 months of age.

MATERIALS AND METHODS

This retrospective cohort study was conducted in six randomly selected Maternal and Child Health (MCH) clinics in Hulu Langat, Petaling, and Sepang districts, Selangor. The study protocol was approved by the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia (NMRR-18-2604-43816). Informed consent was not required due to the retrospective study design, and all participants were anonymised.

Data sources

The source of data was health records of children born between January 2015 to December 2017. The health records contained the parent's background, birth information (e.g., gender, gestational age, length, head circumference, and birth weight), and growth assessment.

Data were extracted from the health records by trained enumerators.

Growth assessment

Growth data at birth, 1, 2, 3, 4, 5 6, 9, 12, 15, 18, 21, and 24 months were extracted. Weight (to the nearest 0.1 kg), and length (to the nearest 0.1 cm), were measured by the clinic nurses using a digital weighing scale with length meter, respectively, according to standard procedures (MOH Malaysia, 2015). Growth data were analysed using the Anthro Plus software that utilises the World Health Organization (WHO) growth standards (2006) (WHO, 2006). Three growth indicators [length-for-age *z*-scores (LAZ), weight-for-age *z*-scores (WAZ), and weight-for-length *z*-scores (WLZ)] were determined. Children were excluded when one of their anthropometric observations was biologically improbable according to the cut-offs defined by WHO (2006). Specifically, the cut-offs were LAZ < –6 *SD* or > +6 *SD*, WAZ < –6 *SD* or > +5 *SD* or WLZ < –5 *SD* or > +5 *SD*. The final data set consisted of 4,570 children. Underweight, stunting, wasting among children were defined as LAZ, WAZ, and WLZ of < –2 *SD*. Meanwhile, overweight (OV) and obesity (OB) were defined as +2 *SD* < WLZ < +3 *SD* and WLZ of > +3 *SD* (WHO, 2006).

Other variables

Mother's socio-demographic information on age, ethnicity, marital status, education level, obstetrical information (e.g., gravidity, parity), medical history [e.g., retroviral, hepatitis B, diabetes/gestational diabetes mellitus (GDM), hypertension/pregnancy-induced hypertension (PIH), thalassaemia], as well as anthropometric measurements (e.g., height, weight at 1 month postpartum, body mass index at one month postpartum) were extracted. Mode of birth (normal vaginal birth, assisted breech delivery, instrumental delivery or caesarean section), sex of infant, infant's birth weight, length, and head circumference were also obtained from the health records. The gestational age at birth was determined by last menstrual period (LMP) or by ultrasonography if the LMP was unsure. Pre-term birth was defined as birth occurring at less than 37 completed weeks of gestation or 259 days of gestation. Birth weight was categorised according to the recommendations of the United Nations Children's Fund (UNICEF) and WHO as < 2.5 kg for low birth weight, 2.5 – 4.0 kg for normal birth weight, and >4.0 kg for high birth weight (UNICEF, 2004).

Data analysis

Data were analysed using SPSS version 26, while Microsoft Excel 2010 was used to generate plots. Descriptive statistics (mean, standard deviation, frequency, and percentage) were used to describe the data. Z-score distribution of different anthropometric indicators was plotted. The *z*-score distribution for the high birth weight group was not presented, as only 15 children were observed in this group. *P* for linear trend (*P*-trend) of growth from birth to 24 months was analysed using repeated measures analysis of variance (ANOVA) for LAZ, WAZ, and WLZ. Independent *t*-test was used to compare the mean values for LAZ, WAZ, and WLZ between groups (birth status and growth status at 24 months of age). The statistical significance level was set at $p<0.05$.

RESULTS

Table 1 shows the characteristics of mothers and infants. The mean maternal age was 30.4±4.6 years, and most mothers were Malays (76.0%). Two-fifth of the mothers were either overweight (30.9%) or obese (17.1%), whereas 6.5% were underweight at one

Table 1. Characteristics of mothers and infants (*N*=4,570)

Characteristics	*n (%)*	*Mean±SD*
Maternal characteristics		
Maternal age (years)		30.43±4.64
Ethnicity		
Malay	3474 (76.0)	
Chinese	638 (14.0)	
Indian and others	458 (10.0)	
Marital status		
Single	10 (0.3)	
Married	4559 (99.6)	
Divorced	1 (0.1)	
Education level (*n*=4502)		
No formal education	4 (0.1)	
Primary to secondary	2846 (63.2)	
STPM/Matriculation/Diploma/Certificate	956 (21.2)	
Tertiary and above	696 (15.5)	
Gravidity		2.00±0.95
1	1576 (34.5)	
2	1883 (41.1)	
3	807 (17.7)	
≥4	304 (6.7)	
Parity		0.96±0.42
0	1631 (35.7)	
1	1874 (41.0)	
2	778 (17.0)	
≥ 3	287 (6.3)	
Height (cm)		155.45±5.69
Weight at 1 month postpartum (kg)		61.12±12.06
Body mass index (BMI) at 1 month postpartum (kg/m^2)		25.28±5.18
Underweight (<18.5)	301 (6.5)	
Normal (18.5 – 24.9)	2079 (45.5)	
Overweight (25.0 – 29.9)	1410 (30.9)	
Obese (≥30.0)	780 (17.1)	
Medical history of		
Retroviral	6 (0.1)	
Hepatitis B	5 (0.1)	
Diabetes / Gestational diabetes mellitus	902 (19.7)	
Hypertension / Pregnancy-induced hypertension	178 (3.9)	
Thalassaemia	7 (0.2)	
Birth information		
Mode of delivery		
Normal vaginal birth	4154 (90.9)	
Assisted breech delivery	10 (0.2)	
Instrumental delivery (forceps, vacuum)	35 (0.8)	
Caesarean section	371 (8.1)	
Complication during birth		
No	4545 (99.5)	
Foetal distress	25 (0.5)	

Table 1. Characteristics of mothers and infants (*N*=4,570) [Cont'd]

Characteristics	*n (%)*	*Mean±SD*
Infant characteristics		
Age (months)		
1 months		1.09±0.15
2 months		2.12±0.19
3 months		3.17±0.22
4 months		4.17±0.25
5 months		5.18±0.23
6 months		6.23±0.30
9 months		9.25±0.33
12 months		12.15±0.21
15 months		15.16±0.28
18 months		18.18±0.29
21 months		21.17±0.30
24 months		24.16±0.21
Gestational age at delivery (weeks)		38.33±2.01
< 37 weeks (pre-term)	679 (14.9)	
≥ 37 weeks	3891 (85.1)	
Infant's sex		
Male	2598 (56.8)	
Female	1972 (43.2)	
Infant's birth weight (kg)		3.02±0.41
< 2.5 (Low birth weight)	535 (11.7)	
2.5 – 4.0 (Normal birth weight)	4020 (88.0)	
> 4.0 (High birth weight)	15 (0.3)	
Infant's head circumference (cm)		32.81±1.49
Infant's length at birth (cm)		49.34±2.86

month postpartum. About 19.7% and 3.9% had a history of diabetes/GDM and hypertension/PIH, respectively. There were 2,598 male infants (56.8%) and 1,972 female infants (43.2%), with 85.1% born full-term. A total of 535 (11.7%) infants had low birth weights (<2.5 kg) and only 15 (0.3%) had high birth weights (>4.0 kg).

At birth and at 24 months, the prevalence of wasting (birth=13.6%; 24 months=8.1%) was higher than the prevalence of stunting (birth=11.3%; 24 months=7.7%), underweight (birth=6.5%; 24 months=5.6%) and OV/OB (birth=10.9%; 24 months=5.5%). However, the prevalence of stunting (11.1 – 16.3%) was the highest from 1 to 21 months of age. The prevalence of underweight remained within 6.8% to 10.8% from 1 to 21 months of age. The prevalence of OV/OB decreased gradually from 9.3% at 1 and 2 months to 2.3% at 12 months, then increased to 5.5% at 24 months. Based on the *z*-score distribution for LAZ, WAZ, and WLZ of children under 24 months compared with the WHO standards, the distribution of LAZ (median= –0.65) and WAZ (median= –0.52) appeared to be skewed to the left, but the curve of WLZ (median= –0.18) lay closely within the range to the right of the WHO standard (Table not shown).

Table 2 shows the nutritional status of children at birth, by birth status. About 41.6%, 86.5%, and 47.6% of the pre-term low birth weight children were stunted, underweight, and wasted at birth. For pre-term normal birth weight children, most of them were non-

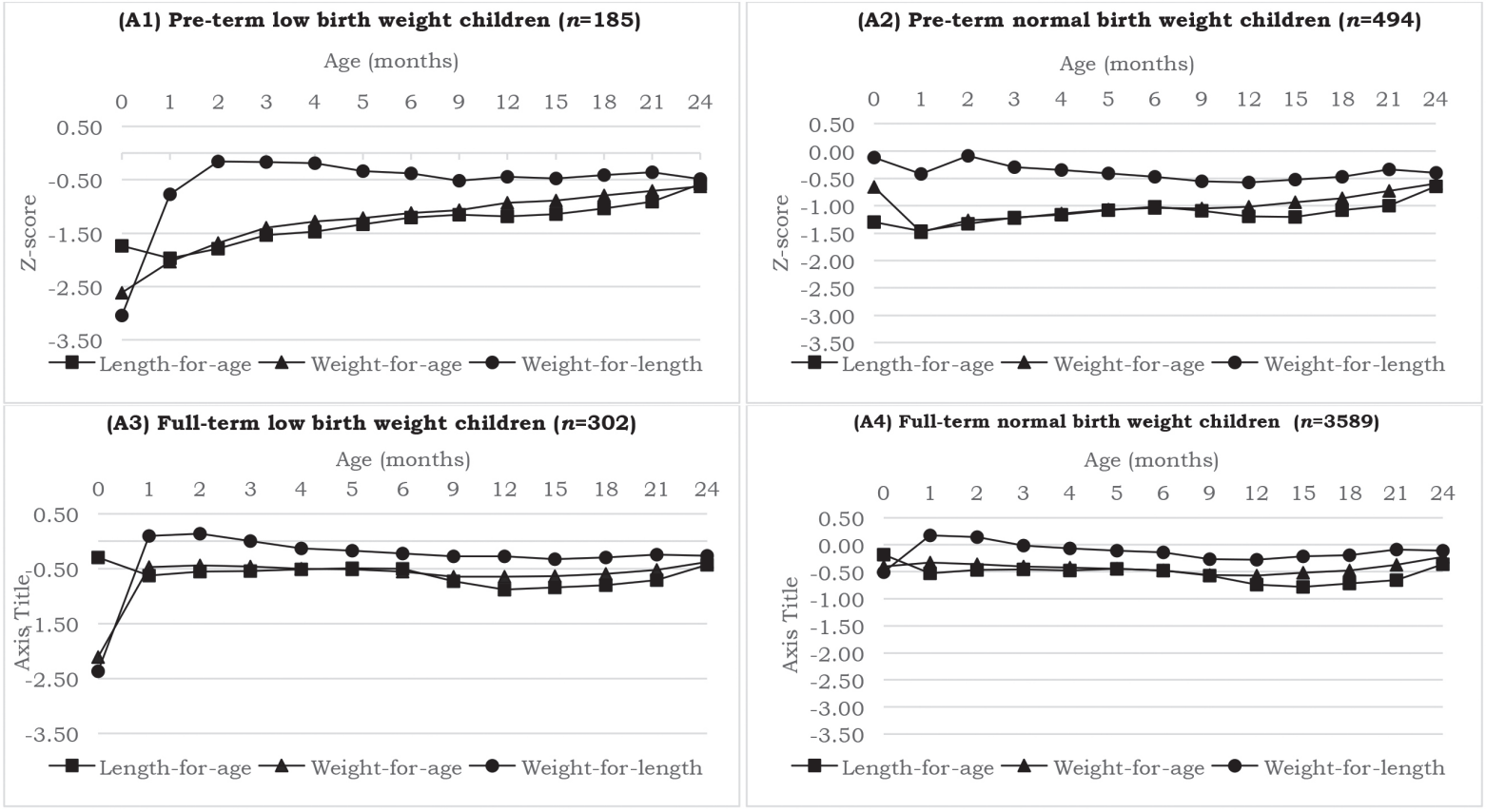
Table 2. Nutritional status of children at birth by birth status (N= 4,570)

	Total (n=4,570)	Birth status				p-value
		Pre-term low birth weight (n=185)	Pre-term normal birth weight (n=494)	Full-term low birth weight (n=302)	Full-term normal birth weight (n=3589)	
At birth						
Length-for-age z-score (LAZ), Mean±*SD*	-0.38±1.50	-1.74±1.92	-1.30±1.07	-0.30±1.44	-0.19±1.36	0.001***
Stunting, *n* (%)	516 (11.3)	77 (41.6)	145 (29.4)	32 (10.6)	262 (7.3)	0.001***
Non-stunting, *n* (%)	4054 (88.7)	108 (58.4)	349 (70.6)	270 (89.4)	3327 (92.7)	
Weight-for-age z-score (WAZ), Mean±*SD*	-0.63±0.91	-2.61±0.60	-0.66±0.78	-2.11±0.33	-0.40±0.71	0.001***
Underweight, *n* (%)	298 (6.5)	160 (86.5)	1 (0.2)	137 (45.4)	0 (0.0)	0.001***
Non-underweight, *n* (%)	4272 (93.5)	25 (13.5)	493 (99.8)	165 (54.6)	3589 (100.0)	
Weight-for-length z-score (WLZ), Mean±*SD*	-0.75±1.01	-2.76±1.56	-0.12±1.05	-2.37±1.06	-0.51±1.21	0.001***
Wasting, *n* (%)	713 (13.6)	88 (47.6)	1 (0.2)	223 (73.8)	401 (11.2)	0.001***
Normal, *n* (%)	3359 (73.5)	97 (52.4)	439 (88.9)	79 (26.2)	2744 (76.5)	
Overweight/obesity, *n* (%)	498 (10.9)	0 (0.0)	54 (10.9)	0 (0.0)	444 (12.4)	

Note: Stunting – LAZ <-2*SD*, Non-stunting – LAZ ≥ 2*SD*; Underweight – WAZ < -2*SD*, Non-underweight – WAZ ≥ -2*SD*; Wasting – WLZ < -2*SD*, Normal – WLZ ≥ ±2*SD*, Overweight/obesity – WLZ > + 2*SD*
***p<0.001

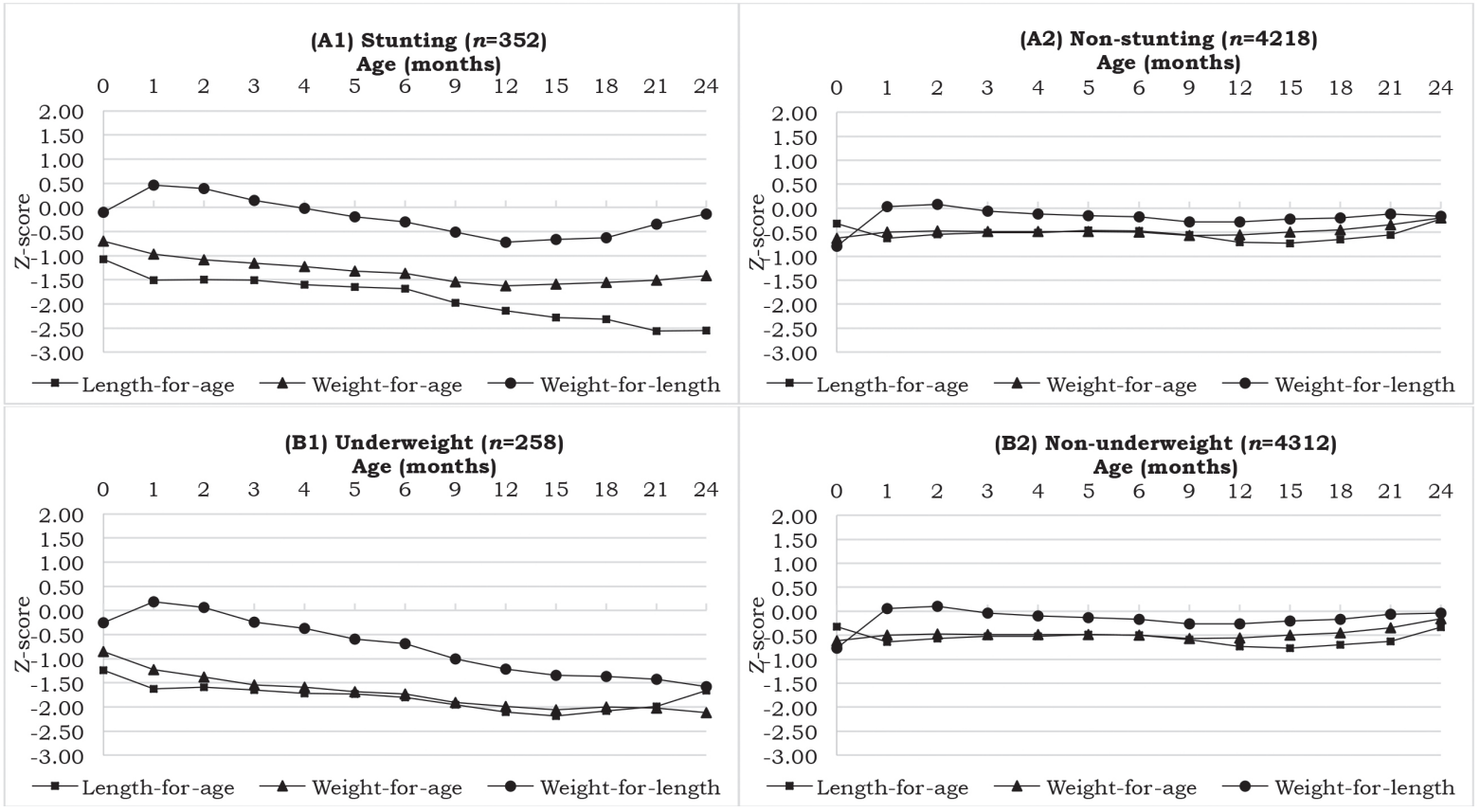
stunted (70.6%), non-underweight (99.8%), and non-OV/OB (88.9%) at birth. Meanwhile, for full-term low birth weight children, about 10.6% were stunted, 45.5% underweight, and 73.8% wasted.

Figure 1 shows the growth trend by birth status. There were significant differences in the means of LAZ, WAZ, and WLZ among children with different birth status (p<0.05). For pre-term low birth weight children, WLZ increased from birth to 2 months (–3.04 *SD* to –0.16 *SD*), decreased thereafter, and plateaued at –0.50 *SD* from 5 months onwards (*P*-trend <0.05). LAZ decreased to less than –1.50 *SD* at one month and increased thereafter to –0.58 *SD* at 24 months (*P*-trend <0.05). WAZ increased from birth to 24 months (–2.61 *SD* to –0.62 *SD*) (*P*-trend <0.05). For pre-term normal birth weight children, WLZ decreased from birth to one month (–0.12 *SD* to –0.41 *SD*), increased at two months (–0.09 *SD*), but decreased thereafter, and plateaued at –0.50 *SD* from five months onwards (*P*-trend <0.05). LAZ and WAZ decreased to less than –1.50 *SD* at one month and increased thereafter to –0.64 *SD* and –0.59 *SD* at 24 months, respectively (*P*-trend <0.05). WAZ for full-term low birth weight children increased from birth (< –2.11 *SD*) to 24 months (~ –0.50 *SD*), while LAZ showed a slight decline from birth to one month, but had a similar trajectory as WAZ thereafter (*P*-trend <0.05). WLZ for full-term and low birth weight children started below –2.00 *SD* at birth, but increased sharply by one month, reaching close to 0.00 *SD* at two months and maintained between –0.50



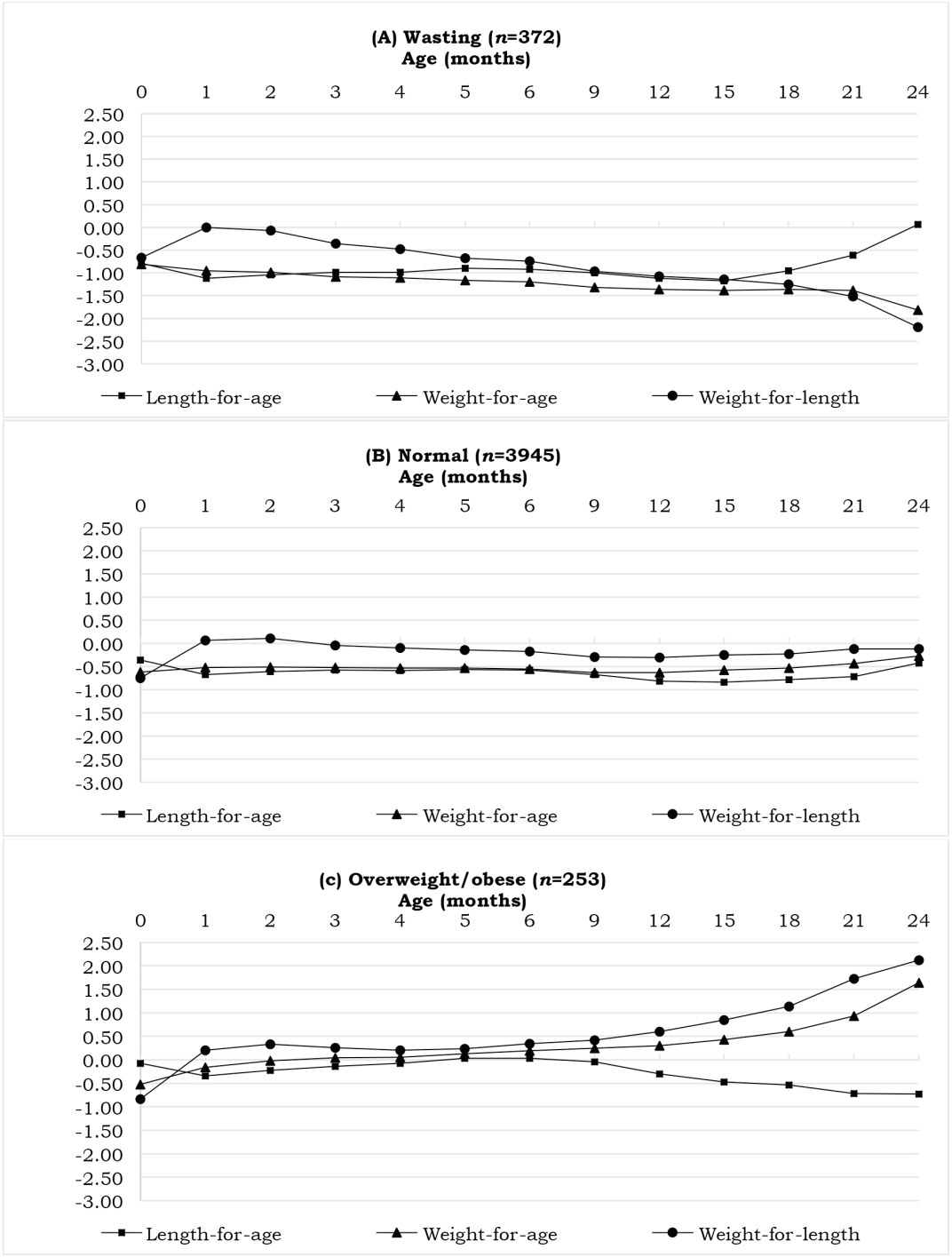
All *p*-trend <0.05.

Figure 1. Mean anthropometric *z*-scores (Length-for-age, weight-for-age, and weight-for-length) according to age relative to the World Health Organization (WHO) standards by birth status - (A1) Pre-term and low birth weight infants, (A2) Pre-term infants, (A3) Low birth weight infants, and (A4) Full-term and normal birth weight infants.



All *p*-trend <0.05.

Figure 2. Mean anthropometric z-scores (Length-for-age, weight-for-age, and weight-for-length) according to age relative to the World Health Organization (WHO) standards for (A1) stunting and (A2) non-stunting status at 24 months; (B1) underweight and (B2) non-underweight status at 24 months.



All *p*-trend <0.05

Figure 3. Mean anthropometric z-scores (Length-for-age, weight-for-age, and weight-for-length) according to age relative to the World Health Organization (WHO) standards for (A) wasting, (B) normal, and (C) overweight/obesity at 24 months.

SD to 0.00 *SD* thereafter (*P*-trend <0.05). For full-term normal birth weight children, both WAZ and WLZ increased from birth to one month, then gradually decreased to reach the lowest at 12 months (WAZ: –0.58 *SD*; WLZ: –0.28 *SD*), but increased thereafter (*P*-trend <0.05). LAZ decreased from birth to one month, remained stable (–0.45 *SD* to 0.48 *SD*) from two to six months, decreased thereafter to the lowest at 15 months, but showed an increasing trend to 24 months (P-trend <0.05).

Figures 2 and 3 show the means of LAZ, WAZ, and WLZ by growth status at 24 months. The means of LAZ, WAZ, and WLZ for stunted children were significantly lower than non-stunted children (Figure 2). For stunted children, there was an obvious decline in LAZ starting at nine months, which exceeded –2.00 *SD* at 12 months, and further exceeded –2.50 *SD* at 23 months and 24 months (*P*-trend <0.05). WAZ maintained between –1.63 *SD* to –1.42 *SD* from nine months until 24 months (*P*-trend <0.05). For underweight children, mean WAZ declined from birth (–0.85 *SD*) to 24 months (–2.12 *SD*) and exceeded –2.00 *SD* from 12 months onwards (P-trend <0.05). While LAZ decreased from birth (–1.63 *SD*) to 15 months (–2.19 *SD*) and increased thereafter to –1.66 *SD* at 24 months, WLZ gradually decreased from 1 to 24 months (0.18 *SD* to –1.58 *SD*) (*P*-trend <0.05). The mean WLZ for wasted children increased sharply from birth to 1 month (–0.66 *SD* to –0.01 *SD*), decreased thereafter, and exceeded –2.00 *SD* at 24 months (*P*-trend <0.05) (Figure 3). Conversely, for OV/OB children, WLZ increased sharply from birth to one month (–0.80 *SD* to 0.21 *SD*), gradually increased thereafter, and exceeded 2.00 SD at 24 months (2.12 SD) (P-trend < 0.05). While mean LAZ increased from 15 months onwards for wasted children, it decreased from 15 months onwards for OV/OB children (*P*-trend <0.05). WAZ for wasted children decreased from birth to 21 months (–0.81 *SD* to –1.39 *SD*) and further decreased to –1.82 *SD* at 24 months (*P*-trend <0.05). In contrast, WAZ for OV/OB children increased from birth to 21 months (–0.50 *SD* to 0.93 *SD*), and was above 1.00 *SD* at 24 months of age (1.64 *SD*) (*P*-trend <0.05). For normal children (non-stunted, non-underweight, non-wasted), WAZ, LAZ, and WLZ showed similar patterns as full-term children with values within –1.00 to 0.00 *SD* from birth to 24 months (*P*-trend <0.05). However, a slight decrease in LAZ was observed between 6 to 12 months in this group of normal children, after which LAZ showed a gradual increasing trend until 24 months (*P*-trend <0.05).

DISCUSSION

The present study found that the nutritional status of children was slightly better than children of a similar age group (24 months) in Thailand (The Thailand Multiple Indicator Cluster Survey (MICS) 2019 – 24 to 35 months, stunting: 11.9%; underweight: 7.5%; wasting: 7.7%) (National Statistical Office of Thailand, 2020), Cambodia (Cambodia Demographic and Health Survey 2014 – 24 to 35 months, stunting: 38.5%; underweight: 8.0%; wasting: 24.9%) (National Institute of Statistics, 2015), and Vietnam (Nutrition Surveillance Profiles 2013 – 24 to 29 months, stunting: 21.3%; underweight: 13.2%; wasting: 5.9%) (Vietnam National Institute of Nutrition, UNICEF, Alive & Thrive, 2014). The differences could be attributed to different socioeconomic status, cultural, and nutrition habits across the settings. The prevalences of stunting (7.7% vs 23.5% and 21.8%), underweight (5.6% vs 12.2% and 14.1%), and wasting (8.1% vs 10.5% and 9.4%) at 24 months for this sample was lower than the prevalences reported by the National Health and Morbidity Survey (NHMS) in

2016 (IPH, 2016) and 2019 (IPH, 2020), respectively. However, the prevalence of OV/OB at 5.5% was slightly higher than in NHMS (2019) (5.2%), but lower than that of NHMS (2016) (7.2%). This might be due to differences in demographic and socioeconomic backgrounds, such as the present data were collected in Selangor – a more developed state than other states in Malaysia, and NHMS 2019 that studied populations under five years old, with a wider age range compared to NHMS 2016 which focused on 24 to 35 months, as well as the inclusion of children from rural areas in NHMS 2019. Studies have shown that rural children have a higher prevalence of undernutrition, but lower prevalences of overweight and obesity compared to urban children, which could be attributed to lower socioeconomic status, poor hygiene and sanitation, as well as compromised living environment (Fagbamigbe, Kandala & Uthman, 2020).

The observed increasing growth trends among pre-term low birth weight, pre-term normal birth weight, and full-term low birth weight children could be attributed to the special postnatal care (e.g., more frequent follow-up to monitor their growth, post-discharge formula to top-up on feeding) provided by hospitals or MCH clinics within the first few years of life, until normal growth was achieved for these infants. This finding also reflects that the first 1,000 days of life is the most critical period of growth, and interventions during this period is likely to have the greatest impact in preventing child malnutrition (Martorell, 2017). It is also important to note that the while WAZ, LAZ, and WLZ for pre-term normal birth weight were within -1.50 to 0.00 *SD*, the WAZ, LAZ, and WLZ for full-term low birth weight children showed similar patterns as full-term children starting from 1 month and onwards, with values within -1.00 to 0.50 *SD* from birth to 24 months. These findings indicated that premature infants tend to grow more slowly compared with infants born at term regardless of birth weight.

Similar to previous studies that found stunting to be more predominant than underweight, wasting, and OV/OB among children at 24 months (Rojroongwasinkul *et al.*, 2016; Tariq *et al.*, 2018), children in the present study also experienced long-term nutritional deprivation. Stunting has been shown to be associated with biological (e.g., short maternal stature, intrauterine growth retardation, poor maternal nutrition before and during pregnancy) and environmental factors (e.g., poor socioeconomic conditions, frequent illness, inappropriate infant and young child feeding and care) (Fitriani, Achmad & Nurdiana, 2020). A meta-analysis showed that the attributed risk of prenatal growth failure (e.g., low birth weight, pre-term birth, small-gestational-age) for stunting at 12 – 60 months in low- and middle-income countries is about 20% (Christian *et al.*, 2013). The present study also found that a proportion of stunted children at 24 months were born pre-term (21.0%), with low birth weight (10.8%), and stunted at birth (20.2%). As this study did not assess maternal nutrition before and during pregnancy, it is unknown whether this contributed to poor intrauterine growth. Additionally, in contrast with previous studies (Karlsson *et al.*, 2021; Salimar, Irawati & Besral, 2019), the present study did not find any significant association between maternal height and stunting. It is speculated that environmental factors could be more important than biological factors for this cohort as only about one-fifth of children was linked to pre-term delivery, low birth weight, and stunted at birth. These children could be at a higher risk of concurrent stunting and OV/OB in the future if they remain in the same environment and have an unhealthy lifestyle, such as sedentary

behaviour and unhealthy eating habits (e.g., consumption of high energy-dense, but low nutrient-dense foods) (Tzioumis *et al.*, 2016).

While stunting and wasting are indicators of chronic and acute malnutrition, respectively, being underweight is a composite indication that encompasses both acute and chronic conditions (De Onis & Blössner, 2003). For example, a child who is underweight may be stunted, wasted, or experiencing both conditions. The present study found that about 48.1% of underweight children were wasted, whereas 32.9% were stunted, and 10.9% were stunted and wasted. Additionally, about 26.7% and 13.2% of underweight children were born pre-term and with low birth weight. These observations indicated that most underweight children in the present study were prone to be acutely undernourished, partly due to restricted intrauterine growth (Christian *et al.*, 2013). Wasting may indicate a problem with current or recent starvation, inadequate or inappropriate supplementary foods, or it may be the result of an acute infectious illness (Caulfield *et al.*, 2006). As slightly less than half of the underweight children were wasted, it is plausible that these children might have experienced inappropriate infant and young child feeding practices (e.g., low frequency of breastfeeding, low quantity and quality of complementary foods) and/or infectious diseases (e.g., diarrhoea, respiratory infections), which caused them to lose weight or fail in weight loss recovery. An in-depth investigation of feeding practices and childhood diseases is needed to confirm such association.

Over the last decade, there has been a greater focus on the occurrence of stunting and wasting as evidence showed that children with concurrent wasting and stunting have the highest risk of mortality (McDonald *et al.*, 2013). South Asia had the greatest prevalence of concurrent stunting and wasting, with a prevalence of 8.0% for children at two years (Mertens *et al.*, 2020) and 4.4% for children under five years (McDonald *et al.*, 2013). Although the sample of children in the present study was from urban areas, about 0.6% (n=28) of them had concurrent stunting and wasting at 24 months of age. This result is consistent with a nationwide study in Thailand, which found that the prevalence of concurrent stunting and wasting was 0.7% and 0.6%, respectively, for children aged 12 to 23 months and for those in the wealthiest households (Okubo *et al.*, 2020). However, a prevalence of 0.2% was reported among children under seven years of age in China (Zhang *et al.*, 2021). Although the causes of wasting and stunting are often the same, the body responds to weight faltering by slowing linear growth, indicating that wasting raises the likelihood of future stunting (Schoenbuchner *et al.*, 2019). Subsequently, adequate weight is needed for linear growth recovery. Further research into the pathophysiology of these two types of malnutrition is required to design effective prevention and management programmes.

It is important to note that the prevalence of OV/OB increased from 2.4% at 15 months to 5.5% at 24 months. A rapid weight gain in OV/OB children was observed, whereby there was a sharp increase in the mean WLZ from six to 24 months. Further sub-sample analysis among OV/OB children showed that about 9.1% of them were born with low birth weight, while the remaining had normal birth weight and none were born with high birth weight (>4.0kg). Studies have documented the positive association between low birth weight and later obesity in children, whereby children with low birth weight might gain

weight more rapidly in order to make up their lack of growth and this further contributes to the major components of metabolic syndrome (Chen *et al.*, 2019). As the prevalence of obesity in Malaysian adults has increased from 4.4% in 1996 to 19.7% in 2019 (IPH, 2020), the findings from the present study also suggest, therefore, that the primary prevention for cardiovascular diseases could begin as early as the first few months of life.

In developing countries, growth faltering in length often starts at 3 months and continues dramatically until 24 months of age (Victora *et al.*, 2010). The present study found that among normal children (non-stunted, non-underweight, non-wasted, or non-OV/OB), there was a slight decrease in LAZ between six to 12 months, but a gradual increase thereafter until 24 months. The WHO recommends that complementary feeding starts at six months of age in addition to breast milk (WHO, 2000). The NHMS (2016) showed that about 80.6% of children under 24 months in Selangor fulfilled the minimum meal frequency (children who received solid, semi-solid, and soft food for breastfed and non-breastfed children), but only 48.4% and 50.3% children met the minimum dietary diversity and minimum acceptable diet (IPH, 2016). Thus, it is plausible that the children in this cohort might have had poor feeding practices, such as inappropriate complementary feeding practices, which increased their risk for poor growth during early infancy. Promoting optimal breastfeeding and complementary feeding practices, through effective policies and interventions, could improve the initiation of breastfeeding, exclusive breast-feeding in the first six months of life, timing of introduction of solid foods, frequency of feeding, diversity of young children's diets, and subsequently child growth and development (Heidkamp *et al.,* 2021). While breastfeeding promotion has been much emphasised in the national plan of action for the nutrition of Malaysia, this study underscores the need for greater efforts in promoting optimal young child complementary feeding practices and preventing macro- and micronutrient deficiencies.

The limitation of this study was the use of anthropometric data from health records that could have introduced bias (e.g., measurement bias, data extraction bias). Nevertheless, all measurements were taken by trained nurses with a standard protocol to maintain the reliability of measurements. Despite this limitation, the present study has provided an insight into the nutritional status of urban children under 24 months of age.

CONCLUSION

Stunting was more common than underweight, wasting, and OV/OB from 1 to 21 months, although wasting prevalence was highest at birth and 24 months. While undernutrition prevailed, the prevalence of OV/OB increased, starting at 15 months up to 24 months. As both growth retardation and rapid growth in early life are predictive of later health outcomes, interventions should be aimed not only at achieving adequate growth for the prevention of growth faltering, but also for the prevention of rapid growth in the early years. With the tremendous progress over the years in maternal and child health care in Malaysia, as well as the global recognition that early life intervention is crucial for future health and disease prevention, strategies related to infant and young child feeding (i.e. breastfeeding, complementary feeding) could be further strengthened to improve the health and nutrition of children.

Acknowledgement

We would like to thank the Director General of Health Malaysia for his permission to publish this article. The authors would like to acknowledge the nurses, staffs, and officials of MCH clinics in Hulu Langat, Petaling and Sepang districts, Selangor, for their excellent assistance during data collection.

Authors' contributions

Yong HY, led the data collection, data analysis and interpretation, prepared the draft of the manuscript, and reviewed the manuscript; Zalilah MS, principal investigator, conceptualised and designed the study with Yong HY, advised on data analysis and interpretation, and reviewed the manuscript; Wong CY, assisted in data analysis, and reviewed the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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Mal J Nutr 29(1): 017-026, 2023

Effect of date palm cultivars on chemical and phytochemical properties of date vinegars

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ABSTRACT

Introduction: *Phoenix dactylifera*, commonly known as date or date palm, is a flowering plant species in the palm family Arecaceae, cultivated for its edible sweet fruit called dates. Dates are high in dietary fibre and antioxidant compounds, known for preventing cancer and cardiovascular diseases. This research studied the chemical properties, antioxidant activities, and total phenolic content of fermented date vinegars from *Phoenix dactylifera* L. fruits, which had three cultivars - Barhi, Siam S1, and KL1. **Methods:** The first step was making date wines by using *Saccharomyces cerevisiae* (0.75% v/v of date juice content) to produce alcohol; the second step was making date vinegars by using *Acetobacter pasteurianus* (10% v/v of inoculum). Thereafter, the wines and vinegars were analysed for their chemical properties [high performance liquid chromatography (HPLC)], antioxidant activities [2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay], and total phenolic content (folin ciocalteu method). **Results:** Results showed that the highest alcohol content was 9.35% (v/v) in Siam S1 wine. The highest acetic acid was 7% (v/v) in Siam S1 vinegar. From the phytochemical analysis of vinegars, the highest antioxidant activity was found to be 24.96 mg/mL in Siam S1 vinegar, while the highest total phenolic content was found to be 208.35 mg GAE/L in KL1 vinegar. **Conclusion:** This novel research showed that the Siam S1 date had the highest acetic acid and antioxidant activity in vinegar. Thus, this cultivar could be processed to make new, healthy products that can further lead to income generation for the people in Thailand.

Keywords: antioxidant activity, chemical properties, date fruits, vinegar, wine

INTRODUCTION

Vinegar, a kind of acidic condiment, has been in use for more than 3000 years (Solieri & Giudici, 2009). Both solid-state and liquid-state fermentation methods are being used in the production of vinegar (Xia *et al.*, 2020). Vinegar is made from sources that contain sugar such as grains, fruits, and honey. This leads to the different types of vinegars available in the market. Different raw materials support the different physiochemical properties of vinegar products. Natural vinegar is a superior food additive as it contains nutrients such as carbohydrates, amino acids and peptides, vitamins and minerals, and antioxidants such as carotenoids and phenolic compounds. From the early days of agriculture until today, mankind has always used vinegar for various purposes, including as a condiment, pickling or preserving

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doi: https://doi.org/10.31246/mjn-2022-0035

agent, disinfectant, cleaning agent, and beverage (Matloob, 2014). Vinegar has been proven useful for the prevention and treatment of diabetes because it decreases the presence of glucose and insulin in the blood (Brahim *et al.*, 2014).

Date vinegar has beneficial effects similar to those of other types of vinegar. It is made from date palm (*Phoenix dactylifera* L.), that is grown in the hot and dry regions of North African countries and the Middle East. Dates are important for agriculture and economy in the Arab Gulf area. They are predominantly grown in Egypt (1,352,950 metric tons), Saudi Arabia (1,078,300 metric tons), Iran (1,023,130 metric tons), the United Arab Emirates (775,000 metric tons), and Algeria (710,000 metric tons) (Chandrasekaran & Bahkali, 2013). Date fruit is divided into various development and ripening stages (Hababouk, Kimri, Bisr or Khalal, Rutab, and Tamer). Generally, the date fruit is harvested and brought to market at three stages, namely Bisr, Rutab, and Tamer—depending on the cultivar (Ahmed *et al.*, 2021). The fruit is high in dietary fibre, proteins, carbohydrates, minerals, vitamins, tannins, phenolic and antioxidant compounds. These phytochemical compounds can prevent the oxidation of other molecules such as proteins and lipids, thus providing a protective role in the body against cancer, cardiovascular diseases, and other degenerative conditions (Matloob & Balakit, 2016). The tannin contained in date palm fruits is used medicinally as a defensive astringent for intestinal troubles. It is commonly administered as a treatment for colds, sore throat and bronchial catarrh, as well as to relieve cystitis, fever, oedema, gonorrhoea, liver and abdominal troubles. It is also said to counteract alcohol intoxication (El-Sohaimy & Hafez, 2010).

The overall objective of this research was to study the effect of date fruit varieties on the chemical and phytochemical properties of date vinegar. This research aimed 1) to produce fermented vinegar from date fruits which had three cultivars – Barhi, Siam S1, and KL1, and 2) to study the chemical properties, antioxidant activity, and total phenolic content of date vinegars.

MATERIALS AND METHODS

Chemicals and reagents

All reagents and solvents used during the experiment were of analytical grades and purchased from various suppliers. 2,2-diphenyl-1-picrylhydrazyl hydrate (DPPH) was bought from Sigma–Aldrich (Steinheim, Germany). Gallic acid standard was supplied by Fluka (Buchs, Switzerland). Folin-ciocalteau reagent was from Merck (Darmstadt, Germany) and sodium carbonate (anhydrous) from Univar (Downers Grove, IL, USA).

Raw materials

Phoenix dactylifera L. fresh date cultivars, namely Barhi (yellow as fresh), Siam S1 (purple as fresh), and KL1 (yellow as fresh) (Khalal developmental stages) were harvested in June 2021 in the Mahasarakham province.

Date vinegar production

The vinegar fermentation process started with date fruits being crushed and mixed with water at a ratio of 1:4 (w/w) to prepare the juice. After adjustment of total soluble solid content up to 20ºBrix by cane sugar, the date juice was pasteurised for 30 minutes (min) at 65ºC. Alcoholic fermentation was conducted for three days at room temperature in plastic vessels containing 2 L of the date juice inoculated with wine yeast, *S. cerevisiae* (LALVIN K1-V1116) at a ratio of 0.75% (v/v). At the end of the fermentation process, the wine was separated from the sediment by allowing it to settle in glass bottles, followed by

pasteurisation for 30 min at 65°C. Then, vinegar production began from the alcohol content of the obtained wine, adjusted to 6% (v/v) and inoculated with *A. pasteurianus* TISTR 521 (Thailand institute scientific and technological research), which was grown in glucose yeast broth at a ratio of 10% (v/v). A glass flask containing 135 mL of the date wine was shaken for 15 days at 30°C on a shaker (150 rpm). After fermenting vinegar for 15 days, the fermentation process was stopped by pasteurisation of vinegar at 65°C for 30 min (Figure 1).

