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Dietary behaviours, cooking practices and their associations with body weight status among Malaysians – a nationwide study during COVID-19 pandemic

Yit Siew Chin[1,2*], Poh Ying Lim[3], Mahenderan Appukutty[4], Nor Baizura Md Yusop[1], Radhika Loganathan[6], Kanga Rani Selvaduray[6] and Yoke Mun Chan[2,5,7*]

Abstract

Objectives This study builds upon our previous MyNutriLifeCOVID-19 online survey conducted during Malaysia's second national lockdown (MCO 2.0), by exploring a broader range of nutritional and lifestyle behaviours and their association with risks of underweight, overweight and obesity among Malaysian adults.

Design Cross-sectional study.

Setting The MyNutriLifeCOVID-19 was a nationwide survey conducted in all five regions (Central Zone, Northern Zone, Southern Zone, East-coast Zone and East-Malaysia) in Malaysia.

Participants A total of 1182 Malaysian adults participated in the online survey between March and May 2021.

Outcome measures Self-reported body weight status, nutritional and lifestyle behaviours, including dietary practices, physical activity, perceived stress, and sleep quality were ascertained using a validated questionnaire.

Results Approximately one-third of the Malaysian adults (36.8%) were either overweight or obese, with 8.63% underweight. Despite widespread intentions to manage weight, only 30% engaged in regular exercise. Poor sleep and unhealthy dietary behaviours, characterised by high sugar intake and low consumption of fruits and vegetables, were prevalent among the respondents. The hierarchical multinomial regression analysis revealed underweight was attributed to being single, experiencing high stress and insufficient exercise. Conversely, overweight and obesity were linked to being male, older, Malay ethnicity, lunch skipping, poor adherence to healthy eating concept, had disordered eating and frequent consumption of roasted foods.

Conclusion The present study revealed significant weight-related challenges faced by Malaysians during the national lockdown. Despite efforts at weight management, insufficient physical activity, poor sleep quality, and unhealthy dietary behaviours persisted. These findings underscore the complex interplay of sociodemographic,

*Correspondence:
Yit Siew Chin
chinys@upm.edu.my
Yoke Mun Chan
cym@upm.edu.my

Full list of author information is available at the end of the article

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lifestyle, and dietary factors in shaping weight outcomes among Malaysian adults, emphasised the importance of addressing sociodemographic, lifestyle, and dietary factors in comprehensive public health strategies, as it highlighted multifaceted risk factors for both underweight and overweight/obesity. There is a need for targeted interventions addressing diverse risk profiles to promote healthier lifestyles and combat the growing burden of obesity-related health issues. The findings of this study offer crucial insights into the enduring consequences of the COVID-19 pandemic on Malaysian health behaviours. As the world grapples with the increasing threat of communicable diseases, understanding the long-term impacts of such events on lifestyle and health outcomes is imperative. Our research underscores the need for comprehensive public health interventions that address not only the immediate health challenges but also the lasting psychological and behavioural effects of crises. By investing in resilient health systems and promoting healthy lifestyles, we can better prepare for future pandemics and mitigate their devastating consequences.

Introduction

Little did we anticipate that the year 2020 would bring a significant threat to public health worldwide. On the 10th of January 2020, the World Health Organisation (WHO) alerted the world to an outbreak of an unknown form of pneumonia with human-to-human transmission occurring in Wuhan, China [1]. The WHO then declared this outbreak as COVID-19, which was brought on by a new coronavirus that later became known as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) on February 11, 2020. This infectious disease, which originated in December 2019 in Wuhan, China's Hubei Province, quickly escalated into a global pandemic, affecting countries worldwide, including Malaysia. As of 15 February 2021 (4:05 pm CET), the WHO reported a staggering 108,579,352 confirmed cases of COVID-19 and 2,396,408 deaths globally, including figures for Malaysia [2].

The virus was confirmed to have reached Malaysia in late January 2020 [3]. Since the 18th of March 2020, Malaysia has entered several phases of restriction [CMCO, Enhanced Movement Control Order (EMCO), Semi Enhanced Movement Control Order (SEMCO), Conditional Movement Control Order (CMCO), Recovery Movement Control Order (RMCO)] and relaxation orders since 18 March 2020 following the federal government's decision based on the severity of the pandemic [4]. These movement control orders have unquestionably disrupted daily routines and induced lifestyle changes. Perveen et al. (2020) reported that the MCO had a profound impact on the mental health of Malaysian adults, resulting in an increased prevalence of stress, anxiety, and depression [5]. The confinement period has limited physical activity, promoted sedentary lifestyles, and led to changes in dietary patterns, including a shift towards consuming 'unhealthy' food and beverages [6]. Additionally, there has been a reduction in food waste generation [7] and an improvement in local air quality [8, 9] and water quality [10] during this period.

Previously, we reported on changes in body weight among Malaysian adults during the MCO 1.0 lockdown period and explored the associations between lifestyle behaviours and body weight using the MyNutriLife-COVID-19 online survey [11]. More than two-fifths of Malaysians (41.2%) adopted a healthier eating pattern, primarily attributing to the use of healthier cooking methods or the adoption of "Quarter-Quarter-Half" healthy eating concept. Nevertheless, the prevalence of snacking and consumption of high-fat or fried food intake remained high. Such deterioration of dietary behaviours during national lockdowns were widely reported [12]. This study represents an extension of our earlier work conducted during the MCO 2.0 COVID-19 pandemic lockdown period, focusing on a broader range of indices related to nutritional and lifestyle behaviours and their impact on changes in body weight.