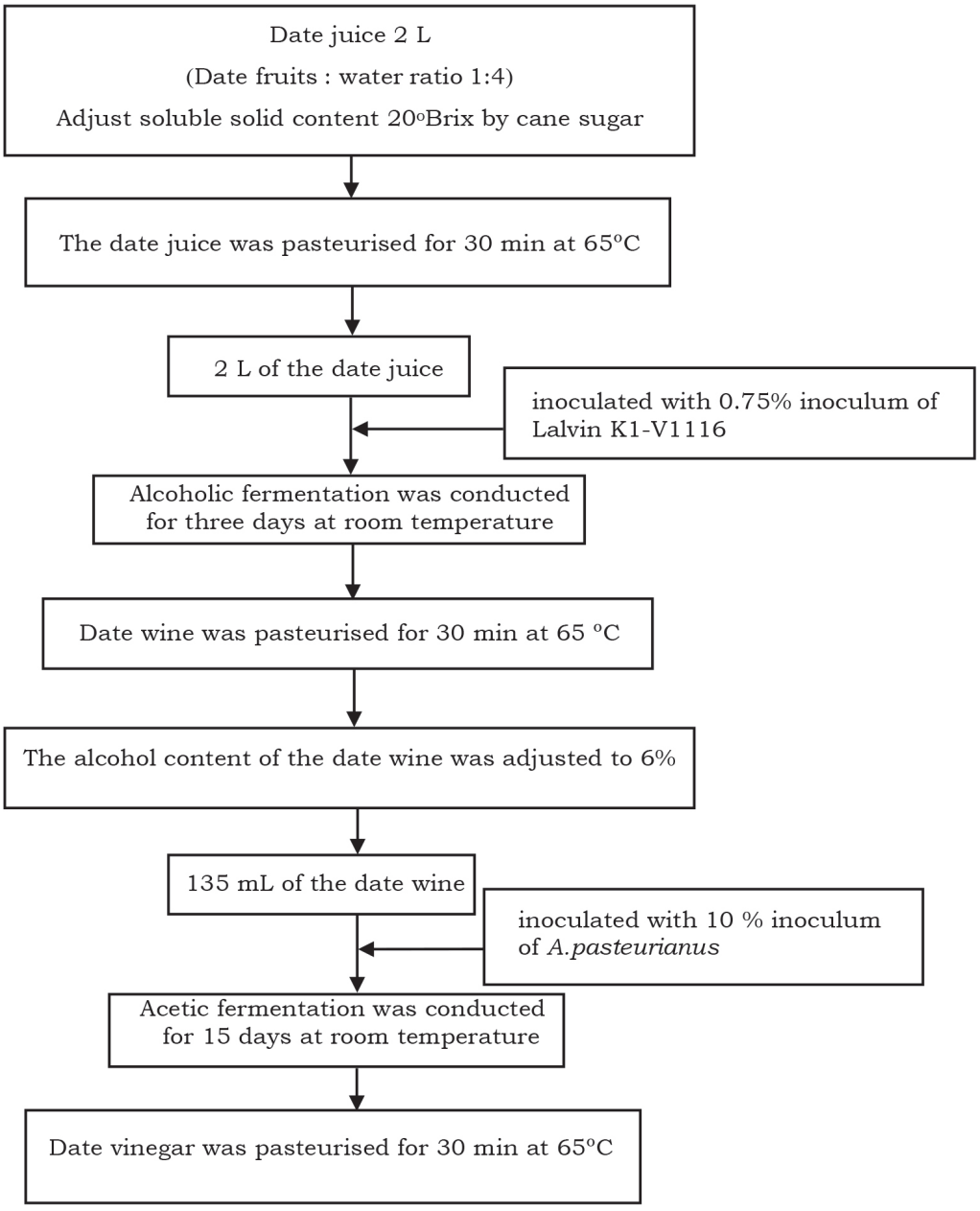

Figure 1. Diagram of date vinegar production

Chemical analysis

The wine and vinegar samples were centrifuged and filtered through a 0.45 µm filter before injection into the HPLC system. The analysis was performed on a Shimadzu HPLC-RID system (Shimadzu, Japan) consisting of Shimadzu LC-20AD pumps and RID-10A refractive index detector. The analytical column was Aminex HPX-87H column (300 mm × 7.8 mm i.d., 9 µm, Bio-Raand Laboratories, Inc., USA) coupled to a cationic exchange pre-column (Bio-Rad Laboratories, Inc., USA). H_2SO_4 (5 mM) was conducted as the mobile phase. The injection volume was 20 mL with a flow rate of 0.6 mL/min. The column temperature was set at 45°C (Aguiar *et al.* 2005). A series of standard solution [ranging from 0-16% of fructose (w/v), glucose (w/v), absolute ethanol (v/v), and acetic acid glacial (v/v)] were prepared. A standard curve with R^2 greater than 0.99 was plotted, and then the concentrations of fructose, glucose, absolute ethanol, and acetic acid glacial in wine and vinegar were quantified accordingly.

Antioxidant activity

The antioxidant activities of the samples were determined by DPPH radical assay (Brand-Williams, Cuvelier & Berset, 1995) during which DPPH radical was used as a stable radical. In brief, 5 mL of every sample was added to 5 mL of 0.1 mM DPPH radical solution prepared in ethanol, and the mixture was incubated for 20 min at room temperature in the dark. After incubation, absorbance was measured at 517 nm using the Shimadzu UV-1800 spectrophotometer (Shimadzu, Japan), and the DPPH radical scavenging activities were expressed as mg ascorbic acid equivalents in 1 mL of sample (mg/mL).

Total phenolic content analysis

The Folin-Ciocalteu method was utilised for the determination of total phenolic content in date vinegars (Singleton, Orthofer & Lamuela-Raventós, 1999). Briefly, 1 mL of each sample was diluted with 9.5 mL of distilled water and then mixed with 0.5 mL of Folin-Ciocalteu reagent and 2 mL of 10% Na_2CO_3 solution. After an incubation time of 30 min at room temperature, absorbance was measured at 765 nm using the Shimadzu UV-1800 spectrophotometer (Shimadzu, Japan). Results were expressed as mg gallic acid equivalents in 1 mL of the sample (mg GAE/L). A standard gallic acid curve was constructed by preparing the dilutions of 0, 20, 40, 60, 80, and 100 µg/10 ml in ethanol.

Statistical analysis

The vinegars were produced with 450 ml of each cultivar in a 250 mL three-glass flask. The trials were repeated three times from the same batch of vinegar. Results were presented as mean±standard deviation (*SD*). The obtained data were analysed by one-way analysis of variance (ANOVA) with Duncan multiple range tests (DMRT) to determine the significance between samples, using SPSS software version 22.0 (SPSS-IBM Chicago, IL, USA). In all cases, $p<0.05$ was regarded as statistically significant.

RESULTS

Chemical properties of date wines and vinegars

The date wines produced via a three-day alcoholic fermentation process using *S. cerevisiae* as an inoculant were analysed for their chemical compositions, and the results are presented in Figure 2. It was observed that the Siam S1 date wine contained the highest alcohol content of 9.35% (v/v). The date vinegars produced via a 15-day acetous fermentation process using *A. pasteurianus* TISTR 521 as an inoculant were analysed for their chemical compositions, and the results are presented in Figure 3. All date

vinegars showed a significant decrease in alcohol content as it was converted to acetic acid by acetic acid bacteria, which was consistent with the increased acetic acid content. However, the alcohols were not completely depleted, with vinegar produced from the Siam S1 cultivar containing the highest acetic acid content of 7.00% (v/v).

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Total phenolic content and antioxidant activities

Bioactive properties, namely DPPH radical scavenging activities and total phenolic content of the wine and vinegar samples, are shown in Figures 4 and 5, respectively. Results showed that the date wine derived from Siam S1 exhibited the highest antioxidant activity of 73.79±0.77 mg/mL. The vinegar produced from Barhi was observed to exhibit the highest antioxidant activity of 24.96±0.29 mg/mL. The levels of total phenolic content detected in the date wines and vinegars produced from different cultivars via a two-stage fermentation process are given in Figure 5. It was noted that the total phenolic content of date wine derived from Siam S1 contained the highest level (343.42±1.43 mg/L). The KL1 vinegar measured at the end of acetous fermentation exhibited the highest total phenolic content of 208.35±0.96 mg/L.

DISCUSSION

Chemical properties of date wines and vinegars

From Figure 2, It was observed that on day 0 of fermentation, the KL1 cultivar had the highest glucose content and the Barhi cultivar had the highest fructose content. On day 3, the Siam S1 date wine contained the highest alcohol content of 9.35% (v/v), which was similar to that detected in Zahdi date wine at 5.61%(v/v), which was produced for a period of four days at a yeast ratio of 10 g/L (Matloob, 2014) and unripe banana, Musa (ABB) 'Kluai Namwa' wine by mixed strains of *S. cerevisiae* for ten days [13.2±0.07% (w/v)] (Thongpoem, *et al.*, 2021). As given in Figure 2, on day 3 of fermentation, glucose and fructose in most wine samples were not completely depleted, except for the glucose in Barhi and Siam S1 date wines. Glucose and fructose were least depleted in KL1 wine. Usually, a typical wine fermentation process comprises a lag phase, which lasts for several hours, a short growth phase of 24–36 hours, followed by a stationary phase, during which most of the sugar (between 50 and 80%) is fermented. During this phase, yeast activity continually decreases, although the viability level remains high, generally over 90%, until the sugar is exhausted (Marsit & Dequin, 2015). According to Jakabová *et al.* (2021), who studied the chemical composition of white wines produced from different grape varieties, glucose and fructose are the main fermentable sugars in wine. In alcoholic fermentation, yeast converts most of the glucose and fructose contents into alcohol and CO_2. Grape must contain equal amounts of glucose and fructose, and during fermentation, glucose is consumed at a higher rate than fructose, which leads to an increased proportion of fructose as fermentation progresses.

In the final process of acetous fermentation, the vinegar produced from the Barhi cultivar contained the highest alcohol content of 0.09% (v/v), while that produced from Siam S1 and KL1 cultivars were completely depleted. According to a previous study by Matloob (2014), homemade date vinegar has an alcohol content of 0.22% (w/v), while commercial date vinegar has an alcohol content of between 0.01-2.53% (w/v). Similarly, Boonsupa & Kerdchan (2021) revealed that at the end of acetic fermentation in prunus vinegar, the alcohol content ranged between 1.14 –

3.35% (v/v). At the end of an acetous fermentation process, acetic acid content was found to range from 2.97-7.00% (v/v), with the highest value of 7.00% (v/v) observed in the date vinegar produced from the Siam S1 cultivar, similar to that detected in homemade date vinegar produced from the Zahdi cultivar [7.24% (w/v)] (Matloob, 2014) and close to the acetic acid content determined in Chinese pomegranate vinegar (7.50±0.21%) (Boonsupa *et al.*, 2021), as well as the lowest of 2.97% (v/v) produced from the Barhi cultivar.

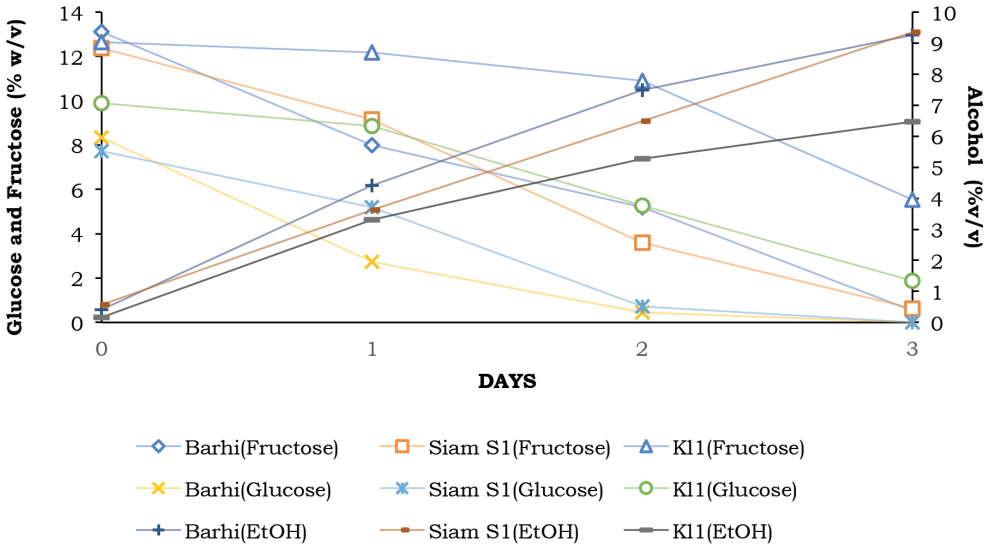

Figure 2. Physicochemical properties of date wines during the 3-day fermentation process

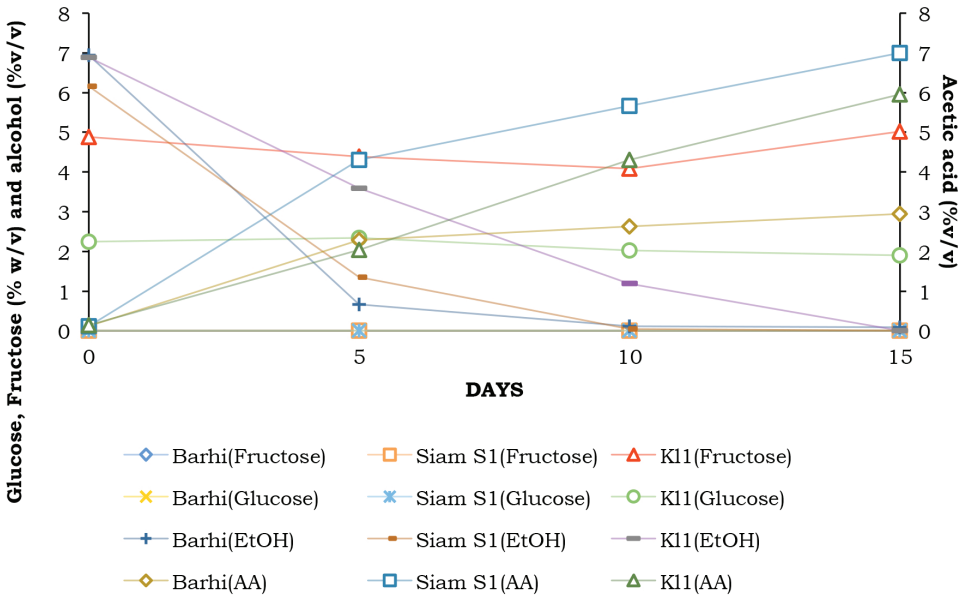

Figure 3. Physicochemical properties of date vinegar during a 15-day fermentation process

Total phenolic content and antioxidant activities

Organic acids and polyphenols, mainly acetic acid, plays a significant role in the beneficial properties provided by fruit vinegar. Recently, studies are being carried out to determine and identify the phenolic composition of vinegar such as palm vinegar having gallic acid (14.14±0.07 µg/mL), catechin (8.61±0.32 µg/mL), rutin (6.67±0.03 µg/mL), isoquercetin (11.27±0.12 µg/mL), and quercetin (10.33±0.16 µg/mL) (Chatatikun & Kwanhian, 2020). The type and quantity of bioactive compounds in vinegar are closely related to the raw matter used to produce vinegar, including the cultivar of the fruits.

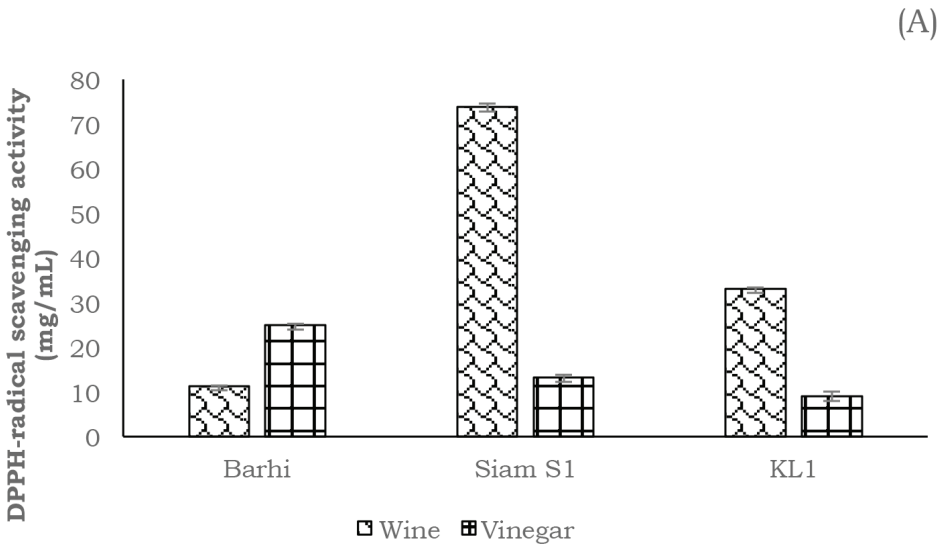

Figure 4. Antioxidant activities of the three date wines and vinegars produced via a two-stage fermentation process.

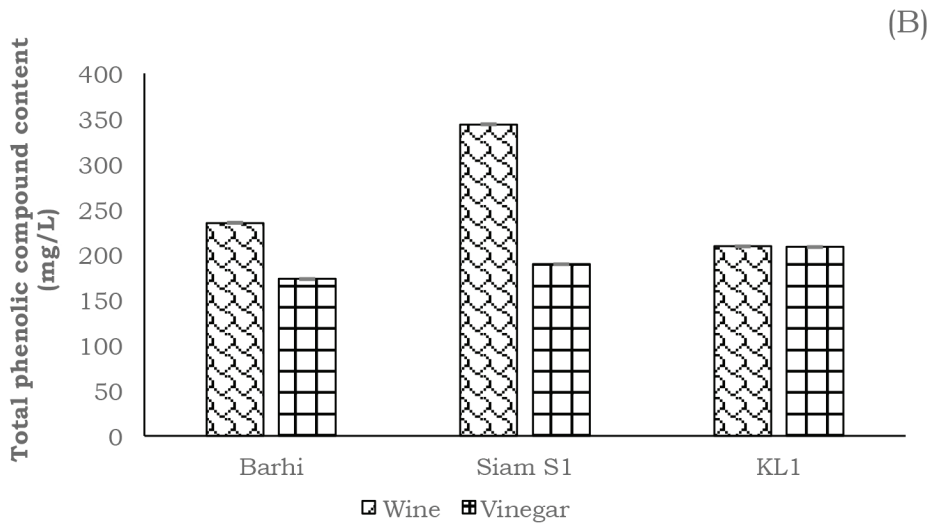

Figure 5. Total phenolic content of the three date wines and vinegars produced via a two-stage fermentation process.

According to Boonsupa (2021), research on the different cultivars of fruits affects the content of phytochemical substances contained in the vinegar. For example mango vinegar, which is produced from the mahacharnok cultivar, has the highest antioxidant activity because of the nature of microorganisms to produce vinegar and the technique selected in the fermentation process. Several studies revealed that bioactive compounds such as polyphenols in vinegar may have protective effects such as anti-hyperglycaemic effect, anti-hyperlipidaemic effect, antimicrobial effect, antioxidant effect, and anti-inflammatory effect (Ousaaid *et al.*, 2022; Chen *et al.*, 2016). Results showed that the date wine derived from Siam S1 exhibited the highest antioxidant activity of 73.79±0.77 mg/mL, which was greater than that produced from black rose hip wine (27.84 mg/mL), a wine with a fermentation period of 45 days (Pashazadeh *et al.*, 2021). The vinegar produced from Barhi was observed to exhibit the highest antioxidant activity of 24.96±0.29 mg/mL, which was greater than that of commercial red date vinegar (1.16±0.16 mg/mL) (Ali *et al.*, 2019). It was noted that the total phenolic content of date wine derived from Siam S1 was highest (343.42±1.43 mg GAE/L), but was much lesser than that of Khistawi date wine (1,179.8±111 mg GAE /L), which is characterised by its high sugar content (Matloob & Balakit, 2016). The KL1 vinegar measured at the end of acetous fermentation exhibited the highest total phenolic content of 208.35±0.96 mg GAE/L, but was much lesser than that detected in Khistawi date vinegar (1,453.4±220 mg GAE /L) (Matloob & Balakit, 2016) and cider vinegar (289±13 mg GAE/L) (Benedek *et al.*,2022). According to Andlauer, Stumpf & Furst (2000), the acetification process is accompanied by a decrease in total phenolic content in cider white and red vinegar.

Nowadays, reports show that date composes intrinsic nutritional and functional properties. They are a good source of simple carbohydrates, mainly in the form of glucose and fructose. Dates are abundant in dietary non-starch polysaccharides (NSPs) and some minerals, such as magnesium and potassium. Bioactive constituents that have been detected in *P. dactylifera* fruits include phenolic acids, carotenoids, and flavonoids. Bioactive compounds of *P. dactylifera* are of two kinds, namely non-nutritive or nutritive molecules. Examples of non-nutritive bioactive molecules detected in *P. dactylifera* are phenolic acids, flavonoids, carotenoids, phytosterols, and polyphenols. The other group can be considered as nutritive bioactive compounds such as soluble and insoluble NSPs, α-tocopherols, β-carotene, ascorbic acid, and selenium (Al-Mssallem, Alqurashi & Al-Khayri, 2019).

CONCLUSIONS

This study was conducted to compare the levels of acetic acid, total phenolic and antioxidant contents of the date vinegars produced from three cultivars of dates via a two-stage fermentation process. The results showed that the vinegar produced from Siam S1 exhibited the highest level of acetic acid (7.00%), while those produced from Barhi displayed the highest antioxidant activities (24.96 mg/mL) measured through DPPH radical assay. Meanwhile, the vinegar produced from KL1 was observed to have the highest total phenolic content (208.35 mg/L). Currently, farmers in Thailand grow a large number of dates, resulting in a large amount of yields. Therefore, research into dates processing will encourage value added to agriculture

and interested entrepreneurs to invest in the production of vinegar from date palms that can be further developed into industrial production in future.

Acknowledgements

The authors would like to thank the laboratory equipment centre of Mahasarakham University and Biology Department of Rajabhat Mahasarakham University for the laboratory facilities**.**

Authors' contributions

Boonsupa W, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Thammajit C, Sittisumran T, Thiansai O, and Kaewsura T conducted the study, data analysis and interpretation, assisted in drafting of the manuscript and reviewed the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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Eating self-regulatory skill, diet quantity, and diet quality of Malaysian healthcare university students: A cross-sectional study

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ABSTRACT

Introduction: The ability to self-regulate eating can improve health. This study aimed to determine the relationship between eating self-regulatory skills, diet quantity, and diet quality among Malaysian university students. **Methods:** This cross-sectional study involved 132 university students. Eating self-regulatory skill was assessed using the Self-Regulation of Eating Behaviour Questionnaire (SREBQ). Dietary intakes from two 24-hour dietary recalls were used to assess diet quantity and quality. Diet quantity was measured as energy and macronutrient intakes, analysed using NutritionistPro. Diet quality was measured using the Malaysian Healthy Eating Index (M-HEI). The relationship between eating self-regulatory skills, diet quantity, and diet quality were evaluated using tests for differences between means and multiple linear regression. **Results:** Male participants (n=47) consumed more energy than female participants (n=85) (Male: 1850±570 kcal/day, Female: 1596±567 kcal/day, p=0.015). Participants from the Nutrition and Dietetics (N&D) course (n=49) had better M-HEI scores than participants from other health courses (n=83) (N&D course: 52.7±10.5, non-N&D course: 47.2±10.7, p=0.005). The predictors of energy intake were gender (β=-0.193, p=0.023) and SREBQ score (β=-0.223, p=0.009). Being female and having higher eating self-regulatory skills were associated with lower energy intake. The predictors of diet quality were university course (β=0.240, p=0.005) and SREBQ score (β=0.181, p=0.033). Studying N&D and having higher eating self-regulatory skills were associated with higher M-HEI scores. **Conclusion:** Higher self-regulation of eating behaviour score is a factor that contributes to lower daily energy intake and higher diet quality score.

Keywords: diet quality, diet quantity, self-regulation, university students

INTRODUCTION

Obesity and non-communicable diseases (NCDs) are health problems (IPH, 2020). A high prevalence and co-occurrence of behavioural risk factors of NCDs were discovered among university students, among which 80.5% had inadequate fruit and vegetable intakes (Pengpid & Peltzer, 2020). Adherence to a healthy diet throughout life helps prevent NCDs. Within this perspective, a healthy diet provides an optimal quantity of nutrients and a variety of food groups for good diet quality (Echouffo-Tcheugui & Ahima, 2019).

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doi: https://doi.org/10.31246/mjn-2022-0025

The increase in the prevalence of obesity and NCDs matches with the quantitative (larger portion sizes, increase in energy and fat intakes, and decrease in dietary fibre intake) and qualitative (increase in animal fat intake and decrease in wholegrain, fruit, and vegetable intakes) dietary changes seen in eating patterns (Popkin, 2006). Summaries of research on nutrition, body weight, and NCDs showed that modifications to both diet quantity and diet quality reduce these health problems (Popkin, 2006; Brandhorst & Longo, 2019). Diet quantity can be expressed as energy, carbohydrate, protein, fat, sugar, salt, and fibre intakes (Popkin 2006; Brandhorst & Longo, 2019). In terms of diet quality, the focus is on dietary patterns, which include intakes of fruits, nuts and seeds, vegetables, fish, legumes, cereals, meat, sugary beverages, high salt, and processed foods (Popkin, 2006; Brandhorst & Longo, 2019).

The ability to successfully self-regulate eating is postulated to prevent weight gain, produce weight loss, and reduce risk factors associated with NCDs (Reed *et al.*, 2016). Self-regulation is defined as the extent to which people influence, modify, or control their behaviour, including thoughts and feelings according to goals or standards (Freund & Hennecke, 2015). A systematic review showed that self-regulatory skills mediate long-term weight and physical activity outcomes, and short-term dietary intake outcomes (Teixeira *et al.*, 2015). Antecedents of eating self-regulation include cognitive restraint, moderation, mindfulness, disinhibition, delayed gratification, emotions and mood, self-efficacy, social support, environment, and physical activity (Reed *et al.*, 2016). These antecedents can vary by setting, including different age groups and environments. University students are emerging adults who must rely more on their own resources in a less supervised environment. This provides a unique setting to study how eating self-regulatory skills affect dietary intake (Wood *et al.*, 2017). Cross-sectional and intervention studies in this area showed that eating self-regulatory skills are associated with the dietary intake of university students, but the context of these studies is limited to Western countries (Ling & Zahry, 2021; Deliens *et al.*, 2016). Hence, this study aimed to determine the relationships between eating self-regulatory skills, diet quantity, and diet quality among Malaysian university students.

MATERIALS AND METHODS

Participants and sampling

This cross-sectional study was conducted among healthcare students in the International Medical University (IMU) Malaysia, from March to June 2021. A minimal sample size of 134 participants was determined with a power of 0.90, an alpha value of 0.05, and a correlation coefficient of 0.30. Using convenience sampling, Malaysian students aged between 18 to 25 years, were invited to participate in this study on a voluntary basis. After the provision of informed consent, the participants were assessed for eligibility. This study excluded students who were pregnant, lactating, trying to lose weight, or diagnosed with medical conditions. The IMU Joint Committee on Research and Ethics provided ethical approval (BDN I/2020(03)) for the study.

Data collection

Data were collected using a self-administered online questionnaire. Following completion of the questionnaire, participants attended two interview sessions via Microsoft Teams lasting approximately 30 minutes each.

Eating self-regulatory skills

The Self-Regulation of Eating Behaviour Questionnaire (SREBQ) was used to assess eating self-regulatory skills (Kliemann *et al.*, 2016). The SREBQ consisted of five items that were rated using a five-point Likert scale: (1) never, (2) rarely, (3) sometimes, (4) often, and (5) always. A higher score indicated higher eating self-regulatory skills. The sum of scores from the SREBQ was then converted into mean scores to group the participants into low self-regulation (mean scores below 2.8), medium self-regulation (mean scores between 2.8 and 3.6), and high self-regulation (mean scores above 3.6) categories.

Diet quantity

During the interview sessions, a two-day (one weekday and one weekend) 24-hour dietary recall was used to assess daily total energy, carbohydrate, protein, and fat intakes. The multiple pass method, photographs of food portions, and household measurements were used to improve recall and estimation of portion size. Energy, carbohydrate, protein, and fat intakes were calculated using the NutritionistPro computer software (Axxya Systems LLC, Redmond USA) to analyse the nutritional composition of foods based on the Malaysian and Singaporean food composition databases.

Diet quality

The Malaysian Healthy Eating Index (M-HEI) was used to measure diet quality (Goh & Norimah, 2012). This tool consisted of nine components, encompassing seven food groups and two nutrient groups, namely grains, cereals and tubers, vegetables, fruits, milk and dairy products, legumes, meat, poultry and eggs, fish and seafood, energy from fat, and sodium intake. The recommended serving sizes for each food group were in accordance with the Malaysian Dietary Guidelines 2020, based on an energy intake (EI) of 1800 kcal/day for females and 2000 kcal/day for males. The total M-HEI score was obtained by summing the scores of all components. The composite M-HEI score was calculated with the formula: [(Total score obtained from 9 components/Maximum score of 90) x 100%]. The possible composite M-HEI score ranged from 0 to 100%, and a higher score indicated better diet quality. The composite M-HEI scores were used to group the participants into poor diet quality (M-HEI % scores <51), moderate diet quality (M-HEI % scores between 51 to 80%), and good diet quality (M-HEI % scores >80%) categories.

Statistical analysis

Statistical analysis was performed using the IBM Statistical Package for the Social Sciences version 28 for Windows (IBM Corp., Armonk, NY, USA). Independent *t*-test was used to determine the differences in mean energy and macronutrient intakes, M-HEI scores, and self-regulation of eating behaviour scores by gender and university course. The one-way analysis of variance (ANOVA) test, followed by Tukey post-hoc tests for multiple comparison were used to determine the differences in mean energy and macronutrient intakes, M-HEI scores, and self-regulation of eating behaviour scores by ethnicity. Multiple linear regression analysis was performed to determine the relationship between the independent variables (age, gender, ethnicity, university course, and self-regulation of eating behaviour score) and the dependent variables (diet quantity – EI and macronutrient intake, and diet quality – M-HEI score). Non-significant independent variables were removed using the backward stepwise method. At each step, the independent variable that had the lowest correlation with the dependent variables was

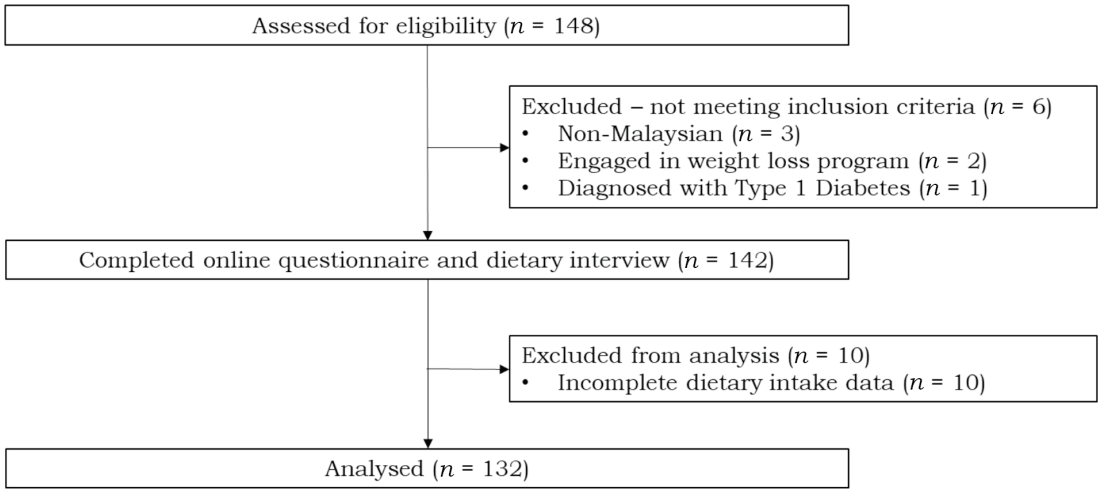

Figure 1. Flow chart on recruitment of study participants

removed from the model (*p* for removal >0.10). Variables remaining in the model were those that were independently predictive of diet quantity and diet quality. Statistical significance was set at <0.05.

RESULTS

A total of ten participants were excluded from the analysis due to incomplete dietary intake data (Figure 1). The study participants had a mean±standard deviation (*SD)* age of 21.2±1.4 years, were predominantly females (64.4%, *n*=85), and of the Chinese ethnic background (94.7%, *n*=125). When segregated by university course, students from non-Nutrition and Dietetics courses (Medicine, Dentistry, and Pharmacy) accounted for 62.9% of the participant pool (Table 1).

Eating self-regulatory skills

The mean±*SD* SREBQ score for all participants was 2.59±0.56, with no significant difference seen between either gender (*p*=0.369) or university course (*p*=0.828) when assessed by

Table 1. Sociodemographic characteristics of participants (*N*=132)

Sociodemographic variables	*Mean±SD*	*Frequency (n)*	*Percentage (%)*
Age (years)	21.2±1.4		
Gender			
Male		47	35.6
Female		85	64.4
Ethnicity			
Malay		4	3.0
Chinese		125	94.7
Indian		3	2.3
University course			
Non-Nutrition and Dietetics		83	62.9
Nutrition and Dietetics		49	37.1

independent *t*-test (Table 2). There was also no significant difference in mean±*SD* SREBQ score between ethnic groups (p=0.414) when assessed by one-way ANOVA test. Half of the participants (55.6%, n=73) were categorised with low self-regulation, while 39.1% (n=52) with medium self-regulation, and 5.3% (n=7) with high self-regulation of eating behaviour.

Diet quantity and quality

Table 2 shows the diet quantity and quality by gender, ethnicity, and course of study. In terms of diet quantity, the participants consumed a mean±*SD* EI of 1690±578 kcal/day with carbohydrate, protein, and fat contributing to 45.3%, 17.1%, and 37.6% of EI, respectively. Independent *t*-test showed that male participants had a higher daily EI than female participants, with a mean±*SE* difference of 254±103 kcal/day (95% *CI*: 50, 458; p=0.015). EI did not differ by ethnicity (p=0.853) or university course (p=0.337). There was no difference in macronutrient composition of the diet between either gender (% EI from carbohydrate, p=0.647; % EI from protein, p=0.096; % EI from fat, p=0.806) or university course (% EI from carbohydrate, p=0.112; % EI from protein, p=0.848; % EI from fat, p=0.117). There was, however, a difference in the % EI from protein between ethnic groups, with Chinese participants consuming more energy from protein than their Indian counterparts (p=0.041).

As for diet quality, the participants had a mean±*SD* M-HEI % score of 49.2±10.1, with 59.8% (n=79) and 40.2% (n=53) of the participants categorised as having poor and moderate diet quality, respectively. Independent *t*-test showed that participants from the Nutrition and Dietetics course had better diet quality scores than participants from the non-Nutrition and Dietetics courses, with a mean±*SE* difference of 5.5±1.9 %

Table 2. Comparisons of SREBQ score, diet quantity and diet quality according to gender, ethnicity, and university course (N=132)[a]

Variables	*Gender*		*Ethnicity*			*University course*	
	Male (*n*=47)	*Female* (*n*=85)	*Malay* (*n*=4)	*Chinese* (*n*=125)	*Indian* (*n*=3)	*Non-Nutrition and Dietetics* (*n*=83)	*Nutrition and Dietetics* (*n*=49)
SREBQ score (mean score)	2.53±0.58	2.62±0.54	2.30±0.50	2.60±0.55	2.33±0.76	2.58±0.60	2.60±0.48
Diet quantity							
Energy intake (kcal/day)	1850±570*	1596±567*	1782±295	1680±585	1835±729	1724±660	1624±376
Carbohydrate intake (% EI)	44.7±8.3	45.5±8.9	43.9±4.5	45.0±8.7	55.5±7.7	44.2±8.7	46.8±8.5
Protein intake (% EI)	18.0±4.9	16.7±4.0	16.0±2.7	17.3±4.4*	11.2±0.9*	17.2±4.7	17.1±3.7
Fat intake (% EI)	37.5±7.0	37.8±7.7	40.0±4.1	37.7±7.5	33.1±7.5	38.5±7.4	36.4±7.4
Diet quality							
M-HEI % score	47.2±2.1	50.3±10.1	43.2±1.7	49.4±11.1	49.4±12.2	47.2±10.7*	52.7±10.5*

SREBQ=Self-Regulation of Eating Behaviour Questionnaire; EI=Energy intake; M-HEI= Malaysian Healthy Eating Index
[a]Data are displayed in mean±*SD*
*Significant difference between means at p<0.05

score (95% *CI*: 1.7, 9.3; *p*=0.005). Diet quality score did not differ by gender (*p*=0.112) or ethnicity (*p*=0.541). None of the participants were categorised as having good diet quality, as less than a quarter of the participants met their daily recommendations from vegetables (4.5%, *n*=6), fruits (9.1%, *n*=12), milk and dairy products (3.8%, *n*=5), and fish (24.2%, *n*=32). Only 16.7% (*n*=22) of the participants kept their EI from fat to ≤30% and 43.9% (*n*=58) consumed ≤2000 mg of sodium/day (Figure 2).

Eating self-regulatory skills, diet quantity, and diet quality

Table 3 depicts the results of the multiple linear regression showing predictors of diet quantity and diet quality. Starting with five independent variables that may predict EI, the backward stepwise linear regression reduced these variables to gender and SREBQ score. Gender and SREBQ score explained 9.4% of the variation in daily EI [*F*(2,129)=6.698, *p*=0.002]. Participants who were female and had higher SREBQ scores had lower daily EI. Starting with five independent variables that may predict carbohydrate and protein intakes, the backward stepwise linear regression reduced these variables to ethnicity. Ethnicity explained 5.9% and 4.4% of the variation in % EI from carbohydrate [*F*(2,129)=4.076, *p*=0.019] and protein [*F*(1,130)=5.948, *p*=0.016], respectively. Participants who were Indian had a higher % EI from carbohydrate, but a lower % EI from protein. The backward stepwise linear regression showed that none of the independent variables were significant predictors of % EI from fat. Starting with five independent variables that may predict M-HEI scores, the backward stepwise linear regression reduced these variables to university course and SREBQ score. University course and SREBQ score explained 9.2% of the variation in M-HEI scores [*F*(2, 129)=6.526, *p*=0.02). Participants who were from the Nutrition and Dietetics course and had higher SREBQ scores had higher M-HEI scores.

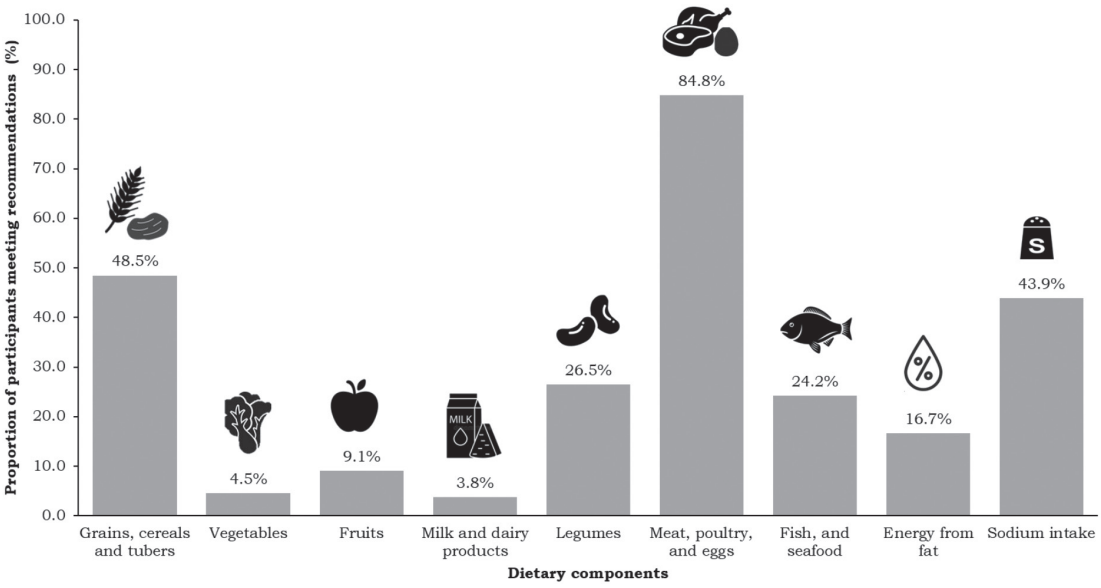

Figure 2. Proportion of participants meeting the dietary recommendations for food groups, energy intake from fat and sodium intake (*N*=132)

DISCUSSION

The results on diet quantity from this study support the viewpoint by Gan *et al.* (2011) and Abdull Hakim *et al.* (2012) that mean EI is consistently higher in male than female university students; and daily EI is below, while fat intake exceeds the recommended levels among university students. Growing evidence shows that diet quality rather than diet quantity is more reflective as an indicator of healthy eating (Echouffo-Tcheugui & Ahima, 2019). This current study showed that none of the study participants had good diet quality and very few included adequate amounts of fresh produce such as fruits, vegetables, and dairy products, into their daily diet. This data confirms previous findings that only 2% of Malaysian university students have good diet quality (Rosnani & Nor Azwani, 2020) and that university students often fail to meet the recommended intakes for fruits and vegetables (Pengpid & Peltzer, 2020; Moy *et al.*, 2009). Indeed, the National Health and Morbidity Survey 2019 showed that the highest prevalence of inadequate fruit and vegetable intakes was among young adults (IPH, 2020). Local cross-sectional studies have shown that access to fresh produce at an affordable price point can affect diet

Table 3. Predictors for diet quantity and diet quality from the multiple linear regression model (N=132)

	B	*SE B*	*95% CI B*	*Standardised β*	*p-value*
Predictors of energy intake[a]					
Intercept	2438.440	235.711	1972.081, 2904.800		<0.001
Female*	-232.830	101.206	-433.068, -32.593	-0.193	0.023
SREBQ score*	-232.623	87.579	-405.901, -59.345	-0.223	0.009
Predictors of carbohydrate intake[b]					
Intercept	43.865	0.945	41.995, 45.735		<0.001
Indian ethnicity*	11.668	4.972	1.832, 21.505	0.202	0.020
Predictors of protein intake[c]					
Intercept	17.296	0.377	16.550, 18.041		<0.001
Indian ethnicity*	-6.098	2.499	-11.040, -1.151	-0.209	0.016
Predictors of M-HEI scores[d]					
Intercept	38.006	4.410	29.280, 46.732		<0.001
University course*	5.409	1.891	1.667, 9.151	0.240	0.005
SREBQ score*	3.555	1.651	0.288, 6.821	0.181	0.033

SREBQ=Self-Regulation of Eating Behaviour Questionnaire; M-HEI= Malaysian Healthy Eating Index

[a] R=0.307, R^2=0.094, F(2,129)=6.698, p=0.002

[b] R=0.244, R^2=0.059, F(2, 129)=4.076, p=0.019

[c] R=0.209, R^2=0.044, F(1,130)=5.948, p=0.016

[d] R=0.303, R^2=0.092, F(2,129)=6.526, p=0.02

*Significant at p<0.05

quality (Karupaiah *et al.*, 2013; Pondor *et al.*, 2017). In this current study, data on dietary intake were collected during a period of national quarantine in response to the COVID-19 pandemic. During the quarantine period, Malaysians behaved in a way that leaned towards cost savings and away from purchase of fresh produce. Changes to eating behaviour included cooking at home to save money, reducing food wastage, eating according to needs and affordability, and choosing to buy food with a longer expiration date (Norshariani, 2020). The current study also highlighted that few study participants met their daily recommendations for milk and dairy products. In general, milk and dairy products are not widely consumed by Malaysians (Goh *et al.*, 2020). Since there is no culture of milk production in Malaysia, most dairy products are imported, and this increases the cost of dairy products (Goh *et al.*, 2020).

This study showed that the study participants from the Nutrition and Dietetics course had better diet quality scores than participants from non-Nutrition and Dietetics courses. A similar study conducted among university students from the east coast of Malaysia showed that health sciences students had higher diet quality scores than non-health sciences students and attributed this difference to the fact that health sciences students had better nutrition knowledge than non-health sciences students (Rosnani & Nor Azwani, 2020). On the contrary, a review showed that university students' food intake was unhealthy regardless of their undergraduate course, and that health sciences students did not have healthier diets than their non-health sciences counterparts (Bernado *et al.*, 2017). The review by Bernado *et al.* (2017) also showed that unhealthy eating was especially reported among students who left their parents' homes and became responsible for their own food (Bernado *et al.*, 2017). While nutrition knowledge is an important determinant of diet quality, other factors can affect the diet quality of students, including individual factors, the physical environment, and university characteristics (El-Kassas & Ziade, 2016). The mediating role of nutrition knowledge was further explored in a study that differentiated practical nutrition knowledge from factual knowledge about nutrition. Practical nutrition knowledge is considered more relevant and closely related to behaviour than factual nutrition knowledge. Deroover *et al.* (2020) showed that practical nutrition knowledge explained part of the association between sociodemographic characteristics and diet quality.

This study showed that few participants had high self-regulation and that higher self-regulation scores were correlated with lower EI and better diet quality scores. Students who attended a different university in Malaysia reported similar average self-regulation score of 3.0±0.5, with few categorised as having high self-regulation (Tan, Tan & Tan, 2022). A study on American undergraduates showed that eating self-regulation was positively correlated with fruit and vegetable intakes, but negatively correlated with sweet intake, suggesting an association between self-regulation and diet quality (Ling & Zahry, 2021). The ability to self-regulate eating has been measured as meal planning skills, self-monitoring behaviour, and dietary restraint. Indeed, the planning and monitoring of eating have been shown to be strongly and positively associated with healthy eating, while strongly and negatively associated with unhealthy eating behaviours (Guertin & Pelletier, 2021). Dietary restraint has also been shown to partially mediate the relationship between stress and dietary intake (Royal & Kurtz, 2010). Although

this current study indicated the role of self-regulation of eating behaviour and dietary intake, the low proportion of study participants categorised as having high self-regulation of eating behaviour and good diet quality underscores the importance of future interventions aimed at developing university students' self-regulation skills to promote healthy eating. Interventions that improve self-regulation of eating behaviour have resulted in short- and long-term increases in fruit and vegetable intakes (Stadler, Oettingen & Gollwitzer, 2010). A systematic review on dietary interventions among undergraduate students showed that the inclusion of self-regulation components, including self-monitoring and goal setting, may maximise dietary outcomes towards better diet quality (Kelly, Mazzeo & Bean, 2013). Improving the diet quality of undergraduate students is important as high diet quality is inversely associated with the risk of all-cause mortality and disease-specific incidence or mortality (Morze *et al.*, 2020).

The findings from this study must be interpreted within its limitations. Most of the participants were young Chinese female adults, and this limits the generalisability of the findings. The cross-sectional nature of the study also precludes inference of causation. Intention is associated with self-regulation. However, the study participants were not screened to exclude individuals who do not have healthy eating intentions.