Methodology

Study design and participants

This study was a national cross-sectional survey during Malaysia's second lockdown, which was conducted between March and May 2021. Non-probabilistic convenience sampling was applied in this study. The data were collected anonymously through Google Forms and written in the main common languages in Malaysia, namely Malay, English, Mandarin, and Tamil. The survey questionnaire was originally prepared in English and translated into Malay, Chinese, and Tamil, respectively. These questionnaires were then back-translated to the English language to ensure translation equivalence. Both translated and back-translated questionnaires were compared for consistency. The forward and backward translation processes were performed by university lecturers with allied health sciences background and proficient in all the respective languages. The self-administered questionnaires were pre-tested to ensure clarity and ease of understanding of the questionnaire for the targeted respondents. Using online surveys, the target demographics were reached utilising social media such as Facebook groups, WhatsApp groups, and Instagram accounts. Eligibilities were Malaysians aged ≥ 18 years, had access to the link, and agreed to the information

collected while ensuring their confidentiality to be used for health and dietary practices research during the COVID-19 lockdown. The study excluded adults who were diagnosed with COVID-19.

Data collection

A respondent-friendly online questionnaire sought to assess socio-demographic background, dietary practices before and during the COVID-19 lockdown and the lifestyle of respondents was constructed using Google Forms in this study. The online survey platform gathered data on sociodemographic characteristics, socioeconomic status, medical history, and self-reported weight and height. In addition, information on lifestyle factors related to health was also gathered. The online survey was designed to ensure the anonymity of the respondents. The online survey was disseminated through emails, social media such as Facebook, Instagram, and WhatsApp, as well as the personal networks of the respondents. The study was performed in accordance with the Declaration of Helsinki, with respondents anonymous remaining confidential, and the protocol was approved by the Ethics Committee for Research Involving Human Subjects of Universiti Putra Malaysia (JKEUPM-2020-163). Prior to the dissemination of the survey form, it was first piloted to ensure the validity and reliability of the instrument, and no changes were recorded.

Instrumentation

This study used a set of pre-tested questionnaires, which consisted of seven instruments to obtain information on socio demographic background, body weight status, waist circumference, health status and disease history, lifestyle habits, eating behaviour, consumption pattern of cooking oil, and perception of the importance of a healthy lifestyle among adults. In addition, the perceived stress scale was also determined. Every item in the survey was intended to be answered so the participant could go on to the next portion and avoid missing any data.

Socio demographic background

Respondents were required to provide information regarding their socio-demographic background, such as age, ethnicity, sex, education level, marital status, occupation, and monthly household income. Other information, namely living conditions and household role(s) during movement control order (MCO), was also obtained. In addition, the survey also included other information such as geographical location by zones (East-coast zone, Northern zone, Central zone, Southern zone and East Malaysia) in Malaysia, working status during MCO, and the number of family members and children in a family.

Self-reported anthropometric indices

Respondents were asked to self-report their previous body weight, current body weight, and height. Previous research has demonstrated substantial agreement between self-reported and measured body weight and height among Malaysian adults, with Body Mass Index (BMI) classifications showing strong concordance [13]. These findings support the reliability and validity of self-reported anthropometric measures in this population, thereby justifying their use in the present study. The weight status of the respondents was classified into underweight (< 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m2) and obesity (≥ 30 kg/m^2) according to WHO classification [6]. Data on body weight changes is ascertained by asking respondents whether they notice any change in their clothes fitting. On the other hand, respondents' satisfaction with body weight status and the adoption of any weight management strategies were also ascertained. A pre-recorded video was uploaded to the Google Form to guide the respondents on the proper technique to measure waist circumference.

Health status and disease history

The presence and type of chronic diseases and respondents' perceptions of current and previous health status, such as pregnancy and COVID-19 vaccination status, were also checked.

Lifestyle habits

The lifestyle habits of the respondents were determined, including their past and present workout routines. Respondents were also asked if there was any change in their exercise or physical activity pattern. Through the universally established sleep quality questionnaire, the Pittsburgh Sleep Quality Index (PSQI), the study also identified respondents' sleep duration, latency, and perception of sleep quality (sleeping behaviour). A high score indicated how severely the sleep was disrupted [14]. Low sleep quality was indicated by a PSQI total score of five or higher, which had a 90% diagnostic sensitivity and a 67% specificity. The internal consistency reliability of the PSS total score was good ($\alpha = 0.806$). Stress levels are rising because of the COVID-19 pandemic. The Perceived Stress Scale (PSS), developed by Cohen et al. [15] was used to measure emotions and sentiments experienced throughout the previous month to assess the overall perception of stress among the respondents. This scale is widely used since it is easy to use and freely available for academic or research purposes.

Eating behaviour

The eating behaviour of respondents was ascertained using the universal instrument - The Eating Attitude Test (EAT-26) [16]. There were inquiries about attitudes, beliefs, and behaviours around food, weight, and body type. A total score and three subscales (dieting, bulimia and oral control) were generated. A score of 20 or above denotes the existence of disturbed eating attitudes and behaviour, which may indicate the presence of eating-related psychopathology, with the subscales giving a profile. The EAT-26 is a validated and reliable measure of disordered eating attitudes and behaviours. Previous studies reported Cronbach's alpha coefficients ranged from 0.77 to 0.91 across various populations, indicating good internal consistency [17]. The Cronbach's alpha coefficient (α) of the EAT-26 was 0.907, indicating good internal consistency reliability.

Besides EAT-26, the respondents administered a series of self-developed questions to identify the changes in eating patterns. These include respondents' perception of changes in eating behaviour, the pattern of main meals (breakfast, lunch and dinner) and snacking behaviour, ordering services and consumption pattern of food groups (cereals and grains, vegetables, fruits, meat and derivatives, milk and dairy products, fat and oil).

Consumption pattern of cooking oil

A pre-testing questionnaire was utilised to determine the cooking oil usage pattern. Questions were asked about the cooking oil used in different cooking methods, the practice of re-use cooking oil, the amount of oil used in cooking and respondents' perception of the different cooking oils available in the market. Further to this, factors determining the choice of cooking oil were ascertained.

Statistical analysis

Data analysis was conducted using SPSS version 28.0. Descriptive analysis was computed for all variables, with frequency and percentage presented for categorical variables. Univariable multinomial regression was used to investigate the effect of each variable associated with the body weight status. Further, hierarchical multivariable multinomial regression was computed with 5 models, where model 1 included sociodemographic variables, model 2 included anthropometric, model 3 included lifestyle variables, model 4 included dietary variables and model 5 included cooking variables. The stepwise variable selection method was used to compute the best-fit model. The final model (model 1–5) adjusted with confounding variables was computed. A variable with $p < 0.05$ was considered statistically significant.

Results

As shown in Table 1, slightly more than half of the respondents self-reported a normal BMI before the pandemic (54.4%), while approximately one-third were either overweight or obese and another 9.5% was underweight. A comparable profile was documented for the current self-reported weight status. More than 80% of respondents reported attempting to manage their weight, where 35.9% always and 49.6% sometimes attempted to do so during MCO 2.0. Close to half of the respondents perceived themselves as either moderately (42.6%) or very active (8.4%) (Table 2). This data could be over-rated as only 30% of the respondents exercised for more than 3 days per week. COVID-19 restrictions have resulted in decreased levels of physical activity among Malaysians. While less than one-quarter had become physically more active, more than 40% of the respondents had decreased levels of physical activity. Poor sleep quality was prevalent with approximately 60%, 20% and 4% of the respondents had mild, moderate and severe poor sleep quality, respectively. Similarly, sleep latency was prevalent, with approximately three-quarters of the respondents having mild, moderate or severe sleep latency, respectively. On the other hand, more than 70% of the respondents were moderately stressed while another 8% were highly stressed.

The food practices and dietary behaviours of respondents are depicted in Table 3. There were 5.5% and 83.4% of the respondents who never consumed home-cooked meals and had outside foods or beverages regularly. On the other hand, ordering food via apps was common, with more than 50% applying the food ordering apps at least once a week. Meal skipping was common, this was especially true for breakfast, with only 65% having breakfast every day. On the other hand, slightly less than 90% of the respondents practised snacking. A total of 35% and 15% of the respondents consumed probiotic beverages less than 3 days per week, and more than 3 days per week, respectively. In general, sugar consumption was considered high among the study population whereby more than 46% and 60% of the respondents consumed sugar sweetened beverages and sweet delicacies at least once a week. Compliance with the recommendations for consuming fruits and vegetables was poor, with only 40% and 60% of the respondents consuming them daily. Similarly, only about 70% of the respondents took starchy foods and protein foods, respectively. Dairy products and legumes were not the habitual intake, with only 21% and 27% consumed daily.

With regard to healthy eating behaviour, it is disappointing that only 16% of Malaysians practise healthy eating using the Quarter-Quarter-Half (QQH) concept for all their main meals. This data was in agreement with the responses to a separate question whereby 18.7%, 17.85%,

Table 1 Distribution of respondents according to socio demographic factors and anthropometry parameters and their associations with body weight status

Variables		Underweight		Normal		Overweight and obesity		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Geographical zones	East-coast zone	11	11.0	53	53.0	36	36.0	100	8.5	15.679	0.047*
	Northern zone	21	12.4	96	56.5	53	31.2	170	14.4		
	Central zone	41	6.3	357	55.0	251	38.7	649	54.9		
	Southern zone	22	12.0	102	55.7	59	32.2	183	15.5		
	East Malaysia	7	8.8	37	46.3	36	45.0	80	6.8		
Body weight status before COVID-19 ($n = 1181$)	Underweight	92	82.1	20	17.9	0	0.0	112	9.5	1637.747	< 0.001*
	Normal	10	1.6	584	90.8	49	7.6	643	54.4		
	Overweight	0	0.0	40	14.9	228	85.1	268	22.7		
	Obesity	0	0.0	1	0.6	157	99.4	158	13.4		
Attempted to manage weight ($n = 1177$)	Always	38	9.0	235	55.6	150	35.5	423	35.9	0.99	0.911
	Sometimes	49	8.4	312	53.4	223	38.2	584	49.6		
	Never	15	8.8	95	55.9	60	35.3	170	14.4		
Weight Changes ($n = 1177$)	Gained weight	30	8.1	211	56.9	130	35.0	371	31.5	2.899	0.575
	Loss Weight	25	10.3	133	55.0	84	34.7	242	20.6		
	No change	47	8.3	298	52.8	219	38.8	564	47.9		
Satisfaction on body weight status ($n = 1177$)	Satisfied	30	9.2	194	59.7	101	31.1	325	27.6	6.653	0.155
	Neutral	34	7.9	228	53.1	167	38.9	429	36.4		
	Dissatisfied	38	9.0	220	52.0	165	39.0	423	35.9		
Sex	Male	8	2.9	128	46.9	137	50.2	273	23.1	34.472	< 0.001*
	Female	94	10.3	517	56.9	298	32.8	909	76.9		
Ethnicity	Malay	30	5.5	259	47.7	254	46.8	543	45.9	87.824	< 0.001*
	Chinese	65	13.7	307	64.6	103	21.7	475	40.2		
	Indian and others	7	4.3	79	48.2	78	47.6	164	13.9		
Age groups	18–29	77	14.8	324	62.1	121	23.2	522	44.2	101.121	< 0.001*
	30–39	19	4.9	192	50.0	173	45.1	384	32.5		
	40–49	5	2.6	86	45.5	98	51.9	189	16.0		
	50 and above	1	1.1	43	49.4	43	49.4	87	7.4		
Marital status	Single/Divorced/Widowed	88	13.5	388	59.4	177	27.1	653	55.2	83.283	< 0.001*
	Married	14	2.6	257	48.6	258	48.8	529	44.8		
Education Attainment	Secondary	0	0.0	44	37.3	74	62.7	118	10.0	42.397	< 0.001*
	Tertiary (University/College)	102	9.6	601	56.5	361	33.9	1064	90.0		
Family Monthly Income	< RM 2300	30	11.5	141	54.2	89	34.2	260	22.0	4.162	0.385
	RM 2300 -RM 5600	36	8.2	236	53.9	166	37.9	438	37.1		
	>RM 5600	36	7.4	268	55.4	180	37.2	484	40.9		