CONCLUSION

In conclusion, this study showed that having higher self-regulation of eating behaviour score is a factor that contributes to lower daily EI and higher diet quality score. This study identified possible predictors of diet quantity and diet quality, that can be explored in future nutrition-based studies. Additionally, health promotion efforts to combat obesity and NCDs with healthier eating behaviours should include strategies that improve eating self-regulatory skills.

Acknowledgement

This study was internally funded by the International Medical University, Kuala Lumpur, Malaysia. The authors received no financial support for the authorship, and/or publication of this article. The authors wish to thank Dr Gloria Koh (Post-doctoral research officer, University of Technology Sydney) for reviewing the data analysis and interpretation of this study, and Mr. Parkash Mathivanan (Senior Lecturer, English for Academic Use, International Medical University) for reviewing the use of English in the manuscript.

Authors' contributions

Lee CL, conceived and designed the project, study recruitment and screening, data collection and analysis, drafting and critical revisions of manuscript; Jamilah AJ, designed the project, study recruitment and screening, data collection and analysis, drafting and critical revisions of manuscript; Chang JT, Yap KX, Yap HY, Khoo WJ, involved in study recruitment and screening, data collection and analysis, and drafting of manuscript. The authors agree with the manuscript and declare that the content has not been published elsewhere.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Mal J Nutr 29(1): 039-049, 2023

Associations between body mass index and physical activity level with mindful eating behaviour among undergraduate medical students of Universiti Sains Malaysia

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ABSTRACT

Introduction: Mindful eating is being fully present in the moment of eating and it is critical in preventing poor eating habits. The main objective for this study was to determine the associations of body mass index (BMI) and physical activity level with mindful eating behaviour among undergraduate medical students of Universiti Sains Malaysia (USM), Health Campus, Kubang Kerian, Kelantan. **Methods:** A cross-sectional study was conducted among 158 students (Years 1-5; 69% females and 31% males) by using a self-administered online questionnaire consisting of socio-demographic data, anthropometric data, short version of the International Physical Activity Questionnaire (IPAQ), and Mindful Eating Questionnaire (MEQ). The associations between BMI and physical activity with MEQ were determined by Spearman's Correlation and One-Way ANOVA or Kruskal-Wallis Test, respectively. **Results:** Majority of the students had normal BMI (66.4%, n=105), and 39.9% (n=63) had low physical activity levels. The mean MEQ summary score of the students was considered high (2.82±0.26). There was a significant negative association between MEQ summary score (r=-0.191; p=0.016) and disinhibition subscale score (r=-0.340; p<0.001) with BMI, whereby MEQ summary and disinhibition subscale scores increased as BMI decreased. However, there was no significant association between physical activity level with MEQ score (p>0.05). **Conclusion:** A student with positive mindful eating behaviour has the potential to lower his/her BMI. However, further research is required to verify this finding.

Keywords: body mass index (BMI), medical students, mindful eating behaviour, physical activity

INTRODUCTION

Medical students are future doctors who are expected to be great role models in the community, especially in terms of health. However, previous studies found that medical students were predisposed to obesity as a result of their sedentary lifestyle (Nisar *et al.,* 2009; Thomas & Geethadevi, 2019) and disordered eating habits (Nor Afiah *et al.,* 2014). Furthermore, the prevalences of overweight (37.1%) and obesity (8.5%)

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doi: https://doi.org/10.31246/mjn-2022-0040

were higher too among medical students in Malaysia (Ghazi *et al.,* 2018).

There are a few reasons that lead medical students to be at a higher risk of being overweight or obese. Diet quality usually is poor during college years (Ramón-Arbués *et al.,* 2021), which may play a key influence on weight increment (Miller & Hartman, 2020). Majority of medical students reportedly consume junk foods and soft drinks, which are linked to obesity (Nisar *et al.,* 2009). For many university students, poor nutrition quality is usually coupled with a decrease in physical activity (Allam *et al.,* 2012) and sedentary hours spent on studying, being in the classroom, watching television, and sitting at a computer (Castro *et al.,* 2018).

In respect of mindful eating, Kristeller & Wolever (2011) found that mindful-based eating behaviour was effective in treating uncontrollable eating patterns (Kristeller & Wolever, 2011). When an individual eats mindfully, he or she is aware of the present moment, paying close attention to how the food affects his or her senses, and recognising the physical and emotional sensations felt in response to eating (Warren, Smith & Ashwell, 2017). In other words, if people pay close attention to their eating, or eat consciously, they are more likely to not overeat. This new concept of intuitive eating in modulating eating habits may benefit medical students in controlling their dietary intake, therefore reducing the risk of obesity in the future.

In terms of physical activity, it was found that being physically active was linked to a longer life expectancy and a life free from diabetes (Jonker *et al.,* 2006). The level of physical activity has decreased in developing countries, where sedentary behaviours are on the rise, thus potentially contributing to an increase in chronic diseases (Musaiger, Al-Khalifa & Al-Mannai, 2016). In addition, lack of physical activity can have a negative impact on an individual's body weight status, thus increasing the risk of obesity.

Accordingly, the purpose of this study was to investigate the associations between BMI and physical activity level with mindful eating behaviour among medical students in Universiti Sains Malaysia, Health Campus, Kelantan, Malaysia.

MATERIAL AND METHODS

Study population

This research used a cross-sectional study design and was conducted from February 2021 to April 2021, using an online survey form. The study setting was at Universiti Sains Malaysia, a local university in Kelantan, situated in the North East region of Malaysia.

The inclusion criteria were subjects aged 18 years and above, Malaysian, and currently enrolled as an undergraduate medical student at the School of Medical Sciences in Universiti Sains Malaysia (Health Campus). The exclusion criteria were having underlying health concerns and chronic health diseases.

Sampling method

This study used convenience non-probability sampling and the sample size calculated for this study was based on the formula by Naing (2003), $n = \left[z \times \frac{\sigma}{\Delta}\right]^2$, whereby n=sample size, z=value representing the desired confidence level, σ=population standard deviation, and Δ=precision (true value). The population standard deviation was taken from a previous study done by Moor and colleagues (Moor, Scott & McIntosh, 2013), whereby the mean score for mindful eating had a standard deviation of 0.32. Meanwhile, the precision was estimated to be within 5% points of the true value. The study took into account a 10% drop-out rate. As a result, a total of 174 students were needed for this study.

Measuring tools

Each set of online survey had four sections – Sections A, B, C, and D, as follows:

Section A (demographic data)

Part A was on demographic data that included information regarding the student's personal information such as age, gender, ethnicity, years of study, household income, and sponsorship.

Section B (anthropometric data)

Self-reported weight and height were used in this study. After that, the researcher was responsible to calculate body mass index (BMI) from the data collected. The classification of BMI was based on the World Health Organization (WHO) cut-off points, which were <18.5 kg/m^2 (underweight), 18.5 – 24.9 kg/m^2 (normal), 25.0 – 29.9 kg/m^2 (overweight), and ≥30.0 kg/m^2 (obese) (WHO, 2000).

Section C (International Physical Activity Questionnaire, IPAQ)

In this study, the short version of IPAQ was used and it was an open-access tool, thus no permission was required to use it (Patterson, 2010). It had seven items and assessed three different forms of activities, which were walking, moderate-intensity activities, and vigorous-intensity activities. The classification of physical activity level were as follows:

i. High physical activity was represented by at least three days of vigorous-intensity activity which achieved at least 1500 metabolic equivalent of task (MET) (minutes/week) or seven or more days of any combination of walking, moderate-intensity, and vigorous-intensity activities which achieve at least 3000 MET (minutes/week);
ii. Moderate physical activity was represented by at least 20 minutes of vigorous-intensity activity in three or more days or at least 30 minutes of moderate-intensity activity and/or walking in five days or more or more days of any combination of walking, moderate-intensity, and vigorous-intensity activities which achieved at least 600 MET (minutes/week).
iii. Low physical activity was defined as not meeting any of the criteria for high and moderate physical activity categories.

Section D (Mindful Eating Questionnaire, MEQ)

Mindful eating behaviour was assessed using the MEQ. This questionnaire was developed by Framson and colleagues (Framson *et al.,* 2009). It comprised of 28 items and five different subscales (awareness, distraction, disinhibition, emotional response, and external cues). The subscales were defined as follows: awareness (noticing the effects of food on the senses and how food affects internal states); distraction (focusing on other activities while eating); disinhibition (the ability to stop eating when full); emotional response (eating in response to negative emotion); and external cues (eating in response to environmental triggers). Out of 28 items, eight items were categorised under disinhibition subscale, seven items under awareness subscale, six items under external cues subscale, four items under emotional response subscale, and three items under distraction subscale. For each item, students must select one out of four frequency categories, which were 'Never/Rarely', 'Sometimes', 'Often', and 'Usually/Always'. A summary score was calculated using the mean of the five subscale scores added together. A higher summary score indicated better mindful eating behaviour. Reports showed that

the reliability of the questionnaire ranged from 0.64 to 0.83, as measured by Cronbach's alpha. A permission to use the MEQ was granted by the institution who was in charge of the survey instrument.

Data collection method

The researchers began collecting data after gaining ethical approval from the Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/21010070). Each batch representative was contacted and given a brief overview of the study. Following that, students were given a soft copy of a poster and message template describing the recruitment of study subjects, along with a link. Students who were interested to participate were directed to a Google Form that included a consent form, as well as a set of self-administered questionnaires. Those who matched the eligibility requirements and wanted to participate filled in the online permission form and questionnaire. The process of resubmission of the advertisement study link was repeated until researchers obtained a total of 174 valid responses.

The participants took about 20 minutes to complete the four-part questionnaire. Student's confidentiality was ensured, and they could withdraw from the study at any time with no repercussions. The study hypothesised that there were associations between BMI and physical activity with mindful eating behaviour among medical students at Universiti Sains Malaysia.

Data analysis

All survey data were analysed using the IBM Statistical Package for Social Science (SPSS) Version 26.0 (IBM Corp., Armonk, NY, USA). BMI was calculated as weight (in kilograms)/height (in meters)^2 using the respondents' self-reported weight and height. In terms of physical activity, total physical activity MET-minutes/week was calculated using the sum of the total IPAQ score and then classified as either low, moderate or high physical activity. The overall mindful eating score was calculated by averaging the mean scores, with higher scores indicating greater mindfulness. The Shapiro-Wilk Test was used to determine whether the distribution was normal. The socio-demographic characteristics of the participants were summarised using descriptive data. Numerical data were presented as mean±standard deviation (*SD*) or median (interquartile range, *IQR*) based on the normality distribution, while categorical data were presented as frequency and percentage. The association between BMI and MEQ score was examined and presented using Spearman's Correlation Test, and the association between physical activity level and MEQ score was examined and presented using one-way analysis of variance (ANOVA) or Kruskal-Wallis Test. Statistical significance was determined at $p<0.05$.

RESULTS

Demographic characteristics

A total of 174 students responded to the survey; nevertheless, 16 were excluded from the analysis because their responses were incomplete. As a result, there were 158 complete responses used for further analysis. There were 49 males (31%) and 109 females (69%) among the 158 students who responded. Students were between the ages of 19 to 27 years old and most of the students (60.8%) were between the ages of 22 and 25 years old. Majority of the students were Malays (62.7%), in year 4 (25.9%), from M40 families (45.6%), and received a scholarship (62.7%). Table 1 represents the demographic characteristics of medical students in this study.

Table 1. Demographic characteristics of medical students (*n*=158)

Characteristics	*n (%)*
Gender	
Male	49 (31.0)
Female	109 (69.0)
Age	
18 – 21 years	61 (38.6)
22 – 25 years	96 (60.8)
> 25 years	1 (0.6)
Ethnicity	
Malay	99 (62.7)
Chinese	46 (29.1)
Indian	10 (6.3)
Others	3 (1.9)
Year of study	
Year 1	28 (17.7)
Year 2	34 (21.6)
Year 3	27 (17.1)
Year 4	41 (25.9)
Year 5	28 (17.7)
Household income	
Not stated/Not sure	8 (5.1)
B40 (RM 0 – RM 4, 849)	61 (38.6)
M40 (RM 4, 850 – RM 10, 959)	72 (45.6)
T20 (≥ RM 10, 960)	17 (10.8)
Sponsorship	
Parents	19 (12.0)
Scholarship	99 (62.7)
Loan	39 (24.7)
Others	1 (0.6)

B40: Bottom 40%, M40: Middle 40%, T20: Top 20% (Malaysian households income classification)

Anthropometric data

The average weight, height, and BMI of the students were 56.0 (16.0) kg, 1.62±0.09 m, and 21.5 (4.4) kg/m^2, respectively. According to WHO (2000), majority of the students had normal BMI (*n*=105, 66.4%), 15.2% were overweight (*n*=24), 14.6% were underweight (*n*=23), and 3.8% were obese (*n*=6).

Physical activity

According to the survey, 63 students (39.9%) had a low level of physical activity, 42 of them (26.6%) had a moderate level of physical activity, and 53 students (33.5%) had a high level of physical activity. The median total MET-min/week for this study was 904.5 (2042.2). Table 2 illustrates the anthropometric data and physical activity of medical students.

MEQ score

The MEQ score of students is shown in Table 3. The MEQ mean summary score of the student was 2.82±0.26. In addition, the mean mindful eating subscale scores ranged from 2.41 to 3.08, with the highest score in the distraction subscale (3.08±0.62) and the lowest score in external cues (2.41±0.60).

Table 2. Anthropometric data and physical activity level of medical students (*n*=158)

Anthropometric Data	*n (%)*	*Mean±SD*	*Median (IQR) [Q1, Q3]*
Weight (kg)			56.0 (16.0) [49.0, 65.0]
Height (m)		1.62±0.09	
Body mass index (kg/m^2)			21.5 (4.4) [19.5, 23.9]
Body mass index category			
Underweight (<18.5 kg/m^2)	23 (14.6)		
Normal (18.5 – 24.9 g/m^2)	105 (66.4)		
Overweight (25.0 – 29.9 kg/m^2)	24 (15.2)		
Obese (≥30.0 kg/m^2)	6 (3.8)		
Physical activity level			904.5 (2042.2) [237.8, 2280.0]
Low	63 (39.9)		
Moderate	42 (26.6)		
High	53 (33.5)		

Association between MEQ score and BMI

Table 4 proves the associations between mindful eating scores with BMI. According to Chan (2005), the correlation coefficient value (*r*-value) is used to interpret the strength of a linear relationship, with a value of <0.3 denoting a poor relationship, 0.3 to 0.5 denoting a fair relationship, 0.6 to 0.8 denoting a moderately strong relationship, and >0.8 denoting a very strong relationship. The MEQ summary score had a significant, negative poor relationship with BMI (*r*=-0.191; *p*=0.016). This meant that as MEQ summary score increased, BMI decreased. Students with lower MEQ summary scores therefore had higher BMI values. BMI and disinhibition subscale score had a fairly negative relationship (*r*=-0.340; *p*<0.001). BMI decreased as disinhibition subscale score increased, similar to the MEQ summary score. Meanwhile, there was no significant associations between BMI and awareness subscale score (*r*=-0.152; *p*=0.056), distraction subscale score (*r*=-0.075; *p*=0.351), emotional response subscale score (*r*=-0.011; *p*=0.895), or external cues subscale score (*r*=0.142; *p*=0.075).

Association between MEQ score and physical activity level

Physical activity level had no significant association with MEQ summary score (*p*=0.931). Likewise, physical activity level had no significant associations with awareness subscale score (*p*=0.172), distraction subscale score (*p*=0.805),

Table 3. Mindful Eating Questionnaire (MEQ) scores of medical students (*n*=158)

Variables	*Subscale score (Mean±SD)*
MEQ Awareness	2.79±0.62
MEQ Distraction	3.08±0.62
MEQ Disinhibition	2.81±0.62
MEQ Emotional Response	3.04±0.70
MEQ External Cues	2.41±0.60
Mean of Summary Score	2.82±0.26

Table 4. Associations between Mindful Eating Questionnaire (MEQ) scores and BMI among medical students (*n*=158)

Variables	*Correlation coefficient value (r)*	*p-value*†
MEQ Awareness	- 0.152	0.056
MEQ Distraction	- 0.075	0.351
MEQ Disinhibition	- 0.340	<0.001*
MEQ Emotional Response	- 0.011	0.895
MEQ External Cues	0.142	0.075
MEQ Summary Score	- 0.191	0.016

†Spearman's Rank-Order Correlation Test, *significant at the 0.001 level (2-tailed)

disinhibition subscale score (*p*=0.626), emotional response subscale score (*p*=0.103), or external cues subscale score (*p*=0.685). The associations between mindful eating score and physical activity among medical students are represented in Table 5.

DISCUSSION

Female students frequently outnumber male students in medical school (Wattanapisit *et al.,* 2016). In terms of ethnic diversity, the majority of participants were Malays, and this was an expected outcome, given that Malays make up the largest ethnic group in Malaysia (69.1%) (*Jabatan Perangkaan Malaysia*, 2018).

In terms of the prevalence for overweight and obesity, the current

Table 5. Associations between Mindful Eating Questionnaire (MEQ) scores and physical activity among medical students (*n*=158)

Variables	*Physical activity*	*n*	*Median (IQR) [Q1, Q3]*	*Chi-Square statistic (df)*	*p-value*†
MEQ Awareness	Low	63	2.7 (0.6) [2.43, 3.00]	3.520 (2)	0.172
	Moderate	42	3.0 (1.0) [2.40, 3.43]		
	High	53	2.9 (0.9) [2.43, 3.29]		
MEQ Distraction	Low	63	3.0 (0.7) [2.67, 3.33]	0.434 (2)	0.805
	Moderate	42	3.2 (1.4) [2.59, 4.00]		
	High	53	3.3 (0.7) [2.67, 3.33]		
MEQ Emotional Response	Low	63	3.3 (1.0) [2.67, 3.67]	4.542 (2)	0.103
	Moderate	42	3.0 (0.8) [2.50, 3.25]		
	High	53	3.0 (0.8) [2.75, 3.50]		
			Mean±SD	*F (df)*	
MEQ Disinhibition	Low	63	2.85±0.59	0.469 (2)	0.626
	Moderate	42	2.73±0.68		
	High	53	2.81±0.61		
MEQ External Cues	Low	63	2.40±0.58	0.379 (2)	0.685
	Moderate	42	2.47±0.64		
	High	53	2.37±0.58		
MEQ Summary Score	Low	63	2.83±0.23	0.071 (2)	0.931
	Moderate	42	2.81±0.27		
	High	53	2.83±0.30		

†Tested using One-Way ANOVA or Kruskal-Wallis Test

study had a higher prevalence as compared to previous studies conducted in Ipoh, Malaysia (Sugathan & Bagh, 2014) and India (Anupama *et al.,* 2017). However, the prevalence was lower when compared to a study that was conducted among medical students in Bangladesh (Akhter *et al.,* 2017). The differences in results could be attributed to different methods of assessing anthropometry, as other studies used measured weight and height, whereas the current study used self-reported weight and height of medical students. However, majority of the studies categorised body weight using the same WHO classification.

For physical activity, the findings showed that most of the medical students had low physical activity. This is in line with the findings of a previous study conducted by Wattanapisit and colleagues among medical students in Southern Thailand, in which they discovered that only half of the students were physically active (Wattanapisit *et al.,* 2016). Time constraints, lack of money, the absence of safe sports venues, lack of interest in sports, and a body that cannot tolerate physical activity were all significant barriers to physical activity among physically inactive medical students (Abdel-Salam & Abdel-Khalek, 2016). Another possible reason for the low physical activity level of most participants could be the shift from clinical rotations to online classes due to the COVID-19 pandemic, which included a period of lockdown in Malaysia when data for this study were collected. This was supported too by a study conducted among Italian medical students who discovered that during the lockdown, universities shifted physical classes to online, allowing students to skip clinical rotations and thus reducing their physical activity (Luciano *et al.,* 2021).

Meanwhile, the MEQ score demonstrated that the distraction and emotional response subscales had the highest scores among the students. These indicated an individual's ability to focus on their food while eating without being affected by disturbances and the ability to resist emotional triggers for overeating (Giannopoulou *et al.,* 2020). The external cues subscale received the lowest score from the students. This revealed that students tend to eat in response to inappropriate external cues such as simply the presence of food nearby, which may lead to overconsumption of calorie-dense foods and long-term weight gain (Taylor, Daiss & Krietsch, 2015).

For the association between BMI and mindful eating behaviour, mindful eating was found to be negatively related to BMI, implying that medical students with lower BMI were more mindful eaters. Köse & Tayfur (2021) found a significant relationship between BMI and MEQ subscales (r=-0.208, p<0.01). This is consistent with the results from previous studies (Moor, Scott & McIntosh, 2013; Taylor *et al.*, 2015; Pintado-Cucarella & Rodríguez-Salgado, 2016). However, only the disinhibition subscale score had a fair negative relationship with BMI, while other subscales were not significant. Overall, the association between BMI and mindful eating behaviour evidenced that as mindful eating was applied, students were less likely to develop poor eating habits and thus have a lower BMI. Therefore, mindfulness may help those with overweight or obesity to develop more adaptive responses to emotional distress, which may lead to healthier eating habits (Gouveia, Canavarra & Moreira, 2019).

There were only a few studies that evaluated the association of physical activity with mindful eating. The current finding reported that there was no association between BMI and physical activity among medical students. Mindful eating is not merely a characteristic

of people who engage in other healthy behaviours, since those who exercise more are not more likely to be mindful eaters. According to a study conducted by Topan and colleagues, mindful eating increases as physical activity increases (Topan *et al.,* 2021). However, a previous study by Moor and colleagues reported that there was no significant relationship between mindful eating behaviour and physical activity level. They suggested that more research needs to be performed on this concept because the relationship between mindful eating behaviour and physical activity is not straightforward. Therefore, a better understanding of these complexities could be very useful in addressing the risk of overweight and obesity in university populations (Moor, Scott & McIntosh, 2013). The disparities in the results of the studies could be attributed to the different tools used to measure mindful eating behaviour (MEQ) score and physical activity component. Concerning mindful eating behaviour (MEQ) score, the present study used 28 items or 28 questions (MEQ-28) from the original source in comparison to a previous study that used an adapted and modified version of the original source that consisted of 30 items or 30 questions (MEQ-30) (Topan *et al.,* 2021). In the meantime, for the physical activity component, the tool used in this study was IPAQ as compared to a previous study that used questions enquiring whether students were exercising regularly or not (Topan *et al.,* 2021).

There are a few limitations to this study. Firstly, due to the COVID-19 pandemic, data collection was conducted online and self-reported weight and height were used, which increased the chance of error. Secondly, due to the COVID-19 pandemic, there were restricted movements that could affect mindful eating behaviour among the medical students since the current study used the original version of MEQ questionnaire without modification. In the future, a modified MEQ questionnaire can be created accordingly based on situations of restricted movement. Besides that, the long version of the IPAQ can be used instead of the short version because it contains a more comprehensive set of questionnaires to accurately assess the subject's physical activity. Thirdly, because convenience sampling was one of the study's limitations, the findings may not be completely generalisable and further raises the possibility of bias in the results due to subject selection. Finally, the current study was a cross-sectional study in which the associations between exposures and outcomes of interest were measured concurrently at a single point in time, which is ineffective for determining the cause-and-effect relationship.

CONCLUSION

In conclusion, being mindful when eating is one of the key factors that could contribute to undergraduate medical students having a lower BMI. Lower BMI was also linked to the ability to quit eating when satisfied. As a result, mindful eating may be a useful intervention for reducing the prevalence of overweight and obesity among undergraduate medical students, but more comprehensive research, with a larger sample size and probability sampling, is essential to confirm the results and the benefits of physical activity in achieving the same goal.

Acknowledgments

The authors acknowledge all USM medical students of Years 1-5 for their participation and cooperation and the Nutrition Assessment Shared Resource/ Fred Hutchinson Cancer Center for permission to use the Mindful Eating Questionnaire (MEQ) in this study.

Authors' contributions

Nurul Zulaikha T and Ang SQ, conducted the study, data analysis, and interpretation of the data with support from Juliana S; Juliana S, helped supervise the study, prepared the draft of the manuscript, and reviewed the manuscript; Zafirah MN, assisted in drafting of the manuscript, reviewed and proofread the manuscript. All authors approved the final manuscript.

Conflict of interest

The authors declare that they have no conflicting financial or non-financial interests in this study.

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Mal J Nutr 29(1): 051-062, 2023

Coeliac disease knowledge and treatment: Potential factors associated with adherence to gluten-free diet

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ABSTRACT

Introduction: Lack of adherence to a strict gluten-free diet (GFD) is the main reason for poorly controlled disease in patients with coeliac disease (CD). This study aimed to assess the association between knowledge of CD and its medical diet to the adherence of GFD among adult patients with CD. **Methods:** A cross-sectional study was carried out with a total of 90 adult patients with CD (aged between 18-65 years). The data collecting instruments were a combination of four questionnaires as follows: assessment of knowledge of coeliac disease (AKCD), gluten-free diet knowledge scale (GFD-KS), coeliac disease adherence test (CDAT), and questions on potential factors influencing GFD adherence among patients. **Results:** An average knowledge score of five points out of seven was obtained from 46 participants (51%). Mean score for knowledge on gluten-free diet was seven points out of 17 in 59 participants (65%). Adequate adherence to GFD was observed in 56% of the participants. No association was found between knowledge of CD and GFD to the adherence of GFD ($p>0.050$). Participants who had higher adherence scores were discussing GFD with a specialist, obtaining educational materials, had enhanced symptoms associated with CD, and did not complain about the taste of GFD ($p<0.050$). **Conclusion:** Patients with CD has adequate knowledge of CD and adherence of GFD. No association was found between the knowledge of CD and GFD to the adherence of GFD. Further research might explore other potential factors influencing the adherence to GFD.

Key words: adherence, coeliac disease, gluten-free diet, knowledge

INTRODUCTION

Coeliac disease (CD) is an autoimmune disorder that occurs in genetically predisposed people where the ingestion of gluten leads to damage in the small intestine (Guandalini & Assiri, 2014). Coeliac disease is considered the most commonly genetically-based food

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doi: https://doi.org/10.31246/mjn-2022-0082

intolerance worldwide, with prevalence of 1% in the general population (Guandalini & Assiri, 2014). A meta-analysis revealed that the seroprevalence of CD in Saudi Arabia is 2.7%, while the prevalence of CD in Saudi Arabia using biopsy is 1.4% (Safi, 2018). The symptoms of CD varies from one person to another (Guandalini & Assiri, 2014). Coeliac disease is broadly described with classic symptoms in which patients may develop symptoms of malabsorption, including diarrhoea and weight loss, or non-classical symptoms such as poor bone health (Parzanese *et al.*, 2017; Volta *et al.*, 2016).

The only efficient treatment for patients with CD so far is a life-long elimination of gluten from the diet (Guandalini & Assiri, 2014). Gluten is a protein found in wheat, rye and barley. Adherence to a strict gluten-free diet (GFD) has been shown to have benefits to CD patients in terms of improvements in depression and infertility, and decrease in the risk of gastrointestinal malignancies (Hallert *et al.*, 2002; Nenna *et al.*, 2011). Adherence to GFD in adult patients varies between 40-90% (Hall *et al.*, 2009). Many factors influencing the adherence to GFD have been explored, including the cost of GFD, eating outside of home, and knowledge of GFD (Ciacci *et al.*, 2002; Hall *et al.*, 2009; Lamontagne *et al.*, 2001; Leffler *et al.*, 2008). In addition, limited studies have reported an association between the adherence to GFD with the knowledge of CD and GFD (Ciacci *et al.*, 1998; Kokkonen *et al.*, 1989; Leffler *et al.*, 2008).

An adequate knowledge on GFD and CD is important to understand the presentations of the disease and to be more aware about the treatment, as well as how to follow a GFD (Ukkola *et al.*, 2012). A previous study reported that 76-85% of patients with CD were educated about GFD by physicians or dietitians (Ukkola *et al.*, 2012). Surprisingly, one out of four patients with CD was dissatisfied with the information regarding CD and GFD offered by their physician, and only 12% of patients with CD were not satisfied of the gluten-free information provided by dietitians (Ukkola *et al.*, 2012). One of the reasons of non-satisfaction was the low-quality information from health practitioners as it was associated with negative attitudes towards having CD (Ukkola *et al.*, 2012). Another study found that poor knowledge of GFD may lead to poor adherence to GFD (Halmos *et al.*, 2018). In addition, it was demonstrated that CD patients with self-perceived insufficient knowledge in reading gluten-free labels were more likely to misidentify gluten-free foods and were reported as non-adherent patients (Halmos *et al.*, 2018).

Up till now, limited studies have emphasised on the importance of disease knowledge and its treatment in influencing adherence to GFD in adult patients with CD. Hence, the objective of the current study was to assess the association between knowledge of CD and GFD with the adherence to GFD in patients with CD, as well as to explore any potential factors that might influence the adherence to GFD among adult patients in Saudi Arabia.

MATERIALS & METHODS

Study setting and population

This cross-sectional study initially included 222 adult patients with CD, after a screening through the Security Force Hospital in the Riyadh database. The inclusion criteria were adult patients (aged between 18 – 65 years old) with confirmed duodenal biopsy-proven CD ≥1 year. Patients with CD undergoing dietary treatment for an underlying medical issue (e.g., type 1 diabetes and multiple food allergies) and those with other chronic diseases (e.g., Down's syndrome, inflammatory bowel

disease, cystic fibrosis, short bowel syndrome, and mental disabilities) were excluded. After reviewing the database, 130 patients met the inclusion criteria. Of these, 26 patients had wrong contact information and 14 patients did not give their consent to enrol in the study. The final number of participants who met the criteria and completed the survey were 90 patients (Figure 1). All participants received phone calls explaining the objectives of the study and the study survey. Participants were also informed that participation in the study was voluntary, anonymous, and confidential, and that they could withdraw at any moment without any penalty. Data collection was conducted for six months between November 2019 to April 2020. After obtaining consent, data were collected from participants. Ethical approval of the current study was obtained from the institutional review board (IRB) of the Security Force Hospital in Riyadh (Saudi Arabia) (IRB number 19-324-22).

Data collection tools

Section 1: General characteristics and medical history

General information contained information that included age, gender, weight and height, monthly income, marital status, level of education, family history of CD, and food allergies. Data related to medical history (age at diagnosis, duration of the disease, and existing co-morbidities) were obtained from patient's medical file. Other information were collected using a self-reported questionnaire. The questionnaire was administrated in Arabic and composed of 4 sections as follows:

Section 2: Assessment of knowledge on coeliac disease (AKCD)

This section aimed to assess the

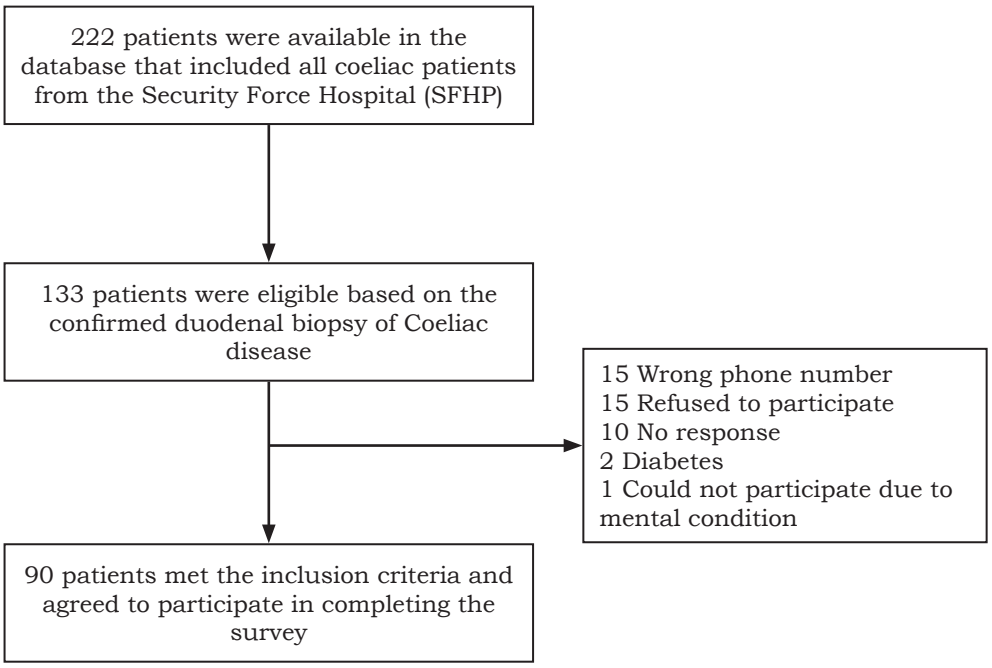

Figure 1. Flow chart of the patient sampling

knowledge about CD (AKCD). It was composed of seven questions. The questions were focused on the physiological, medical, and nutritional aspects of CD. There were no questions about the type of CD or its symptoms, as the manifestation of the disease differs from one person to another. The questionnaire was developed by three clinical dietitians in Arabic. Before being used, the questionnaire was piloted for ease of understanding and use among 50 patients with CD through an online support group for coeliac patients in Saudi Arabia. Participants in the pilot study were not included in the current study. Several feedback and comments were received regarding the clarity of the questions, which were all addressed. The revised and finalised version was used for the survey. The maximum score a participant could obtain was seven points. The mean AKCD score of all participants was five; therefore, an AKCD score of ≥5 indicated good knowledge and an AKCD score of <5 was considered as poor knowledge.

Section 3: Gluten-free diet knowledge scale (GFD-KS)

The GFD knowledge scale (GFD-KS) was used to assess the knowledge of GFD (Silvester *et al.*, 2016). The questionnaire included various foods that have been listed in the GFD as "allowed", "foods to question" or "not allowed" in a GFD (Silvester *et al.*, 2016). The scale included 17 food items, seven foods allowed, seven foods to question, and three not permitted foods. The GFD-KS questionnaire was translated to Arabic and back translated to English to ensure the accuracy of the language. Minor modifications were made to the food options in the questionnaire that were commonly consumed food items among the Saudi population (Ahmed, Salih & Khan, 2014). The modifications consisted of substituting chickpea flour, croutons, and spelt with hummus tahini, pieces of toast, and black wheat, respectively. One point was given for each correct answer to a maximum score of 17 points (Silvester *et al.*, 2016). The mean GFD-KS score of all participants was seven; therefore, a GFD-KS score of ≥7 indicated good knowledge and a GFD-KS score of <7 was considered poor knowledge.

Section 4: Self-reported adherence to gluten-free diet (CDAT)

Adherence to GFD was assessed using a validated tool (coeliac disease adherence test, CDAT) and administrated in Arabic to the participants (Leffler *et al.*, 2009). The CDAT questionnaire was translated to Arabic and back translated to English by two experts to ensure the accuracy of the language. The questionnaire consisted of seven questions ranked on a Likert scale (1 to 5) (Leffler *et al.*, 2009). The sum of the numeric values for the seven items ranged between 7 to 35, in which lower scores reflected better adherence to GFD (Leffler *et al.*, 2009). The mean score obtained from study participants was 13. Adherence to GFD scores (CDAT) of >13 was considered "inadequate adherence to GFD" and CDAT scores of £13 reflected "adequate adherence to GFD". The same cut-off point for good GFD adherence was also applied by a similar study (Leffler *et al.*, 2009).

Section 5: Factors potentially associated with adherence to GFD

Eight questions were included in the questionnaire to assess the potential factors that were associated with the adherence to GFD. As published by Butterworth *et al.* (2004), these factors included an evaluation of the information discussed with the hospital doctor and dietitian, whether the patient was

satisfied with the information given or not, was he/she part of an online support group, and if he/she had any difficulties in following the GFD. Participants were asked to choose more than one relevant answer. The questionnaire was translated to Arabic and back translated to English.

Statistical analysis

All data analysis was performed using the JMP Statistical software (North Carolina, America) for Mac, version 15. Descriptive analyses were presented as frequencies and percentages for categorical variables and means and standard deviations for continuous variables. All assessments on the association between knowledge of CD and GFD with the adherence to GFD were done using an analytical statistical test that included *t*-test and one-way ANOVA. *T*-test was performed to assess the association between a set of potential factors to the adherence of GFD (CDAT). Results were considered significantly different at a *p*-value of <0.05.

Table 1. Socio-demographic characteristics and medical history of patients with coeliac disease (*n*=90)

Socio-demographic characteristics	*n (%)*	*mean±SD or median (inter-quartile range)*
Age in years		
< 30 years old	39 (43.3)	
30 – 60 years old	46 (51.1)	
> 60 years old	5 (5.6)	
Gender		
Male	16 (17.8)	
Female	74 (82.2)	
Duration of CD (years)		4 (2-8)
Age at diagnosis of CD (years)		25.4±10.8
BMI (kg/m^2)		24.0±5.2
Marital status[†]		
Single	19 (25.0)	
Married	56 (73.7)	
Divorced	1 (1.3)	
Monthly income[‡]		
<10000 SAR	46 (51.1)	
>10000 SAR	44 (48.9)	
Level of education		
School graduate/ Diploma degree	45 (50.0)	
Bachelor's/Master's/Doctorate degree	45 (50.0)	
Food allergy and/or lactose intolerance		
Yes	10 (11.1)	
No	80 (88.9)	
Family history of CD		
Yes	22 (24.4)	
No	68 (75.6)	
Dietitian consultation		
Yes	79 (87.8)	
No	11 (12.2)	

BMI, body mass index; CD, coeliac disease; GFD, gluten-free diet

[†]*n*=76

[‡]USD 1=SAR 3.76 (as of 25 November 2022)

RESULTS

Socio-demographic characteristics and medical history

The socio-demographic characteristics and medical history of patients with CD are presented in Table 1. Majority of the participants were females (*n*=74, 82%). The average duration of the disease was 5.5 years. Mean body mass index (BMI) was within the normal range (24 kg/m^2). The majority of participants (*n*=80, 88%) did not report suffering from any other additional conditions, such as other food allergy or lactose intolerance, that might restrict them following a medical diet for the disease.

Association between knowledge of CD and GFD (AKCD and GFD-KS) and adherence to GFD (CDAT)

Table 2 shows the response rate of each item in the knowledge of CD questionnaire. The average score of the assessment on knowledge of coeliac disease was five points out of seven (71%). Only one patient had answered

Table 2. Assessment of knowledge on coeliac disease (AKCD)

AKCD	†*n (%)*
Coeliac disease is an auto-immune disease	
Yes‡	57 (63.3)
No	7 (7.8)
I don't know	26 (28.9)
Coeliac disease is a	
Chronic‡	78 (86.7)
Acute	4 (4.4)
I don't know	8 (8.9)
Coeliac disease is a genetic disease	
Yes‡	22 (24.4)
No	33 (36.7)
I don't know	35 (38.9)
The available treatment for CD	
Gluten-free-diet‡	27 (30.0)
Medications	61 (67.8)
Gluten-free-diet and medications	1 (1.1)
I don't know	1 (1.1)
The affected part of body from gluten	
Stomach	19 (21.1)
Small intestine‡	61 (67.8)
Large intestine	10 (11.1)
The gluten-free diet is	
A lifelong diet‡	83 (92.2)
A temporary diet	2 (2.2)
I don't know	5 (5.6)
I don't need to see a doctor or a registered dietitian if I'm following the GFD	
True	31 (34.4)
False‡	59 (65.6)

CD, coeliac disease; GFD, gluten-free diet
†Patients with coeliac disease (*n*=90)
‡Represents the correct answer

all the questions correctly and two patients had answered only one question correctly. For the gluten-free diet knowledge scale (GFD-KS), respondents identifying the food items correctly ranged from 3-11 out of 17. The highest score was obtained by two patients (11 out of 17) and the lowest score was obtained by seven patients (three out of 17). The mean GFD-KS score was seven points out of 17 (41%), with around 65% of the participants (n=58) having scored above the mean score. The average score for self-reported adherence to gluten-free diet (CDAT) was 13.3±4.1 (ranged between 7-24). Majority of the participants were classified as adequate (good) adherence to GFD (n= 50, 56%) (Figure 2). No associations were found between knowledge of CD and adherence to GFD (p=0.490) or knowledge of GFD and adherence to GFD (p=0.423) (Figure 3).

Factors associated with the adherence to GFD

Table 3 represents the factors that may be associated with the adherence to GFD. Participants who discussed GFD with a health care provider (e.g., dietitian) were more adherent to the GFD compared to those who did not (p=0.034) (Table 3). Patients who did not receive educational materials, such as starter packs, food list, educational brochure, etc., were more adherent to the GFD compared to those who did (p=0.010). More than half of the participants (66%) reported that they had never included a gluten food into their diet since they have been diagnosed with CD and they were more adherent to the GFD compared to those who reported daily, weekly, and monthly ingestion of gluten (p<0.001). Adequate adherence to GFD was observed in patients who found that GFD had a similar taste to non-gluten-free items compared to participants who had an unpleasant taste with GFD (p=0.043). Majority of the participants (88%) who adhered to GFD reported that they felt different after following GFD (p=0.003).

DISCUSSION

Different variables have been explored as factors influencing adherence to GFD, including knowledge of CD

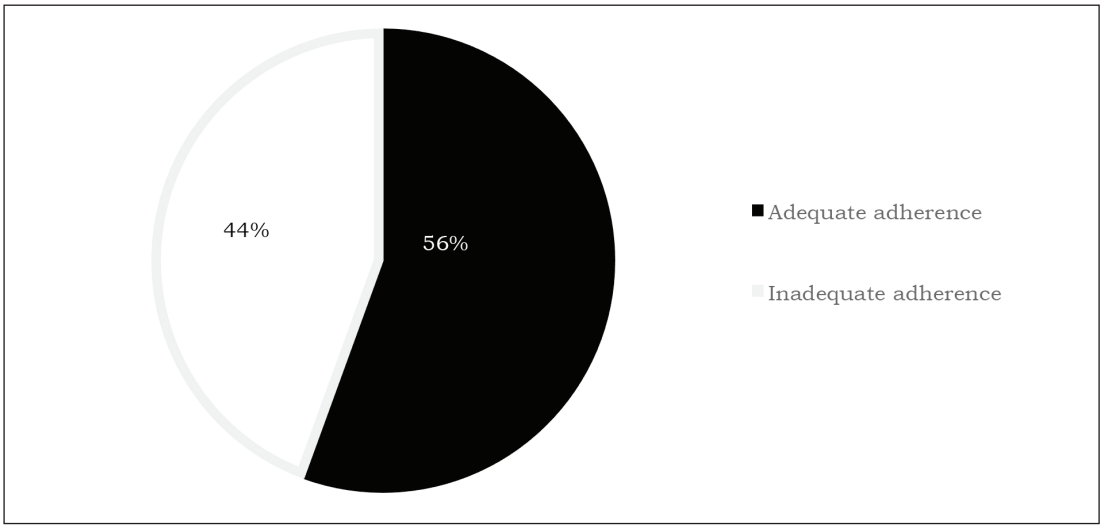

Figure 2. Adherence to gluten-free diet (GFD) using the coeliac disease adherence test (CDAT) in patients with coeliac disease (n=90). Adequate adherence to GFD was considered as CDAT scores ≤13 and inadequate adherence to GFD was considered as CADT scores >13.

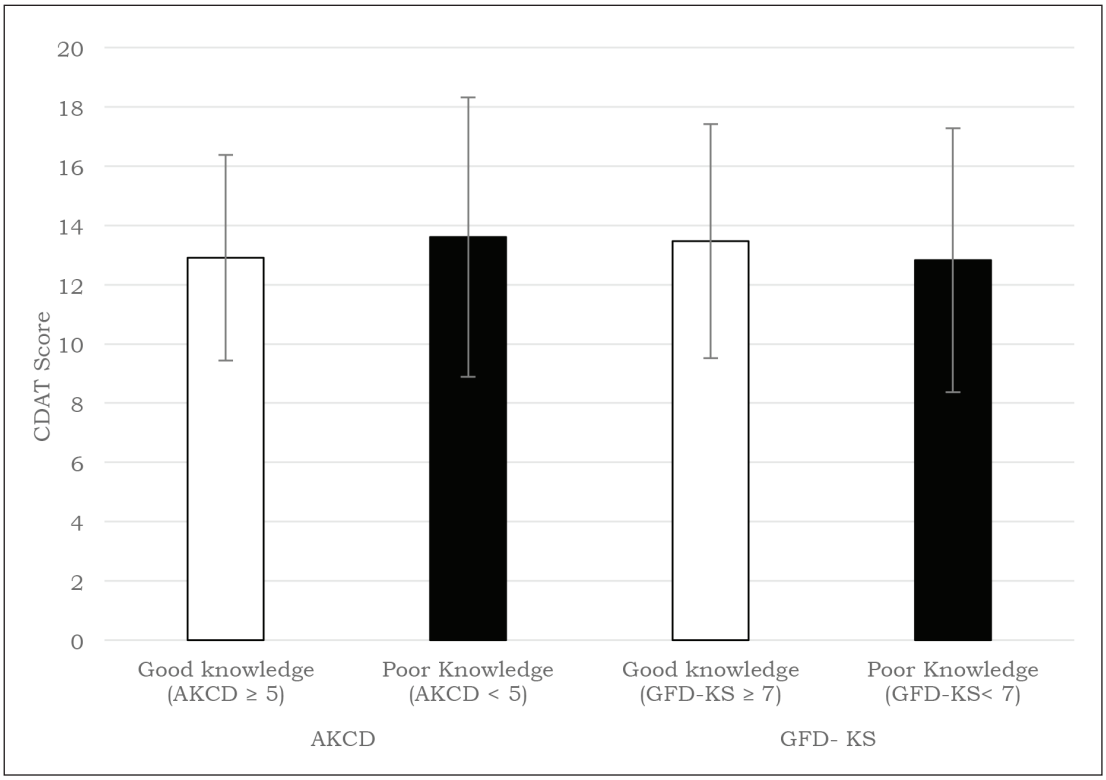

Figure 3. Associations between assessment of knowledge of coeliac disease (AKCD) and gluten-free diet knowledge scale (GFD-KS) with adherence to gluten-free Diet (CDAT) in patients with coeliac disease (*n*=90). Lower CDAT scores reflect higher adherence to a gluten-free diet (GFD). Results are presented as mean±*SD*.

and GFD (Abu-Janb & Jaana, 2020; Butterworth *et al.*, 2004; Kurppa *et al.*, 2012; Villafuerte-Galvez *et al.*, 2015). In this study, self-reported adherence to GFD was found in 50 adult patients with CD (56%), but no association was obtained between knowledge of CD and GFD with adherence to GFD. However, the present study indicated that other factors played a role in influencing the adherence to GFD in patients with CD such as discussing GFD with a specialist (registered dietitian), obtaining educational materials, perceived effectiveness of GFD, self-effectiveness (frequency of gluten ingestion), and the taste of GFD.