* $p < 0.05$

and 16.82% of the respondents adhered to portion size recommendations for starch, protein sources, fruits, and vegetables for all main meals, respectively. In addition, 22.4%, 8.6% and 5.3% of the respondents practised the QQH concept for both lunch and dinner, lunch alone and dinner alone, respectively. Nevertheless, another 15.5% of the respondents never practised QQH while eating. Factors attributed to the non-adherence to QQH among respondents were further explored. While approximately 14% have never heard about the QQH, 17% of them perceived the QQH was too complicated to practise with another 46% perceiving the concept did not work well or confer any health benefits.

Stir-flying was the most common cooking preparation, with about one-third of the respondents having stir-fried dishes daily (Table 4; Fig. 1). Deep-fried food consumption was much higher than either steam or braised food consumption in our study population, denoted by more than 35% of the respondents had at least one deep-fried food on an alternative day (equal or more than 4 times per week). Other cooking preparations, namely grilling, roasting, and air-frying, were less favourable, with approximately half the respondents never or hardly considering the above in cooking.

The respondents used six major cooking oils, as depicted in Table 4; Fig. 2. Palm olein was the most used cooking oil among Malaysians, which 60% of respondents used. This was followed by olive and sunflower oils, with approximately 30% of the respondents using the above unsaturated fatty acids in cooking. About 2 in 5 respondents were using corn oil in cooking. On the other hand, approximately 15%, 11.5% and 6% of the respondents used sesame or ginger oil, canola and red palm olein as their cooking oils, respectively. The use of blended oil was not a common practice, with only approximately 5% of the respondents practising this cooking behaviour. In contrast, slightly more than 60% of the respondents recycled their cooking oil, with 6 in 10 recycling it more than once.

Univariable multinomial regressions were used to investigate the effect of variables (sociodemographic factors, lifestyle) on body weight status, with normal BMI set as the reference group (Appendix 1: Tables A1-5). Among the sociodemographic factors, younger age (specifically in the 18–29 years category) was associated with a higher risk of being underweight but a lower risk of being overweight and obese. Compared to females, male respondents have a lower risk of being underweight. Correspondingly, they were also at higher risk of being overweight and obese. A comparison between different ethnicities showed Chinese were more prone to underweight and less likely to be overweight and obese. There was no significant difference in weight status between Malay and Indian respondents. Compared to single counterparts, married respondents were more likely to be overweight and obese while less likely to be underweight. Level of education did not influence the risk of being underweight. Notwithstanding, respondents with secondary education attainment were more likely to be overweight and obese compared to their counterparts with higher education attainment. On the other hand, interestingly, contrary to the initial hypothesis, family income was not associated with body weight status. The current body weight status of respondents was influenced by their weight status prior to the COVID-19 pandemic (Appendix Table A2). Compared to those overweight and obese, respondents with normal BMI prior to the pandemic were less likely to be overweight and obese during the COVID-19 pandemic. However, these respondents were more likely to be underweight currently. Despite the attempts to manage weight among the respondents, such attempts were not associated with body weight status.

In the present study, the level of physical activity was not associated with the risk of being overweight and obese (Appendix Table A3). On the other hand, contrary to common belief, respondents who were sedentary were 2.6-fold more likely to be underweight. The associations between exercise and body weight status did not produce consistent or dose-dependent findings. Performing daily exercise was not associated with body weight status. However, compared to respondents who never exercise or hardly exercise (defined as less than once a week), exercising 3–4 times per week was associated with approximately 70% less likelihood of being underweight. Our study revealed an important finding on how sleep quality may influence body weight status. While sleep quality did not affect the risk of being overweight and obese, poor sleepers have a 43% higher risk of being underweight. We further examined the difficulty of sleeping with the risk of being underweight. Compared to their counterparts with severe difficulty in sleeping, respondents without sleep problems had a 67.3% lower risk of being underweight. Although the findings indicated a degree of sleep difficulty was associated with the risk of being underweight in a dose-dependent manner, the association was only significant for the non-sleeping difficulty group compared to respondents with severe sleeping difficulty. With regards to sleep duration, respondents with a moderate deficit in sleep duration were two times more likely to be overweight and obese as compared to their counterparts with a severe deficit in sleep duration. The stress level was not associated with the risk of being overweight and obese. Nonetheless, highly stressed respondents were more likely to be underweight as compared to their counterparts, who self-perceived themselves as low or moderately stressed.

The associations between dietary behaviours and body weight status are depicted in Table A4 (appendix).

Table 2 Distribution of respondents according to lifestyle variables and their associations with body weight status

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Perception on physical activity pattern	Sedentary	62	10.7	301	52.0	216	37.3	579	49.0	9.910	0.042*
	Moderately active	35	6.9	280	55.6	189	37.5	504	42.6		
	Very active	5	5.1	64	64.6	30	30.3	99	8.4		
Performed moderate/vigorous intensity exercise for at least 30 min/day	Everyday	1	2.5	25	62.5	14	35.0	40	3.4	17.403	0.026*
	5–6 days/week	5	6.8	46	63.0	22	30.1	73	6.2		
	3–4 days/week	9	3.8	142	60.7	83	35.5	234	19.8		
	1–2 days/week	39	9.8	211	52.8	150	37.5	400	33.8		
	Never/Less than once per week	48	11.0	221	50.8	166	38.2	435	36.8		
Perception of exercise level compared to before COVID-19	Exercise more	23	8.2	167	59.2	92	32.6	282	23.9	7.911	0.095
	Exercise less	38	7.4	287	55.6	191	37.0	516	43.7		
	No difference	41	10.7	191	49.7	152	39.6	384	32.5		
Perception of sleep quality compared to before COVID-19	No difference	55	7.3	409	54.5	286	38.1	750	63.5	7.164	0.127
	Better	16	8.6	105	56.5	65	34.9	186	15.7		
	Poorer	31	12.6	131	53.3	84	34.1	246	20.8		
Sleep Duration (Hours)	> 7 h	37	14.2	147	56.5	76	29.2	260	22.0	28.315	< 0.001*
	5–6 h	52	7.8	362	54.6	249	37.6	663	56.1		
	less than 5 h	7	3.6	97	49.5	92	46.9	196	16.6		
	6–7 h	6	9.5	39	61.9	18	28.6	63	5.3		
Sleep quality	No difficulty	10	5.4	108	58.1	68	36.6	186	15.7	6.744	0.345
	Mild difficulty	60	8.5	379	53.5	269	38.0	708	59.9		
	Moderate difficulty	26	10.6	137	55.9	82	33.5	245	20.7		
	Severe difficulty	6	14.0	21	48.8	16	37.2	43	3.6		
Sleep latency	No difficulty	25	7.9	190	59.7	103	32.4	318	26.9	8.68	0.192
	Mild difficulty	36	8.4	233	54.2	161	37.4	430	36.4		
	Moderate difficulty	27	9.8	132	48.0	116	42.2	275	23.3		
	Severe difficulty	14	8.8	90	56.6	55	34.6	159	13.5		
Perceived Stress Level	Low stress	14	6.3	121	54.3	88	39.5	223	18.9	15.205	0.004*
	Moderate stress	70	8.1	476	55.1	318	36.8	864	73.1		
	High stress	18	18.9	48	50.5	29	30.5	95	8.0		
Perception of stress level compared to before COVID-19	No difference	35	7.4	261	55.1	178	37.6	474	40.1	6.067	0.194
	Less stressful	16	8.4	93	48.9	81	42.6	190	16.1		
	More stressful	51	9.8	291	56.2	176	34.0	518	43.8		

* $p < 0.05$

While the risk of being underweight did not differ significantly between respondents who consumed more often home-cooked meals (more than 3 days per week) or less home-cooked meals, there was a 35% increased risk of overweight and obese correspondents with frequent home-cooked meal consumption. Skipping lunch and dinner more often was associated with an increased odd ratio of overweight and obese, by 2.19 and 1.79, respectively. Interestingly, higher consumption of outside foods produced different findings on body weight status, depending on the ordering platform and type of eateries. Respondents who eat out more often at either the local cuisine restaurants, hawker centres or fast-food restaurants had an increased risk of being overweight and obese, with a higher odd ratio of overweight and obese for western fast-food restaurants (48.4%) compared to local cuisine restaurants or hawker centres (31.4%). On the other hand, taking away meals or ordering meals using food delivery application platforms did not affect the risk of being underweight or overweight/obese. While the consumption of sugar-sweetened beverages and sweet delicacies were both prevalent among the respondents, their associations with the risk of being overweight and obese produced different findings. There was no difference in the risk of being overweight and obese compared to respondents who consumed more and less frequent sweet delicacies such as cakes and local desserts. In contrast, more frequent consumption of sugar-sweetened beverages, namely carbonated, energy or cordial drinks, increases the risk of being overweight and obese by 32%.

Skipping starchy foods was associated with a higher risk of overweight and obesity. Having starchy foods such as rice, noodles, bread, cereals and tubers more than 4 days per week was associated with a 56.7% lower risk of being overweight and obese. In contrast, having fried foods regularly, as defined as more than 4 times per week, was associated with a 56.2% increased risk of overweight and obesity in the study population. Respondents who consumed fruits at least on alternate days have a 70% lower risk of being underweight when compared to their counterparts who consumed fruits less frequently. Contrary to common belief, there was no association between the frequency of vegetable consumption and the risk of being underweight or overweight/obese. A similar scenario was observed for protein foods, except for milk and dairy products. Consuming milk and dairy products such as yoghurt and cheese at least on alternative days reduced the risk of being underweight by 76.8%, while there was no further increase in overweight or obese.

Attempting to practice healthy eating concepts for lunch and dinner decreased the risk of being overweight and obese by 37.2%. Practising healthy eating for all main meals (breakfast, lunch and dinner) was associated with a 29.4% lower risk of being overweight and obese; however, the association was insignificant. Specifically, practising a controlled portion of protein foods for lunch and dinner was associated with approximately 50% lower risk of being overweight and obese when compared to never practising portion recommendation for protein foods. Adherence to portion recommendations for starch foods (occupying a quarter of the total portion of foods) or fruits and vegetables (occupying half of the total food portions) were not associated with a lower risk of being underweight, overweight or obese. The reasons for this matter are unclear and probably due to the smaller proportion of the respondents who practised the above as compared to the protein foods recommendation.