The current study found that study participants had adequate knowledge about CD (five points out of seven, 71%). On the other hand, the mean GFD-KS score was seven points out of 17 (41%), which was not different than other study (Silvester *et al.*, 2016). The knowledge of CD and GFD could be attributed to patients being a part of advocate or social support groups in which patients have the opportunity to frequently obtain information related to their condition, as the current study found that 63% of respondents were part of support groups or following advocate accounts though social media. In addition, the average duration of the disease among the study participants was five and a half years, which is considered as an adequate duration for a patient to be knowledgeable about the disease

Table 3. Factors that may influence the adherence to gluten-free diet in patients with coeliac disease (*n*=90)

Factors that may influence GFD adherence	*Factors that may influence GFD adherence*				*CDAT score (mean±SD)*		*p-value t-test*
	Yes		*No*		*Yes*	*No*	
	n	*%*	*n*	*%*			
At the time of your diagnosis, what was discussed at your consultation with your hospital doctor? †							
Explained what coeliac disease was	50	55.5	40	44.4	13.4±4.4	13.1±3.7	0.707
Told me to follow a strict gluten-free diet	59	65.5	31	34.4	13.1±3.8	13.1±4.7	0.616
Referred me to a dietitian	45	50.0	45	50.0	13.2±4.1	13.4±4.2	0.819
Arranged a follow-up appointment	31	34.4	59	65.5	13.9±4.2	13.3±4.1	0.919
Gave written information	17	18.8	73	81.1	12.6±1.0	13.4±0.5	0.538
Were you satisfied with the information given?	73	81.1	17	18.8	13.0±0.5	14.2±1.0	0.263
If you were referred to a dietitian, what advices were you given? †							
Explained the diagnosis and the reasons for the diet	34	37.7	56	62.2	12.6±0.7	13.7±0.5	0.199
Discussed a gluten-free diet	50	55.5	40	44.4	12.4±0.6	14.3±0.6	0.034
Provided an information pack (containing diet sheet, food list, starter packs)	41	45.5	49	54.4	14.5±4.1	12.2±3.9	0.010
Discussed the coeliac society and local groups	8	8.8	82	91.1	13.5±1.5	13.2±0.5	0.861
Discussed the prescribing of gluten-free products	24	26.6	66	73.3	13.6±0.8	13.1±0.5	0.677
A follow-up appointment was made	25	27.7	65	72.2	13.9±0.8	13.0±4.3	0.331
Given a contact telephone number for advice, if needed	7	7.7	83	92.2	13.0±1.7	13.3±0.6	0.904
Were you satisfied with the information given?	78	86.6	12	13.3	13.2±4.1	13.9±1.9	0.586
Do you think the dietician should play an important role in the long-term management of coeliac disease?	77	85.5	13	14.4	13.3±0.5	12.8±3.7	0.677
I'm a part of an online support group for coeliac patients?	57	63.3	33	36.6	12.8±0.5	14.0±0.7	0.176
How many times you include gluten food in your diet?							
Never	60	66.6			11.9±3.6		<0.001
Once a month	17	18.8			14.7±0.9		
Once a week	8	8.8			16.9±1.3		
Daily	5	5.5			18.6±1.6		
What are the difficulties you face when following gluten free diet? †							
I don't understand what foods I can and cannot eat	14	15.5	76	84.4	13.5±1.3	13.2±0.5	0.858
I don't have the time to prepare different meals	39	43.3	51	56.6	14.1±0.7	12.6±0.6	0.088
Gluten-free foods have an unpleasant taste	40	44.4	50	55.5	14.3±0.6	12.5±0.6	0.043
Gluten-free foods are expensive to buy	65	72.2	25	27.7	13.1±0.5	13.6±0.8	0.685
My General Practitioner does not prescribe sufficient amounts of gluten-free	17	18.8	73	81.1	14.6±1.0	12.9±0.5	0.173
I don't feel any different on a gluten-free diet	10	11.1	80	88.8	9.9±1.3	13.8±0.4	0.003
I don't understand the labelling on foods	10	11.1	80	88.8	14.9±1.1	13.0±4.0	0.146

†Participants were asked to choose more than one relevant answer.

and how to manage its symptoms by following the treatment. Not to mention that 79% of the study population had a consultation regarding GFD treatment from a dietitian. Additionally, majority of the respondents expressed satisfaction with the information they have received from both their primary physician and the dietitian.

A number of studies have assessed the adherence to GFD in children with CD in Saudi Arabia (Saadah, 2011; Safi, 2019; Sarkhy *et al.*, 2015). However, limited studies have assessed the adherence to GFD and its relation to knowledge on CD and GFD. More than 50% of the participants were adhering to GFD in this study. The prevalence of adherence to GFD varies in the literature, ranging from 42-91% (Hall *et al.*, 2009). The varying changes could be explained by the use of different methods in assessing adherence (serology versus self-reported) and the tools used to assess self-reported adherence to GFD. The result of the current study was not different than the literature. Knowledge on CD complications may be a factor that make patients understand the consequence of not adhering to GFD, which consequently improves the awareness and adherence to GFD. However, the current study did not observe any association between knowledge and adherence to GFD. This result was not consistent with a previous study conducted in Italy, which investigated the association between knowledge of CD and GFD with adherence to the diet in adults with CD (Paganizza *et al.*, 2019). The Italian study had no validated instrument for that purpose; the authors developed an instrument to assess the knowledge of CD and GFD via a collaboration between a gastroenterologist and a dietitian with expertise in GFD. The study found that knowledge of CD and GFD was strongly associated with adherence to GFD (Paganizza *et al.*, 2019). Possible reasons for the inconsistency in results between the current study and the Italian study were the sample size and the duration of the disease. Also, the average duration of the disease was 5 years in the current study compared to a duration of 10 years in the Italian study (Paganizza *et al.*, 2019).

Previous studies have explored various factors associated with the adherence to the GFD such as the taste and cost of GFD (Butterworth *et al.*, 2004; Kurppa *et al.*, 2012; Leffler *et al.*, 2008; Paganizza *et al.*, 2019; Villafuerte-Galvez *et al.*, 2015). Our findings were broadly consistent with other literature on self-effectiveness (the frequency of gluten ingestion) as a factor related to GFD among white Caucasian and South Asian patients (Butterworth *et al.*, 2004). Additional factors, such as the perceived effectiveness of GFD, was also indicated in previous study findings (Villafuerte-Galvez *et al.*, 2015). In addition, the unpleasant taste was observed to be a significant factor associated with a lower likelihood of following the GFD. This finding was reported in various studies in different countries; therefore, numerous studies have been conducted to enhance the taste of processed gluten-free products (Mazzeo *et al.*, 2014; Muhammad *et al.*, 2017; Padalino, Conte & Del Nobile, 2016). Furthermore, there was no significant positive association between the cost of GFD and adherence to GFD, as shown in a previous study (Villafuerte-Galvez *et al.*, 2015). Around 70% of the respondents reported that GF foods being expensive as one of the difficulties they faced when following GFD, but this did not influence their adherence to GFD.

The findings of the current study showed the influence of healthcare providers, especially registered dietitian on the adherence to GFD. Registered dietitians have remarkable responsibilities in teaching the gluten-

free diet to patients with CD, including reading food labels, cooking skills, and providing written materials. One unanticipated finding of the current study was that patients who did not receive educational materials about GFD, such as diet sheet, food list, starter packs, from their general practitioner were more adherent compared to those who did. This could be attributed to the influence of educational materials and sessions that were provided by the Coeliac Association (Paganizza *et al.*, 2019).

Two main limitations of the current study need to be reported. Firstly, majority of the patients were female. However, this limitation is overcame by the fact that CD is more common in females than males with an occurrence ratio of 2:1. Secondly, the serology test to assess adherence to GFD was not collected because majority of the participants did not follow-up with their primary physician for more than three to six months. Therefore, a serology test did not reflect the current adherence to GFD.

CONCLUSION

In conclusion, no association was found between knowledge of CD and GFD with the adherence to GFD among adult patients with CD. Factors influencing adherence to GFD were: discussing GFD with a specialist, obtaining educational materials, enhance symptoms associated with CD, and the taste of GFD. Further research is needed to explore other potential factors related to the adherence to GFD.

Acknowledgement

The authors would like to thank the participants for their time and contribution towards the study. This project was supported by Princess Nourah bint Abdulrahman University Researchers Supporting Project number (PNURSP2023R207), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

Authors' contributions

Alorayyidh N, designed research, conducted research, led data collection, analysed data, wrote the manuscript; Alswaji MH, Almujammamy E & Alhujairy B, conducted research, collected the data, and wrote the first version of the manuscript; Benajiba N & Alzaben AS, led data collection, analysed data and data interpretation, assisted in drafting of the manuscript, reviewed the manuscript and supervised the whole study. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no potential conflicts of interest.

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Mal J Nutr 29(1): 063-075, 2023

Government-Industry-Academia Alliance: A multi-sectoral collaboration for improved nutrition of children and well-being of mothers

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Abstract

Introduction: Consistent with the Sustainable Development Goal 17 highlighting partnership to achieve development, this study demonstrated the convergence among government, industry and academe in carrying out a nutrition intervention to improve the nutritional status, knowledge, attitude and behaviour of school community (school children and mothers). **Methods:** A school-based intervention study comprising of school lunch feeding and nutrition lessons was conducted. Quasi-experimental design was used in the intervention research. Data were analysed using Stata 12.0. Descriptive statistics were generated using the survey module (svy) of Stata. The food and nutrition intervention mix composed of the government-partner School Feeding Programme (SFP) and the nutrition education campaign. The government-partner SFP involved lunch feeding of 7 to 9 years old students based on the standardised *Pinggang Pinoy*® recipes. The government-partner nutrition education component involved teaching of the developed modules to students and their mothers. **Results:** The intervention resulted in improvements in nutritional status, knowledge, attitude and behaviour of students. Investing an average of Php 15.00 or USD 0.29 (as of 2017) in a school feeding programme following the government-partner food and nutrition intervention mix improved nutritional status and shifted the number of underweight children to normal nutritional status by 25.3% after 120 feeding days. This intervention was implemented through a multi-sectoral collaboration during the pre-implementation, implementation, and post-implementation phases of the study. **Conclusion:** Partnerships among stakeholders provided the context towards healthier children as demonstrated by improved nutritional status, knowledge, attitude and behaviour of participants.

Keywords*:* Filipino school children, multi-sectoral collaboration, nutrition, partnership, school feeding programme

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doi: https://doi.org/10.31246/mjn-2022-0019

INTRODUCTION

Goal 17 of the Sustainable Development Goals (SDGs) accentuates the value of partnership to achieve sustainable development. A successful sustainable development agenda requires partnerships between government, the private sector, academe, and civil society. According to the United Nations (UN, 2015), these inclusive partnerships built upon principles, values, a shared vision and goals placing people at the centre, are needed at the global, regional, national, and local levels.

It is increasingly recognised that achieving effective health outcomes requires approaches that extend beyond the provision of health services. As a result, there has been a call for the health sector to work across sectors to effectively address health challenges, a concept referred to as inter-sectoral collaboration (Barr *et al.*, 2008; De Leeuw, 2017). Inter-sectoral collaboration for health has been defined as "a recognised relationship between part or parts of the health sector with parts of another sector which has been formed to take action on an issue to achieve health outcomes (or intermediate health outcomes) in a way that is more effective, efficient or sustainable than could be achieved by the health sector acting alone" (Adeleye & Ofili, 2010).

Recent studies have described the processes of multi-sector coordination in various countries and identified the challenges and key factors for successful coordination. A five-country study showed that differences in institutional mandates leading to lack of sound coordination mechanisms, and dissent among mid-level actors in formulating and agreeing upon different intervention strategies are common barriers. However, these challenges can be addressed through leadership, defined roles and responsibilities, and individual and strategic capacity (Pelletier *et al.*, 2012). On the other hand, qualitative institutional study of national policy-making in four Sub-Saharan African countries observed that policies and agencies that have cross-sectoral scope do not usually fit the sectoral pattern of resource allocation, thus the ministries may view themselves as in competition with each other (Benson, 2008). High-level political support and processes that bring together a wide variety of stakeholders (Garrett & Natalicchio, 2011), as well as shared vision, capacity strengthening, joint accountability, and supervision (Ved & Menon, 2012) are critical for multi-sector convergence. However, there are limited literatures on how convergence is made operational to ensure effective service delivery.

Chronic malnutrition, including stunting, is an important example of a global challenge that needs multiple sector partnership. Globally, undernutrition, including vitamin and mineral deficiencies, contributes to about 45% of deaths among children, and impairs healthy development and life-long productivity (WHO, 2018).

In a study by the Department of Science and Technology-Food and Nutrition Research Institute (DOST-FNRI) and Save the Children in 2013, Php 328 billion or 2.84% of the Gross Domestic Product was lost due to child undernutrition, while around Php 1.23 billion was lost due to stunting-related grade level repetition brought about by frequent absenteeism and repetition of subjects (Save the Children, 2016). The joint study of the United Nations Children's Fund (UNICEF) and the Department of Health—National Nutrition Council (DOH-NNC) using the DOST-FNRI data showed that child stunting, iron deficiency anaemia (IDA), and iodine deficiency disorder (IDD) accounted for the highest economic

losses, which is more than $3 billion per year (UNICEF, 2017).

Addressing malnutrition requires a strong focus on governance, involving coordinated actions by many actors across sectors and levels of government. This paper aimed to demonstrate how multiple sectors converged to examine the benefits of various strategies in improving the nutrition of 7 to 9 years old children (Grades 2 to 3) and the well-being of their mothers in nine (9) selected schools in the municipalities of Bay and Calauan, Laguna in the Philippines, through the provision of a school-based feeding and nutrition intervention mix.

MATERIALS AND METHODS

This paper was part of a larger mixed-method research on Forging Public, Industry Society Alliance – A Programme United for Healthier Kids, intended to improve the nutrition and well-being of selected school children and nutrition knowledge of their mothers.

The operational framework of the study was based on the Input-Process-Output-Outcome System Approach (Figure 1), highlighting the three-pronged partnership between the Government (DOST-FNRI), Academe (Department of Education), and Industry (Nestle Philippines, Inc.) for the well-being of the School Community (school children and mothers). This three-pronged partnership was based on the Triple Helix Model of University-Industry-Government Relations developed by Henry Etzkowitz & Loet Leydesdorff (1998).

The INPUT consisted of contributions from the main partners such as technical resources from the government partner and logistics from the industry partner. The PROCESS of the system approach centred on the actual implementation of the plan through selected public elementary schools, with the academe as the third partner, to improve the nutritional status of school children and knowledge in nutrition of mothers. The OUTPUT of the research process consisted of the tangible results of the PROCESS to achieve the OUTCOME, which pertains to the improvement of nutritional status among school children and nutrition knowledge of their mothers in the selected schools.

The approach of the PROCESS (Figure 1) included the translation of the *Pinggang Pinoy*® Kid's Plate into adequate meals, Recipe Development, Nutrition Education Campaign, and Evaluation Research.

The *Pinggang Pinoy*® Kid's Plate is a food plate for children with colour-coded portions representing the different food groups. The plate serves as a guide in achieving adequate and well-balanced meals for school children aged 7-9 years old. It also provides consumers, especially the mothers with simple graphic recommendations showing the proper portions of foods. It uses a food plate model, which is simple and understandable, to convey the concept of eating a variety of foods in the right proportions to meet the body's energy and nutrient needs.

Translation of *Pinggang Pinoy*® into Kid's Plate

The *Pinggang Pinoy*® Kid's Plate was translated into adequate meals for the target group of 7-9 years old. A nutritionally adequate four-week cycle menu was developed, consisting of easy-to-prepare and commonly consumed dishes fit for 7-9 years old. The nutritional adequacy of the four-week cycle menu was computed and cross-checked against the Philippine Dietary Reference Intake for children 7-9 years old. Trial cooking, visualisation, and validation of the actual weight of the food per meal was also done to check on its suitability for a child's consumption.

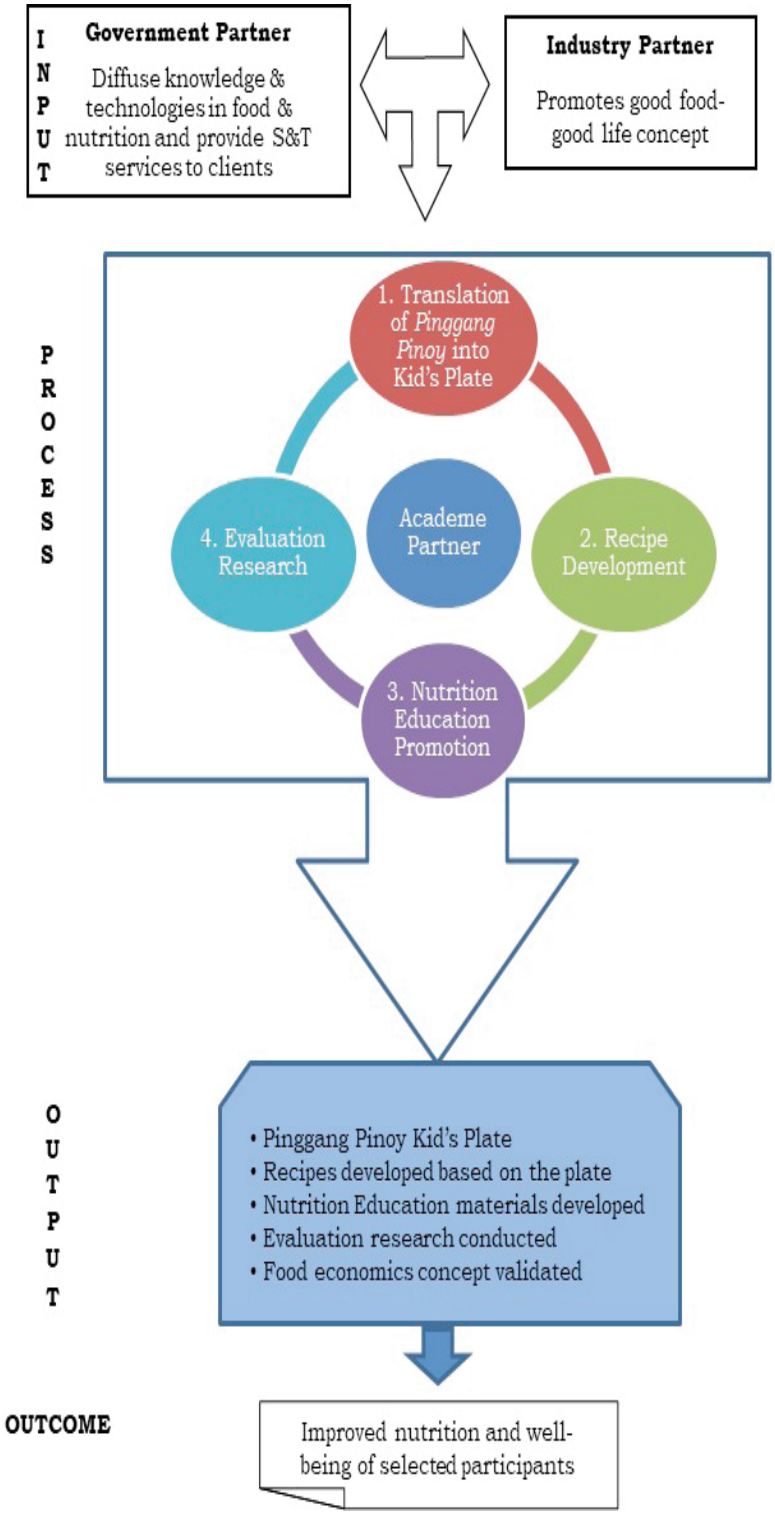

Figure 1. Operational framework of the study

Recipe development

The Recipe Development component of the programme translated the *Pinggang Pinoy*® proportion for 7 to 9 years old school children to nutritious recipes for the School Feeding Programme. Recipes underwent two trials of recipe testing and passed the acceptability test using a nine-point hedonic rating scale. In addition, the recipes were developed within the concept of food economics by optimising the nutritional value of foods to meet a part of the daily energy and protein requirements. It considered the availability, accessibility, taste, cultural acceptability, and affordability by targeting a raw food cost of PHP15.00 per meal (USD 0.29 per meal, as of 2017). A total of twenty (20) meals or twenty-seven (27) recipes were developed and rated acceptable. An assortment of pasta (five), fish (seven), chicken (six), and *tokwa* or soybean curd (two) made up the meals. Each meal consisted of viand, ¾ cup white rice, and one piece banana - *señorita*, a banana variety common in the project area.

Development of nutrition education materials

For the Nutrition Education component, a workshop was held among selected Nutritionist-Dietitians from the government partner and teachers from the academe to develop a comprehensive nutrition education module that was aligned with the Philippines's current K-12 curriculum. A total of five (5) nutrition education modules were developed with key messages on:

1) Go, Grow and Glow + Water/ beverage in every plate (*Pinggang Pinoy*);
2) Eat fruits and vegetables of varied colours (the colourful plate);
3) Consume various kinds of protein sources;
4) Consume more nutrient-dense sources of energy; and
5) Drink recommended glasses of water and complement it with nutritious beverages.

The developed nutrition education modules for Grades 2 and 3 students were pre-tested among teachers based on the indicators of attractiveness, comprehensibility, acceptability, and self-involvement (ACAS). Likewise, the modules were assessed for sufficiency and adequacy as materials for the conduct of nutrition education classes. Teachers from the selected schools comprising the intervention group also underwent training on "Teaching Nutrition for Healthier Kids".

Evaluation research

The improvement in nutritional status of the school children and their mothers was measured through an Evaluation Research that used the quasi-experimental design. The school children were categorised into four groups: three intervention groups and one non-intervention. The two types of interventions implemented were: 1) School feeding using government partner-developed recipes based on *Pinggang Pinoy*® given during lunch time; and 2) Nutrition education using government partner-developed modules among children and their mothers/ caregivers. Three schools were provided with feeding only (Feeding Only group); two schools received nutrition education only (Nutrition Education Only group); two schools were given both types of interventions (Complete Intervention group); and another two schools did not receive any intervention from the government partner (Non-Intervention group), instead they continued with their regular school-based feeding programme (SBFP) implemented by the academe.

For the evaluation component, a total of 385 underweight children and their mothers/caregivers were recruited and

included in the study groups mentioned. The interventions provided to children (feeding and nutrition education) and their mothers/caregivers (nutrition education) were assessed in terms of attaining good nutrition. The schools were assigned to the different groups and received the designated intervention.

The industry partner assisted in the conduct of the School Feeding Programme (SFP) by outsourcing their team members to be in charged of the marketing, preparations, cooking, and distribution of cooked meals for 120 days. The academe partner on the other hand were involved in the implementation of the school-based nutrition education sessions to selected school children and their mothers.

Descriptive statistics, such as means and percentages, were generated using the survey module (svy) of Stata. Data were analysed using Stata Statistical Software: Release 12 (StataCorp LP, College Station, Texas, USA). A written informed consent was obtained from all the participants of this study through their mother or guardian. Ethical clearance and approval prior to project implementation was provided by the FNRI Institutional Ethics Review Committee.

RESULTS

This study demonstrated the collaboration between the government partner, the industry partner, and the academe to improve the nutrition, knowledge, attitude and behaviour (KAB) of 7-9 years old school children and knowledge of their mothers in nine (9) selected schools in Bay and Calauan, Laguna, Philippines through the provision of a school-based food and nutrition intervention mix.

Pre-implementation collaboration

The collaboration among the partners started in the pre-implementation stage with consultations at various levels. Specifically, the consultation with the industry partner was conducted in 2016 for the development of key messages in the nutrition modules, along with the formatting and printing of all nutrition materials. On the other hand, consultations with the academe focused on threshing out concerns in the actual implementation of the nutrition intervention mix.

Translation of Pinggang Pinoy® for kids into adequate meals

Recipe testing showed that the amount of vegetables may not be totally consumed by 7 to 9 years old children based on comments from sensory panelists. Hence, two tablespoons were reduced in the amount of vegetables, without significant effect to the caloric content of the meal.

Recipe development based on the Pinggang Pinoy Kid's Plate

The meals contributed an average of 22% and 36% of the recommended intakes for energy and protein, respectively, for 7 to 9 years old children. The average vitamin A and C contents of the meals were adequate, contributing 81% and 40% of the daily requirements, respectively. On the other hand, the average calcium and iron contents of the meals were below 1/3 of the recommended daily intakes, signifying the need for consumption of milk and other mineral-rich food sources to supplement the meal.

The recipe cost ranged from PHP12.00 (USD 0.23) to PHP15.00 (USD 0.29). Moreover, the original four-week cycle menu (20 meals/27 recipes) was reduced to a three-week cycle menu (15 meals/21

Table 1. Mean scores on knowledge, attitude and behaviour (KAB) of children at baseline and endline

Period	*Intervention groups*			*Non-intervention*	*p-value*
	Feeding only	*Nutrition education only*	*Complete intervention*		
Knowledge					
Baseline	14.07±4.49	13.71±4.27	13.59±4.53	14.60±5.21	0.490
Endline	16.90±4.06	16.63±4.13	17.47±5.33	16.71±3.68	0.590
p-value (base-end)	<0.001	<0.001	<0.001	<0.001	
Attitude					
Baseline	64.01±6.65	63.31±7.74[a]	63.37±7.60[b]	66.53±6.63[ab]	0.010
Endline	66.54±6.70	64.87±7.73	65.84±8.38	66.17±7.76	0.540
p-value (base-end)	<0.001	0.110	0.050	0.640	
Behaviour					
Baseline	54.96±6.11[a]	56.42±5.10[b]	55.69±7.28[c]	60.07±5.48[abc]	<0.001
Endline	58.25±6.11	56.76±5.72	58.55±4.73	58.98±5.73	0.059
p-value (base-end)	<0.001	0.648	<0.001	0.109	

[a, b, c] Intervention Groups of the study
[ab] Mean score of children in Non-intervention is significantly higher than Nutrition education only and Complete intervention (Feeding and Nutrition Education)
[abc] Mean score of children in Non-intervention is significantly higher than the Intervention Groups

recipes) as seven recipes were excluded from the cycle menu due to difficulty in preparation, cooking, and transporting. In addition, all recipes received high scores with a mean overall liking of 4.3 to 5, which roughly translated to *"medyo gusto"* (like) to *"gustung-gusto"* (like very much).

Recipes that received a perfect hedonic rating of five, such as chicken *afritada*, (a type of Filipino chicken stew with tomato-based sauce, potato, carrots, and bell pepper), fried chicken, chicken spaghetti, and chicken *tinola* (a Filipino soup dish with chicken pieces and vegetables in ginger broth), signified that children preferred dishes that were simpler to prepare and more familiar to them. In contrast, uncommon and newly-introduced recipes such as *tokwa* (tofu) steak, squash soup with *saluyot* (Egyptian spinach), and stir-fried *toge* (mongo sprout) and carrots received the lowest scores.

Nutrition education modules and sessions

School children were exposed to nutrition education topics such as proper nutrition and correct food perceptions through 25-minute sessions totalling to 60 hours, as recommended by Perera *et al.* (2015) to exhibit behavioural change. The nutrition education sessions among Grades 2 and 3 students of the four selected schools lasted for seven months, while nine (9) separate sessions were conducted among mothers and caregivers of these children. Among the exercises and activities in the modules, the easiest and most liked by the students were drawing, colouring, word search, games, singing, and dancing.

Furthermore, the nutrition education modules appeared as very useful aid in teaching proper nutrition and good food habits to school children. Incorporating strategies and materials, such as storytelling, games, and group activities, beyond the conventional lectures were

Table 2. Mean scores on knowledge, attitude and behaviour (KAB) of mothers at baseline and endline

Period	*Intervention Groups*			*Non-intervention*	*p-value*
	Feeding only	*Nutrition education only*	*Complete intervention*		
Knowledge					
Baseline	31.65±7.14	32.87±5.90	33.11±6.29	32.07±6.95	0.450
Endline	32.88±6.66[a]	34.04±5.87	35.94±6.63[a]	33.88±5.79	0.020
p-value (base-end)	0.050	0.020	<0.001	<0.001	
Attitude					
Baseline	105.15±8.94	106.47±7.24	106.00±8.15	105.26±9.54	0.720
Endline	105.12±9.23	106.55±7.71	107.65±8.22	107.12±7.80	0.220
p-value (base-end)	0.960	0.910	0.040	0.060	
Behaviour					
Baseline	87.18±10.17	89.13±8.91	86.33±9.46	88.25±10.23	0.265
Endline	86.43±10.76	86.66±9.22	88.63±9.29	86.47±9.67	0.401
p-value (base-end)	0.476	0.036	0.036	0.071	

[a] Mean score of mothers in Complete intervention (Feeding and Nutrition Education) is significantly higher than mean score of mothers in Feeding only

found to be effective in encouraging participation, promoting information and retention of lessons among children.

Implementation

Multi-sector collaboration was evident during the implementation of food and nutrition intervention mix, which was composed of the government partner's SFP and the nutrition education campaign. The school feeding programme involved feeding 7 to 9 years old students with standardised *Pinggang* Pinoy® recipes during lunch. On the other hand, the nutrition education component involved the teaching of the government partner's developed nutrition education modules to students and their mothers or caregivers. The industry partner also assisted in managing the provision of school lunch feeding by outsourcing a team who shopped for the needed raw materials, prepared the dishes, and served the food to the school children.

Evaluation of the intervention

The evaluation research conducted by the government partner aimed to document the effectiveness of the intervention on the nutritional status of the school children and changing behaviour of the children and mothers. Overall, the complete intervention (government partner feeding and nutrition education) had been effective in increasing the KAB scores among children and mothers (Tables 1 and 2).

Children in all study groups had significant improvement in their mean scores on knowledge from baseline to endline, but greater improvement was seen in study groups with nutrition education. In terms of attitude, children in the intervention groups showed increases in their mean scores from baseline to endline, with the Feeding Only group having significant result. Mean scores on behaviour of children in the intervention groups increased from baseline to endline but were only significant in the Feeding Only and Complete Intervention study groups.

Comparing between groups, the mean attitude score of children in the non-intervention group was significantly higher than the Nutrition Education

Table 3. Proportion of underweight school children at baseline and endline

Period	*Intervention groups*			*Non-intervention*	*p-value*
	Feeding only	*Nutrition education only*	*Complete intervention*		
Weight-for-age Underweight (%)					
Baseline	100.0	100.0	100.0	100.0	-
Endline	83.3	84.3	74.7	76.4	0.300
p-value (base-end)	<0.001	<0.001	<0.001	<0.001	

only and Complete Intervention groups; while the mean behavior score of children in the non-intervention group was significantly higher than all the intervention groups.

At baseline, mothers in the Complete Intervention study group had similar mean scores on knowledge. At endline, the Complete Intervention group obtained the highest mean score among study groups and it was significantly different compared with the Feeding Only group. The mean scores on attitude among mothers increased from baseline to endline; however, only mothers in the Complete Intervention group exhibited significant increases. In terms of behaviour, only mothers in the Complete Intervention group exhibited an increase in mean score from baseline to endline.

Comparing between groups, the mean knowledge score of mothers in the Complete Intervention group was significantly higher than the mean score of mothers in the Feeding Only group. On the other hand, the Complete Intervention group had the highest percentage of children shifting from underweight to normal nutritional status (25.3%) from baseline to endline (Table 3).

DISCUSSION

Multi-sector collaboration may be considered as a process towards achieving higher efficiency, quality, coverage, and effectiveness. According to FAO (Food and Agricultural Organization) (2013), the fight against hunger can only be won in partnership with the government and other non-state actors, among which they all have fundamental roles to play. In our paper, we focused on the triad partnership as a process in service delivery, with the ultimate vision of a holistic approach to improve the nutrition and well-being of children.

Undernutrition among children was identified as the main nutritional problem at the start of the project. This problem was considered to be further aggravated by challenges in the capacity and capability of mothers and caregivers to take care of their children and provide nutritious meals for the family. The Philippines has taken various actions involving inter-sectoral collaboration in response to these challenges as stipulated under the Philippine Plan of Action for Nutrition 2017-2022 (NNC, 2017).

The partners: government, industry, and academe concurred that improving maternal and child health and nutrition is a shared goal and the joint responsibility of the three sectors. Thus, in a pilot study to demonstrate this shared goal, it was found that a mixed programme of school lunch feeding and nutrition education, led to a considerable higher change in mean weight among child participants. This evidence confirmed the effectiveness of the intervention, only when both school lunch and nutrition education were provided to the children.

As a joint effort and responsibility of the three sectors, several mechanisms were put in place to facilitate regular coordination and collaboration such as monthly and quarterly meetings to update and monitor of the programme activities that were convened by the government partner as the lead programme proponent. Within these different meetings and activities, well-positioned leadership (or champions) have been identified as a key facilitator for convergence. However, there was limited joint planning and coordination due to demands arising from the core sector priorities, particularly that of the academe, where nutrition is not part of the curriculum of elementary school children.

In the present study, strategic alliances forged between the three sectors enabled them to gain competitive advantage through access to partner's resources, including technical matters, technologies, capital and human resources. Team efforts in this study strengthened complementarities in terms of resources and capabilities, enabling participants to grow and expand more quickly and efficiently. In the process, it became time-saving and boosted productivity by not having to develop their own resources from scratch.

The government partner was intended to be the site of planning, training capacity building and supervision; the industry partner through a third party player was the site of support in the implementation of the school-based feeding; while the academe partner was the site of service delivery and support in conducting nutrition education classes and feeding the children. Our findings concur with results from another field study of various sites in India that highlighted needs for nutrition-focused outreach to families and more structured collaboration between health and nutrition (Bajpai & Dholakia, 2011). Government and private sectors in India, just like in the Philippines, worked toward a common goal to reduce infant mortality, which facilitated coordinated actions and effective programme implementation (Menon *et al.*, 2016). In the present study, coordinated functioning between the three partners may be a result of understanding of their tasks, guided by protocols, advisories, and formal agreements. For example, in the case of the academe partner, head of schools and concerned teachers were oriented and made aware of the responsibilities of each in the delivery and conduct of nutrition education classes to children, while the manpower contracted by the industry partner were guided by the written protocols and food safety regulations in the administration of the school-based feeding among children.

In this study, the three partners valued working together and realised their interdependent roles in delivering the services. However, inadequate or unbalanced incentives (e.g., teachers were not paid for extra effort given in preparing the nutrition education classes) and work roles (e.g., additional load to teachers in integrating nutrition lessons as part of the curriculum, and in ensuring that children will attend the regular feeding sessions) may exhaust or wear them leading to resentment as in the case of several community workers' experiences in integrated service delivery (Mishra, 2014).

Mutual respect, support and understanding of each partner's responsibilities is critical in achieving a shared goal, which in this case, was improving the nutritional status and knowledge of school children and nutrition knowledge of mothers/ caregivers. The academe issued clear guidelines and ensured that each teacher was given proper recognition

for the work delivered. Similarly, in the present study, the government partner and academe partner provided the teachers with certificate of appreciation and recognition for their participation in the joint project.

The study can be considered as a concrete example of an application of Goal 17 of the SDGs referring to Partnerships for the Goals. The SDGs can only be realised with a strong commitment to partnership and cooperation. In the present study, without adequate and sustained support from all the partners, the goal of improving the nutritional status and KABs of children and their mothers may not have been achieved.

One of the limitations of this study was that it was conducted in a purposively selected province; therefore, the results was not representative of the entire region. Nevertheless, our study findings may contribute to the growing evidence on multi-sector convergence processes and hold relevance for other countries committed to scaling up nutrition interventions, where coordination has been identified as a major challenge (Gillespie *et al.*, 2013).

CONCLUSION

This paper demonstrated the significance of convergence and partnerships among key stakeholders, such as government, industry, and academe, in facilitating the development, implementation, monitoring, and evaluation of a nutrition intervention to benefit school children and their mothers.

Effective partnership between the public and private sectors rely on various factors for improved multi-sector actions and positive outcomes. The findings of our study highlighted the recognised mandate for convergence for health and nutrition in the form of shared values and guidelines at the agency level, understood and articulated by the leadership in both sectors. As such, each of the partners in this study had performed specific priority actions, which contributed in the efficient implementation of the nutrition intervention.

This paper confirmed that the *Pinggang Pinoy*® can be adopted as the basis for school feeding programmes, and that the Nutrition Education Modules developed for this study can serve as educational materials for teaching about nutrition, food and health among children in Grades 2-3. Based on the results, the intervention that combined the government partner's school lunch feeding and nutrition education sessions would be the most promising option in improving the nutritional status and KAB of students.

The triad partnership between the government, industry and academia could be continuously adopted as an effective approach to improve the nutrition and KAB of selected school children as reflected in the improved weight-for-height *z*-score and shift in the number of underweight children to normal by 25.3% after 120 feeding days.

Successful convergence and partnership among the government, academia, and the industry can result in a "win-win situation," in which every key player in the programme can benefit. This project provided an example of such cooperation. Challenges during programme implementation have been expected, especially when the project was performed on a voluntary basis. However, once it is sustainable, the programme participants will benefit the most.

Acknowledgment

The authors would like to acknowledge the support of Nestle Philippines, Inc. for funding the study. Acknowledgement is given to the Project Team I, led by Ms. Ma. Jovina A. Sandoval for translating the Pinggang Pinoy into adequate meals for children; Project Team II led by Ms. Marietta B. Bumanglag and Mr. Eirene Agustin Arnejo for recipe

development, cycle menu preparation and testing, and providing preliminary comments to improve the manuscript; Project Team III led by Dr. Milflor S. Gonzales and Idelia G. Glorioso for the conduct of the nutrition education module development and intervention, and also for providing preliminary comments in the manuscript; Project Team IV members for leading in the conduct of data collection, analysis and write-up, and Denniese C. Sy for ensuring that all comments have been integrated. Due acknowledgement is also given to the management of the DepEd Sta. Cruz, Bay and Calauan, Laguna, as well as the teachers and students of the nine selected schools for the study.

Authors' contributions

Aguila DV, programme coordinator, conceptualised and designed the entire programme together with the programme leader and project team leads, prepared the draft and final manuscript, reviewed the final manuscript before submission to journal and revised the manuscript based on the comments of reviewers; Dorado JB, conceptualised and designed the study, assisted in drafting of the manuscript, reviewed the final manuscript before submission to the journal; Capanzana MV, provided overall guidance and direction in data analysis and interpretation, proofread the manuscript before submission to the journal.

Conflict of interest

This study was funded by Nestle Philippines Inc. The authors declare no potential conflict of interests in the conduct of the study. The funding agency had no role and involvement in the design of the study and collection, analysis and interpretation of data, and in writing the manuscript.

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Mal J Nutr 29(1): 077-087, 2023

Association of dietary pattern and childhood obesity with cardiovascular disease in patients from Tangail city, Bangladesh

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ABSTRACT

Introduction: Obesity in childhood is a major cause for developing cardiovascular diseases (CVD) at adulthood. The present study was a cross-sectional research aimed to examine the relationship between childhood obesity and dietary pattern with CVD in patients (n=100) from Tangail City, Bangladesh. **Methods:** Dietary patterns, laboratory tests, demographic, and anthropometric interrelated data were measured in patients with stroke and heart attack from five hospitals. The research also used 24-hour recall method and a food frequency questionnaire for assessing daily energy and macronutrient intakes. **Results:** Weight (p=0.004), body mass index (BMI) (p=0.001), mid-upper arm circumference (MUAC) (p=0.009), and waist circumference (WC) (p=0.030) was significantly different between males and females whereas lipid profile was not significantly different between genders. There were no significant associations between intakes of red meat, salt, fast food, fish, egg, nuts and seeds with heart attack and stroke. On the contrary, there were significant associations between fried food intake with heart attack and stroke (p=0.080 and p=0.020). The results indicated that there was a significant relationship between carbohydrate (p=0.001), protein (p=0.001), and fat (p=0.001) intakes with the total energy intake of respondents. The findings also showed that there was a significant relationship between carbohydrate (p=0.003), protein (p=0.001), and fat (p=0.001) intakes with body mass index of the respondents. **Conclusion:** CVD diagnosis in adult patients was found to be associated with fried food intake but not with childhood obesity.

Keywords: body mass index, cardiovascular disease, childhood obesity, dietary pattern, lipid profile

INTRODUCTION

Cardiovascular disease (CVD) is considered as the primary reason for mortality in the world, which alone causes 16% of total global death (WHO, 2017). In 2016, CVD was responsible for 31% of all fatalities worldwide, with stroke and heart attack accounting

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doi: https://doi.org/10.31246/mjn-2022-0063

for 85% of these deaths (WHO, 2020). Nowadays, CVD is a massive interest in the world of epidemiology and needs more attention to mitigate (Roth *et al.,* 2017). In Bangladesh, most people have little knowledge about CVD (Rahman *et al.,* 2018) and the death rate for CVD has increased rapidly (Karar, Alam & Kim Streatfield, 2009) with 17% of total mortality (Islam, Mohibullah & Paul, 2016). About half of the world's adults are overweight and obese, and obesity is a global risk factor for CVD (including high blood pressure, heart failure, coronary artery disease, sudden cardiac death) and cerebrovascular disease (Koliaki, Liatis & Kokkinos, 2019) due to the accumulation of fat within the arteries and an expanded threat of blood clots (Boffa *et al.,* 2019).

Several factors like family history, high blood pressure, fatty diet, diabetes, smoking (Banks *et al.,* 2019), stress (Steptoe & Kivimaki, 2013), alcohol (Zhang *et al.,* 2021), and lack of physical activity can also induce CVD (Thomas & Princy, 2016). Childhood obesity is a notorious threat to adult obesity and later on to the development of CVD and diabetes. The occurrence of obesity among adolescents and children has increased dramatically over the years and this rate is significant in Bangladeshi children (Raut *et al.,* 2014; Bulbul & Hoque, 2014). Dietary pattern, especially excessive amount of calorie intake, can cause obesity and later CVD (Tedstone, Duval & Peacock, 2020). On the contrary, eating whole grain foods (Seal, 2007), nutritious foods (Grossman *et al.,* 2017), and a low amount of salt (Karppanen & Mervaala, 2006) can diminish the dangers of stroke and heart attack.

A lot of research has been done on diet and its relationship with other lifestyle diseases such as obesity and diabetes in others countries, but there are only a few studies about the relationship of diet and childhood obesity with CVD development in the Bangladeshi context. Even though childhood obesity is a major factor in the development of CVD, and a lot of patients are dying from CVD in Bangladesh, yet information about this disease concerning childhood obesity is scarce. In this context, understanding all aspects of CVD epidemiology are essential. Hence, the authors wanted to elucidate the association of dietary pattern and childhood obesity with cardiovascular disease in patients of Tangail city, Bangladesh.

MATERIALS AND METHODS

Study location and study population

This study was conducted at five private hospitals in Tangail city, Bangladesh. The hospitals were randomly selected from 20 hospitals in Tangail city based on convenient sampling of patients with CVD from Tangail city and nearby villages.

Study design and sample size

This was a cross-sectional descriptive study, conducted at the cardiology department of selected hospitals. A total of 100 eligible participants (patients with a history of chest pain, cardiac arrest, and stroke) agreed to be enrolled in the current research and provided all the required information.

Data collection, verification, and questionnaire design

Data collection was done via face-to-face interviews using structured questionnaires, which were prepared by the research team and validated by an expert team. Anthropometric and biochemical data were collected using different tools and hospital lab reports. The questionnaires were checked each day after interviews and re-checked carefully after completion of all data collection.

Assessment of anthropometric measurements

Height and weight of the respondents were collected using weighing balance and measuring tape. Body mass index (BMI) was classified according to the World Health Organization (WHO) regulations (WHO, 2000). A measuring tape (non-elastic) was used for measurement of waist circumference (WC) and hip circumference. The participants' waist-to-hip ratio (WHR) was calculated as the ratio of WC divided by hip circumference. The mid-upper arm circumference (MUAC) was measured using MUAC tape, where subjects were told to bend their left arm, then the olecranon process and the acromion process were located and marked. The midpoint between these two marks was measured and recorded as the MUAC.