As predicted, food steaming was the most appropriate cooking method for reducing the risk of being overweight and obese (Appendix Table A5). Increased frequency of having steamed foods at least on alternate days (more than 4 days per week) was associated with approximately 48% lower risk of overweight and obesity. While having 1–3 times grilled foods per week increased the risk of being overweight and obese by 33.1%, consuming more often than the above did not associate with a higher risk of being overweight and obese, probably attributed to the small proportion of respondents (less than 15%). While 1–3 days of having baked foods was associated with a 56.6% lower risk of being underweight, having more frequently baked foods was not associated with a lower risk of being underweight. We further explored the impact of baking on the risk of being overweight and obese. Compared to respondents who hardly consumed baked products, there was a dose-dependent association between the frequency of baked food consumption and risk of being overweight and obese, whereby the risk increased by 57.8% and 90.1% for respondents who had baked foods for 1–3 days per week and more than 3 days per week, respectively. Both roasting and deep-frying increased the risk of overweight and obesity in a dose-dependent manner. To be specific, while having roasted foods more than 3 days per week will have an increased odds ratio of overweight and obese by 1.842, similarly consuming frequency of deep-fried foods increased the risk of being overweight and obese by 2.3-fold. The usage of the new cooking technology, air-frying, deserves further elaboration. Despite this new cooking technology was not favoured by the study population, having foods prepared using this low-fat cooking option on alternate days increased the risk of overweight and obesity by 63.7% when compared to non-users. There were consistent findings whereby there were no significant associations between cooking oil and the risk of being underweight among the study population. In the univariable multinomial regression, sunflower oil was the only one significantly reduced the risk of overweight and obesity by

Table 3 Distribution of respondents according to food practices and dietary behaviour and their associations with body weight status ($n = 1171$)

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Consumed home-cooked meals	Everyday	47	9.6	264	53.8	180	36.7	491	41.9	7.373	0.288
	4–6 days/week	35	8.5	242	58.6	136	32.9	413	35.3		
	1–3 days/week	16	7.9	100	49.3	87	42.9	203	17.3		
	Never	4	6.3	34	53.1	26	40.6	64	5.5		
Went out to pack foods or drinks	Everyday	4	4.6	50	57.5	33	37.9	87	7.4	9.454	0.150
	4–6 days/week	13	6.6	97	49.0	88	44.4	198	16.9		
	1–3 days/week	65	9.4	388	56.1	239	34.5	692	59.1		
	Never	20	10.3	105	54.1	69	35.6	194	16.6		
Order foods through Food Delivery Application	Everyday	2	9.1	10	45.5	10	45.5	22	1.9	7.722	0.259
	4–6 days/week	7	5.9	61	51.3	51	42.9	119	10.2		
	1–3 days/week	43	8.5	267	52.8	196	38.7	506	43.2		
	Never	50	9.5	302	57.6	172	32.8	524	44.7		
Obtained free/donated foods/drinks	Everyday	0	0.0	5	50.0	5	50.0	10	0.9	-[a]	0.006*
	4–6 days/week	1	1.8	23	41.1	32	57.1	56	4.8		
	1–3 days/week	14	6.6	110	52.1	87	41.2	211	18.0		
	Never	87	9.7	502	56.2	305	34.1	894	76.3		
Consumed breakfast	Everyday	61	8.0	415	54.6	284	37.4	760	64.9	4.081	0.666
	4–6 days/week	18	10.7	94	56.0	56	33.3	168	14.3		
	1–3 days/week	14	8.0	98	55.7	64	36.4	176	15.0		
	Never	9	13.4	33	49.3	25	37.3	67	5.7		
Consumed lunch	Everyday	85	9.3	513	56.3	314	34.4	912	77.9	17.344	0.008*
	4–6 days/week	11	6.7	89	54.6	63	38.7	163	13.9		
	1–3 days/week	4	4.8	33	39.8	46	55.4	83	7.1		
	Never	2	15.4	5	38.5	6	46.2	13	1.1		
Consumed dinner	Everyday	83	9.8	470	55.2	298	35.0	851	72.7	20.495	0.002*
	4–6 days/week	14	7.2	113	58.2	67	34.5	194	16.6		
	1–3 days/week	4	3.6	54	49.1	52	47.3	110	9.4		
	Never	1	6.3	3	18.8	12	75.0	16	1.4		
Taking Snacks	Everyday	20	9.1	123	56.2	76	34.7	219	18.7	9.097	0.168
	4–6 days/week	27	8.9	163	53.4	115	37.7	305	26.0		
	1–3 days/week	52	10.1	281	54.5	183	35.5	516	44.1		
	Never	3	2.3	73	55.7	55	42.0	131	11.2		
Consumed meals from restaurants, hawker centres, coffee shops or other food stalls	Everyday	4	5.2	38	49.4	35	45.5	77	6.6	10.087	0.121
	4–6 days/week	17	7.7	109	49.3	95	43.0	221	18.9		
	1–3 days/week	55	8.7	358	56.7	218	34.5	631	53.9		
	Never	26	10.7	135	55.8	81	33.5	242	20.7		

Table 3 (continued)