Assessment of biochemical information and dietary patterns

Patients' blood test reports were collected from the hospital's laboratories (n=44). The study used 24-hour recall method and a food frequency questionnaire (FFQ) for assessing data and menu serving size of macronutrients and total energy intakes. Nutrient databases were used to calculate the carbohydrate, protein, fat, and daily energy intakes. Food exchange list was used to see the amount and measurement for each group of food (Cade *et al.,* 2002).

For food grouping, different food items were grouped into 13 groups, which consisted of a total of 37 food objects (Cade *et al.,* 2002; Islam *et al.,* 2021). Participants reviewed the food groups and informed the amount and collected food serving size of each group they have consumed (Islam *et al.,* 2021) according to the food items. Furthermore, serving size was converted into macronutrients using the food exchange list (Islam *et al.,* 2021; Nahar *et al.,* 2013). The calculation of the total serving size per day for each food group was done using the following equation:

Intake of nutrient (carbohydrate, protein, fat) = No. of serving of acceptable daily intake (ADI) × Nutritive values

After that, calculation of energy intake was done according to the USDA guidelines (National Agricultural Library, Baltimore Avenue): carbohydrates=4 kcal/g, protein=4 kcal/g, fat=9 kcal/g.

The study also calculated the dietary requirement of each subject from an equation using a person's body weight and daily exercise factor. Furthermore, a 5-point Likert scale was used to evaluate the patient's dietary information from the 24-hour recall method (very frequent or many times at short intervals, frequent or often, occasionally or infrequent, rarely or not occurring at regular intervals, and not at all).

Ethical consideration

The study was approved by the Ethical Review Committee of Food Technology and Nutritional Science department, Mawlana Bhashani Science and Technology University and Civil Surgeon Office, Tangail with the ethical approval number MBSTU/FTNS/42/2021/02 and CSTANG/SHA-3/MISS/2021/3681(05). Informed consent was obtained from the participants using a short form consent process. The confidentiality of the participants was maintained and will be maintained in the future.

Statistical analysis

Statistical evaluation was carried out with IBM SPSS Statistics for Windows version 25.0 (IBM Corporation, Armonk, New York, USA). Results were expressed as mean±standard deviation (*SD*), range or fraction, and numbers with percentages. Analysis of variance (ANOVA) test and independent sample t-test were applied to determine the difference/comparison in mean values and proportion of the participants'

characteristics. Also, Pearson's correlation was used to determine the linear relationship between continuous variables. Chi-square (χ^2) test was used to determine the association between two categorical variables. A value of $p<0.05$ was considered statistically significant.

RESULTS

Demographic data of the sample

In this research, the information was collected from 100 patients with CVD, from which 55% were males. Table 1 represents the demographic data of the respondents by distribution of their

Table 1. Demographic data of respondents, *n=100*

Variables	*n*	*%*	*Total energy intake (kcal/day) mean±SD*
Gender			
Male	55	55	2479±272
Female	45	45	2384±269
Religion			
Islam	67	67	2439±292
Hinduism	32	32	2428±238
Christianity	1	1	2550±0
Occupation			
Service	14	14	2500±218
Business	41	41	2472±290
Homemaker	45	45	2384±269
Level of education			
Illiterate	17	17	2424±329
Primary (1-5 classes)	15	15	2463±294
Secondary (6-10 classes)	31	31	2395±257
Higher Secondary (11-12 classes)	28	28	2471±264
Graduate (University level)	9	9	2450±250
Education level of spouse			
Illiterate	53	53	2394±284
Primary	19	19	2458±271
Secondary	7	7	2457±226
Higher Secondary	14	14	2557±308
Graduate	7	7	2436±63
Monthly household income (Taka)			
<10000	1	1	2300±0
10000-20000	14	14	2504±247
20000-40000	64	64	2402±283
40000-60000	21	21	2505±254
Food expenditure purpose (Taka)			
<10000	36	36	2378±297
10000-15000	54	54	2468±252
15000-20000	10	10	2480±289
Residential area			
Rural	55	55	2420±259
Sub-urban	22	22	2439±300
Urban	23	23	2474±289

religion, level of education, living areas, and total energy intake.

Anthropometric characteristics of the respondents and comparison between males and females

Table 2 shows the anthropometric characteristics of the participants and comparison between males and females. Age (p=0.842) and weight (p=0.004) was not significantly different between genders. Mean BMI was 27.1±3.0kg/m^2 and was significantly different between males and females. Similarly, the MUAC, WC and WHR of our CVD patients were significantly different between the genders (p=0.009; p=0.030 and p=0.109, respectively).

Table 2. Anthropometry, energy intake and lipid profile of respondents

Variables	*mean±SD*	*p*
Age (years)†		
Males	52.0±11.5	0.842
Females	49.0±12.4	
All	51.0±11.9	
Weight (kg)†		
Males	71.7±10.4	0.004
Females	63.1±9.9	
All	67.4±10.9	
Height (m)†		
Males	1.6±0.05	0.173
Females	1.6±0.07	
All	1.6±0.07	
BMI (kg/m^2)†		
Males	27.6±2.9	0.001
Females	26.5±3.1	
All	27.1±3.0	
MUAC (cm)†		
Males	32.4±2.0	0.009
Females	31.3±2.2	
All	31.9±2.2	
WC (cm)†		
Males	98.7±8.4	0.030
Females	92.3±11.5	
All	95.5±10.4	
WHR†		
Males	0.99±0.06	0.109
Females	0.96±0.07	
All	0.98±0.07	
Total Energy Intake (kcal/day)†		
Males	2479±272	-
Females	2384±268	
All	2436±272	
LDL-C (mmol/L)‡		
Males	7.9±0.7	0.471
Females	7.6±0.8	
All	7.8±0.8	
HDL-C (mmol/L)‡		
Males	2.7±0.4	0.796
Females	2.7±0.6	
All	2.7±0.5	
TAG (mmol/L)‡		
Males	13.8±1.2	0.675
Females	14.0±1.6	
All	13.9±1.4	
TC (mmol/L)‡		
Males	14.6±1.6	0.932
Females	14.6±1.2	
All	14.6±1.5	

BMI: body mass index; MUAC: mid-upper arm circumference; WC: waist circumference; WHR: waist-hip ratio; LDL-C: low-density lipoprotein cholesterol; HDL-C: high-density lipoprotein cholesterol; TAG: triacyl glyceride; TC: total cholesterol.

Data are presented as mean±*SD* and significance level of all variables was considered by two sample *t*-test when $p<0.05$ between males and females.

†n=100; ‡n=44

Biochemical and clinical data of the respondents

Table 2 also describes the biochemical and clinical data of the respondents. LDL-cholesterol and HDL-cholesterol, triacyl glyceride (TAG) and plasma total cholesterol (TC) did not show statistical significance between the genders.

Association of different food items with heart attack and stroke

Table 3 shows the association of different food items that are related to heart attack and stroke. It was found that there was not enough evidence to suggest an association between the intakes of red meat (p=0.820), salt (p=0.830), fast food (p=0.580), fish (p=0.890), egg (p=0.440), nuts and seeds (p=0.990) with heart attack of our patients. On the other hand, there was enough evidence to suggest an association between the intakes of soft drink (p=0.080) and fried food (p=0.080) with heart attack of CVD patients.

It was found that there was not enough evidence to suggest an association between the intakes of red meat (p=1.000), fast food (p=0.160), salt (p=0.670), fish (p=0.890), egg (p=0.810), nuts and seeds (p=0.890) in patients with stroke. On the other hand, there was enough evidence to suggest an association between the intakes of soft drink (p=0.100) and fried food (p=0.020) towards patients with stroke.

Association between childhood obesity with adulthood BMI, heart attack, and stroke

Table 4 illustrates the association between childhood obesity with adulthood BMI, heart attack, and stroke. The p-values between childhood obesity and adulthood BMI, proneness to heart attack and stroke were not statistically significant.

Relationships between macronutrient intakes with total energy intake and BMI of CVD patients

Table 5 represents the dietary patterns of the respondents. All macronutrients were highly significant in correlation with total energy intake and BMI at a 95% significance. The results indicated that there was a significant relationship between carbohydrate (p=0.001), protein (p=0.001), and fat (p=0.001) intakes with the total energy intake of respondents. The findings also showed that there was a significant relationship between carbohydrate (p=0.003), protein (p=0.001), and fat (p=0.001) intakes with BMI of the respondents.

DISCUSSION

Childhood obesity has been reported as the leading cause for the development of CVD in the future. The present research was focused on the relationship of obesity in childhood and dietary intake with CVD in later life. It was found that the total energy intake of male respondents was slightly higher than female respondents; and the energy intake of Christians was slightly higher than Muslims and Hindus. It was also noticed that servicemen needed more energy than businessmen and homemakers.

In this study, the respondents' age and height was not significantly different between males and females, but was significant (p=0.004) in the case of weight. Similarly, BMI (p=0.001), MUAC (p=0.009), and WC (p=0.030) was significantly different between males and females, but not WHR (p=0.109). It was observed that low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, TAG, and TC in CVD patients did not show statistical significance between males and females. Most of the CVD respondents were overweight

Table 3. Associations of different food items with heart attack and stroke

Food intake	*Total (n, %)*	*Heart attack*		χ^2	*p*
		Yes (n, %)	*No (n, %)*		
Red meat					
Very frequently	28	17	11	0.387	0.820
Frequently	56	30	26		
Occasionally	16	9	7		
Total	100	56	44		
Soft drink					
Frequently	9	5	4	6.800	0.080
Occasionally	29	11	18		
Rarely	31	22	9		
Not at all	31	18	13		
Total	100	56	44		
Salt					
Frequently	31	18	13	0.078	0.830
Not at all	69	38	31		
Total	100	56	44		
Fast food					
Frequently	7	5	2	1.900	0.580
Occasionally	30	14	16		
Rarely	31	18	13		
Not at all	32	19	13		
Total	100	56	44		
Fried food					
Very frequently	4	4	0	8.300	0.080
Frequently	16	7	9		
Occasionally	11	6	5		
Rarely	17	6	11		
Not at all	52	33	19		
Total	100	56	44		
Fish					
Very frequently	28	15	13	0.238	0.890
Frequently	55	32	23		
Occasionally	17	9	8		
Total	100	56	44		
Egg					
Very frequently	19	13	6	2.700	0.440
Frequently	60	34	26		
Occasionally	19	8	11		
Rarely	2	1	1		
Total	100	56	44		
Nuts and seeds					
Very frequently	26	15	11	0.268	0.990
Frequently	12	6	6		
Occasionally	24	14	10		
Rarely	18	10	8		
Not at all	20	11	9		
Total	100	56	44		

Table 3. Associations of different food items with heart attack and stroke *(continued)*

Food intake	*Total (n, %)*	*Stroke*		χ^2	*p*
		Yes (n, %)	No (n, %)		
Red meat					
Very frequently	28	14	14	0.000	1.000
Frequently	56	28	28		
Occasionally	16	8	8		
Total	100	50	50		
Soft drink					
Very frequently	9	4	5	6.200	0.100
Occasionally	29	20	9		
Rarely	31	12	19		
Not at all	31	14	17		
Total	100	50	50		
Salt					
Frequently	31	14	17	0.420	0.670
Not at all	69	36	33		
Total	100	50	50		
Fast food					
Very frequently	7	2	5	5.200	0.160
Occasionally	30	19	11		
Rarely	31	12	19		
Not at all	32	17	15		
Total	100	50	50		
Fried food					
Very frequently	4	0	4	11.800	0.020
Frequently	16	9	7		
Occasionally	11	7	4		
Rarely	17	13	4		
Not at all	52	21	31		
Total	100	50	50		
Fish					
Very frequently	28	15	13	0.240	0.890
Frequently	55	32	23		
Occasionally	17	9	8		
Total	100	56	44		
Egg					
Very frequently	19	8	11	0.950	0.810
Frequently	60	30	30		
Occasionally	19	11	8		
Rarely	2	1	1		
Total	100	50	50		
Nuts and seeds					
Very frequently	26	14	12	1.200	0.890
Frequently	12	6	6		
Occasionally	24	12	12		
Rarely	18	10	8		
Not at all	20	8	12		
Total	100	50	50		

Chi-square test was carried out, with $p<0.05$ considered as statistically significant.

Table 4. Association between childhood obesity with adulthood BMI, heart attack, and stroke

Adulthood	*Overweight and obesity at childhood*			χ^2	*p*
	Total (n, %)	*Yes (n, %)*	*No (n, %)*		
BMI (kg/m^2)					
<25	15	11	4	1.400	0.500
25-30	70	46	24		
>30	15	8	7		
Total	100	65	35		
Heart attack					
No	44	28	16	0.835	0.064
Yes	56	37	19		
Total	100	65	35		
Stroke					
No	50	34	16	0.675	0.396
Yes	50	31	19		
Total		65	100		

BMI: body mass index
Chi-square test was carried out, with $p<0.05$ considered as statistically significant.

at their early life and also overweight and obese presently, affected by stroke and heart attack; but this result was not statistically significant. Previous research has observed that childhood obesity is associated with heart attack and stroke in later life (Raut *et al.,* 2014; Bulbul & Hoque, 2014).

The high amount of salt and red meat intakes can lead to stroke and heart attack, while the opposite can reduce CVD (Karppanen & Mervaala, 2006). Also, previous study revealed that a Western dietary pattern (like soft drinks, fast foods, beer and liquor, and deep-fried snacks) (Sichieri, 2002; Fung, 2001) was

Table 5. Relationships between macronutrient intakes with total energy intake and BMI of CVD patients, *n*=100

Variables	*mean±SD*	*Range*	*Total energy intake*		*BMI*	
			r	*P*	*r*	*P*
Carbohydrate (g/d)	397.9±43.7	288-473	0.290	0.001	0.296	0.003
Carbohydrate (kcal/d)	1590.8±173.7	1152-1892				
Carbohydrate (% total energy)	64.7±1.7	61-68				
Protein (g/d)	98.8±10.5	76-126	0.360	0.001	0.363	0.001
Protein (kcal/d)	395.4±42.4	304-524				
Protein (% total energy)	16.2±0.5	15-17				
Fat (g/d)	52.8±6.9	40-71	0.350	0.001	0.347	0.001
Fat (kcal/d)	475.1±62.1	360-639				
Fat (% total energy)	19.3±1.6	17-24				

BMI: body mass index
Data are presented as mean±standard deviation and range.
The correlations are significant at $p<0.05$ tested by Pearson's correlation test.

found to be significantly associated with overweight and BMI (Naja *et al.,* 2015; Naja *et al.,* 2011).

All macronutrients were highly significant with total energy intake and BMI at a 95% level of significance. The results indicated that there was a significant relationship between carbohydrate (p=0.001), protein (p=0.001), and fat (p=0.001) intakes with the total energy intake of respondents. These results also showed that there was significant relationship between carbohydrate (p=0.003), protein (p=0.001), and fat (p=0.001) intakes with the BMI of respondents. Some previous research reported that overweight was significantly (p<0.05) associated with protein intake (Scaglioni *et al.,* 2000). However, a significant interaction between carbohydrate intake and obesity is apparent (Martinez *et al.,* 2003), and higher BMI is associated with a direct relationship with dietary fat quality (Javardi *et al.,* 2020).

CONCLUSION

It is concluded that weight (p=0.004), body mass index (BMI) (p=0.001), mid-upper arm circumference (MUAC) (p=0.009), and waist circumference (WC) (p=0.030) was significantly different between males and females whereas lipid profile was not significantly different between genders. CVD diagnosis in adult patients was found to be associated with fried food intake but not with childhood obesity. We opine that childhood obesity remains one of the major causes of CVD in later life, even though not significant in the current study, but dietary patterns were significantly related with CVD in adulthood.

Acknowledgement

The authors would like to express their gratitude to the research subjects who took part in this study and also thank the five selected clinics and hospitals for providing laboratory support and space for this study.

Authors' contributions

Linkon KMMR, responsible for supervision and design of the research, and protocol development; Meem NES, Noory SH, Hossain MH, participated in data collection, data curation, data analysis; Nitu RM, Islam MF, Shyfullah M, Jalil S, Esrafil M, contributed in methodology, reviewing and referencing; Alim MA, responsible for methodology, manuscript writing, reviewing and editing.

Conflicts of interest

The authors declare that they have no conflict of interest.

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Mal J Nutr 29(1): 089-102, 2023

Dietary patterns associated with the risk of type 2 diabetes in women with and without a history of gestational diabetes mellitus: A pilot study

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ABSTRACT

Introduction: There is limited evidence on dietary patterns and the risk of type 2 diabetes (T2D) in women with a history of gestational diabetes mellitus (GDM) compared to their non-GDM counterparts, especially in the Asian population. The pilot study investigated dietary patterns in women with a history of GDM (HGDM) and without a history of GDM (non-HGDM), and the association with T2D risk. **Methods:** This comparative cross-sectional study involved 64 women (32 HGDM, 32 non-HGDM). Food intake was assessed using a validated food frequency questionnaire. Principal component analysis derived the dietary patterns. T2D risk score was determined using the Finnish Diabetes Risk Score tool. **Results:** HGDM group had significantly higher proportion of first-degree family history of diabetes; higher risk of T2D and better diabetes knowledge; lower gestational weight gain and postpartum weight retention; and consumed more fast food than non-HGDM. 'Rice-noodle-pasta-meat' dietary pattern was significantly associated with increased T2D risk after adjusting for age (β=0.272, p=0.032). 'Bread-cereals-fast food-meat' dietary pattern was positively and significantly associated with T2D risk after adjusting for confounders, including age, education level, family history of diabetes, diabetes knowledge score, gestational weight gain, and postpartum weight retention (β=0.251, p=0.012). **Conclusion:** Dietary patterns high in bread, cereals and cereal products, fast food and meat, as well as rice, noodle, pasta and meat were associated with an elevated T2D risk. A more extensive study is warranted to establish the association between dietary patterns and risk of T2D, focusing on women with a history of GDM.

Keywords: dietary patterns, gestational diabetes mellitus, type 2 diabetes

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doi: https://doi.org/10.31246/mjn-2022-0056

INTRODUCTION

Type 2 diabetes (T2D) accounts for approximately 90% of diabetes cases worldwide (International Diabetes Federation, 2019). Women with pregnancy complicated with gestational diabetes mellitus (GDM) have a 10-fold risk of developing T2D following delivery, compared to those who have normoglycaemic pregnancy (Vounzoulaki *et al.*, 2020). Hence, early detection is critical to reduce the risk of T2D in women with a history of GDM.

The mainstay of GDM treatment is lifestyle interventions, which include medical nutrition therapy (MNT), regular physical activity, and diabetes self-management education (American Diabetes Association, 2022). Dietary interventions during GDM pregnancy have been shown to improve glycaemic control and neonatal outcomes (Yamamoto *et al.,* 2018). However, it is unknown whether these women retain their diabetes knowledge and continue healthy dietary practices after delivery. Women with a history of GDM were reported to have suboptimal physical activity levels and dietary intake despite their knowledge on prevention strategies for T2D (Jones, Roche & Appel, 2009).

A diet relatively low in carbohydrates, but high in animal fat and protein was associated with an increased risk of T2D in women with a history of GDM (D'Arcy *et al.*, 2020). In contrast, dietary patterns characterised by high intakes of vegetables, fruits, nuts, legumes, and fish; and low intakes of red/processed meats and sugar-sweetened beverages were found to reduce the risk of T2D in this population (D'Arcy *et al.*, 2020). However, most studies investigating dietary patterns among women with a history of GDM were conducted in the Western population (D'Arcy *et al.*, 2020). There is little evidence on the association between Malaysian-tailored dietary patterns and the risk of T2D in women with a history of GDM compared to their non-GDM counterparts. Furthermore, the dietary patterns of the Malaysian population might be different compared to the Western population (Norimah *et al.*, 2008), prompting the current investigation. Therefore, this study aimed to determine the dietary patterns of Malaysian women with and without a history of GDM and their association with the risk of T2D.

MATERIALS AND METHODS

Study design and participants

This comparative cross-sectional study was a pilot study for a more extensive study aiming to investigate the dietary patterns, metabolomic profile, and risk of T2D in Malaysian women with a history of GDM (Hasbullah *et al.*, 2022). The study has been registered on ClinicalTrials.gov (NCT04190199). The study was conducted at Universiti Putra Malaysia (UPM), Selangor, Malaysia from February to March 2020. Out of 16 faculties and two research centres in UPM, simple random sampling was used to select half of the faculties (n=8) and research centre (n=1). The faculties selected were Faculties of Food Science and Technology, Environmental Studies, Sciences, Engineering, Economics and Management, Human Ecology, Educational Studies, and Modern Languages and Communication. The research centre randomly selected was the Family, Adolescent and Child Research Centre of Excellence. The study was approved by the Research Committee of Universiti Putra Malaysia (JKEUPM)(ID: 2019-404).

Participants were Malaysian women aged 18-49 years old who had previously given birth and had no prior diagnosis of type 1 or type 2 diabetes. Women were selected from the staff name list obtained from the selected faculties/

institute and screened for eligibility. Eligible participants were then invited to participate in the study. Participants were divided into two groups: those with a history of GDM (HGDM) and without a history of GDM (non-HGDM). History of GDM was self-reported by the participants; the diagnosis was made by medical doctors based on their oral glucose tolerance test (OGTT) results during pregnancy. All participants provided written consent before enrolment.

Sample size was calculated based on a previous study comparing the prevalence of postpartum T2D between women with and without a history of GDM (6.5% vs. 0%) (Moleda *et al.*, 2015), with 80% power and 95% confidence interval, yielding a total of 270 participants. The sample size for pilot studies is recommended to be 10% from the parent study (Connelly, 2008). Hence, a minimum of 27 participants were required for this pilot study.

Dietary assessment

A trained dietitian administered a 165-item food frequency questionnaire (FFQ) adapted from the nationwide Malaysian Adult Nutrition Survey (MANS) 2014 to determine food consumption in the past one month (IPH, 2014). The FFQ comprised 14 food groups: cereals and cereal products, fast food, meat and poultry, fish and seafood, eggs, legumes, milk and dairy products, vegetables, fruits, beverages, alcoholic drinks, confectionaries, bread spreads, and condiments. Participants reported their consumption frequencies (daily, weekly, monthly, or not consumed) and serving sizes for each food item. The amount of food consumed was converted into g/day for each food item (Norimah *et al.*, 2008). Energy and macronutrient intakes were calculated using Nutritionist Pro software version 5.1.0 (Axxya Systems, WA, USA). The HGDM and non-HGDM groups were compared on their intakes of energy, macronutrients, and the 14 food groups (comprising 165 items) based on MANS FFQ.

Socio-demographic, obstetric and anthropometric assessments

Socio-demographic information on participants' age, ethnicity, education level, household income, family history of diabetes, and smoking habit were collected using a general questionnaire. Obstetric information during their index pregnancy (defined as the most recent GDM pregnancy for HGDM group and most recent pregnancy for the non-HGDM group) was obtained from their antenatal records. These included their parity, weight history, delivery method, and breastfeeding duration. Gestational weight gain was calculated as the difference between weight at the last prenatal visit and pre-pregnancy weight, whereas postpartum weight retention was the difference between weight at six months postpartum and pre-pregnancy weight. Total gestational weight gain cut-offs were based on the Institute of Medicine (2009) guidelines.

Height was measured using a stadiometer (SECA model 206, seca GmbH, Germany), whereas weight was assessed using a body composition monitor (Tanita Health Equipment Ltd., Tokyo, Japan). Body mass index (BMI), calculated from height and weight, was classified according to the World Health Organization (WHO) BMI guidelines for adults (WHO, 1998). Waist circumference was measured using a measuring tape (SECA model 203, seca GmbH, Germany) according to the measurement protocol by WHO (2011). The cut-off point for waist circumference in women was ≥80cm to indicate abdominal obesity (WHO, 2011).

Type 2 diabetes risk and knowledge assessment

Finnish Diabetes Risk Score (FINDRISC) predicted participants' risk of T2D within ten years (Lindström & Tuomilehto, 2003). The risk score cut-offs were low risk (<7), slightly elevated risk (7-11), moderate risk (12-14), high risk (15-20), and very high risk (>20). Meanwhile, the 24-item Diabetes Knowledge Questionnaire (DKQ-24) determined participants' level of diabetes knowledge; the tool was reliable as shown by a Cronbach's alpha value of 0.78 (Garcia *et al.*, 2001).

Statistical analyses

Principal component analysis (PCA) was conducted to obtain dietary patterns. From 165 items in the FFQ, ten food items with no responses were removed (ham, bacon, luncheon meat, herbal/ botanical brewed drinks, all alcoholic beverages). Plain water was also removed as it contained no calories.

The remaining 154 food items were re-categorised into 12 food groups: rice, noodle and pasta; bread, cereals and cereal products; fast food; meat and poultry; fish and seafood; eggs; legumes; milk and dairy products; fruits and vegetables; beverages; confectionaries and bread spreads; and condiments. Food items under the fast food, meat and poultry, fish and seafood, eggs, legumes, milk and dairy products, beverages, and condiments food groups were similar with the MANS FFQ. Confectionaries and bread spreads were combined into one food group, as well as fruits and vegetables (the food items under these categories were also similar with the MANS FFQ). Only cereals and cereal products were divided into two food groups: rice, noodle and pasta; and bread, cereals and cereal products (containing all breads, local flatbread, sago, corn, breakfast cereals, and oats). This categorisation was made based on nutrient profile similarities and data from previous local studies (Shyam *et al.*, 2020; Yong *et al.*, 2020; Nik Mohd Fakhruddin *et al.*, 2019).

Data suitability was determined prior to performing PCA using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (>0.50) and Bartlett's test of sphericity (BTS, p<0.05) (Nik Mohd Fakhruddin *et al.*, 2019). KMO value in this study was 0.512, while BTS value was <0.001, indicating that the data were adequate for PCA. Eigenvalue cut-off >1.0 determined the number of factors. Factor scores were orthogonally rotated by varimax transformation to increase loading differences for easier interpretability. Factor loadings of <±0.3 were removed from further analysis. Factor scores for each dietary pattern were the summation of food item intakes weighted by their factor loadings. A high factor loading score for a given dietary pattern indicated a high intake of that food group, and a low score indicated low intake of those foods.

Statistical analyses were performed using SPSS software version 25.0 (IBM Corp, Armonk, NY, USA). Data were expressed as mean±standard deviation (*SD)* for continuous variables; and frequencies and percentages for categorical variables. Characteristics of HGDM and non-HGDM groups were compared using independent *t*-test for continuous variables, or Pearson's chi-square test for categorical variables (Fisher's Exact Test for non-parametric parameters). Pearson's correlation coefficient determined the strength of the association between dietary patterns and intakes of energy and nutrients. Dietary patterns associated with the risk of T2D were determined using multiple linear regression, with T2D risk score as the dependent variable. The dietary patterns were adjusted for significant covariates at the bivariate regression level (p<0.20): age, education level, family

history of diabetes, gestational weight gain, postpartum weight retention, and diabetes knowledge. Significant value for all statistical tests was set at $p<0.05$.

RESULTS

A total of 64 participants participated in the pilot study (n=32 in each group). Participants were in their mid-thirties

Table 1. Characteristics of participants

Variables	*HGDM (n=32)*	*Non-HGDM (n=32)*	*p-value*
	Mean±SD or n (%)		
Socio-demographic background			
Age (years)	35.8±5.2	37.9±6.3	0.1610.387
≤25	0 (0.0)	1 (3.1)	
26-34	14 (43.8)	10 (31.3)	
≥35	18 (56.3)	21 (65.6)	
Ethnicity			0.500†
Malay	31 (96.9)	32 (100.0)	
Chinese	1 (3.1)	0 (0.0)	
Education level			0.113†
Secondary education	0 (0.0)	4 (12.5)	
Tertiary education	32 (100.0)	28 (87.5)	
Monthly household income (RM)	6625±3628	6877±4574	0.808
Family history of diabetes	23 (71.9)	18 (56.3)	0.193
Degree of family history of diabetes‡			<0.001***
First-degree	23 (71.9)	8 (25.0)	
Second-degree	0 (0.0)	10 (31.3)	
Current smoker	0 (0.0)	2 (6.3)	0.492†
Obstetric history			
Parity	1.8±0.6	1.8±0.6	0.824
Pre-pregnancy weight (kg)	61.3±13.9	57.9±13.7	0.317
Pre-pregnancy BMI (kg/m^2)	24.5±5.1	23.5±5.4	0.262
Underweight (<18.5 kg/m^2)	3 (9.4)	6 (18.8)	0.523
Normal (18.5-24.9 kg/m^2)	14 (43.8)	16 (50.0)	
Overweight (25.0-29.9 kg/m^2)	10 (31.3)	6 (18.8)	
Obese (≥30.0 kg/m^2)	5 (15.6)	4 (12.5)	
Gestational weight gain (kg)	8.4±3.9	12.6±6.8	0.003**
Inadequate	21 (65.6)	10 (31.3)	0.020*
Within recommendation	6 (18.8)	14 (43.8)	
Excessive	5 (15.6)	18 (56.3)	
Postpartum weight retention (kg)	-0.6±5.0	3.1±4.8	0.003**
Delivery method	19 (59.4)	22 (68.8)	0.434
Normal	13 (40.6)	10 (31.2)	
Caesarean section			
Breastfeeding duration			0.453
<6 months	9 (28.1)	13 (40.6)	
6-12 months	3 (9.4)	4 (12.5)	
>1 year	20 (62.5)	15 (46.9)	

Table 1. Characteristics of participants *(continued)*

Variables	*HGDM (n=32)*	*Non-HGDM (n=32)*	*p-value*
	Mean±SD or n (%)		
Anthropometry measurements			
Height (m)	1.56±0.05	1.57±0.05	0.457
Current weight (kg)	63.3±13.3	64.6±13.7	0.709
Current BMI (kg/m^2)	25.9±5.3	26.1±5.1	0.879
Underweight (<18.5 kg/m^2)	1 (3.1)	0 (0.0)	0.438
Normal (18.5-24.9 kg/m^2)	17 (53.1)	15 (46.9)	
Overweight (25.0-29.9 kg/m^2)	9 (28.1)	14 (43.8)	
Obese (≥30.0 kg/m^2)	5 (15.6)	3 (9.4)	
Waist circumference (cm)	83.9±13.6	80.4±8.5	0.213
Within recommendation (<80cm)	17 (53.1)	16 (50.0)	0.802
Exceeded recommendation (≥80cm)	15 (46.9)	16 (50.0)	
Diabetes risk			
Risk score	13.0±3.4	7.2±4.5	<0.001***
Risk category			
Low risk (<7)	0 (0.0)	13 (40.6)	<0.001***
Slightly elevated risk (7-11)	11 (34.4)	14 (43.8)	
Moderate risk (12-14)	10 (31.3)	4 (12.5)	
High risk (15-20)	10 (31.3)	0 (0.0)	
Very high risk (>20)	1 (3.1)	1 (3.1)	
Diabetes knowledge			
Knowledge score (%)	62.5±15.8	42.1±15.7	<0.001***
Knowledge category			0.001**
Poor (<60%)	13 (40.6)	27 (84.4)	
Acceptable (60-80%)	15 (46.9)	5 (15.6)	
Good knowledge (>80%)	4 (12.5)	0 (0.0)	

BMI: body mass index; HGDM: women with history of gestational diabetes mellitus; non-HGDM: women without history of gestational diabetes mellitus
p-value based on independent *t*-test (continuous variable) or Pearson's chi-square test (categorical); †*p*-value based on Fisher's Exact Test
‡Degree of family history of diabetes: First-degree includes parents and siblings; Second-degree includes grandparents, aunts, uncles, nieces and nephews.
**p*<0.05, ***p*<0.001, ****p*<0.001

(36.8±5.9 years old), predominantly of the Malay ethnicity (98.4%), and most were university graduates (93.8%). On average, participants were currently overweight (26.0±5.1 kg/m^2) and their waist circumference exceeded the recommended cut-off value (82.2±11.4 cm). The HGDM group had significantly lesser gestational weight gain and postpartum weight retention (both *p*=0.003), but higher diabetes risk and knowledge (both *p*<0.001) (Table 1). The HGDM group also had a significantly higher prevalence of a first-degree family history of diabetes (*p*<0.001). Other characteristics did not significantly differ between the two groups (Table 1).

The HGDM group significantly consumed more fast food compared to the other group (*p*=0.035). The HGDM group consumed 89.3±82.9 g/day of fast food, which is equivalent to one serving

Table 2. Energy, nutrient, and food group intakes of participants

Energy, nutrient, and food group intakes	*HGDM (n=32)*	*Non-HGDM (n=32)*	*p-value*
	Mean±SD		
Energy (kcal/day)	2090±607	1949±510	0.321
Carbohydrate			
g/day	302.5±109.0	296.7±100.5	0.827
As % of energy	57.3±8.8	60.6±9.6	0.161
Protein			
g/day	84.1±32.3	83.8±29.3	0.962
As % of energy	16.2±4.5	17.3±5.0	0.361
Fat			
g/day	56.9±20.6	48.9±20.9	0.128
As % of energy	24.6±6.3	22.7±6.9	0.256
Total fibre (g/day)	10.7±11.3	9.2±6.5	0.515
Sugar			
g/day	44.5±30.4	42.9±29.5	0.825
As % of energy	8.4±4.8	8.5±4.9	0.918
Cereals and cereal products (g/day)	473.5±260.1	399.0±221.0	0.222
Fast food (g/day)	89.3±82.9	54.5±35.9	0.035*
Meat and poultry (g/day)	53.9±44.7	43.9±36.0	0.329
Fish and seafood (g/day)	79.9±74.7	357.4±1444.8	0.286
Eggs (g/day)	31.9±25.1	28.6±27.2	0.615
Legumes (g/day)	15.1±20.2	22.5±42.0	0.372
Milk and dairy products (g/day)	165.7±367.1	93.5±141.8	0.303
Vegetables (g/day)	58.2±45.9	53.0±54.2	0.683
Fruits (g/day)	234.8±182.1	234.9±209.8	0.998
Beverages (g/day)	336.7±345.7	302.0±289.0	0.664
Alcoholic drinks (g/day)	0.5±3.0	0.0±0.0	0.325
Confectionaries (g/day)	75.3±59.7	61.5±45.6	0.305
Bread spreads (g/day)	1.3±1.1	1.3±1.8	0.951
Condiments (g/day)	29.9±50.6	23.3±28.9	0.525

Food groups are according to food groups in the Malaysian Adult Nutrition Survey 2014 food frequency questionnaire (IPH, 2014)
p-value based on independent *t*-test
*$p<0.05$

of fried chicken per day (90 g), compared to the non-HGDM group (54.5±35.9 g/day of fast food). Intakes of energy, nutrients, and other food groups did not significantly differ between the two groups ($p>0.05$) (Table 2).

Table 3 presents the factor loading scores for dietary patterns identified by PCA. A total of five *a posteriori* dietary patterns were derived from the food groups. The first dietary pattern, 'Dairy-beverages-confectionaries-condiments', explained 20.4% of the variance and was characterised by high intakes of milk and dairy products, beverages, confectionaries and bread spreads, and condiments. The 'Egg-legume' dietary pattern, explaining 13.7% of the variance, had high intakes of eggs and legumes. The 'Bread-cereals-fruits-vegetables' dietary pattern was characterised by high intakes of bread, cereals and cereal products, and fruits and vegetables (accounted 11.8% of the

Table 3. Factor loading scores for dietary patterns identified by principal component analysis

Food groups	*Dietary patterns and factor loading scores*				
	DP 1 (Dairy-beverages-confectionaries-condiments)	*DP 2 (Eggs-legumes)*	*DP 3 (Bread-cereals-fruits-vegetables)*	*DP 4 (Bread-cereals-fast food-meat)*	*DP 5 (Rice-noodle-pasta-meat)*
Rice, noodle and pasta	0.196	0.015	-0.142	0.107	**0.590**
Bread, cereals and cereal products	-0.116	0.130	**0.727**	**0.308**	0.133
Fast food	-0.030	-0.011	0.107	**0.696**	-0.140
Meat and poultry	0.079	0.029	-0.119	**0.617**	**0.409**
Fish and seafood	0.258	0.010	-0.124	0.135	**-0.730**
Eggs	0.148	**0.781**	0.164	0.165	-0.036
Legumes	0.049	**0.710**	0.101	**-0.394**	0.101
Milk and dairy products	**0.847**	0.048	0.155	-0.053	-0.014
Fruits and vegetables	0.127	-0.023	**0.812**	-0.195	-0.187
Beverages	**0.804**	0.045	-0.089	-0.070	0.212
Confectionaries and bread spreads	**0.371**	**-0.660**	0.228	-0.092	0.031
Condiments	**0.862**	-0.131	-0.061	0.164	-0.233

DP: dietary pattern
Bold indicates factor loading score ≥0.3 (high intake of dietary pattern) or ≤-0.3 (low intake of dietary pattern)

variance). The 'Bread-cereals-fast food-meat' dietary pattern had high intakes of bread, cereals and cereal products, fast food, meat and poultry; and low intake of legumes (accounted 10.6% of the variance). Lastly, the 'Rice-noodle-pasta-meat', which explained 9.0% of the variance, had high intakes of rice, noodle and pasta, meat and poultry; and low intake of fish and seafood.

Table 4 shows the association between dietary patterns and the risk of T2D. The 'Rice-noodle-pasta-meat' dietary pattern was positively and significantly associated with the risk of T2D after adjusting for age (β=0.272, p=0.032). The 'Bread-cereals-fast food-meat' consistently remained positively and significantly associated with T2D after adjusting for confounding variables (β=0.251, p=0.012). The final models (each dietary pattern adjusted for age, education level, family history of diabetes, diabetes knowledge score, gestational weight gain, and postpartum weight retention) contributed towards 43.8-49.8% of the variance.

None of the dietary patterns had a strong correlation with energy or macronutrient intakes (Table 5). The 'Dairy-beverages-confectionaries-condiments' dietary pattern had a moderate, positive association with total fibre intake (p<0.001). The 'Eggs-legumes' dietary pattern was moderately and linearly associated with protein intake (p=0.002). The 'Bread-cereals-fruits-vegetables' dietary pattern showed a moderate and positive association with energy (p=0.003), protein (p<0.001), and sugar intakes (p<0.001). There was a moderate and linear correlation between 'Bread-cereals-fast food-meat' dietary pattern and fat intake (p=0.003), and

Table 4. Linear regressions of dietary patterns associated with risk of type 2 diabetes

Dietary pattern	*Model 1*		*Model 2*		*Model 3*		*Model 4*		*Model 5*	
	Standardised β	*95% CI*	*Standardised β*	*95% CI*	*Standardised β*	*95% CI*	*Standardised β*	*95% CI*	*Standardised β*	*95% CI*
DP 1 (Dairy-beverages-confectionaries-condiments)	-0.022	-1.364, 1.143	-0.022	-1.375, 1.153	0.035	-0.858, 1.204	0.021	-0.933, 1.137	0.028	-0.897, 1.172
DP 2 (Eggs-legumes)	0.05	-1.006, 1.498	0.051	-1.021, 1.521	-0.141	-1.737, 0.344	-0.129	-1.683, 0.406	-0.151	-1.788, 0.297
DP 3 (Bread-cereals-fruits-vegetables)	-0.064	-1.568, 0.935	-0.067	1.614, 0.954	-0.047	-1.323, 0.857	-0.068	-1.433, 0.760	-0.152	-1.932, 0.427
DP 4 (Bread-cereals-fast food-meat)	0.274	0.145, 2.557*	0.276	0.143, 2.585*	0.260	0.324, 2.243*	0.253	0.291, 2.210*	0.251	0.284, 2.198*
DP 5 (Rice-noodle-pasta-meat)	0.269	0.120, 2.535*	0.272	0.121, 2.570*	0.173	-0.147, 1.859	0.172	-0.151, 1.848	0.139	-0.354, 1.731

Model 1: unadjusted
Model 2: adjusted for age
Model 3: adjusted for age, education level, family history of diabetes
Model 4: adjusted for age, education level, family history of diabetes, diabetes knowledge score
Model 5: adjusted for age, education level, family history of diabetes, diabetes knowledge score, gestational weight gain, and postpartum weight retention
DP: dietary pattern
*$p<0.05$

Table 5. Correlation coefficients between intakes of energy and macronutrients with dietary patterns

Energy and macronutrient intakes	*DP 1 (Dairy-beverages-confectionaries-condiments)*	*DP 2 (Eggs-legumes)*	*DP 3 (Bread-cereals-fruits-vegetables)*	*DP 4 (Bread-cereals-fast food-meat)*	*DP 5 (Rice-noodle-pasta-meat)*
Energy intake (kcal/day)	0.215	0.120	**0.363***	0.287*	0.291*
Carbohydrate intake (g/day)	0.133	-0.015	0.257*	0.155	**0.349***
Protein intake (g/day)	0.049	**0.389***	**0.470***	0.287*	0.123
Fat intake (g/day)	0.183	0.202	0.296*	**0.367***	0.028
Fibre intake (g/day)	**0.632***	-0.120	0.272*	-0.193	-0.001
Sugar intake (g/day)	0.187	0.131	**0.502***	-0.078	-0.052

DP: dietary pattern
Bold indicates at least a moderate correlation ($r \geq 0.3$), *$p<0.050$

between 'Rice-noodle-pasta-meat' dietary pattern and carbohydrate intake ($p=0.005$). The other correlations between dietary patterns and intakes of energy or macronutrients were either weak ($r<0.30$) or were not statistically significant (Table 5).

DISCUSSION

In this study, women with a history of GDM had increased risk of T2D, which was consistent with current literature (Vounzoulaki *et al.*, 2020). In comparison to non-HGDM, the HGDM group also had significantly higher proportion of first-degree family history of diabetes, higher diabetes knowledge, lower gestational weight gain, and postpartum weight retention. Women with previous GDM and had a family history of diabetes were significantly more likely to develop metabolic syndrome, T2D, and cardiovascular events at a younger age than their non-GDM counterparts (Carr *et al.*, 2006). Hence, women with both a family history of diabetes and a history of GDM are at even greater risk of T2D and its complications; and this warrants immediate intervention to prevent or delay T2D.

The HGDM group was also more knowledgeable on diabetes, possibly because they received diabetes education and dietary counselling during their GDM pregnancies (Malaysian Dietitians' Association, 2013). Women with GDM would receive an individualised MNT delivered by a clinical dietitian, which include education on appropriate weight gain and nutritional strategies to improve their glycaemic control (Malaysian Dietitians' Association, 2013). In this study, women with a history of GDM had lower gestational weight gain and postpartum weight retention at six months, which may indicate the short-term benefits of lifestyle interventions in managing GDM. However, despite a higher level of diabetes knowledge, the HGDM group also consumed significantly higher amount of fast food and had higher T2D risk score. Altogether, this may signify the need for continuous postpartum lifestyle interventions to sustain their nutrition-related diabetes knowledge and healthy dietary patterns.

The HGDM group consumed significantly higher amount of fast food (the equivalent of one fried chicken per day). Based on MANS 2014 findings, a Western dietary pattern (characterised

by fast food, meat, and carbonated beverages) was the predominant dietary pattern in Malaysian adults (Shyam *et al.*, 2020). Ready-to-eat fast foods offer accessible, convenient and quick meal solutions for families of working adults (Shyam *et al.,* 2020). Nevertheless, frequent consumption of fast food has been associated with obesity, impaired insulin and glucose homeostasis, dyslipidaemia, systemic inflammation, and oxidative stress, thus increasing the risk of T2D in adult populations (Bahadoran, Mirmiran & Azizi, 2015).

The 'Bread-cereals-fast food-meat' dietary pattern was shown to be positively and significantly associated with increased T2D risk score in women with and without a history of GDM. This dietary pattern was characterised by high intakes of bread, cereals and cereal products, fast food, meat and poultry, and low intake of legumes. A meta-analysis involving adults from several populations reported that refined grains, red and processed meat were strongly correlated with elevated T2D risk, whereas legume intake was inversely correlated with T2D risk (Jannasch, Kro & Schulze, 2017). A possible mechanism leading to the development of T2D is the advanced glycation end (AGE) products in red and processed meat. AGE products are produced via the glycation and oxidation of proteins and lipids (Dariya & Nagaraju 2020). AGE product accumulation in the body generates reactive oxygen species (ROS), increases oxidative stress and inflammation, which plays a pivotal role in the development of T2D and its complications (Dariya & Nagaraju 2020). Furthermore, this dietary pattern was also shown to be moderately correlated with total fat intake. In the PREvención con DIeta MEDiterránea (PREDIMED) cohort study among Spanish adults, participants who consumed the highest amount of saturated and animal fat had more than two-fold higher risk of T2D compared to the lowest quartile (Guasch-Ferré *et al.*, 2017).

Another dietary pattern had high intakes of bread, cereal and cereal products in addition to fruits and vegetables, but were inversely associated with T2D risk instead (although not statistically significant). We postulated that the healthy components of fruits and vegetables in this dietary pattern may have offset the influence on T2D risk, suggesting the importance of consuming a variety of foods and maintaining a mainly healthy and balanced diet. Although this dietary pattern was moderately correlated with sugar intake, this could be due to the fructose content in the fruits and not because of added sugars. Moderate consumption of fructose (<50g/day) was shown to exert beneficial effects on glycaemic control in individuals with T2D (Cozma *et al.*, 2012).

The 'Rice-noodle-pasta-meat' was also significantly associated with elevated T2D risk. This dietary pattern was moderately correlated with total carbohydrate intake, which was mostly due to the intakes of rice, noodle, and pasta. Carbohydrate intake ≥70% from total energy intake was associated with a higher risk of T2D (Hosseini *et al.*, 2022). In terms of carbohydrate type or quality, consumption of carbohydrates that are high in starch and low in cereal fibre was associated with an elevated risk of T2D (AlEssa *et al.*, 2015). High fibre intake from whole grain cereals have been consistently correlated with lower risk of T2D (Weickert & Pfeiffer 2018). The soluble fibre component in whole grain cereals delays the digestion and absorption of carbohydrates, thus lowering postprandial glucose responses and insulin excursions (Weickert & Pfeiffer 2018). On the other hand, the consumption of refined grains may

elevate the risk of T2D due to their high glycaemic index and glycaemic load, and lower fibre and nutrient contents (Aune *et al.*, 2013).

The study has a few limitations. Firstly, the cross-sectional nature of this study did not enable the causal relationship between dietary patterns and risk of T2D. There was also a lack of participants from various socio-demographic (ethnicities, education, and age); hence, findings from this study may not be generalisable to the target population at large. Secondly, some analyses were not adequately powered due to the small sample size. Results from this small-scale pilot study are promising and further explorations on dietary patterns will be conducted in a more extensive study (Hasbullah *et al.*, 2022). Metabolomic biomarkers related to dietary patterns will also be investigated to better understand the mechanism involved in T2D development in women with a history of GDM, thus helping to inform on the appropriate nutritional interventions for T2D prevention in women with a history of GDM (Hasbullah *et al.*, 2022).

CONCLUSION

Despite having previous diabetes knowledge, women with a history of GDM had higher risk of T2D and fast food consumption than women with normoglycaemic pregnancy. Dietary patterns with high intakes of bread, cereals and cereal products, fast food and meat; as well as rice, noodle, pasta and meat, were associated with an elevated risk of T2D. This indicates that dietary patterns high in saturated fat and protein from animal sources, and food high in carbohydrates, particularly from refined cereal products, may play a role in the development of T2D in women with and without a history of GDM. A more extensive study considering larger sample size and identification of certain metabolites is needed to explore the association between dietary patterns and the risk of T2D, focusing on women with a history of GDM. Continuous postpartum lifestyle interventions are needed to educate women with a history of GDM on healthy dietary patterns to delay their progression to T2D.

Acknowledgement

The study was funded by the Fundamental Research Grant Scheme under the Ministry of Higher Education Malaysia (FRGS/1/2018/SKK05/UPM/02/2; code 04-01-18-1974FR; grant number 5540099).

Authors' contributions

Hasbullah FY, conducted the study, data analysis and interpretation, and prepared the draft of the manuscript; Mohd Yusof BN, principal investigator, conceptualised and designed the study, and assisted in drafting of the manuscript; Abdul Ghani R, Appannah G, Mat Daud ZA, and Abas F, supervised the study, assisted in data analysis and interpretation, and reviewed the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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Mal J Nutr 29(1): 103-113, 2023

Effects of chocolate milk consumption on muscle recovery following rowing exercise: A randomised crossover study

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ABSTRACT

Introduction: For athletes, an excessive increase in blood urea nitrogen (BUN) after multiple endurance exercises indicates muscle glycogen depletion that induces a diminution in performance. Our study aimed to examine the efficacy of chocolate milk (CM) compared with carbohydrate-protein replacement drink (CHOPRO) in suppressing the increase in BUN level following multiple rowing exercises among national male rowing athletes aged 18–23 years. **Methods:** Seven male athletes from the Rowing National Training Centre, Pengalengan, West Java, participated in this single-blind, randomised crossover study. They received CM or CHOPRO during four hours of recovery between two endurance exercises. Before (pre) and after (post) multiple exercises, a venous blood sample was collected to measure the increase in BUN level. The effects of each beverage on BUN level were compared using an independent *t*-test. **Results:** The increase in pre-post BUN level was significantly lower for CM trial compared to CHOPRO trial (164.0±61.3 mmol/L vs 293.5±88.3 mmol/L, p=0.012). **Conclusion:** It was observed that CM reduced rate of increase in BUN level following multiple rowing exercises. Thus, CM can be useful for athletes during intense training regimen with multiple exercise sessions. Future studies should investigate the effect of CM in various types of sports, using convenient, non-invasive, and real-time measurement.

Keywords: athletes, glycogen, milk, muscles, water sports

INTRODUCTION

Rowing is a high-energy demand exercise that involves both aerobic and anaerobic metabolism (Winkert *et al.*, 2022). About 77% of the total energy expenditure yielded during 2000-m rowing comes from the aerobic system, while the remaining 33% comes from anaerobic catabolism (Kim & Kim, 2020). As aerobic and anaerobic system substrates are mainly derived from carbohydrate (CHO), this type of exercise induces muscle glycogen depletion and leads to muscle fatigue (Hargreaves & Spriet, 2020). For elite male rowers, even low-intensity rowing training results in great energy expenditure; and muscle glycogen is likely to be depleted due to

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doi: https://doi.org/10.31246/mjn-2022-0086

huge CHO utilisation (Winkert *et al.*, 2022). Therefore, rowers, particularly those who train in consecutive exercise sessions with 4–6 hours recovery periods, need to consume adequate post-exercise intake to promote muscle glycogen recovery (MGR) (Kim & Kim, 2020).

Blood urea nitrogen (BUN) has been shown as an indirect biomarker of muscle fatigue (Wan *et al.*, 2017), as a result of muscle glycogen depletion during prolonged strenuous exercise (Hargreaves & Spriet, 2020). As muscle glycogen is depleted, adenosine triphosphate (ATP) production and supply will be inadequate to accomplish ATP consumption for skeletal muscle contraction (Hargreaves & Spriet, 2020), which leads to peripheral fatigue (Lee *et al.*, 2017). To retain adenosine triphosphate (ATP)/adenosine diphosphate (ADP) ratio, two ADP molecules will be transformed into one ATP and one AMP molecule. AMP is afterwards degenerated into inosine monophosphate (IMP) and ammonia, while ammonia is then transformed into urea nitrogen, thus increasing BUN level (Wan *et al.*, 2017). In addition, the increase in BUN level may also occur when muscle protein, the last energy reserve, is catabolised for energy supply (Howarth *et al.*, 2010) due to depleted muscle glycogen and fat reserves during an intense and long-lasting exercise (Hearris *et al.*, 2018).

Since the post-exercise period is a critical nutrient timing for recovery, a proper nutritional recovery aid is needed immediately after an intense endurance exercise to stimulate MGR (Murray & Rosenbloom, 2018). Studies have found that ingesting carbohydrate and protein (CHOPRO) recovery drinks will result in a higher rate of MGR compared to CHO alone (Alghannam *et al.*, 2018; Nielsen, Lambert & Jeppesen, 2020). Co-ingestion of CHO with protein may directly increase the rate of MGR, independent of protein's ability as an energy source (Burke, Van Loon & Hawley, 2017). A combination of an insulin-tropic protein and/or amino acid may enhance post-meal insulin release that encourages skeletal muscle glucose absorption and glycogen synthase activity (Kleinert *et al.*, 2011), thus accelerating MGR rate.

As an alternative to CHOPRO, there is a growing interest to use chocolate milk (CM) to promote the improvement of MGR during a short-term recovery period, as it contains CHO and protein with an ideal ratio (4:1) (Pritchett & Pritchett, 2013; Molaeikhaletabadi *et al.*, 2022). Previous studies have compared CM and CHO only (Born *et al.*, 2019), as well as CM vs CHO only vs CHO + electrolytes (Ferguson-Stegall *et al.*, 2011). These studies found that CM is either similar or superior compared to the other supplements in promoting MGR and/or performance.

However, since previous studies mainly focused on comparing CM and CHO only supplements among aerobic-dominant exercise athletes (cycling and running) (Amiri *et al.*, 2019), the data cannot be directly adjusted for rowing, as it occupies not only a high-demand aerobic and anaerobic capacity, but also strength and power that lead to injury and unexplained underperformance syndrome (Kim & Kim, 2020). Due to high-risk muscle breakdown, CHO only supplement is inadequate to promote a positive protein balance for muscle repair (Nielsen *et al.*, 2020). The three components of recovery, including refuel (CHO), rehydrate (fluid), and repair (protein), need to be administered (Kim & Kim, 2020). Hence, the effectiveness of CM compared to CHOPRO supplement on MGR needs to be investigated.

During preparation for international competitions, highly trained Indonesian rowing athletes perform multiple exercises a day with short recovery periods. To avoid muscle fatigue during subsequent training sessions, nutrition recovery is required to promote MGR. Therefore, our study aimed to compare the efficacy of recovery drinks (CM vs CHOPRO) in stimulating MGR by using BUN level as a biomarker of metabolic imbalance. Since milk-based drinks give similar results on MGR when compared to CHO replacement drinks (if they contain an adequate amount of CHO) (Loureiro *et al.*, 2021), we hypothesised that our iso-carbohydrate and iso-protein drinks will have similar effects on BUN levels.

MATERIALS AND METHODS

Subject

Seven healthy, non-smoking, highly-trained elite male rowing athletes (defined by a minimum of two years involvement), aged 18–23 years old from the Pengalengan National Training Centre, Indonesia, volunteered to participate in this study. The participants' physical characteristics are listed in Table 1. Using G-Power version 3.1.9.7 (Informer Technologies, Inc., USA) (Faul *et al.*, 2007), the sample size was determined in which a minimum of seven samples yielded a 95% confidence interval (CI) and an effect size of d=0.5, a=0.05, and b=0.85.

Recovery drinks

CM was a readily drink-box package, while CHOPRO was a combination of five sachets of CHO replacement drink and two scoops of formulated protein hydrolysate. CM product consisted of fresh cow's milk, water, sugar, skimmed milk, fat milk, milk identical flavour and stabiliser, whereas CHOPRO consisted of sugar, dextrose, sucralose, flavouring, casein hydrolysate, soya lecithin and citric acid. As a single-blind control, all beverages were poured into unmarked, opaque bottles. In addition, we poured chocolate paste and chocolate flavour into the CHOPRO beverages to create a similar colour and taste perception. Both drinks contained similar amounts of CHO (iso-carbohydrate) and protein (iso-protein), whereas calories was 35% in CM and potassium was almost six times higher in CM. The comparisons of

Table 1. Physical characteristics of subjects (n=7)

Subject	*Age (year)*	*Mass (kg)*	*Height (cm)*	*BMI (kg/m^2)*	*Body Fat Percentage (%)*	*VO_2 Max ($mL.kg^{-1}.min^{-1}$)*
1	21	72.8	175.5	23.6	17.5	40.3
2	22	69.2	176.5	22.2	18.7	54.4
3	23	71.6	179.2	22.3	15.8	53.1
4	19	72.0	179.2	22.4	15.6	54.3
5	18	72.4	184.6	21.2	18.9	54.3
6	19	70.8	181.7	21.4	15.1	54.6
7	18	83.2	187.8	23.6	19.4	46.2
Mean	20	73.1	180.6	22.4	17.3	51.0
Median	19	72.0	179.2	22.3	17.5	54.3
Standard deviation	2.0	4.6	4.4	0.9	1.7	4.5
Minimum	18	69.2	175.5	21.3	15.1	40.3
Maximum	23	83.2	187.8	23.6	19.4	54.6

BMI: body mass index; VO_2 Max: maximal oxygen uptake

the nutrient content of both drinks are listed in Table 2.

Table 2. Comparison of nutrient content of recovery drinks

Content/ 500 ml	*CM*	*CHOPRO*
Energy (kcal)	450	333
Carbohydrate (g)†	70	70
Protein (g)	12.5	12.5
Fat (g)	12.5	0.3
Sodium (mg)	225	468
Potassium (mg)	1050.0	187.2

CM: chocolate milk; CHOPRO: carbohydrate-protein recovery drink
†Carbohydrate amount was based on 1 g/kg body mass as recommended today (Kerksick *et al.*, 2017)

Study design

This study was a randomised, single-blind experimental study with a crossover design to investigate the effect of iso-carbohydrate and iso-protein post-recovery aid (333-450 kcal) on muscle MGR, marked by BUN level, following muscle glycogen depletion-inducing exercises. Every subject received both beverages (CM or CHOPRO) on two different experimental days separated by a one-week wash-out period. Four subjects received CM on the first experimental day and then received CHOPRO on the second day, and vice versa for the remaining subjects. BUN level was measured four times: before exercise I (pre), after exercise I (before drinking), before exercise II (after drinking), and after exercise II (post).

Experimental procedures

The subjects were asked to refrain from any strenuous activity a day before the experimental day. All subjects discontinued other supplementations three days before and on the experimental day. After fasting for eight hours, the subjects arrived in the morning at the training venue. Height was measured using a wall-mounted stadiometer (OneMed Medicom stature meter, YF.05.05.V.A.1022, Indonesia) to the nearest 0.1 cm, while body mass (to the nearest 0.1 kg) and body fat percentage were measured using the Karada scan body composition monitor HBF-375 (OMRON Healthcare Co., Kyoto, Japan); then BMI was calculated as body mass (kg)/square of height (m). VO_2 max (maximum oxygen uptake during maximal workload) was measured by the researcher and coaches using the rowing ergometer test (Concept II, model C air braked rowing ergometer, Nottingham, UK). The subjects were asked to complete a rowing ergometer test, then total work (watt) was recorded. VO_2 max was estimated using the formula: VO_2 max=[350+(watt x 12)]/body mass (kg).

Exercise I

All subjects performed the first exercise (ED Boat 5 x 15 minutes) in the morning, where they rowed a boat across the waters (Figure 1). Exercise I was performed as a glycogen depletion trial. During the exercise, the subjects were allowed to drink mineral water as much as they needed. Blood samples were collected before and upon completion of exercise I to measure BUN levels. About 3–5 mL blood sample of plasma heparin was taken through the left and right arms. BUN measurement was conducted using the Cobas C111 by Urease GLDH kinetic UV method. Blood samples were poured into a tube to be centrifuged. All procedures of blood sampling were done professionally by the team from P Laboratory. Body mass changes were examined by body mass measurements prior to and upon completion of Exercise I. Extreme body mass changes showed a state of dehydration; subjects had to replace body water as much as their water loss. In addition, body mass changes also showed the exercise intensity.

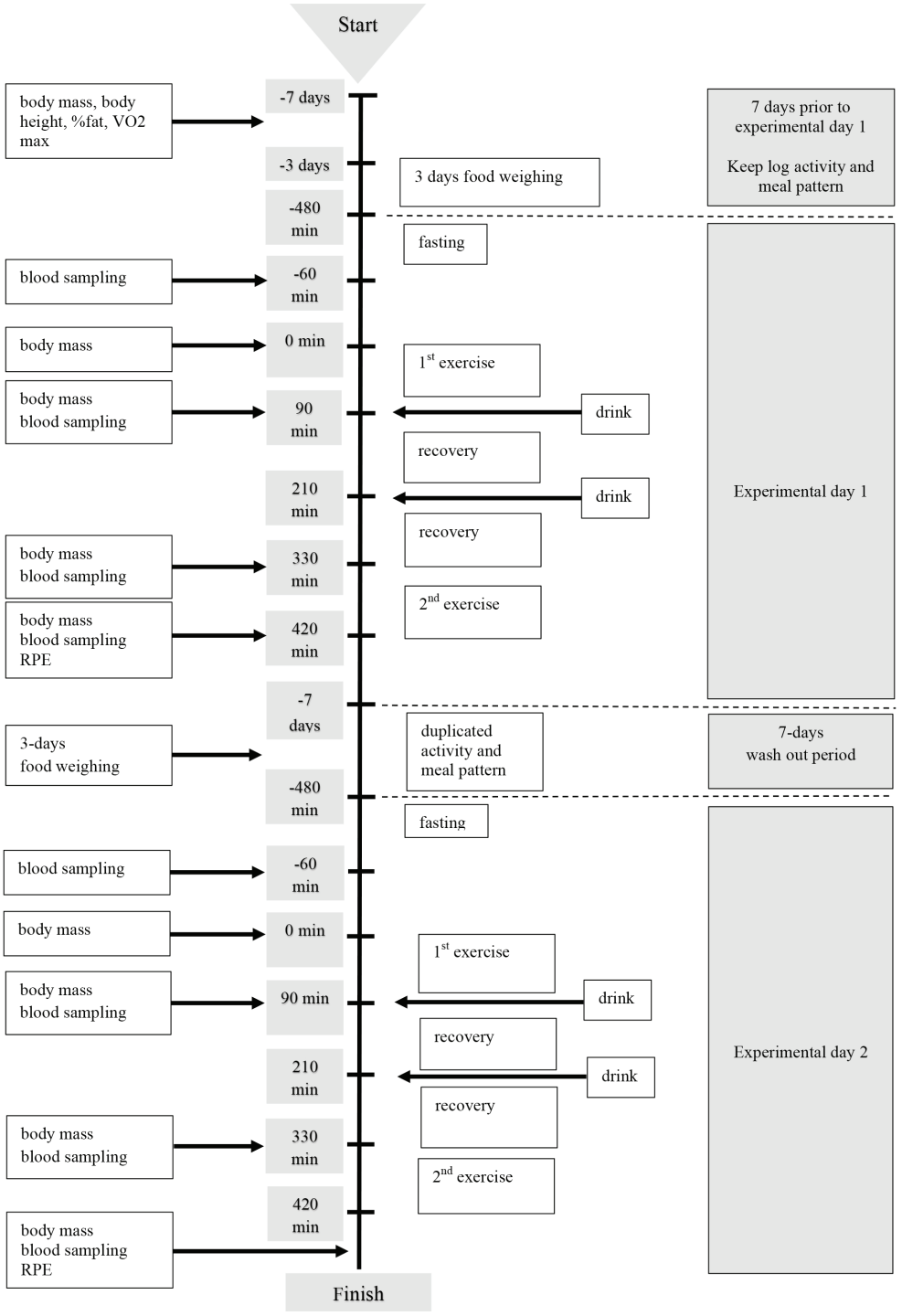

Figure 1. Experimental procedures
*min= minutes
RPE=Rating of Perceived Exertion (Borg, 1982)

Recovery period

After performing the first exercise, the subjects started their recovery period (four hours) to replenish depleted muscle glycogen, rebuild muscle fibres, and replace water and electrolytes. The subjects received 500 mL of recovery drink (CM or CHOPRO) immediately after the exercise and again two hours into the recovery period, respectively (Figure 1). Provision of recovery drinks immediately after a workout is one of the rules of nutrient timing to hasten the rate of MGR (Kerksick *et al.*, 2017). During the recovery period, no other foods or strenuous activities were allowed. However, subjects were allowed to drink mineral water and engage in simple activities (listening to music, reading, walking around, etc.). All subjects were asked to stay in the rowing venue until all procedures had been completed.

Exercise II

By the end of the recovery period, the subjects were ready for the second exercise (ED Ergo 4 x 20 minutes) using a rowing ergometer (Figure 1). Similar to the first exercise, blood samples were collected, and body mass was determined prior to and upon completion of the exercise. During the exercise, subjects were allowed to drink mineral water as much as they needed. To control for a similar exercise intensity between the two trials, Rating of Perceived Exertion (RPE) was obtained from all the subjects immediately after the exercise. RPE aimed to examine the workout intensity using the Borg Scale (scoring was from 6 to 20, where 6 was very, very light and 20 was very hard) (Borg, 1982).

Wash-out period

After completing the first experimental day, the subjects went into a one-week wash-out period where they duplicated a similar activity and meal pattern prior to the second experimental day (Figure 1). During this period, no trial was given. In order to control for a similar dietary intake during the two experimental periods, the subjects duplicated a similar meal pattern for one week prior to each experimental day. Three days prior to each trial, we conducted three days of food weighing to ensure a similar dietary intake.

Ethical approval and permission

The Committee of Experts for Research and Research Ethics, School of Public Health, Universitas Indonesia approved this study, including the protocols and informed consent forms for athletes (No.186/H2.F10/PPM.00.02/2015). All subjects provided written, informed consent prior to the study.

Data analysis

IBM SPSS Statistic for Windows Version 22.0 (IBM Corp, Armonk, NY, USA) was employed for data analysis. All data from the two trials were compared using independent *t*-test (Mann-Whitney U test for data that were not normally distributed). Statistical significance was set at $p<0.05$. To determine the intervention effect on muscle recovery, Cohen's *d* was applied.

RESULTS

Dietary intake, body mass change, and RPE score

Table 3 showed that there were no significant differences in any of the supporting variables, including dietary intake, body mass change, and RPE score. These findings indicated that both experimental periods took place in similar conditions. Moreover, all subjects who participated in our study were highly trained athletes with relatively stable performances. Hence, their mood changes were less likely to vary, as they were not beginners.

Table 3. Comparison of dietary intake, body mass change, RPE score, and BUN level between CM and CHOPRO trials

Variable	*CM*	*CHOPRO*	*p-value*
Dietary intake			
Calories (kcal)	3857±555	3846±485	0.970
Carbohydrate (g)	544.0±100.7	563.3±88.7	0.738
Protein (g)	145.6±12.1	137.2±22.0	0.062
Fat (g)	121.8±18.3	115.1±14.7	0.676
Changes of body mass			
Exercise I (kg)	- 0.9±0.4	- 0.9±0.6	0.932
Exercise II (kg)	- 1.0±0.4	- 1.0±0.6	0.779
RPE score	15.7±1.0	15.3±1.0	0.416
BUN level			
Before exercise I (mmol/L) (a)	10.9±1.5	11.0±2.6	0.569
After exercise I (mmol/L) (b)	11.4±1.7	11.3±2.5	-
Before exercise II (mmol/L) (c)	11.0±1.7	12.1±2.7	-
After exercise2 (mmol/L) (d)	14.1±2.2	16.8±2.7	-
Δ (b – a)/effect of exercise I	0.4±0.5	0.4±0.9	0.706
Δ (c – b)/effect of drinks	-0.4±0.7	0.8±0.3	0.002*
Δ (d – c)/effect of drinks & exercise II	3.1±1.3	4.6±1.5	0.031*
Δ (d – a)/Pre – Post	3.3±1.2	5.8±1.7	0.012*

CM: chocolate milk; CHOPRO: carbohydrate-protein recovery drink; RPE: rating of perceived exertion; BUN: blood urea nitrogen
*Significant at 5% level

BUN level

Before exercise I (pre)

There were no significant differences in BUN level between the trials before exercise I, suggesting that all subjects started exercise I with the same glycogen reserves (Figure 2).

After exercise I (before drinking)

Exercise I caused a rise in BUN level in

Figure 2. BUN levels (mmol/L) at four points of measurement

all subjects (0.4±0.5 mmol/L increase for CM and 0.4±0.9 mmol/L for CHOPRO, respectively) (Table 3). There were no significant differences in this increase between the trials, suggesting that both trials were exercise-induced ammonia increment that was later converted into BUN (Lin *et al.*, 2011).

Before exercise II (after drinking)
At the end of the recovery period (before exercise II), it appeared that CM caused a decrease in BUN level (-0.4±0.7 mmol/L), while CHOPRO caused an increase in BUN level (0.8±0.3 mmol/L) (Table 3). An increase in BUN level following CHOPRO trial indicated a higher level of ATP utilisation to compensate for the need for energy metabolism caused by a higher level of muscle glycogen depletion (Hargreaves & Spriet, 2020).

After exercise II (post)
All subjects performed exercise II to re-examine the effect of the recovery drinks on BUN level. Again, after the exercise, BUN levels increased in all subjects (Figure 2). However, the increase in BUN level was significantly lower in the CM trial (3.1±1.3 mmol/L) than in the CHOPRO trial (4.6±1.5 mmol/L) (Table 3). This showed that although muscle glycogen was re-depleted after exercise II, the increase in BUN level was still much lower after the CM trial.

Effect of recovery drink on BUN level
Overall, the effect of the recovery drinks on BUN level was determined by the increase in pre-post BUN level (before exercise I and after exercise II) (Table 3). Analysis showed that the increase in pre-post BUN level was significantly lower in the CM trial (3.3±1.2 mmol/L) than in the CHOPRO trial (5.8±1.7 mmol/L). It was found that at the end of the recovery period (after drinking/ before exercise II), CM decreased, while CHOPRO increased BUN levels. Also, after exercise II, the increase in BUN level was significantly lower after the CM trial than the CHOPRO trial.

DISCUSSION

The purpose of the present study was to examine the effect of post-workout drinks (CM vs CHOPRO) on the biomarker of MGR (BUN level) after subsequent rowing exercises with a short recovery period. In detail, our main findings were as follows: (1) Before the trial was given, there were no discernible variations in mean BUN levels between the two drinks. However, mean BUN level at the initial stage of both trials (10.9±3.6 mmol/L) was higher than the normal range (1.8–7.2 mmol/L) (Yu, 2011). A higher degree of BUN level may result from an intense rowing exercise in the previous week since BUN recovers slowly after a week of intense-subsequent training (Yun, 2007); (2) After the trials were completed, the total elevation of BUN level was significantly higher in the CHOPRO trial compared to the CM trial. Various physiological indicators other than the rate of MGR, as well as the nutrient substances in both drinks, may influence the change in BUN level.

Besides as an indirect biomarker of muscle glycogen depletion (Hargreaves & Spriet, 2020), BUN level may also be influenced by other conditions such as kidney function, muscle breakdown, and acute kidney injury. When it comes to athletes, conditions such as shock, stress, extreme sunburn or dehydration that decreases blood supply to the kidney may cause BUN to be elevated (Fischbach & Dunning, 2014). Moreover, a high protein diet may also contribute to high BUN levels (Ko *et al.*, 2020). Since our athletes had no kidney disease and were controlled for a similar exercise intensity (muscle breakdown rate), dietary protein intake, and fluid consumption between both trials, thus the different BUN levels

following sports beverages consumption may have come from the discrepancy in muscle glycogen reserves influenced by recovery drink intake.

This finding was surprising because it was hypothesised that the increase in BUN levels would be similar between the two drinks since they were iso-carbohydrate and iso-protein. However, we need to consider the other nutrients contained in CM since apart from CHO and protein contents, milk-based beverages contain several other nutrients that may help muscle recovery (Loureiro *et al.*, 2021).

Our findings were consistent with previous studies that found a higher MGR after a CM trial compared with a CHOPRO trial (Karp *et al.*, 2006) and a placebo trial (Molaeikhaletabadi *et al.*, 2022). In contrast to our study that measured the increase in BUN level as an indicator, Karp *et al.* (2006) measured performances as an indirect indicator of MGR rate among men cyclists. Karp *et al.* (2006) proved that total work was 57% greater and time to exhaustion was 49% longer after CM trial than CHOPRO drink trial. Meanwhile, Molaeikhaletabadi *et al.*, (2022) measured the delayed onset of muscle soreness (DOMS) along with aerobic and anaerobic performances as an indirect indicator of MGR among female badminton players. They found that aerobic and anaerobic capacities were significantly higher, whereas DOMS was significantly lower after a low-fat CM trial ($p<0.05$). Since muscle biopsy is invasive and may impair athlete's performance, the need for novel non-invasive techniques to measure MGR rate is inevitable (Greene *et al.*, 2017). Karp *et al.* (2006) and Molaeikhaletabadi *et al.* (2022) suggested that performances and DOMS are closely related to MGR.

In Karp *et al.* (2006)'s study, both drinks had similar amounts of calories, CHO, protein and fat. The different rates in muscle glycogen recovery were caused by the different types of sugar. The CM used by Karp *et al.* (2006) contained disaccharide sucrose that absorbs as easily as glucose (Burke *et al.*, 2017). This explains why during four hours of recovery period, MGR was faster after the CM trial than the CHO-protein replacement drink trial.

In our study, both drinks had the same amount of CHO and protein; however, the number of calories in CM was higher because it contained fat (12.5 g/500 mL), similar to Molaeikhaletabadi *et al.* (2022) who used fat, but in a lower content (7.5 g/500mL). It has been demonstrated that the fat in CM raises free fatty acid circulation in the bloodstream and thereby inhibits muscle glycogen depletion, acting as a fuel that spares glycogen during exercise, as it has a glycogen-sparing effect (Muscella *et al.*, 2020). This explains the higher rate of MGR following CM consumption.

Another explanation is the potassium content that was almost six times higher in CM (1050.0 mg vs 187.2 mg), which may have promoted a higher MGR and thus led to a lower increase in BUN level. Theoretically, potassium stimulates the uptake of glucose by cells, thereby increasing muscle glycogen replenishment. However, potassium requirement after an intense and prolonged endurance exercise will increase due to excessive potassium losses through urine, and to a small degree, through faeces and sweat (DiNuzzo *et al.*, 2014). Thus, an adequate potassium intake is needed immediately after exercise, mostly because of a high rate of potassium uptake by muscle to replenish muscle glycogen (DiNuzzo *et al.*, 2014). It was possible that due to higher potassium content, CM led to a very rapid MGR rate and suppressed the increase in BUN level after four hours of recovery rather than CHOPRO.

A limitation in our study was that there was no control group that received

a placebo (plain water) after the exercise since giving plain water after a heavy workout may deteriorate an athlete's recovery and lead to exhaustion. In addition, our study did not examine other indicators of MGR that were used in previous studies, such as post-exercise glucose and insulin level, as well as athlete's performances, which may strengthen our interpretation of BUN level. Thus, the closure that CM was superior compared to CHOPRO in promoting MGR cannot be established. However, in the absence of kidney problems and the same rate of excessive protein intake, exercise intensity and fluid consumption, different increments in BUN levels between the two drinks may result from different muscle glycogen reserves after drinking.

CONCLUSION

We found that the increase in BUN level was lower after the CM trial than the CHOPRO replacement drink trial. Our findings suggest that CM induces a lower increase in BUN level following multiple rowing exercises. Hence, CM may be advantageous for athletes during an intense training regimen with multiple exercise sessions.

Acknowledgement

We would like to express our appreciation to SP for funding the laboratory assessment, ZA for his willingness to guide and introduce us to E, and all national rowing athletes who voluntarily participated in our study.

Authors' contributions

Fitriani A, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript, and reviewed the manuscript; Setiarini A, advised on the data analysis and interpretation, and reviewed the manuscript; Ahmad EK, advised on data analysis and interpretation, and reviewed the manuscript; Desiani RP, prepared the draft of methods and results; Fitria, assisted in data collection and data analysis.

Conflict of interest

The authors declare no conflict of interest. This work was supported by DI, Jakarta, Indonesia.

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Mal J Nutr 29(1): 115-135, 2023

Validity and reliability of online questionnaire on awareness, knowledge, attitude and self-efficacy (AKAS) on healthy eating for nutrition education and promotion

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ABSTRACT

Introduction: This study entailed the process of developing an online questionnaire to determine awareness, knowledge, attitude and self-efficacy (AKAS) on healthy eating for nutrition education. Currently, there is no local validated questionnaire that can be used to assess AKAS on healthy eating among Filipino adults. **Methods:** The study developed the questionnaire based on theoretical frameworks and literature review. The draft questionnaire underwent three stages of development: (1) online modified Delphi technique composing of seven subject matter experts (SME) for content validity; (2) online cognitive debriefing with 32 participants (14 nutrition experts and 18 general public) for construct validity; and (3) online pre-testing with 35 participants (non-nutritionists) using test-retest method. **Results:** For first stage, the questionnaire contained 16 questions for awareness, 17 questions for knowledge, 17 questions for attitude, and 15 questions for self-efficacy. For second stage, significantly different scores (p-value<0.00) between nutritionist experts and general public were observed, showing good construct validity. For third stage, Spearman's correlation of test-retest method was 0.640. The questionnaire yielded Cronbach's alpha of 0.467 to 0.923 (round 1) and 0.435 to 0.923 (round 2). A second analysis was done to improve the internal consistency of the questionnaire. By combining two question categories (awareness and knowledge), the Cronbach's alpha increased to 0.659 (round 2), and by deleting three questions in attitude category, the Cronbach's alpha improved to 0.626 (round 2). **Conclusion:** The process used ensured the questionnaire's validity and reliability. Hence, this online questionnaire may be adopted by parties interested in developing and assessing nutrition education.

Keywords: cognitive debriefing, Delphi technique, nutrition education

INTRODUCTION

To have healthy eating habits, adults must consume varied, moderate and balanced meals. The *Pinggang Pinoy* (Healthy Plate Food Guide) serves as a guide for Filipinos in eating healthy meals. Based on a study by Lopez-Madrid *et al.* (2018), there is little awareness on *Pinggang Pinoy* among meal planners in the Philippines. Furthermore, based

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doi: https://doi.org/10.31246/mjn-2021-0099

on the 2018-2019 Philippine dietary survey, Filipino adults ate less healthy foods like vegetables and fruits. Daily vegetables intake decreased from 145 grams in 1978 to 127 grams in 2018-2019; meanwhile, fruits intake per day decreased from 104 grams to 34 grams during the same period (DOST-FNRI, 2021).

Nutrition education was found to improve dietary intake among the general population (Blistein *et al.,* 2016). The conduct of nutrition education activities are aimed to initiate positive behavioural changes like improving one's eating behaviour.

Several Behaviour Change Theory (BCT) can explain a person's intention to change eating behaviour. For example, the Social Cognitive Theory states that personal, behavioural, and environmental factors are interrelated, and in combination, can influence behaviour change. Critical constructs of social cognitive theory are self-observation, self-evaluation, self-reaction, and self-efficacy (Espinosa-Curiel *et al*, 2020).

Another is the Theory of Reasoned Action developed by Fishbein and Ajzen in 1975, which assumes that most behaviours of social relevance (including health behaviours) are under volitional control and that a person's intention to perform a behaviour is both an immediate determinant and the single best predictor of that behaviour. The intention, in turn, is held to be a function of two basic determinants: attitude towards the behaviour or the person's overall positive or negative evaluation of performing the behaviour, and subjective norm or perceived expectations of important others concerning the individual performing the behaviour in question.

The two BCTs can be used as guides in planning, monitoring, and evaluating nutrition promotion and education activities. Nutrition promotion and education initiatives should be user-specific to be relevant and useful to targeted audiences (Zakria *et al.*, 2020). One strategy to address this prerequisite is to come-up with questionnaires that will serve as guides in developing nutrition education and promotion activities that advocate healthy eating.

Questionnaires can be used for needs assessment for programme planning and evaluation (North Carolina State University, 2017). A validated questionnaire is also a critical tool to assess current programmes and projects in place, and thus, ensures that proper measures can be enforced (Abdullah *et al.*, 2020). Proper validation and design of a questionnaire is also essential to facilitate the ease of data collection (Diedre *et al.,* 2012).

Several questionnaires on nutrition knowledge have been developed, such as those for obese adults (Feren, Torheim & Lillegaard, 2011) and for consumers (Dickson-Spillmann, Siegrist & Keller, 2011). These questionnaires were mostly on knowledge only and were constructed primarily for developed countries. Meanwhile, several questionnaires on knowledge, attitude and practices on different nutrition-related topics were formulated, like those on healthy lifestyle for Malaysian adolescents (Hiew *et al.,* 2015), and infant and young child feeding practices for Malaysian mothers (Zakria *et al.*, 2020). A questionnaire on nutrition knowledge, attitude and self-efficacy was also developed for adolescents in India (Sharma *et al.,* 2019).

Currently, there is no local, standard and culturally-appropriate questionnaire for Filipino adults that combines the domains of awareness, knowledge, attitude and self-efficacy (AKAS) on healthy eating. In addition, conduct of synchronous internet-based educational presentations like webinar

was part of the Philippine government's recommendations to adopt to the new normal caused by the COVID-19 pandemic (NEDA, 2020). Since several nutrition-related webinars were conducted during the pandemic, it is therefore important to devise a validated online questionnaire that can be used to plan, monitor, and evaluate online nutrition education and promotion programmes.

This study aimed to describe the development of an online questionnaire on AKAS on healthy eating for Filipino adults aged 19 to 59 years old. The content and construct validity and reliability of the developed questionnaire were also assessed.

MATERIALS AND METHODS

The present study adopted the methodology of Zakria *et al.* (2020) in developing a questionnaire on knowledge, attitude and practices (KAP) for infant and young child feeding (IYCF) with some modifications.

The developed questionnaire was intended to be administered online for adults 19-59 years old. Thus, participants in the study, such as in the cognitive debriefing and pre-testing of the questionnaire, belonged to this age group (Refer to Figure 1 for the stages in the development of the questionnaire). Snowball technique and purposive sampling were used to identify participants in the second and third stages of development, respectively. Since all activities were conducted via the use of internet, participants came from all over the Philippines.

Emails containing informed consent forms were sent to qualified participants. After submission of signed informed consent form, instructions for cognitive debriefing and pre-testing were given to

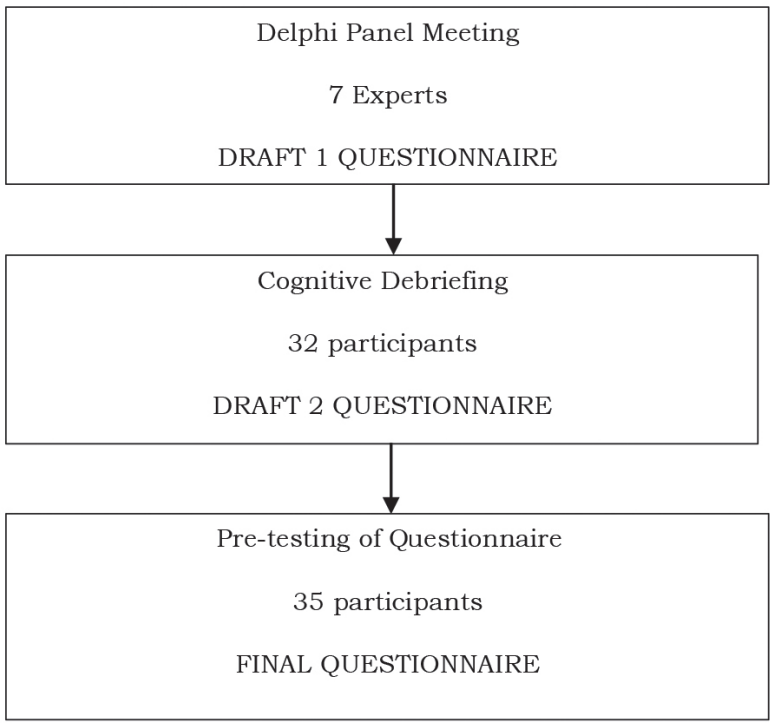

Figure 1: Steps in developing the questionnaire

the participants. No names and emails were asked in the questionnaire to ensure anonymity.

A draft questionnaire was initially developed based on literature review, the Social Cognitive Theory, and Theory of Reasoned Action. The draft questionnaire contained 16 questions for the domain of awareness, 17 for knowledge, 17 for attitude, and 15 for self- efficacy. Questions were on functions and food sources of three food groups (Go, Grow and Glow), recommended serving sizes of the *Pinggang Pinoy*, and intention to buy and eat healthy meals as recommended by the *Pinggang Pinoy*. Awareness and knowledge questions were answerable by 'Yes', 'No' or 'Don't Know' and 'True', 'False' or 'Don't Know', respectively. The attitude and self-efficacy questions were answerable by 'Agree', 'Don't Agree' or 'Neutral'.

Stage 1: Modified Delphi panel meeting

The Delphi technique was used as a guide in questionnaire development. This method is a structured anonymous communication between individuals who are experts on a certain topic with the goal of reaching consensus in areas of policy, practice, or organisational decision making (Brady, 2015).

A modified Delphi technique was used for the study. Instead of the use of questionnaires to reach a consensus, an actual online meeting was conducted to develop the questionnaire. The following steps were followed: (1) Exploration of subject by expert group (literature search, question formulation); (2) Reaching understanding of how the group viewed the questions formulated; (3) Resolving disagreements on questions formulated; and (4) Final evaluation of the questionnaire.

Five nutritionist-dietitians (NDs) and two communication specialists served as panel members, and they were involved in nutrition education and promotion activities.

In the first round, the Delphi process started with the presentation of the draft AKAS questionnaire, which served as a basis for soliciting information, comments and suggestions on content area from the Delphi subjects. The facilitator discussed each item and asked the Delphi panelists' opinions on the formulated questions.

After receiving the panelists' responses and opinions, the facilitator together with the investigator, converted the collected information into a well-structured questionnaire. The well-structured questionnaire that was revised based on comments and suggestions of Delphi panelists from Round 1 was used in Round 2 of the Delphi meeting.

In the second round, the facilitator presented the second draft of the AKAS questionnaire and asked the Delphi panelists to review the items summarised by the investigators based on information provided in the first round. The Delphi panelists were asked to rank-order items in each component of the questionnaire to establish priorities among items. Ranking of items was based on food groupings and functions of foods in the questionnaire. During the second round, there were also disagreements and agreements identified on the formulation of questions and arrangement of question items among Delphi panelists. The facilitator mediated the discussion of panelists until a consensus was reached.

In the third round, the facilitator presented the second draft of the AKAS questionnaire that included the comments and suggestions of seven Delphi panelists in the second round. The facilitator gave Delphi panelists an opportunity to make a final evaluation of the questionnaire before pre-testing. During the third round, the panelists

reached a consensus and approved the final draft of the AKAS questionnaire.

Stage 2: Cognitive debriefing

Cognitive debriefing is a qualitative method to assess respondents' interpretation of a questionnaire. It aims to identify the mental processes respondents use when completing a questionnaire. These processes usually follow a question-answer model (Ploughman *et al.*, 2010). This type of pre-testing belongs to active pre-testing method, which aims to identify problems in each of the questions (Lenzner, Neuert & Otto, 2016).

The study followed the steps in cognitive debriefing by Campanelli *et al. (*1997), as cited in Farnik & Pierzchala (2012) and as used in the methodology of Zakria *et al.* (2020): (1) Comprehension of each question (question intent, meaning of terms); (2) Retrieval of memory of relevant information (what type of information do respondents need to recall and what types of strategies are used to retrieve information?); (3) Decision processes (do respondents devote sufficient mental effort in answering accurately or do the respondents choose an answer because they think a given answer may be expected from them?); (4) The response process (the response options should be clear and allow respondents to choose the appropriate answers); and (5) General comments (example: length of questionnaire).

Informed consent forms were accomplished upon acceptance of invitation during the recruitment stage. On the day of online cognitive debriefing, the participants were asked to accomplish the first draft of the developed AKAS questionnaire. While accomplishing the said questionnaire, participants were encouraged to take note of their comments and suggestions to improve the online questionnaire. This helped in the process of conducting the cognitive debriefing.

Cognitive debriefing was conducted online via Zoom among nutritionist experts and the general public from both rural and urban areas. A total of 14 experts comprising of nutritionists from the academe and hospitals, and 18 general public research participants consisting of students, housewives, and employees from non-health-related fields joined the sessions. For this stage, the total number of participants was 32. In a study by Perneger *et al.* (2015), a suitable number of participants for the pre-testing method of questionnaires was identified. Based on the study, 30 participants is a reasonable default value for pre-testing, as it can achieve a high power to detect a problem in the questionnaire that occurs in 5% of the population, as well as in 10% of the population. Hence, the sample size of 32 was a reasonable size to conduct the pre-testing.

A total of four online cognitive debriefing sessions were conducted. Each session lasted for one-and-a-half to two hours and was recorded for documentation. It was conducted as an interactive discussion through a structured interview. The facilitator asked questions and encouraged interaction among participants. Based on the comments and suggestions gathered, corresponding revisions were made to the questionnaire.

Construct validity of the questionnaire was assessed by comparing the scores of the experts and general public participants. Hence, an overall composite score was computed for the questionnaire. Points were given to the awareness of healthy eating habits, correct answer to knowledge questions, positive attitude, and positive self-efficacy. The total score was 79 points.

Stage 3: Pre-testing

Pre-testing is the assessment of the entire questionnaire, its administration, and encoding of its data for analysis. As compared to stage 2, pre-testing stage aims to stimulate the actual use of the questionnaire (Lenzner *et al.*, 2016). Similar to stage 2, the recommended sample size is 30.

A total of thirty-four (34) participants answered the online questionnaire twice via the test-retest method, while one participant was not able to answer the retest. Participants were asked to take the retest seven days after answering the first test. They also answered a short questionnaire regarding the comprehension of questions, format, time, and interest in answering the questionnaire.

Data processing and analysis

Summarised reports for the Delphi panel meeting and cognitive debriefing sessions were generated. For pre-testing, Google sheets were generated from the answers of the Google form.

Descriptive data were processed to describe the participants who joined the pre-testing. Non-parametric tests, such as Mann-Whitney U test, was used to compute the significant difference in the scores between nutritionists and non-experts. A significantly different score meant that the questionnaire had good construct validity. It was also used to compute the significant difference between the first round and second round of pre-testing scores.

The reliability of the instrument was tested. Reliability meant that the instrument was consistent and produced similar results when administered repeatedly (Farnik & Pierzchala, 2012). To analyse the internal consistency, reliability or the homogeneity of the instrument, Cronbach's alpha coefficient was computed.

Meanwhile, the test-retest reliability was computed using Spearman's correlation. This measured the questionnaire's consistency over time. The level of significance used in the study was alpha (α) equal to 0.05. Data were analysed using IBM SPSS Statistics for Windows version 21.0 (IBM Corporation, Armonk, New York).

Ethics approval

The study was approved by the Institutional Ethics Review Committee of the Department of Science and Technology-Food and Nutrition Research Institute.

RESULTS

Stage 1: Modified Delphi panel meeting

The first draft of the developed questionnaire, which was in English and with Filipino translation, was divided into five parts: socio-demography, awareness, knowledge, attitude, and self-efficacy. Seven panelists reviewed thoroughly the developed questionnaire. The panel met two times via Zoom to review the questionnaire before it underwent cognitive debriefing with the stakeholders. Panelists composed of communication and nutrition experts.