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Consumed meals from western fast-food restaurants	Everyday	0	0.0	5	26.3	14	73.7	19	1.6	24.686	< 0.001*
	4–6 days/week	5	5.7	41	46.6	42	47.7	88	7.5		
	1–3 days/week	55	8.5	345	53.3	247	38.2	647	55.3		
	Never	42	10.1	249	59.7	126	30.2	417	35.6		
Consumption of dietary supplements	Everyday	24	8.8	143	52.4	106	38.8	273	23.3	3.150	0.790
	4–6 days/week	11	7.6	79	54.5	55	37.9	145	12.4		
	1–3 days/week	26	10.6	129	52.7	90	36.7	245	20.9		
	Never	41	8.1	289	56.9	178	35.0	508	43.4		
Consumption of probiotic drinks	Everyday	3	6.8	23	52.3	18	40.9	44	3.8	1.726	0.943
	4–6 days/week	10	7.3	80	58.4	47	34.3	137	11.7		
	1–3 days/week	37	9.0	219	53.3	155	37.7	411	35.1		
	Never	52	9.0	318	54.9	209	36.1	579	49.4		
Consumption of sugar sweetened beverages	Everyday	7	11.5	25	41.0	29	47.5	61	5.2	19.917	0.003*
	4–6 days/week	1	0.8	72	54.1	60	45.1	133	11.4		
	1–3 days/week	53	9.8	294	54.1	196	36.1	543	46.4		
	Never	41	9.4	249	57.4	144	33.2	434	37.1		
Drinking of plain water	Everyday	100	9.2	599	55.2	386	35.6	1085	92.7	-[a]	0.049*
	4–6 days/week	0	0.0	23	46.0	27	54.0	50	4.3		
	1–3 days/week	2	6.9	13	44.8	14	48.3	29	2.5		
	Never	0	0.0	5	71.4	2	28.6	7	0.6		
Consumption of fruits	Everyday	26	6.0	247	57.4	157	36.5	430	36.7	13.219	0.040*
	4–6 days/week	31	8.4	190	51.8	146	39.8	367	31.3		
	1–3 days/week	41	12.8	171	53.3	109	34.0	321	27.4		
	Never	4	7.5	32	60.4	17	32.1	53	4.5		
Consumption of vegetables	Everyday	65	9.3	398	57.1	234	33.6	697	59.5	7.532	0.274
	4–6 days/week	23	8.1	146	51.2	116	40.7	285	24.3		
	1–3 days/week	13	7.9	83	50.3	69	41.8	165	14.1		
	Never	1	4.2	13	54.2	10	41.7	24	2.0		
Consumption of milk and dairy products	Everyday	20	8.3	128	53.1	93	38.6	241	20.6	13.047	0.042*
	4–6 days/week	17	5.5	193	62.1	101	32.5	311	26.6		
	1–3 days/week	46	10.0	239	51.8	176	38.2	461	39.4		
	Never	19	12.0	80	50.6	59	37.3	158	13.5		
Consumption of rice, noodles, bread, cereals, cereal products and tubers	Everyday	82	9.6	489	57.3	283	33.1	854	72.9	18.501	0.005*
	4–6 days/week	13	6.6	94	48.0	89	45.4	196	16.7		
	1–3 days/week	7	6.4	52	47.7	50	45.9	109	9.3		
	Never	0	0.0	5	41.7	7	58.3	12	1.0		

Table 3 (continued)

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Consumption of egg, fish, chicken, meat and meat products	Everyday	77	9.2	473	56.7	284	34.1	834	71.2	11.584	0.072
	4–6 days/week	17	7.2	118	49.8	102	43.0	237	20.2		
	1–3 days/week	8	10.4	35	45.5	34	44.2	77	6.6		
	Never	0	0.0	14	60.9	9	39.1	23	2.0		
Consumption of legumes and nuts (e.g. peanuts)	Everyday	24	7.7	184	58.8	105	33.5	313	26.7	7.678	0.263
	4–6 days/week	27	7.8	191	55.2	128	37.0	346	29.5		
	1–3 days/week	47	10.8	221	50.6	169	38.7	437	37.3		
	Never	4	5.3	44	58.7	27	36.0	75	6.4		
Consumption of fried foods/high fat foods	Everyday	13	7.2	91	50.6	76	42.2	180	15.4	25.751	< 0.001*
	4–6 days/week	23	7.1	154	47.2	149	45.7	326	27.8		
	1–3 days/week	57	10.3	323	58.5	172	31.2	552	47.1		
	Never	9	8.0	72	63.7	32	28.3	113	9.6		
Consumption of sweet foods/high sugary foods	Everyday	8	10.0	40	50.0	32	40.0	80	6.8	3.855	0.696
	4–6 days/week	16	7.3	116	52.7	88	40.0	220	18.8		
	1–3 days/week	59	8.6	380	55.2	250	36.3	689	58.8		
	Never	19	10.4	104	57.1	59	32.4	182	15.5		
Practising healthy eating concept (QQH)	For all main meals (everyday)	13	7.0	110	59.1	63	33.9	186	15.9	22.272	0.035*
	Lunch and dinner only (everyday)	28	10.7	155	59.2	79	30.2	262	22.4		
	Lunch only (everyday)	5	5.0	46	45.5	50	49.5	101	8.6		
	Dinner only	8	12.9	37	59.7	17	27.4	62	5.3		
	4–6 days/week	15	8.5	100	56.5	62	35.0	177	15.1		
	1–3 days/week	15	7.4	102	50.5	85	42.1	202	17.3		
	Never	18	9.9	90	49.7	73	40.3	181	15.5		
Complied to QQH for starchy foods	For all main meals (everyday)	19	8.7	124	56.6	76	34.7	219	18.7	14.512	0.269
	Lunch and dinner only (everyday)	29	11.5	145	57.3	79	31.2	253	21.6		
	Lunch only	5	5.1	52	52.5	42	42.4	99	8.5		
	Dinner only	4	9.5	25	59.5	13	31.0	42	3.6		
	4–6 days/week	13	7.9	95	57.6	57	34.5	165	14.1		
	1–3 days/week	14	6.4	111	50.5	95	43.2	220	18.8		
	Never	18	10.4	88	50.9	67	38.7	173	14.8		
Complied to QQH concept for meat and legumes	For all my main meals (everyday)	19	9.1	120	57.4	70	33.5	209	17.8	23.200	0.026*
	Lunch and dinner only (everyday)	30	10.5	177	61.9	79	27.6	286	24.4		
	Lunch only	7	7.4	45	47.9	42	44.7	94	8.0		
	Dinner only	3	5.5	29	52.7	23	41.8	55	4.7		
	4–6 days/week	16	8.3	106	55.2	70	36.5	192	16.4		
	1–3 days/week	13	6.3	101	49.3	91	44.4	205	17.5		
	Never	14	10.8	62	47.7	54	41.5	130	11.1		

Table 3 (continued)