In the first round, discussions dwelt more on socio-economic status, such as on decisions to use proxy indicator or simply ask the family's monthly income in the questionnaire, to split question for number of actual children or total number of children in the household, and to include highest educational attainment. For awareness, knowledge, attitude, self-efficacy questions, seven panelists had the same observations on the formulation of questions, particularly on the inclusion of examples of food items in the question for easy understanding, re-statement of the question, and

translation of some English words into local terms. A total of five questions were deleted in the knowledge domain portion: three about *Pinggang Pinoy* and two about milk consumption. Based on the panel's review, these questions were just repetition of concepts already asked in other knowledge questions. For the attitude domain, one statement on milk consumption for children and two statements on *Pinggang Pinoy* were deleted due to the same reason stated for the knowledge domain.

In the second round, the panelists again reviewed the questionnaire to check if the comments and suggestions from the first round were applied. During the second round of panel meeting, majority of panelists agreed to simply ask about the monthly family income and not use proxy indicators. The employment status - either employed or unemployed – was also suggested to be included in the questionnaire. Choices in some questions, like highest educational attainment was revised to describe a broader classification of educational attainment. All members of the panel accepted the suggestion. Words used, sentence structure and construction, and the translation were revised based on the panel's consensus in the first round.

After two rounds of Delphi panel meetings, the AKAS online questionnaire was finalised. No additional questions were incorporated by the Delphi panel members, only revision to the wordings used in the questions and statements. The final questionnaire contained 16 questions for awareness, from 17 questions to 12 questions for knowledge, from 17 questions to 14 questions for attitude, and 15 questions for self-efficacy (same number from the first round). The first two domains were answerable by 'Yes', 'No' or 'Don't Know' and 'True', 'False' or 'Don't Know', respectively. The attitude and self-efficacy questions were answerable by a three-point Likert scale - 'Agree', 'Don't Agree' or 'Neutral'.

Stage 2: Cognitive debriefing

Results revealed that the average duration in answering the online self-administered AKAS questionnaire was 14 minutes. During cognitive debriefing, choices for several items in the socio-demographic part of the questionnaire were revised, such as monthly household income, physiological status, and marital status. Moreover, some uncommon Filipino words were reverted back to English for ease in answering. The nutrition expert group commented that the questionnaire was easy to read because they were familiar with the *Pinggang Pinoy*. For responses to the questions, both nutritionist experts and the general public found it easy to answer. Furthermore, the options for attitude and self-efficacy questions were changed from a three-point Likert scale to a five-point Likert scale. There were no deletion or addition of questions in the questionnaire. The revised questionnaire based on the results of online cognitive debriefing was used for pre-testing.

The average scores from answering the questionnaire were 63.5 and 56.7, respectively, for the nutritionists and non-experts who joined the cognitive debriefing. Using the Mann-Whitney U test, there was a significant difference between the two scores ($p<0.001$).

Stage 3: Pre-testing

Table 2 presents the general characteristics of 35 pre-testing participants recruited through social media announcement. Most of the participants were female, single, employed, college graduate with an average age of 30.3 years old.

The average score of the participants for the first and second rounds were 60.9 and 60.0, respectively. Based on the Mann-Whitney U test, there was no

Table 1: AKAS questions and Cronbach's alpha of questions

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
Awareness (answerable by 'Yes', 'No' or 'Don't Know')				0.467	0.435	0.453	0.629
1. Are you aware that GO foods are sources of energy for body activities?	/	/	/- combined as one domain knowledge and awareness questions	0.399	0.437	0.465	0.630
2. Are you aware that eating whole grains like brown rice, corn, oatmeal, and whole wheat bread can lower risk of heart disease, diabetes and other health problems?	/	/	/- combined as one domain knowledge and awareness questions	0.479	0.290	0.436	0.589
3. Check which of these you think are GO foods.	/	/	/- combined as one domain knowledge and awareness questions	0.469	0.437	0.454	0.630
4. Are you aware that GROW foods are rich in protein?	/	/	/- combined as one domain knowledge and awareness questions	0.399	0.437	0.465	0.630
5. Are you aware that eating fish, eggs, meat and drinking milk are good for building bones and muscles?	/	/	/- combined as one domain knowledge and awareness questions	0.469	0.437	0.454	0.630
6. Check which of these you think are GROW foods	/	/	/- combined as one domain knowledge and awareness questions	0.469	0.437	0.454	0.630
7. Are you aware that GLOW foods are rich in vitamins and minerals?	/	/	/- combined as one domain knowledge and awareness questions	0.399	0.437	0.465	0.630
8. Are you aware that eating GLOW foods like fruits and vegetables are for good eyesight and strong immune system?	/	/	/- combined as one domain knowledge and awareness questions	0.399	0.437	0.465	0.630

Table 1: AKAS questions and Cronbach's alpha of questions *(continued)*

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
9. Check which of these you think are GLOW foods	/	/	/- combined as one domain knowledge and awareness questions	0.469	0.437	0.454	0.630
10. Are you aware that milk is a rich source of protein, vitamins and minerals?	/	/	/- combined as one domain knowledge and awareness questions	0.469	0.437	0.454	0.643
11. Are you aware that drinking milk everyday is good for strong bones and teeth?	/	/	/- combined as one domain knowledge and awareness questions	0.496	0.437	0.458	0.635
12. Are you aware that it is important to drink enough water everyday to stay healthy and strong?	/	/	/- combined as one domain knowledge and awareness questions	0.496	0.437	0.458	0.630
13. Are you aware that drinking milk is important for proper growth especially among young children?	/	/	/- combined as one domain knowledge and awareness questions	0.524	0.437	0.452	0.630
14. Are you aware that *Pinggang Pinoy* is specially designed for Filipinos?	/	/	/- combined as one domain knowledge and awareness questions	0.356	0.397	0.404	0.622
15. Are you aware that *Pinggang Pinoy* is a simple guide for healthy eating?	/	/	/- combined as one domain knowledge and awareness questions	0.451	0.437	0.424	0.630
16. Are you aware that half of the *Pinggang Pinoy* should contain GLOW foods like vegetables and fruits?	/	/	/- combined as one domain knowledge and awareness questions	0.386	0.095	0.415	0.594
Knowledge (answerable by 'True', 'False' or 'Don't Know')				0.538	0.594		
1. Go foods contain fibre, vitamins and minerals.	/	/	/- combined as one domain knowledge and awareness questions	0.449	0.572	0.359	0.614

Table 1: AKAS questions and Cronbach's alpha of questions *(continued)*

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
2. Go foods provide energy for daily activities.	/	/	/- combined as one domain knowledge and awareness questions	0.550	0.599	0.444	0.630
3. Dried beans and legumes are examples of Go foods.	/	/	/- combined as one domain knowledge and awareness questions	0.420	0.460	0.377	0.546
4. Grow foods are rich sources of protein.	/	/	/- combined as one domain knowledge and awareness questions	0.531	0.599	0.449	0.631
5. Papaya and pechay are examples of Grow foods.	/	/	/- combined as one domain knowledge and awareness questions	0.586	0.530	0.474	0.582
6. Grow foods like eggs, cheese and milk make the body strong and healthy.	/	/	/- combined as one domain knowledge and awareness questions	0.542	0.591	0.454	0.626
7. An adult 20 to 39 years old should consume 2 to 3 servings of fruits and 3 servings of vegetables per day.	/	/	/- combined as one domain knowledge and awareness questions	0.460	0.542	0.411	0.588
8. Potato is an example of GLOW food.	/	/	/- combined as one domain knowledge and awareness questions	0.545	0.479	0.490	0.546
9. GLOW foods do not contain vitamins and minerals.	/	/	/- combined as one domain knowledge and awareness questions	0.503	0.620	0.400	0.643
10. Milk is a good source of calcium for bone health.	/	/	/- combined as one domain knowledge and awareness questions	0.542	0.599	0.454	0.630

Table 1: AKAS questions and Cronbach's alpha of questions *(continued)*

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
11. Water is essential for health.	/	/	/- combined as one domain knowledge and awareness questions	0.542	0.599	0.454	0.630
12. The *Pinggang Pinoy* recommends drinking one (1) glass of milk everyday for children and adults.	/	/	/- combined as one domain knowledge and awareness questions	0.448	0.600	0.443	0.629
13. Milk is an example of Glow food.	†	-	-	-	-	-	-
14. Milk should be important part of a child's diet.	†	-	-	-	-	-	-
15. *Pinggang Pinoy* is a food plate model that shows the proportions of food on a per meal basis	†	-	-	-	-	-	-
16. *Pinggang Pinoy* is a food guide that shows the recommended portions by food groups such as Go, Grow and Glow on per meal basis.	†	-	-	-	-	-	-
17. *Pinggang Pinoy* is a guide that shows the kinds and amounts of food a plate should contain every meal.	†	-	-	-	-	-	-
Attitude (answerable by 'Strongly Agree', 'Agree', 'Strongly Disagree', 'Disagree', 'Neutral')				0.456	0.573	0.506	0.626
1. Go foods are good for me.	/	/	/	0.472	0.572	0.517	0.636
2. I don't like to eat whole grains like brown rice, corn, oatmeal, and whole wheat bread.	/	/	/	0.363	0.557	0.396	0.630
3. It is important for me to eat whole grains like brown rice than refined grains like white rice.	/	/	/	0.392	0.594	0.460	0.655

Table 1: AKAS questions and Cronbach's alpha of questions *(continued)*

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
4. GROW foods are good for me to make bones strong.	/	/	†-deleted in the second analysis	0.476	0.604	-	-
5. I don't like eating dried beans and nuts because they cause arthritis.	/	/	/	0.414	0.556	0.465	0.617
6. It is important to include milk, cheese and eggs in child/ children's diet for their proper growth and development.	/	/	/	0.458	0.596	0.509	0.650
7. I believe that GLOW foods should always be in my market list.	/	/	/	0.403	0.501	0.458	0.555
8. I believe that eating the right amount of GLOW foods everyday will keep my body healthy.	/	/	†-deleted in the second analysis	0.457	0.501	-	-
9. I believe that I should consider the nutritional value of foods before I buy.	/	/	/	0.403	0.501	0.509	0.555
10. Eating GO, GROW, and GLOW foods in proper amount would help me stay healthy.	/	/	/	0.457	0.575	0.458	0.555
11. Drinking one glass of milk per day is enough for me.	/	/	/	0.411	0.560	0.455	0.640
12. I like liquid milk better than powdered milk.	/	/	/	0.468	0.584	0.547	0.658
13. I like drinking milk in small tetra packs.	/	/	†-deleted in the second analysis	0.482	0.606	-	-
14. I do not like drinking water.	/	/	/	0.457	0.575	0.509	0.632
15. It is important to include milk and milk products in children's diet for their proper growth and development.	/	/	/	0.451	0.493	0.501	0.556

Table 1: AKAS questions and Cronbach's alpha of questions *(continued)*

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
16. I can attain and maintain a healthy weight by following the *Pinggang Pinoy*.	/	/	/	0.425	0.501	0.474	0.555
17. Following the *Pinggang Pinoy* would give me adequate vitamins, minerals and energy.	/	/		0.457	0.575	0.509	0.632
Self-efficacy (answerable by 'Strongly Agree', 'Agree', 'Strongly Disagree', 'Disagree', 'Neutral')				0.700	0.923	0.700	0.923
1. I am confident that I can follow the recommended servings of GO foods based on *Pinggang Pinoy*.	/	/	/	0.718	0.914	0.718	0.914
2. I am confident that I can eat recommended servings of GO foods based on *Pinggang Pinoy*.	/	/	/	0.727	0.920	0.727	0.920
3. I am confident that I can include GO Foods in my market list.	/	/	/	0.694	0.921	0.694	0.921
4. I am confident that I can serve protein-rich foods in our daily meals.	/	/	/	0.707	0.920	0.707	0.920
5. I am confident that I can include milk or cheese in my market list.	/	/	/	0.668	0.914	0.668	0.914
6. I am confident that I can drink eight (8) or more glasses of water everyday.	/	/	/	0.693	0.927	0.693	0.927
7. I am confident that I can drink one (1) glass of milk everyday based on *Pinggang Pinoy*.	/	/	/	0.651	0.913	0.651	0.913
8. I am confident that I can always include milk in my daily diet.	/	/	/	0.616	0.910	0.616	0.910

Table 1: AKAS questions and Cronbach's alpha of questions *(continued)*

Questions	*Stage 1*	*Stage 2*	*Stage 3*	*Cronbach's alpha if item is deleted*			
				Frist analysis		*Second analysis*	
				Round 1	*Round 2*	*Round 1*	*Round 2*
9. I am confident that I can include milk in my market list.	/	/	/	0.659	0.914	0.659	0.914
10. I am confident that I can follow the recommended amounts of GROW foods in my daily diet.	/	/	/	0.676	0.917	0.676	0.917
11. I am confident that I can always include GLOW foods in my daily meal.	/	/	/	0.669	0.915	0.669	0.915
12. I am confident that I can follow the recommended daily servings of fruits and vegetables.	/	/	/	0.684	0.915	0.684	0.915
13. I am confident that I can differentiate between healthy and less healthy foods.	/	/	/	0.704	0.928	0.704	0.928
14. I am confident that I can always include vegetables in my every meal.	/	/	/	0.677	0.913	0.677	0.913
15. I am confident that me and my family can make healthier food choices with the help of nutrition labels.	/	/	/	0.704	0.924	0.704	0.924

Labels: †deleted questions; /questions retained

Table 2. General characteristics of pre-testing participants (*n*=35), *n* (%)

Characteristics	*Urban*	*Rural*	*Total*
Sex			
Male	2 (12.5)	5 (26.3)	7 (20.0)
Female	14 (87.5)	14 (73.7)	28 (80.0)
Age			
19 to 20 years old	1(6.2)	0 (0.0)	1 (2.9)
21 to 30 years old	9 (56.3)	8 (42.1)	17 (48.6)
31 to 40 years old	4 (25.0)	10 (52.6)	14 (40.0)
41 to 50 years old	1 (6.2)	1 (5.3)	2 (5.7)
51 to 59 years old	1 (6.2)	0 (0.0)	1 (2.9)
Marital status			
Single	11 (57.9)	12 (63.2)	23 (65.7)
Married	4 (21.0)	7 (36.8)	11 (31.4)
Widowed	1 (5.2)	0 (0.0)	1 (2.9)
Number of son/daughter under 18 years old living in the same household			
None	13 (81.3)	14 (73.7)	27 (77.1)
1	2 (12.5)	3 (15.8)	5 (14.3)
2-4	1 (6.3)	2 (10.5)	3 (8.6)
Number of other children in your care under 18 years old living in the same household			
None	13 (81.3)	19 (100)	32 (91.4)
1	2 (12.5)	0 (0.0)	2 (5.7)
2-4	1(6.25)	0 (0.0)	1 (2.90)
Family size			
≤ 3 household members	6 (37.5)	7 (36.8)	13 (37.1)
4-5 household members	6 (37.5)	10(52.6)	16 (45.7)
≥ 6 household members	4(25.0)	2(10.5)	6 (17.1)
Educational Attainment			
High school undergraduate	1 (6.3)	0 (0.0)	1 (2.9)
High school graduate	0 (0.0)	1 (5.3)	1 (2.9)
Vocational	1 (6.3)	0 (0.0)	1 (2.9)
College undergraduate	1 (6.3)	1 (5.3)	2 (5.7)
College (BS or BA)	9 (56.3)	8 (42.1)	17 (48.6)
Masteral (MS/MA)	4 (25.0)	9 (47.3)	13 (37.1)
Family Income (Php)			
≤ 6,000	0 (0.0)	1 (5.3)	1 (2.9)
6,001 –10, 000	1 (6.3)	1 (5.3)	2 (5.7)
10,001 – 20,000	1 (6.3)	4 (21)	5 (14.3)
20,001 – 30,000	2 (12.5)	6 (31.6)	8 (22.9)
30,001 – 40, 000	4 (25.0)	0 (0.0)	4 (11.4)
40,001 – 50, 000	2 (12.5)	3 (15.8)	5 (14.3)
50,001 and up	6 (37.5)	4 (21.0)	10 (28.6)
Source of Income			
None	3 (18.8)	1 (5.3)	4 (11.4)
Employment	11 (68.8)	17 (89.5)	28 (80.0)
Remittance	1 (6.2)	0 (0.0)	1 (2.9)
Self-employed	1 (6.2)	1 (5.3)	2 (5.7)
Occupation			
Employees of government and special interest organisations, corporate executives, managers, managing proprietors and supervisors	8 (50.0)	4 (21.0)	12 (34.3)
Professional	1 (6.3)	11 (57.9)	12 (34.3)
Clerks, technicians and associate professionals	1 (6.3)	2 (10.5)	3 (8.6)
Not applicable	3 (18.8)	1 (5.3)	4 (11.4)
No answer	3 (18.8)	1 (5.3)	4 (11.4)

BS: Bachelor of Science; BA: Bachelor of Arts; MS: Master of Science; MA: Master of Arts

Table 3. Frequencies of answers of the feedback form about the questionnaire (n=35)

Questions	*Yes, n (%)*	*No, n (%)*
1. Do you understand what is being asked?	35 (100.0)	0 (0.0)
2. Do you understand the terminology used in the questions?	35 (100.0)	0 (0.0)
3. Was there any response for the answers you think maybe missing in the questions?	1 (2.9)	34 (97.1)
4. Was there any question that is offensive?	0 (0.0)	35 (100.0)
5. Was there any question that is difficult to understand?	0 (0.0)	35 (100.0)
6. Did you feel that some questions are biased?	3 (8.6)	32 (91.4)
7. Was there any question that should not be included?	0 (0.0)	35 (100.0)
8. Did the flow and language of the questionnaire seem logical and natural?	34 (97.1)	1 (2.9)
9. Did the time taken to answer the questionnaire seem reasonable?	35 (100.0)	0 (0.0)
10. Is the font size in the questionnaire too small?	0 (0.0)	35 (100.0)

significant difference between the two scores (p=0.390).

Test-retest reliability was computed using Spearman's correlation. The result showed that the Spearman's correlation coefficient was 0.620 (p<0.001), indicating moderate correlation.

Cronbach's alpha was used to analyse the internal consistency of the questionnaire. Results of the analysis can be found in Table 1. For the first round, the Cronbach's alpha ranged from 0.467 to 0.700; while for the second round, it ranged from 0.435 to 0.923. The awareness and self-efficacy categories showed the lowest and highest Cronbach's alpha, respectively.

Since the Cronbach's alpha computed was considered unacceptable, thus, a second analysis was done to improve the Cronbach's alpha of the questionnaire. In the second analysis, the awareness and knowledge questions were combined. In addition, attitude questions numbers 4 and 13 were deleted. Based on the first analysis, deletion of these questions may lead to a higher Cronbach's alpha.

Table 3 presents the frequencies of answers of the feedback form about the questionnaire. Based on the answers, the participants found the questionnaire easy to understand, inoffensive, and unbiased. The format of the questionnaire was also acceptable.

The average duration for answering the questionnaire was 17.3 minutes for the first round and 12.0 minutes for the second round.

DISCUSSION

The study developed an online questionnaire on AKAS on healthy eating for Filipino adults aged 19 to 59 years old. The content and construct validity and reliability of the questionnaire were assessed.

The *Pinggang Pinoy* was used as the basis for questionnaire development. *Pinggang Pinoy* is a healthy food plate guide for Filipinos that is used to promote healthy eating. It identifies the right proportions of Go (carbohydrate-rich foods), Grow (protein-rich foods), and Glow (vitamins and minerals-rich foods) food groups on a per meal basis. The *Pinggang Pinoy* promotes balance and variety wherein half of the plate

represents Glow foods consisting of fruits and vegetables. One sixth of the plate shows proportion for Grow foods and one third of the plate for Go foods. The *Pinggang Pinoy* was developed based on the usual dietary pattern of Filipinos. The Philippine national food consumption survey showed that rice, fish, and vegetables are the usual Filipino diet (FNRI-DOST, 2016). Fruit was added in Pinggang Pinoy as there is a decreasing consumption of fruits among Filipinos (FNRI-DOST, 2016).

The final version of the questionnaire developed was composed of three components, namely awareness and knowledge, attitude, and self-efficacy. Questions on awareness and knowledge on functions and sources of Go, Grow and Glow food groups were formulated. There were also questions on recommended number of serving portions based on the *Pinggang Pinoy* for adults. For awareness and knowledge components, 28 questions were answerable by 'Yes' or 'No' or 'True' or 'False'. Attitude and self-efficacy questions were about intention and confidence, respectively, of respondents to follow the *Pinggang Pinoy* as a guide in healthy eating. Attitude questions were about believing in the importance of following the *Pinggang Pinoy* for good health. Meanwhile, self-efficacy questions were about the confidence of an individual if he/she can follow the *Pinggang Pinoy* recommendations. The attitude component had 17 questions and self-efficacy component had 15 questions. Both components were answerable by a five-point Likert scale.

Content validity of the questionnaire was evaluated through the conduct of Delphi panel meeting. Content validity refers to the process of evaluating a new survey instrument to ensure that it contains all of the necessary items, while excluding those that are not relevant to the questionnaire being developed. This involves literature reviews and evaluation by experts (Taherdost, 2016).

During the Delphi panel meeting, panelists ensured correct technical content, relevant and understandable questions. Panel members were nutritionist-dietitians and communication specialists involved in the development and led the promotion of *Pinggang Pinoy*. Hence, they were considered experts in their respective fields and could evaluate the content validity of the questionnaire. According to Shariff (2015), there are no clear guidelines on the appropriate number of sample size for a Delphi panel, and that heterogenous sample size of experts from different fields can be five to ten per professional group. In this study, there were only seven Delphi panelists from two different fields – nutrition and communication. Furthermore, sample size for Delphi panel can vary according to the purpose of the study, its complexity and resources (Shariff, 2015). For this study, Delphi panel meeting was only the first stage of questionnaire development. Although the sample size for the expert panel was small, there was still a second stage of questionnaire development wherein nutrition experts and non-experts commented on the questionnaire.

Meanwhile, cognitive debriefing assesses the understanding of target respondents on the developed questionnaire. Categorising or grouping of responses by the cognitive debriefing participants was used as the technique in the analysis of the questionnaire modifications to be considered. From the responses, modifications were done in terms of shortening the questions and restructuring of questions for easy comprehension. Misunderstanding of questions by respondents may weaken the content validity of the questionnaire. Incorrect responses and skipped items may be due to irrelevant responses to

the question or misunderstanding of question instructions relevant to them (Ploughman *et al.,* 2010).

Construct validity refers to whether the combination of items in a specific construct provides a good measure. One way to assess construct validity is by comparing two groups - one group composing of nutrition experts, while the other group consisting of the general public. The expert group should score significantly higher, which can be tested using independent samples *t*-test (Feren *et al.,* 2011). A significantly higher score means the questionnaire is able to distinguish the level of knowledge between experts and non-experts; hence, a well-constructed questionnaire.

A number of studies utilised this method in assessing the construct validity of nutrition knowledge questionnaire. In the nutrition knowledge questionnaire for obese adults (Feren *et al.,* 2011), significantly different scores were obtained from nutrition and non-nutrition students. This was also used in the dietary fibre-related questionnaire in Turkey, which showed significantly different scores between nutrition and engineering students (Deniz & Alsaffar, 2013). In this study, participants of cognitive debriefing sessions who were grouped into nutrition experts and the general public answered the questionnaire. Using non-parametric test, it showed significantly different scores, consistent with the results of other studies.

Spearman's rank correlation was used to assess test-retest reliability. The test-retest correlation coefficient for the overall score of the questionnaire was 0.62, which indicated moderate correlation (Akoglu, 2018). Overall, correlation coefficients of between 0.4 and 0.7 indicate moderate correlation, while those between 0.7 and 0.9 indicate strong correlation (Lee, Yim & Kim, 2018). Several factors were identified to affect test-retest reliability. One was the administration of the first test, which may influence participants' answers in the retest. They may have acquired knowledge after the first test that might have improved their scores in the retest. Another disadvantage was the reactivity, which is the act of measuring a person's attitudes that may lead to increased awareness of the phenomenon being studied. As a result, it may change a person's attitude in retesting and lower the correlation coefficient (Karras, 1997). The questionnaire developed was on healthy eating and it may be easy for participants to change their answers in the retest stage due to reactivity or actual changes in eating habits. This may explain the moderate correlation coefficient. The main aim of the questionnaire was for it to be used as a baseline and end line questionnaire for nutrition education interventions, hence, a strong correlation was not expected.

An alpha of 0.60 and above is indicative of good reliability (Lee *et al.,* 2018); a nutrition knowledge questionnaire is recommended to have a Cronbach's alpha of 0.70 (Deniz & Alsaffar, 2013). In another nutrition knowledge questionnaire reliability study in Turkey (Alfassar, 2012), Cronbach's alpha ranged from 0.80 to 0.90. One study in India (Sharma *et al.,* 2019) assessed nutrition-related knowledge, attitude and self-efficacy of adolescents using a questionnaire. The internal reliability of the questionnaire used was 0.70, close to the internal reliability of the present study. A 20-item questionnaire developed by Kumari *et al.* (2020) to assess lifestyle-related behaviours of individuals showed a satisfactory validity and good internal consistency, with a Cronbach's alpha value of 0.72, which was likewise close to the internal reliability of the present study.

Another study that had almost the same Cronbach's alpha with the overall Cronbach's alpha of the present study was a study by Reethest *et al.* (2019), showing the KAP developed questionnaire with 42 items categorised under three domains, namely Knowledge (14 items-0.75), Attitude (15 items-0.75), and Practice (13 items-0.63), had good internal consistencies. The lower Cronbach's alpha reported in this study compared to other studies may also be attributed to the lack in variation in the answers of the respondents since 85% of the respondents had an educational attainment of either college or postgraduate degree. This may reflect very high knowledge in good nutrition practices. Hence, most of the answers were correct or positive, producing a very homogenous sample. The Cronbach's alpha value is highly affected by homogeneity of subject responses (Pike & Hudson, 1998). Although there was a low variation in answers, the calculated Cronbach's alpha was still within the acceptable range after a second analysis was done to conform with the recommended value of Cronbach's alpha.

CONCLUSION

The questionnaire development underwent rigid process. It utilised both qualitative and quantitative methods to ensure that the content of the questionnaire was valid and reliable. A limitation of the questionnaire is that it is available only in English and Filipino, hence not considering other dialects in the country. The questionnaire is intended for online use. In addition, this is the first local study which attempted to validate an online questionnaire on the AKAS on healthy eating. With the digitalisation brought about by the COVID-19 pandemic, it is important to develop validated questionnaire that can be used to plan and assess the conduct of online nutrition education and promotion activities. Overall, the developed questionnaire was found to be valid and reliable, and can be used in assessing AKAS of participants of nutrition education for healthy eating. For future studies, it is recommended to pre-test and print the developed questionnaire for face-to-face survey to assess its content and construct validity and reliability.

Acknowledgement

The authors would like to acknowledge the support of the following DOST-FNRI-TDSTSD staffs: Nichole M, Bristol, Science Research Specialist I; Maja Bethzaida Decena, Science Research Specialist I; Shannen Faye Arevalo, Science Research Specialist II, Josefina T. Gonzales, Senior Science Research Specialist; Salvador R. Serrano, Senior Science Research Specialist, Dexter de Leon, Science Research Specialist II , Lea B. Landicho, Science Research Specialist II and Theresa Krista Jolejole, former TDSTSD staff for assisting in the development of the proposal, the conduct of the Delphi meetings, cognitive debriefing and pre-testing of online AKAS questionnaire and data analysis. The authors also acknowledge the active participation of study participants during the Delphi meetings, cognitive debriefings and pre-testing of the study.

Authors' contributions

Gonzales MS, principal investigator, conceptualised and designed the study, served as critique during Delphi meeting; reviewed the drafts and final manuscript before submission to the Malaysian Journal of Nutrition; Glorioso IG, co-investigator, assisted in the conceptualisation and designing the study, led in the conduct of Delphi meeting, assisted in the conduct of cognitive debriefing, prepared the draft and final manuscript, revised the manuscript based on comments of reviewers, reviewed the final manuscript before submission to the Malaysian Journal of Nutrition; Navarro CAJ, co-investigator, led in the conduct of pre-testing (test and re-test), data analysis and interpretation, assisted in drafting of the manuscript, revised the manuscript based on the comments of reviewers, reviewed the final manuscript before submission to the Malaysian Journal of Nutrition; Jolejole TKB, co-investigator, data analysis and interpretation of the highlights of cognitive debriefing, assisted in drafting of the manuscript, proofread the manuscript and assist in the revision of manuscript based on the comments of reviewers.

Conflict of interest

The authors declare no conflict of interest.

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Weight cycling among Indonesian college students in West Java province during the COVID-19 pandemic

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ABSTRACT

Introduction: Changes in our bodies can cause several problems, particularly for students who are concerned about maintaining an ideal body shape. Many of them try to diet, but their body returns to its previous weight or even increases in weight. Thus, this study aimed to determine the factors that influence the incidence of weight cycling in Indonesian students during the COVID-19 pandemic. **Methods:** This cross-sectional study used purposive sampling to collect data. Three hundred college students from West Java province, Indonesia, participated. Weight cycling was the dependent variable and the independent variables were physical activity, sex, and weight management. Multivariate logistic regression analysis was used to determine the factors influencing the incidence of weight cycling. **Results:** Sex, physical activity, skipping meals, and snacking were determinants related to weight cycling incidence. Females had a 0.7 times higher risk of experiencing weight cycling than males. Inactive students were 4.7 times more likely to become weight cyclers, and those who rarely skipped mealtime had lower risk of being weight cyclers. Students who sometimes and always consumed snacks had higher risk of becoming weight cyclers by 3.3 and 2.7 times, respectively, compared to those who rarely consumed snacks. **Conclusion:** Regular physical activity, not skipping meals, especially breakfast, and practising a healthy diet every day are recommended strategies to avoid weight cycling during a pandemic.

Keywords: dietary habits, physical activity, weight cycling, weight management

INTRODUCTION

Changes in body shape frequently result in many individual problems. One of the most significant issues confronting young adults over the age of 18 years related to body weight. The response behaviour is to pay attention to changes in body shape with the goal of making it look ideal (Stavridou *et al.*, 2021). Many young adults engage in dieting without considering the nutritional composition of the food they consume. They diet to appear attractive and be accepted by their friends. A strict diet, such as eating once a day without consulting a doctor or nutritionist, is one of the diets that jeopardises health. Many people who start a diet only think about how to get thin quickly and easily without considering the effects of the diet (Tapsell *et al.*, 2016).

Weight cycling is a condition of losing weight after a diet, but then re-gaining weight rapidly, and repeatedly. The effects often occur in people who make frequent dietary changes. It can also

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doi: https://doi.org/10.31246/mjn-2021-0125

occur if a young adult goes back to their previous eating pattern after reaching her ideal weight. This weight gain can return to the pre-diet weight; however, it can also be larger and lead to obesity. Obesity and its co-morbidities, such as cardiovascular disease, type 2 diabetes, and various types of cancer, are the main health issues to address because they are the leading global causes of death; thus, efforts must be made to minimise their prevalences. More than 1.9 billion adults were overweight or obese in 2016, yet efforts to combat obesity have mostly failed (Contreras, Schriever & Pfluger, 2019). The incidence of obesity has doubled in more than 70 nations in recent decades, and obesity cases have tripled among young people in many places, particularly in emerging and low-income countries such as China, Brazil and Indonesia (Pellegrini *et al.*, 2020).

Obesity develops as a result of a long-term imbalance between energy intake and production, leading to the accumulation of fat tissue. Weight loss is important in preventing disease complications. Successful weight loss is defined as a person voluntarily losing 10% of their initial body weight and maintaining it for a year (Contreras, Achriever & Pfluger, 2019). Although guidelines for recommending various types of weight loss have been developed, most are known to be effective only in the short term. Nearly 80% of obese people who intentionally reduced weight are likely to regain their previous weight within five years (Yumuk *et al.,* 2015). Weight cycling is defined as a 2.25 kg-10.00 kg or 5-10% fluctuation in body weight over one month or one year (Carey & Vitek, 2020).

Weight cycling is unlike weight change, in that it does not just measure changes in body weight during a diet; there is also further assessments of changes in weight before and after dieting. This is important because weight cycling can lead to obesity and can put individuals at a higher risk of future weight gain (Mackie, Samocha-Bonet & Tam, 2017).

Weight cycling has previously been seen in people with overweight and obesity issues who intended to go on a weight loss programme. However, it is becoming more prevalent in students with normal nutritional health who feel dissatisfied with their body shape and embark on a weight loss programme. In addition to body image, the COVID-19 pandemic has had an impact on students' lifestyles, activities and diet. College students are obliged to engage in more activities at home, which leads to an increase in sedentary behaviour, such as sitting, lying down, and playing video games (Alafif *et al.*, 2021). Since the pandemic, college students have been involved in extensive online learning activities, resulting in increased screen time, which leads to behavioural changes in weight control. Therefore, the objective of this study was to identify the factors associated with the occurrence of weight cycling among college students in West Java province, Indonesia, during the COVID-19 pandemic.

MATERIALS AND METHODS

Study population

The Ethics Committee of Universitas Gadjah Mada approved this study under the number KE/FK/0670/EC/2021. The inclusion criteria for the sample were: 1) college students above the age of 18 years; 2) college students living in West Java, Indonesia; and 3) college students who were still registered at the university. The exclusion criteria for this research sample were: 1) college students who had a history of diabetes mellitus or who were diagnosed with cancer; 2) college students who were pregnant; and 3) college students who did not respond to all questions in the questionnaire.

Sampling method

The sample size was determined using Cochran's formula for an unknown

population ($n=z^2pq/d^2$). On the basis of accuracy levels of d=0.05, q=0.5, p=0.5, and a 90% confidence interval (z=0.164), the required sample size for this study was 270. The study included 300 participants to overcome participant drop-out. The formula for adding the sample size was *n'=n/(1-f)*; *n'*: number of samples after revision, *n*: number of samples; and the estimated proportion of drop-outs as 10%.

Instrumentation

This research used a cross-sectional design, with structured questionnaires based on interviews. The reliability and validity of the questionnaires were validated in the Indonesian language. Before completing the questionnaires, the respondents signed an informed consent form as proof of their consent. Weight cycling, physical activity, and weight management behaviour were the variables measured in this study.

The incidence of weight cycling during the COVID-19 pandemic was divided into two categories: those who experienced weight cycling and those who did not experience weight cycling. Weight cycling was assessed using the questionnaire developed by Panarotto *et al.* (2014). It included respondents general data, such as sex and residence. To collect information about cycling of body weight, students were asked if they were in Indonesia during the COVID-19 pandemic, that was from 2 March 2020 to the time this research was carried out. To determine whether there was any fluctuation in their weight, the students were asked if they had experienced any weight gains after weight loss treatments. If they answered 'Yes' and it turned out to be an increase in weight of about 2.25 kg–10.00 kg, the student was categorised as a weight cyclist. This was in accordance with the statement by Carey & Vitek (2020) that someone can be regarded as a weight cyclist if they diet by intentionally reducing energy intake to lose weight, but once successful, regains weight by about 2.25 kg–10.00 kg or 5–10% of their initial body weight over one month or one year.

Weight management behaviour was measured using a questionnaire modified from Robinson *et al.* (2021), with each question item assessed using the following terms: 1= rarely, 2= sometimes, 3= often, and 4= always. A short version of the International Physical Activity Questionnaire (IPAQ) was used to assess the respondents' physical (Orcid & Orcid, 2020). There were two ways to measure scores on the Short-IPAQ: continuous scores and category scores. The category scoring technique used in this study divided physical activity into three categories: (1) category I/inactive, (2) category II/minimally active, and (3) category III/HEPA (health enhancing physical activity). These were defined as follows:

a. Category 1 (inactive) was the lowest level, comprising those who did not fit into the second and third categories.
b. Category II (minimum activity) comprised those with the lowest activity pattern that could be classified as sufficient activity. The criteria for inclusion were three or more days per week of vigorous activity for at least 20 minutes per day, five days or more of moderate intensity activity or walking 30 minutes per day, or five or more days of any combination of walking, moderate-intensity exercise and vigorous-intensity activities achieving a minimum of at least 600 MET-min/week.
c. Category III (HEPA) comprised those who did 1.5-2.0 hours of exercise per day with high intensity.

Data analysis

Data analysis was performed using IBM SPSS Statistics for Windows version 26 software (IBM Corporation, Armonk,

New York, USA). In addition, the validity of the questionnaires was tested using the Pearson Product Moment technique, while reliability was tested using Cronbach's alpha. All variables showed strong reliability test results: weight cycling variables (Pearson's R=0.824, p<0.05), physical activity variables (Pearson's R=0.764, p<0.05) and weight management behaviour (Pearson's R=0.684, p<0.05). Descriptive, bivariate, and multivariate study data processing were performed using STATA Statistical software: Release 17 (StataCorp LP, College Station, Texas, USA). The variables were subjected to bivariate analysis to identify independent variables that met the requirements for multivariate logistic regression analysis. Independent variables with p value <0.25 can be investigated further using a multivariate model.

RESULTS

Respondent characteristics

The findings showed that 61.3% of college students in West Java were not weight cyclists during the COVID-19 pandemic, while 38.7% of students were. Table 1 lists the factors associated with weight cycling. Most of the students (54%) who participated in this study were female, and nearly all lived with their parents or family (78%) during the pandemic from 2020 to 2021. Since the implementation of the large-scale social restriction policy (PSBB; *Pembatasan Sosial Berskala Besar*) by the Indonesian government, schools and other public facilities were closed to prevent the virus from spreading. It was found that most students (50.7%) did not engage in sufficient physical activity. The students' weight management habits were also poor during the pandemic, with 38.4% frequently skipping meals, 51.7% frequently consuming snacks, and 38.7% sometimes eating more food when stressed (Table 1).

Table 1. Socio-demographic background, dietary habits, and physical activity of the respondents (N=300)

Variable	*n (%)*
Sex	
Male	136 (45.3)
Female	164 (54.7)
Residence	
Family/ relatives	236 (78.7)
Dormitory	64 (21.3)
Physical activity	
HEPA	73 (24.3)
Minimum active	75 (25.0)
Sedentary	152 (50.7)
Skip mealtime	
Rarely	70 (23.3)
Sometimes	115 (38.4)
Often	79 (26.3)
Always	36 (12.0)
Taking dietary supplements	
Rarely	271 (90.6)
Sometimes	23 (7.7)
Often	0 (0.0)
Always	5 (1.7)
Snacking	
Rarely	75 (25.0)
Sometimes	70 (23.3)
Often	0 (0.0)
Always	155 (51.7)
Eating when stressed	
Rarely	101 (33.7)
Sometimes	116 (38.7)
Often	0 (0.0)
Always	83 (27.6)

HEPA: health enhancing physical activity

Bivariate analysis of factors related to weight cycling

According to the bivariate analysis (Table 2), only 28.7% of male students in this study experienced weight cycling during the COVID-19 pandemic. Weight cycling was more common among female students, with 47.0% engaging in weight cycling. According to the bivariate analysis, 61.4% of those who lived with their family did not experience weight cycling. The result was similar for those in student dormitories (60.9%). With regard to level of physical activity, 49.3%

of sedentary students experienced weight cycling, and 40.0% of students categorised as minimally active experienced weight cycling. Surprisingly, 15.1% of the physically active students also experienced weight cycling during the pandemic.

The results of the bivariate study on weight management behaviour factors, such as skipping mealtimes, consumption of dietary supplements, snacking, and eating while stressed, are shown in Table 2. The vast majority of the 300 students (77.1%) rarely skipped meals. College students who always skipped meals had higher risk of being weight cyclists (50.0%). Although most were found to rarely use dietary supplements, 47.8% occasionally did. Snacking was observed in 155 students, with 45.7% of weight cyclists snacking occasionally during the pandemic. Stress was a regular issue for college students during the pandemic, and most of the participants ate more to reduce their stress;38.6% of students ate more food whenever they were stressed, while 42.2% of weight cyclists consumed more food whenever they were stressed (Table 2).

Multivariate analysis of factors related to weight cycling

Following the bivariate analysis, sex, physical activity, skipping meals, and snacking were included in

Table 2. Bivariate analysis of independent variables related to weight cycling (*N*=300)

Variable	*Weight cycling n (%)*		*OR*	*95% CI*
	Yes	*No*		
Sex				
Male	39 (28.7)	97 (71.3)	1	
Female	77 (47.0)	87 (53.0)	2.2	1.3 – 4.6
Residence				
Family/ relatives	91 (38.6)	145 (61.4)	1	
Dormitory	25 (39.1)	39 (60.9)	1.0	0.8 – 3.2
Physical activity				
HEPA	11 (15.1)	62 (84.9)	1	
Minimum active	30 (40.0)	45 (60.0)	3.8	2.4 – 5.5
Sedentary	75 (49.3)	77 (50.7)	5.5	5.7 – 7.7
Skip mealtime				
Rarely	16 (22.9)	54 (77.1)	1	
Sometimes	46 (40.0)	69 (60.0)	2.2	0.9 – 3.5
Often	36 (45.6)	43 (54.4)	2.8	1.9 – 4.4
Always	18 (50.0)	18 (50.0)	3.4	1.3 – 5.9
Taking dietary supplements				
Rarely	102 (37.6)	169 (62.4)	1	
Sometimes	11 (47.8)	12 (52.2)	1.5	0.4 – 3.2
Always	2 (40.0)	3 (60.0)	1.1	0.2 – 3.5
Snacking				
Rarely	17 (22.7)	58 (77.3)	1	
Sometimes	32 (45.7)	38 (54.3)	2.9	0.9 – 6.2
Always	67(43.2)	88 (56.8)	2.6	0.5 – 6.7
Eating when stressed				
Rarely	41 (40.6)	60 (59.4)	1	
Sometimes	40 (34.5)	76 (65.5)	0.8	0.3 – 2.7
Always	35 (42.2)	48 (57.8)	1.1	0.4 – 3.4

HEPA: health enhancing physical activity

the multivariate analysis (p<0.25). The multivariate analysis aimed to determine which of the variables affected the incidence of weight cycling among students in West Java during the COVID-19 pandemic. According to the results of the multivariate analysis (Table 3), there was no interactions between the independent and covariate variables. Thus, the fit model shown in Table 3 was obtained. According to the results of the multivariate analysis, factors related to weight cycling were sex, physical activity, skipping mealtime, and snacking.

Table 3. Factors associated with the incidence of weight cycling among Indonesian college students (Fit Model)

Variable	*OR*	*95% CI*
Sex		
Male	1	
Female	1.9	0.6 – 4.3
Physical activity		
HEPA	1	
Minimum active	3.4	2.2 – 5.2
Sedentary	4.7	2.0 – 7.2
Skip mealtime		
Rarely	1	
Sometimes	2.2	0.8 – 3.4
Often	2.6	1.2 – 4.6
Always	2.7	1.8 – 5.2
Snacking		
Rarely	1	
Sometimes	3.3	1.2 – 5.7
Always	2.7	0.8 – 4.1

HEPA: health enhancing physical activity

Physical activity was the determinant variable of weight cycling, especially in sedentary (B:1.5) and minimally active (B:1.2) students. Sedentary students were 4.7 times more likely to become weight cyclists, and those who were slightly active had a 1.2 times higher risk of becoming weight cyclists than those who actively engaged in HEPA. The prevalence of weight cycling was also found to be affected by sex. Female students were 0.7 times more likely to become weight cyclists than male students.

Skipping meals was also associated with an increased risk of weight cycling among college students. When compared to those who rarely skipped meals, students who always skipped mealtimes had a 2.7 times greater chance of becoming weight cyclists, while students who frequently skipped mealtimes had a 2.6 times larger risk of becoming weight cyclists. College students who sometimes skipped meals were only 2.2 times more likely to become weight cyclists than those who rarely skipped meals. Similar results were found for the snacking habits of college students. Those who snacked sometimes and frequently had a 3.3 and 2.7 times higher risk, respectively, of becoming weight cyclists, compared with those who rarely snacked.

DISCUSSION

This study aimed to explore the phenomenon of weight cycling among college students and to identify the factors affecting weight cycling during the COVID-19 quarantine period from 2020 to 2021. According to the multivariate logistic regression analysis, sex, type of physical activity, skipping meals, and snacking were variables that predicted weight cycling among students. In this study, 39.7% of college students in West Java province, Indonesia, experienced weight cycling. A systematic scoping review published in 2021 indicated that during the COVID-19 pandemic, more than half of the young adult participants gained weight, while one-fifth lost weight (Chew & Lopez, 2021). Several studies have reported predictors of weight gain, including female sex (Di Renzo *et al.*, 2020), increased food consumption (Keel *et al.*, 2020), snacking after dinner (Zachary *et al.*, 2020), sedentary behaviour for six hours a day (Reyes-Olavarría *et al.*, 2020), and a lack of sleep at night (Zachary *et al.*, 2020).

Sex

In this study, women were shown to be 0.7 times more likely to suffer weight cycling than men. A study conducted in Saudi Arabia also found a significant correlation between sex and weight cycling. The number of female students who experienced weight cycling was higher than that of male students during the COVID-19 pandemic (Alafif *et al.*, 2021). Men are anticipatory when dealing with weight gain. For male students, social support from peers can act as a buffer against stress eating and weight increase. Adult women are known to be inclined to gain or lose weight repeatedly. A study of 167 obese women aged 18–60 years in the United States showed that 63% had experienced weight cycling and more than half had done so more than three times. They also have a higher BMI and maximum body weight than men (Darling *et al.*, 2017).

Women place such a high value on their appearance because they frequently experience low self-esteem and low physical satisfaction. There is significant difference in subjective perceptions of body image between sexes, with women demonstrating a higher disparity between real and perceived body image (Lôbo *et al.*, 2020). Moreover, overweight female students have a significantly higher prevalence of body image dissatisfaction (Ugelta *et al.*, 2022). There is more weight cycling among women, not only because of their body image, but also because women tend to be less eager to engage in physical activity than men. This fact is supported by data from the Basic Health Study conducted by the Indonesian Ministry of Health in 2018, which showed that around 36.4% of males and 30.7% of females over the age of 10 years engaged in insufficient physical activity (Ministry of Health of the Republic of Indonesia, 2018).

Physical activity

Physical activity was the most influential variable in the occurrence of weight cycling among the Indonesian students in West Java. The results of the multivariate regression analysis showed that students who had minimum physical activity habits had a 4.7 times greater risk of experiencing weight cycling than those who actively engaged in HEPA. A systematic review in 2019 reported that 89% of people who experienced weight cycling had strict commitment to performing high levels of physical activity and consuming low-calorie foods (Contreras, Schriever & Pfluger, 2019). The PSBB policy, which limited activities outside the home, altered the activity patterns of students, who were obliged to stay at home throughout the pandemic. Many studies found a decline in activity among teenagers and college students after the COVID-19 outbreak (Contreras, Schriever & Pfluger, 2019). Sedentary behaviour in college students changed during confinement due to the COVID-19 pandemic. Adults may have been forced to spend more time at home during this period of activity limitation, increasing the prevalence of sedentary behaviour (Romero-Balco *et al.*, 2020).

During the pandemic, the number of minutes per week spent engaging in moderate to vigorous physical activity significantly declined by about 20%, whereas time spent being inactive increased by three hours per day. Many students were forced to return to living with their parents and were forced to work from home, making access to sports facilities more challenging. The availability of sporting facilities such as gyms, fitness centres, swimming pools, and parks influences students' levels of physical activity (Bertrand *et al.*, 2021). College students can spend all day sitting in front of a computer, which can cause the abdominal muscles to soften and become distended. In addition, weight gain can be caused among students by eating unhealthy snacks while sitting in front of the computer and failing to engage in sufficient physical activity. The

World Health Organization recommends 150 minutes per week of exercise, which not only maintains the immune system and reduces stress from exhaustion or studying, but also helps maintain body weight (Ugelta *et al.*, 2022).

Skipping mealtime and snacking

In this study, weight cycling was found to be related to skipping meals and frequent snacking. Students who skipped meals consistently had a 2.7 times higher risk of weight cycling than those who skipped meals infrequently. Students who snacked frequently had a 2.7 times higher risk of weight cycling than students who seldom snacked.

Skipping meals is one of the behaviours that influences body weight. Research on those above 18 years of age has shown that those who skip meals have a higher body weight than those who do not. Young adults who skip breakfast consume an extra 193 kJ of energy at lunch. They also consume 114 kJ more at dinner when they just skip breakfast, 369 kJ more at dinner when they just skip lunch, and another 783 kJ at dinner when they skip both breakfast and lunch. Skipping meals (particularly dinner) reduces daily energy intake, but the reduction in daily diet quality (particularly when skipping breakfast) may negatively impact health over time. Skipping mealtimes, especially skipping breakfast, can cause overweight and obesity. This will undoubtedly increase the incidence of weight cycling (Zeballos & Todd, 2020).

Changes in eating habits, especially skipping meals and replacing them with snacks, are common in adults with stress or depression. Stress has also been associated with failure of weight loss programmes and high-calorie food consumption (Araiza & Lobel, 2018). Since the COVID-19 outbreak, many adults have felt significantly more anxious about being infected with the virus (Pellegrini *et al.*, 2020). Though the PSBB has prevented direct public interaction, yet many people have become stressed by the pandemic's boring routines at home (Hasanzadeh & Alishahi, 2020).

Several studies have investigated the association between the prevalence of weight cycling and stress (Quinn, Puhl & Reinka, 2020). It has been discovered that stress has an impact on an individual's food habits and exercise levels (Araiza & Lobel, 2018). Snacking and high-fat/high-sugar meals are frequently found in stressed adults (Silverman & Wang, 2021). One study found that during the pandemic, eating habits changed, with a 73% increase in eating when bored, a 65% increase in snacking after dinner, and a 73% increase in eating to satisfy food cravings. In 2020, a study on the Italian general population and students discovered new eating behaviours that resulted in a higher intake of "comfort foods" including chocolate, desserts, ice cream, and salty snacks (Scarmozzino & Visioli, 2020).

The PSBB altered the activity patterns of students, where they were obliged to stay at home. Online learning activities carried out by students during this pandemic also resulted in increased screen time and changes in weight management behaviour (Zachary *et al.*, 2020). Excessive weight gain can alter body composition and have an impact on a person's level of fitness, as well as their metabolic system (Carey & Vitek, 2020). Several methods may be used to maintain a healthy lifestyle and prevent weight cycling, including participation in regular physical exercise, not missing meals (particularly breakfast), and keeping a balanced diet. Exercise is fundamental for both burning calories and increasing the body's metabolism, both of which are essential for weight management and overall health (Ross *et al.*, 2020). Furthermore, a low-calorie, high-protein, and high-fibre diet should be considered; this can help prevent

overeating, since protein and fibre can help to reduce excessive appetite and produce a full stomach.

The limitation of this research is its cross-sectional design, which meant that it was not possible to evaluate cause and effect, and there was no information on food consumption patterns from the respondents. To fully understand the determining factors of weight cycling, other variables in eating behaviour should be included.

CONCLUSION

Many Indonesian students do not pay attention to the nutritional content of the food they eat when they go on a diet. Consequently, they go through a heavy cycle. Several factors can affect the onset of weight, including sex, physical activity, and skipped meals and snacks. Weight cycling needs to be avoided because it not only increases the risk of future weight accumulation, but also increases the risk of death, heart disease, and type 2 diabetes mellitus. Regular physical activity, not skipping meals (especially breakfast), and following a healthy diet every day are some strategies that are recommended to avoid becoming a weight cyclist.

Acknowledgement

The authors extend their gratitude to the Research and Community Service Institutions (LPPM; Lembaga Penelitian dan Pengabdian Masyarakat), Universitas Pendidikan Indonesia, for funding this research.

Authors' contributions

Mulyana B, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Fitrianingsih ADR, led the data collection, data analysis and interpretation, and reviewed the manuscript; Syihab SF, data interpretation, assisted in drafting of the manuscript, reviewed the manuscript; Novan NA, prepared the draft of the manuscript and took care of administration for research permits.

Conflict of interest

All authors declare that there is no conflict of interest.

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Mal J Nutr 29(1): 147-162, 2023

Diabetes prevention through digital therapy for high-risk individuals: Study protocol for the Malaysia Diabetes Prevention Programme (MyDiPP)

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ABSTRACT

Introduction: Intervention approaches that integrate human coaching into technology are considered as a convenient, accessible and scalable method to reach a larger population at risk. The objective of this paper is to present the protocol for a randomised controlled trial that evaluates the efficacy of a lifestyle intervention programme via a mobile phone app (MyDiPP), which aims to prevent diabetes among adults at risk of developing diabetes. **Methods:** MyDiPP intervention is to be delivered for 12 months with multiple approaches (weight loss, dietary modification, physical activity, and quality of life). Eligible adults aged 18-65 years, overweight/obese (body mass index, BMI ≥ 23kg/m^2), and at high risk of type 2 diabetes [American Diabetes Association (ADA) Diabetes Risk Score ≥5, or haemoglobin A1c (HbA1c) of 5.6-6.2%], will be randomly assigned to one of two study groups (intervention or usual care control groups) in a 1:1 ratio using simple randomisation. **Results:** Changes in weight and HbA1c level (primary outcomes), and changes in physical activity level, dietary intake, and quality of life (secondary outcomes) will be assessed at 6 and 12 months. **Conclusion:** This study protocol describes the first digital therapy for diabetes prevention in Malaysia, which will determine whether the effect of this intervention is larger than the effect of usual care in reducing body weight and HbA1c level, and improving dietary intake, physical activity, and quality of life of high-risk individuals. Results from this trial may be useful for preventing type 2 diabetes mellitus in Malaysia.

Keywords: lifestyle intervention, prediabetes, protocol, randomised controlled trial, T2DM

INTRODUCTION

In 2017, diabetes affected 8.4% of the world's population, or 451 million adults aged 18-99 years, and it is growing rapidly in low- and middle-income countries. The prevalence of diabetes is expected to rise to 693 million by 2045, representing 9.9% of the same population (Cho *et al.* 2018). In Malaysia, according to the National

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doi: https://doi.org/10.31246/mjn-2022-0015

Health and Morbidity Survey (NHMS) 2019, 18.3% or 3.6 million Malaysians have diabetes, the highest incidence rate in Asia and one of the highest in the world (IPH, 2020). Individuals who have blood glucose higher than normal level, but not as high to be classified as diabetes, are regarded as having pre-diabetes. A person diagnosed with pre-diabetes has a higher risk of developing diabetes. Worldwide, over 260 million or 6.4% adults have pre-diabetes (IDF, 2011). A recent study conducted in Terengganu reported that the prevalence of pre-diabetes in Kuala Terengganu is double (7.6%) (Wan Nur Atirah & Wafa, 2020) that reported by NHMS in 2015 (3.5%) (IPH, 2015). Being overweight is one of the factors that is associated with a higher probability of both diabetes and pre-diabetes. In Malaysia, the prevalence of overweight and obesity among adults aged 18 years and above had increased from 30% in 2015 to 30.4% in 2019, and from 17.7% in 2015 to 19.7% in 2019, respectively (IPH, 2020; IPH, 2015).

A study has shown that approximately 37% of individuals with pre-diabetes will have diabetes in four years if they do not change their lifestyle through any intervention (Knowler *et al.*, 2002). Lifestyle modification intervention such as the Diabetes Prevention Programme (DPP) has been shown to be effective in reducing or delaying the onset of type 2 diabetes mellitus (T2DM) among high-risk individuals by 58% over a long-term period (Knowler *et al.*, 2002). Furthermore, a 10-year DPP study reduced the prevalence of T2DM by 34% (Knowler *et al.*, 2009). Similarly, the English National Health Service Diabetes Prevention Programme also reported a favourable impact in reducing body weight (3.3 kg) and haemoglobin A1c (HbA1c) level (2.04 mmol/mol) of subjects who had non-diabetic hyperglycaemia (Valabhji *et al.*, 2020). DPP is the first large-scale trial to demonstrate the efficacy of intensive behavioural counselling in reducing weight and risk of diabetes that involves in-person and group meetings in a research setting. Since then, many translations of the DPP have been further developed in order to provide approaches that can be used widely, including a community setting that involves group face-to-face sessions (Katula *et al.*, 2011).

However, such programmes also have several barriers such as lack of professional staffs, institutional resources, substantial costs incurred, participants' reluctance to allocate their time to attend a series of in-person meetings, as well as transportation, distance, and childcare issues (Venditti *et al.*, 2014). To overcome these problems, an intervention approach known as digital therapy has integrated human coaching with the use of technology such as website, email, or short message service (SMS) to enable a wider reach (Castro *et al.*, 2017). It is considered as a convenient, accessible and scalable method that can reach a larger population at risk (Sepah *et al.*, 2017).

The purpose of this article is to present the Malaysia Diabetes Prevention Programme (MyDiPP) study protocol. The objective of the MyDiPP randomised controlled trial (RCT) is to implement and evaluate the efficacy of lifestyle intervention programme to prevent T2DM among adults who are at risk of developing diabetes via a mobile phone app. The study is an assessor-blinded, parallel-group RCT for overweight/obese adults who are at high risk of having T2DM. The eligible participants will be randomised in a 1:1 ratio to either undergo a 12-month MyDiPP intervention or receive standard health education from primary care providers at a university clinic. The design conduct and reporting will adhere to the consolidated standards of reporting trials (CONSORT) guidelines. We used the SPIRIT checklist when writing our report (Chan *et al.*, 2013).

MATERIALS AND METHODS

Study setting

The trial will be carried out in the district of Kuala Terengganu, in the state of Terengganu, Malaysia. This location was selected due to continuous urbanisation, improved socioeconomic status, and adoption of more sedentary lifestyle and unhealthy dietary habits, where obesity might develop. In addition, Terengganu has a prevalence of diabetes (10.5%) that is higher compared to the national prevalence (9.4%), as well as the highest prevalence of diabetes compared to the other East Coast states - Kelantan (9.7%) and Pahang (9.5%) (IPH, 2020). According to NHMS 2015, diabetes and obesity have a moderate prevalence in the East Coast states (IPH, 2015).

Eligibility criteria

Participants are deemed eligible if they: (1) are 18-65 years old who live, work, or study in Kuala Terengganu, Terengganu, Malaysia with a body mass index (BMI) of ≥23 kg/m^2; (2) have a high risk for diabetes [diabetes risk test score ≥5 (Lindström & Tuomilehto, 2003) or HbA1c of 38-44 mmol/mol or 5.6-6.2%]; (3) own a smartphone (only Android); (4) are fluent in the Malay or English language; and (5) are willing to participate in the weight management programme or physical activities. BMI ≥23 kg/m^2 was chosen, as it is the World Health Organization (WHO) BMI cut-off for the Asian and Pacific populations.

The exclusion criteria include: (1) those with a clinical history of diabetes or newly diagnosed with diabetes at the time of screening, with their HbA1c level ≥45 mmol/mol or ≥6.3%; (2) those taking oral anti-diabetic agents; (3) those participating in other weight management programmes or interventional research; (4) those on a prescribed medical diet or anti-obesity or diabetes therapy in the past four months; (5) those who had a clinical history of cardiovascular diseases in the past six months; (6) those who used to undergo any treatments for cancer, dementia or probable Alzheimer's disease, advanced arthritis; (7) those who are pregnant, had given birth in the recent six weeks, or are planning to become pregnant in the next twelve months; or (8) those with liver and renal diseases or hyperthyroidism, or other causes that can interfere with their participation (for being physically disabled or have any mental health conditions that include eating disorder or alcohol/substance abuse).

Development of the Malaysia Diabetes Prevention Program (MyDiPP) mobile app

The development of the MyDiPP mobile app was outsourced to Trivotec Technology, which is a website and software/app development company based in Kota Bharu, Kelantan, Malaysia. The MyDiPP mobile app has the following components:

a. Backend (server) and database

The backend was developed using a Javascript-based stack based on NodeJS. As opposed to more traditional technologies, Javascript is newer, and one that is growing quickly on the server-side. It was selected because of its stellar performance and better scalability.

b. Admin area and website (web client)

The admin area has a simple user interface and functionality, and is implemented using a template based on Bootstrap 4.0. Both the website and the admin area can run on all current major browsers: Chrome, Firefox, Safari, and Internet Explorer.

c. Mobile app

The Android mobile client application can run on all phones with Android 5.0 or newer that includes Google services. It was developed using the native development tools provided by Google. The app runs in portrait mode and has

a common layout, as well as look-and-feel across all form factors (phones and tablets).

During the development, there were two important milestones: alpha milestone and beta milestone. For the alpha milestone, around 40-60% of the features were working; for the beta milestone, 100% of the features were working, but with chances of bugs. After the beta milestone, the app went through a quality assurance testing and identified bugs were fixed. After fixing these bugs, the app went through a pilot testing among target users to evaluate its usability. After the pilot test, the app is now ready to be used by participants during the intervention programme.

Interventions

The intervention group will access the MyDiPP app that consists of educational lessons, health coaches, peer group, and technology-enabled tools to track their nutritional intake, physical activities, body weight, as well as HbA1c level. The educational lessons have been adopted from publicly available materials from the United States Diabetes Prevention Programme (US DPP) of Centre for Disease Control and Prevention (CDC), combined with the Malaysian Dietary Guidelines (MDG) 2020 and the 5th edition of the Management of T2DM Clinical Practice Guidelines (CPG) from the Ministry of Health Malaysia by referring to Diabetes Malaysia. The materials have been modified to meet the needs and cultural sensitivity of Malaysians. A few consultations will be conducted with the stakeholders (i.e., dietitian, nutritionist, physiotherapist, psychologist, and clinician) prior to the intervention. The educational materials will be refined and pre-tested on high-risk individuals who have volunteered prior to the delivery of the intervention.

In order to successfully engage high-risk individuals in the process of lifestyle behaviour change, the content focus was based on Bandura's Social Cognitive Theory (SCT) (Bandura, 2004). SCT framework is the most used framework in digital diabetes prevention intervention (Van Rhoon *et al.*, 2020). It states that an individual, the environment, and the cognitive and emotional processes interact with each other to influence behaviour. SCT sets a framework of key constructs based on the determinants of behaviour, the mechanism of action, and the optimal strategies for effecting positive health behaviour changes. Self-efficacy, which refers to the confidence of a person in his or her ability to act and persevere in an action despite obstacles or challenges, is thought to be the most important construct of SCT and is suggested to impact health behaviour directly (Glanz, 2016). Other constructs include knowledge, outcome expectation, goal setting and planning, barriers and opportunities, social support, feedback on behaviour, feedback on outcome of behaviour, and self-monitoring. The taxonomy for behaviour change techniques was used for the operationalisation of SCT for MyDiPP (Michie *et al.*, 2013).

The intervention group will undergo 22 lessons that consist of two parts: (1) a six-month active period, and (2) a six-month maintenance period. Each lesson will take about 30 to 60 minutes to complete. For the first six months during the core programme, the participants will undergo 16 lessons that need to be completed within the first 24 weeks after randomisation by focusing on dietary change, increased physical activity, and relapse prevention. Eight sessions will be conducted once a week, and eight more sessions will be conducted every fortnight (Table 1). Meanwhile, during the maintenance period, which consists of six months of post-core lessons, the participants will focus on maintaining their lifestyle and weight loss achieved during the core programme. The sessions

Table 1. First six months of the MyDiPP intervention programme

Social Cognitive Theory Construct Targeted	*Behaviour Change Technique*	*Module*	*Content*	*Action*	*Week*
• Knowledge • Self-efficacy • Outcome expectation • Goal-setting and -planning • Barriers and opportunities • Social support • Feedback on behaviour and on outcome of behaviour • Self-monitoring	• Providing information about health consequences • Encouraging goal-setting and -planning • Providing information to create positive outcome expectations • Providing information about social and environmental consequences • Offering tips on behaviour substitution • Encouraging negative habit reversal • Encouraging positive habit formation • Giving instructions on how to perform a behaviour • Prompt goal-setting (behaviour and outcome) • Action-planning • Encouraging social support • Encouraging self-monitoring (behaviour and outcome of behaviour) • Prompt self-monitoring of behaviour and outcome of behaviour • Repetition of behaviour • Behavioural practice • Problem-solving/coping-planning • Providing information about emotional consequences • Regulate negative emotions • Reviewing behaviour goals	Introduction to the Programme	• Introduction to MyDiPP. • What are prediabetes and T2DM.	Dietitian	1
		Be Active!	• The meaning of physical activity and sedentary lifestyle. • Ways to get active. • Types of physical activities for adults. • Types of physical activities that are recommended for general population. • Ways to work out safely. • Benefits of getting active.	Physiotherapist	2
		Track Your Activity	• The purpose of tracking physical activity. • How to track physical activity.	Physiotherapist	3
		Eat Well	• How to eat well to prevent or delay T2DM. • Ways to eat right according to the Malaysian Food Pyramid and Malaysian Healthy Plate. • The items in each food group. • How to make healthy meals.	Dietitian	4
		Track Your Food	• The purpose of tracking food. • How to track food. • How to understand and use Food Label.	Dietitian	5
		Be More Active!	• The purpose of getting more active. • Some ways to get more active.	Physiotherapist	6
		Burn More Calories than You Take In	• The link between calories and weight. • How to track burned calories. • How to burn more calories than take in. • How to reduce calories intake through the changes of dietary habits. • Examples of physical activities that can be done to burn calories in foods.	Dietitian and Physiotherapist	7
		Healthy Shopping and Cooking	• Healthy food. • How to shop for healthy food and ways to save time and money before and during shopping. • How to cook healthy food.	Dietitian	8

Table 1. First six months of the MyDiPP intervention programme *(continued)*

Social Cognitive Theory Construct Targeted	*Behaviour Change Technique*	*Module*	*Content*	*Action*	*Week*
		Manage Stress	• Causes of stress. • The link between stress and T2DM. • Ways to reduce stress. • Healthy ways to cope with stress. • Ways to calm down.	Psychologist	10
		Find Time for Fitness	• Benefits of being active. • Challenges of fitting in fitness. • How to find time for fitness.	Physiotherapist	12
		Cope with Triggers	• Examples of unhealthy food shopping triggers and ways to cope with them. • Examples of unhealthy eating triggers and ways to cope with them. • Examples of triggers of sitting still and ways to cope with them.	Psychologist	14
		Take Care of Your Heart!	• Why hearth health matters. • How to keep heart healthy. • How to be heart smart about fat.	Dietitian	16
		Take Charge of Your Thoughts	• The difference between harmful and helpful thoughts. • How to replace harmful thoughts with helpful thoughts.	Psychologist	18
		Get Support	• How to get support from family, friends and co-workers. • How to get support from groups, classes and clubs. • How to get support from professionals.	Psychologist	20
		Eat Well Away from Home	• Challenges of eating well at restaurants and social events. • How to plan for and cope with the challenges.	Dietitian	22
		Stay Motivated	• Reflect on the progress. • How to keep making positive changes over the next 6 months.	Psychologist	24

Table 2. Final six months of the MyDiPP intervention programme

Social Cognitive Theory Construct Targeted	*Behaviour Change Technique*	*Module*	*Content*	*Action*	*Week*
• Knowledge • Self-efficacy • Outcome expectation • Goal-setting and -planning • Barriers and opportunities • Social support • Feedback on behaviour and on outcome of behaviour • Self-monitoring	• Providing feedback on behaviour and outcome of behaviour • Reviewing behaviour goals • Reviewing outcome goals • Renewing goal-setting and -planning • Prompt goal-setting (behaviour and outcome) • Action-planning • Problem-solving/coping-planning • Offering tips on behaviour substitution • Providing information about social and environmental consequences • Providing information to create positive outcome expectations • Maintaining negative habit reversal • Maintaining and improving positive habit formation • Giving instructions on how to perform a behaviour • Maintaining self-monitoring (behaviour and outcome of behaviour) • Maintaining social support • Repetition of behaviour • Behavioural practice • Providing information about emotional consequences • Regulate negative emotions	When Your Weight Loss Stalls	• Why weight loss can slow down or stall. • How to start losing weight again.	Dietitian and Physiotherapist	28
		Steal Your Time for Fitness Break!	• The link between sitting still and T2DM. • Challenges of taking fitness breaks and ways to cope with them.	Physiotherapist	32
		Eat Healthy Food that You Enjoy!	• Healthy approach to eating. • How to have healthy food that you enjoy.	Dietitian	36
		Get Enough Sleep	• Why sleep matters. • Challenges of getting enough sleep and ways to cope with them.	Psychologist	40
		Get Back on Track!	• Stay positive. • Five steps of problem solving.	Psychologist	44
		Prevent T2DM for Life!	• Reflect on the progress. • How to keep making healthy lifestyle going once the program ends. • How to keep making positive changes over the long term.	Dietitian and Psychologist	48

will be held monthly (sessions 17 to 22) (Table 2).

During the first week of intervention, participants will receive online orientation on what MyDiPP entails and learn how to use the app, interact with their coach, and stay motivated throughout the programme. Once the participants have registered the app, they will be alternately divided into either blue or red teams. The purpose for the group division is to motivate the participants into making healthy lifestyle changes. The team members can compete with those in the other team to achieve their group's diet and activity goals.

The participants are encouraged to aim for a minimum of 5-10% weight loss of their starting weight on the 6th month and to keep working on losing weight even if their target has not been reached on the 12th month. Participants can set their target for percentage weight loss for the first and last six months in the app. After they have set this target, a target body weight that they are required to achieve will be automatically calculated. Participants are also encouraged to increase their physical activity to a minimum of 150 minutes per week and aim for moderate-intensity exercises. They have the option to do more. Meanwhile, for dietary intervention, participants are advised to eat well by following the Malaysian Food Pyramid, as well as the Malaysian Healthy plate (module 4), to track their food by understanding and using food label (module 5), to burn more calories than they consume by changing their dietary habits and engaging in physical activities (module 7), to do healthy shopping and cooking by learning how to shop and prepare healthy food (module 8), to eat well while dining outside by educating them about potential obstacles to their weight loss goals and how to overcome them (module 15), and also to eat healthy foods that they enjoy by learning how to make them healthier (module 19). The contents for each module are described in Table 1 and Table 2.

At their convenience where internet connection is available, participants will be encouraged to complete the curriculum lessons on lifestyle and behavioural change, communicate with health coaches or group mates through private messaging or group discussions, self-monitor their diet and physical activities, and view their weight loss progress (Sepah *et al.*, 2017). The development of the MyDiPP mobile app, as well as its feasibility study, will be published elsewhere.

Participants in the control group will receive standard health education from primary care providers at the university's clinic with regards to weight loss, increasing physical activity, and dietary advice, undergo anthropometric and laboratory tests, as well as comprehensive surveys at baseline, six months, and twelve months after commencement of the intervention. They will also be provided with pamphlets and booklets about various health topics such as diabetes, hypertension, dyslipidaemia, cardiovascular disease, and kidney disease.

Participants are given the freedom to withdraw voluntarily at any time during the trial by informing the research team that he/she wishes to withdraw. The participant is also given the choice whether to provide the research team with the reason(s) for leaving the study. Participants who do not log in to the app for one month and/or are not present at evaluation will be contacted by telephone. After three unsuccessful calls, the participant will be considered a dropout.

The research team can also, at any time, withdraw (remove) the subject from the study at its discretion. The criteria for withdrawing include: when a subject's health may be compromised, such as when a subject experience related adverse events requiring discontinuation

of intervention, when the research team ends the study due to increased risk to the participant, or when the subject does not comply with the required study schemes or procedures.

Outcomes

The primary outcome measures for this study are the changes in weight and HbA1c level. Secondary outcome measures include physical activity level, dietary intake, and health-related quality of life (HRQoL). All these will be taken at baseline, sixth month, and twelfth month. The study's primary assessment time point is at sixth month in order to assess the immediate impact of the intervention. The final visit that will take place at the twelfth month will be used to assess the intervention's sustainability.

Sample size

The sample size was estimated using the study by Ibrahim *et al.* (2016), who performed a community-based lifestyle intervention programme study to prevent T2DM occurrence in Malaysia. It is the only available long-term (twelve-month) diabetes prevention study that focuses on the Malaysian population. Considering the difference in the change in % HbA1c by 0.27% between groups and standard deviation (SD) of the change in % HbA1c by 0.4, a sample size of 35 high-risk adults per group will give 80% power at 0.05 significance level for the twelve-month study. Assuming a dropout rate of 30%, 100 high-risk adults (50 in each group) is required. Probability sampling method will be applied.

To determine the sample size, equation (1) was used (Florey, 1993):

$$n \text{ (sample size in each group)} = \frac{2\,[(a + b)^2 \times \sigma^2]}{(\mu 1 - \mu 2)^2} \quad (1)$$

where:

a = conventional multiplier for alpha (0.05) = 1.96

b = conventional multiplier for power (0.80) = 0.842

Recruitment

The target sample comprises 100 adults who live in Kuala Terengganu, Terengganu, Malaysia, and are at high risk of T2DM. They will be identified by a two-stage screening process. In the first stage, patients who are at high risk of T2DM will be assessed via the American Diabetes Association (ADA) diabetes risk score distributed using Google Forms through social media (Facebook). Google Forms will be used due to its advantages: easy to build the questionnaire, has unlimited surveys, and is free. ADA diabetes risk test was translated and validated into the Malay language by two experts in the fields of nutrition and dietetics, as well as 35 target users (Nurul Fatihah *et al.,* 2022). The risk score is based on a set of variables not requiring laboratory tests that are used as a tool to predict the risk of T2DM or identify undetected T2DM; these variables are age, gender, and family history of diabetes, history of gestational diabetes in women, history of hypertension, physical activity, and BMI. The researcher will invite those who scored ≥5 via telephone call to attend a second stage screening test via a HbA1c test at the UniSZA Medical Specialist Clinic. At this stage, blood will be extracted by pricking the finger to assess HbA1c level for those with BMI ≥23 kg/m^2. Those with HbA1c level in the range of 20-44 mmol/mol or 4.0%-6.2% will be invited to participate in the study. However, individuals with HbA1c level ≥45 mmol/mol or ≥6.3% will be referred to healthcare providers immediately for follow-up. Figures 1 and 2 describe the SPIRIT flow diagram of the MyDiPP trial and the study flowchart from recruitment process at baseline stage to assessments at the sixth and twelfth months (primary time point), respectively.

Randomisation will be performed by the co-investigator (NBR) in this trial, once the baseline data collection is completed. Each participant will be randomly assigned to one of two study

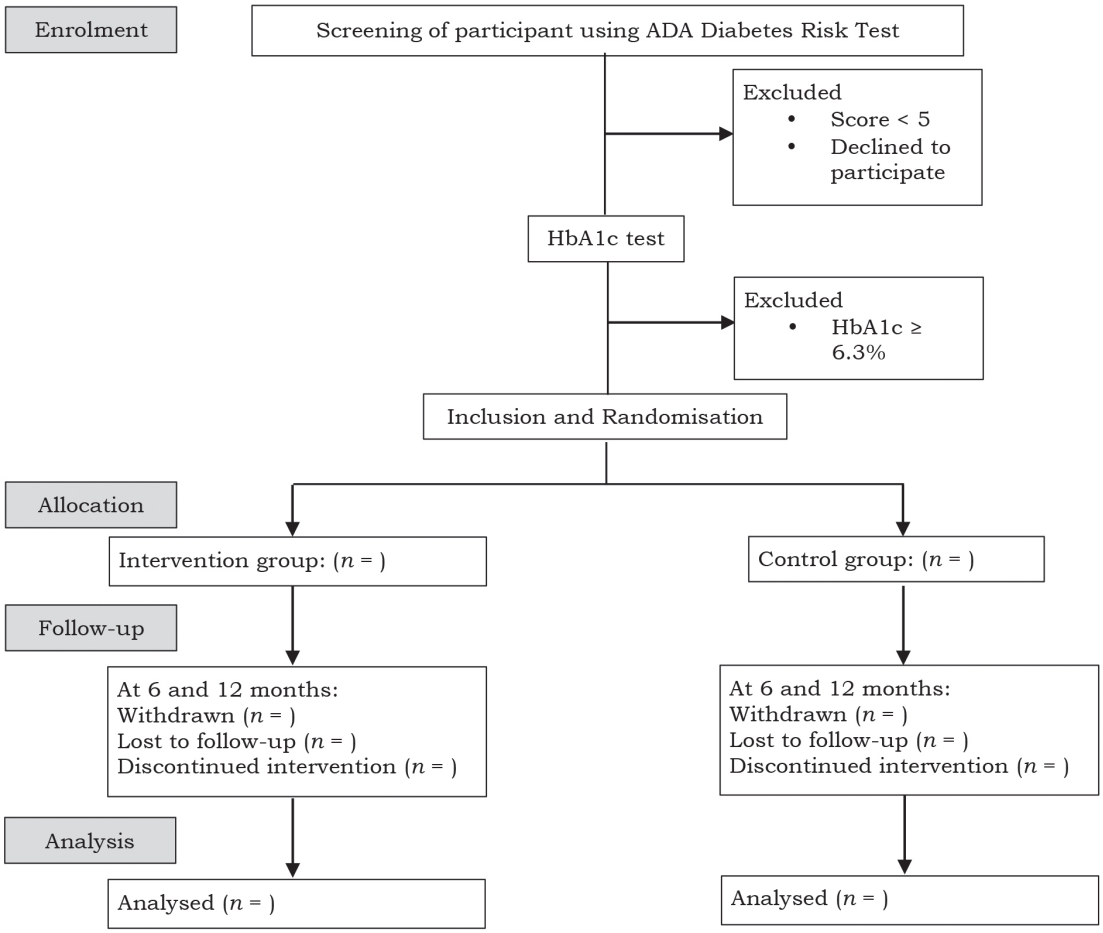

Figure 1. SPIRIT Flow Diagram of the MyDiPP Trial

groups in a 1:1 ratio using simple randomisation. Random numbers will be generated by the Research Randomiser software, which uses the "Math.random" method with JavaScript programming language to generate random numbers. The random number and instructions for the participants will be placed in sealed envelopes. The co-investigator will select the envelope sequentially to be distributed to each participant indicating which group (intervention or control) he/she will be allocated to and the next processes in this study.

This study uses the single-blind approach. All measurements will be taken at baseline, sixth and twelfth months of the study by the main researcher (NFMF), who will remain blinded to group allocations throughout the study. However, the nutritionists, dietitians, clinicians, physiotherapists, and psychologists are, for obvious reasons, not blinded to group allocations.

Data collection and management

The participants' timeline is presented in Table 3.

Anthropometric measurements

During the tests, participants are instructed to wear light clothing and no

shoes. By using a digital stadiometer and SECA scale, height and weight will be measured to the nearest 0.1 cm and 0.1 kg, respectively; these measurements will be used to calculate BMI (kg/m^2). BMI classification is based on the updated cut-off points for Asian. Those with BMI ranging from 23.0 kg/m^2 to

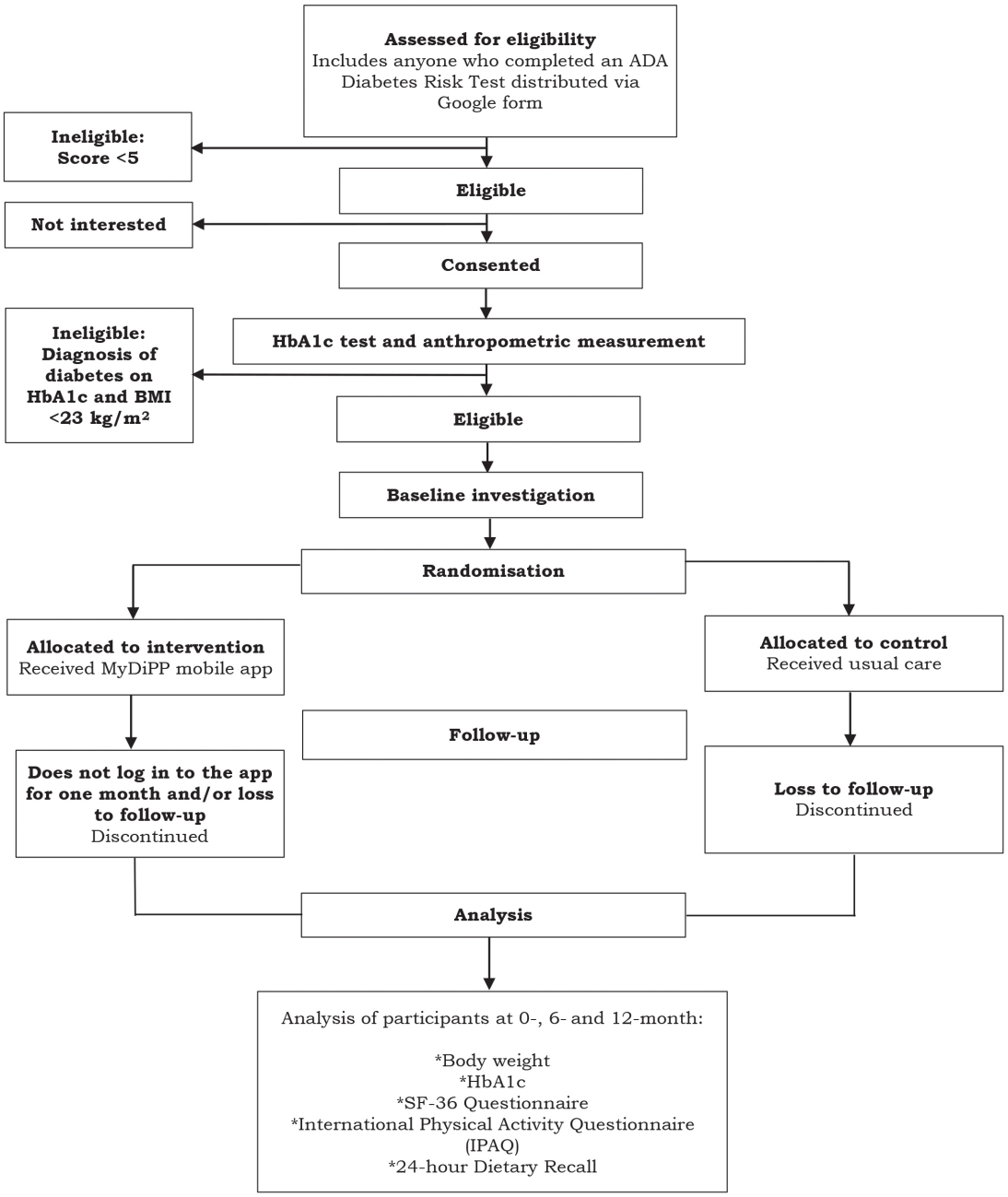

Figure 2. Study flow chart

Table 3. Participants' timeline

	Study Period			
	Enrolment	*Allocation*	*Follow-Up*	
Time-Point	$t_{inclusion}$	t_0	t_6	t_{12}
Enrolment:				
Eligibility screening	x			
Informed consent	x			
Allocation		x		
Interventions:				
Intervention group		x	x	x
Control group		x	x	x
Assessments:				
Baseline sociodemographic assessment		x		
Body weight		x	x	x
HbA1c		x	x	x
Physical activity questionnaire		x	x	x
Dietary intake status		x	x	x
Health-related quality of life questionnaire		x	x	x

24.9 kg/m^2 is classified as overweight, while a BMI of ≥25 kg/m^2 is obese (WHO Expert Consultation, 2004).

Laboratory measurement

HbA1c level will be tested using the point-of-care technology, which is PTS Diagnostics A1CNow$^+$ test kit from finger-prick blood samples collected in a capillary tube according to the manufacturer's guidelines. It is a lightweight, portable, and disposable handheld immunoassay device certified by the National Glycohaemoglobin Standardisation programme and is Clinical Laboratory Improvement Amendments (CLIA)-waived. It does not require calibration. The participants' fingers will be cleaned with an alcohol swab, left to dry, and lanced with a sterile lancet in order to obtain a drop of blood using the finger-prick method. A 5 µl blood sample is then mixed with a reagent supplied with the test kit and then transferred to a sample well in the testing device with a pipette provided. The results is provided in 5 minutes and then recorded.

Evaluation of physical activity (PA)

Physical activity (PA) will be assessed using the Malay-translated and validated version of the IPAQ (Chu & Moy, 2015). The questionnaire demonstrated good reliability with intra-class correlation coefficient (ICC) of 0.54-0.92 on items categorised by intensities and domains, as well as good validity across intensities and domains with Spearman correlation coefficient (ρ) of 0.67-0.98 (Chu & Moy, 2015). It consists of seven items that identify frequency and time spent on three types of physical activities (walking, moderate-intensity activity, and vigorous-intensity activity) during the past seven days. The metabolic equivalent (MET) values will be measured. The participants' total physical activity (MET-minute/week) will be calculated by summing up the walking, moderate-, and vigorous-intensity activity scores. The subjects will be categorised as "high physical activity", "moderate physical activity", and "low physical activity" if they achieved ≥1500 MET-minutes/ week, 600-1500 MET-minutes/ week, and <600 MET-minutes/week,

respectively (IPAQ Research Committee, 2005).

Evaluation of dietary intake

The dietary intake of the participants will be measured using a 24 hours diet recall. They will be asked to record their dietary intake for three days (two weekdays and one weekend), and the average measurement will be taken. Dietary analysis software Nutritionist Pro Inc. will be used to analyse energy and nutrient intakes (carbohydrate, fat, protein, and fibre).

Evaluation of Health-Related Quality of Life (HRQoL)

HRQoL will be assessed using the translated and validated version of the SF-36 health survey questionnaire (Sararaks *et al.*, 2005). It consists of 36 items with eight health domains: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH), with a score from 0 to 100 indicating the worst to the best state of health. The scores are further summarised in the physical component summary (PCS) and mental component summary (MCS) scores.

Baseline sociodemographic assessment

Sociodemographic variables encompass age, sex, race, education level (primary, secondary, or tertiary), and household income.

Statistical methods

Independent *t*-test will be used to compare participants' demographic characteristics and baseline measurements between groups, while chi-square test will be used for categorical variables. The analysis will be performed according to the intention-to-treat (ITT) principle. Missing values will be replaced by carrying forward the last readings. Repeated measures ANCOVA will be performed to examine the changes over time within and between groups. The analyses will be performed using SPSS. Differences will be defined as statistically significant at $p<0.05$.

Ethics

Ethical approval was obtained from the UniSZA Human Research Ethics Committee (UHREC/2018/77).

Informed consent

A written consent will be obtained from participants before any intervention or procedures are conducted on them. Information sheets and consent forms will be provided to all participants involved in the trial. The participants will be informed regarding the purpose of the study and have the right to refuse participation in the study. The safety of the participants is the main concern of this study. Participants will be informed on the signs and symptoms of angina and heart attack, which they should promptly notify. They will be given a consent form during baseline visit at the UniSZA Medical Specialist Clinic. After they have signed the form, a copy of the signed consent form will be given to them and kept for their records.

Confidentiality

Participants' study information will be kept confidential by the researchers and will not be made publicly available unless disclosure is required by law. Data obtained from this study that do not identify them individually will be published in scientific journals for knowledge purposes. Participants' original records may be reviewed by the researchers, the Ethical Review Board for this study, and regulatory authorities for the purpose of verifying the study procedures and/or data. Their information may be held and processed on a computer. Only research

team members are authorised to access the information.

DISCUSSION

Intervention to prevent blood glucose increases must begin much earlier, ideally before glucose levels reach levels indicative of diabetes or disease symptoms. This study is necessary because it is important to know if this intervention programme leads to the reduction in body weight, as well as HbA1c level, and whether these reductions are larger than the effect of usual care, as weight loss is the main predictor of reduced diabetes incidence; a reduction of 5-10% of body weight can improve fitness and reduce HbA1c level (Wing *et al.*, 2011). If successful, the results of this trial will open a window of opportunity for other researchers to test MyDiPP on the whole population, or to healthcare providers to use it as a preventive approach on their patients.

While many other health apps are designed solely to monitor calories or fitness records, the MyDiPP mobile app is designed to engage its audiences and guide them to fun and realistic lifestyle changes. Furthermore, it allows individuals who are at increased risk of developing diabetes to be able to monitor their health, track their progress, and even connect with a personal health coach, where they can receive real-time feedback on behaviours related to wellness and diabetes prevention. This app makes them more aware of the easy changes they can make to their lifestyles and keep them motivated to prevent diabetes.

The incorporation of the diabetes prevention modules into the mobile app may lead to greater engagement of the participants with the programme because it frees them from the requirement of travelling to a specific location and thus more flexible with their time to participate. A greater engagement has the potential to reduce the risk of progression to diabetes (Katula *et al.,* 2022). Moreover, this mobile app can convincingly improve the daily quality of life for millions of people, not to mention drive billions of ringgit in system-wide savings (Bonoto *et al.,* 2017).

Despite its aforementioned strengths, this study may encounter some challenges in terms of recruitment, engagement, and long-term retention in the programme. However, providing incentives to participants may boost their engagement and long-term retention. A systematic review of effective recruitment strategies revealed that involving primary care practitioners may be the most effective recruitment strategy for managing study budget and timelines (Ngune *et al.,* 2012). They can help promote the programme on their clinic's Facebook Page or on their own Facebook, if they have one. Furthermore, there could be bias in the information provided for physical activities and dietary intake recall. This can happen when respondents do not provide the true or correct answers to questions, either because they have forgotten or refused to disclose information. Sometimes, the meaning of the questions may be interpreted differently by the respondents. However, properly training the interviewer to avoid inappropriate questioning techniques such as leading questions or judgmental comments, as well as conducting interviews in a private setting with no distractions, can help avoid or reduce bias in the information provided by respondents (Gibson, Charrondiere & Bell, 2017).

Acknowledgements

The module for this study was adopted from the United States Diabetes Prevention Program (US DPP) of Centres for Disease Control and Prevention (CDC) and was translated into the Malay language, as well as underwent forward-backward translation by Khuzaiton Zakaria, Aveleena Afzan Hassan and Nor Fazura Md Zulkifle, who were language

lecturers at University Malaysia Kelantan, Malaysia. This trial was retrospectively registered with Clinical Trial Registry (NCT03997656) on 21 June 2019.

Authors' contributions

Nurul Fatihah MF, conceptualised and designed the study, and prepared the draft of the manuscript; Wafa SW, principal investigator, conceptualised and designed the study, and reviewed the manuscript; Raj NB, designed the study (physical activity) and reviewed the manuscript; Mohd Ibrahim A, designed the study (diet) and reviewed the manuscript; Norkhairani AR, designed the mobile app and reviewed the manuscript; Nurulhuda MH, designed the study (HbA1C) and reviewed the manuscript; Rohayah H, designed the study (psychology) and reviewed the manuscript.

Conflict of interest

The authors declare that they have no competing interests.

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