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Complied to QQH concept for fruits and vegetables	For all main meals (everyday)	17	8.6	108	54.8	72	36.5	197	16.8	13.434	0.338
	Lunch only	5	6.0	43	51.2	36	42.9	84	7.2		
	Dinner only	9	13.0	34	49.3	26	37.7	69	5.9		
	4–6 days/week	16	7.7	116	55.5	77	36.8	209	17.8		
	1–3 days/week	20	8.2	122	50.2	101	41.6	243	20.8		
	Never	14	9.9	75	53.2	52	36.9	141	12.0		
Factors for non-compliance to QQH concept	Never heard about this concept before	11	15.9	34	49.3	24	34.8	69	13.8	27.544	0.001*
	Too complicated to follow	5	5.8	43	50.0	38	44.2	86	17.2		
	Perceived not offering much health benefits	2	2.7	40	54.8	31	42.5	73	14.6		
	Others	10	8.9	63	56.3	39	34.8	112	22.4		
Perception on current eating pattern compared to before COVID-19	No difference	49	9.6	280	54.7	183	35.7	512	43.7	5.423	0.247
	More Healthy	39	9.4	232	55.8	145	34.9	416	35.5		
	Less healthy	14	5.8	128	52.7	101	41.6	243	20.8		
Eating Disorder ($n = 1162$)	Present	8	3.0	129	47.6	134	49.4	271	23.3	32.824	< 0.001*
	Absent	92	10.3	509	57.1	290	32.5	891	76.7		

[a] Fisher exact test

* $p < 0.05$

Table 4 Cooking patterns and their associations with body weight status ($n = 1118$)

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Braise	Everyday	6	10.0	30	50.0	24	40.0	60	5.4	6.120	0.410
	4–6 days/week	19	8.4	138	61.1	69	30.5	226	20.2		
	1–3 days/week	36	7.9	244	53.3	178	38.9	458	41.0		
	Rare/Never	30	8.0	198	52.9	146	39.0	374	33.5		
Steam	Everyday	3	4.9	38	62.3	20	32.8	61	5.5	23.177	0.001
	4–6 days/week	29	12.8	138	60.8	60	26.4	227	20.3		
	1–3 days/week	31	6.6	256	54.6	182	38.8	469	41.9		
	Rare/Never	28	7.8	178	49.3	155	42.9	361	32.3		
Grill	Everyday	1	6.7	6	40.0	8	53.3	15	1.3	11.055	0.087
	4–6 days/week	10	6.8	79	53.7	58	39.5	147	13.1		
	1–3 days/week	27	6.3	226	52.7	176	41.0	429	38.4		
	Rare/Never	53	10.1	299	56.7	175	33.2	527	47.1		
Baking	Everyday	2	10.0	7	35.0	11	55.0	20	1.8	31.941	< 0.001*
	4–6 days/week	6	6.2	47	48.5	44	45.4	97	8.7		
	1–3 days/week	17	4.3	207	51.9	175	43.9	399	35.7		
	Rare/Never	66	11.0	349	58.0	187	31.1	602	53.8		
Stir-fry	Everyday	30	8.7	186	53.9	129	37.4	345	30.9	7.987	0.239
	4–6 days/week	25	5.9	242	57.2	156	36.9	423	37.8		
	1–3 days/week	25	9.6	132	50.6	104	39.8	261	23.3		
	Rare/Never	11	12.4	50	56.2	28	31.5	89	8.0		
Deep-fry	Everyday	8	5.4	62	42.2	77	52.4	147	13.1	39.847	< 0.001*
	4–6 days/week	16	6.2	131	50.8	111	43.0	258	23.1		
	1–3 days/week	28	7.0	223	56.0	147	36.9	398	35.6		
	Rare/Never	39	12.4	194	61.6	82	26.0	315	28.2		
Roast	Everyday	2	7.7	7	26.9	17	65.4	26	2.3	24.193	< 0.001*
	4–6 days/week	6	4.7	66	52.0	55	43.3	127	11.4		
	1–3 days/week	30	6.9	227	52.1	179	41.1	436	39.0		
	Rare/Never	53	10.0	310	58.6	166	31.4	529	47.3		
Air-fry ($n = 960$)	Everyday	2	3.1	27	42.2	35	54.7	64	6.7	19.525	0.003*
	4–6 days/week	8	5.6	75	52.8	59	41.5	142	14.8		
	1–3 days/week	14	6.1	122	53.3	93	40.6	229	23.9		
	Rare/Never	53	10.1	302	57.5	170	32.4	525	54.7		
Corn oil	Yes	21	9.6	113	51.8	84	38.5	218	19.5	1.222	0.543
	No	70	7.8	497	55.2	333	37.0	900	80.5		
Soybean oil	Yes	4	15.4	12	46.2	10	38.5	26	2.3	2.071	0.355
	No	87	8.0	598	54.8	407	37.3	1092	97.7		
Sunflower oil	Yes	30	9.2	199	60.9	98	30.0	327	29.2	10.621	0.005*
	No	61	7.7	411	52.0	319	40.3	791	70.8		

Table 4 (continued)

Variable		Underweight		Normal		Overweight and obese		Total	%	χ^2	*p* value
		n	%	n	%	n	%				
Olive oil	Yes	27	7.1	204	53.4	151	39.5	382	34.2	1.735	0.420
	No	64	8.7	406	55.2	266	36.1	736	65.8		
Canola oil	Yes	9	7.0	72	55.8	48	37.2	129	11.5	0.284	0.867
	No	82	8.3	538	54.4	369	37.3	989	88.5		
Palm Oil	Yes	58	7.4	409	52.1	318	40.5	785	70.2	12.033	0.002*
	No	33	9.9	201	60.4	99	29.7	333	29.8		
Blended oil	Yes	11	17.7	31	50.0	20	32.3	62	5.5	8.133	0.017*
	No	80	7.6	579	54.8	397	37.6	1056	94.5		
Recycling of cooking oil (*n* = 1117)	Yes	45	6.5	374	54.1	272	39.4	691	61.9	7.996	0.018*
	No	46	10.8	235	55.2	145	34.0	426	38.1		
Frequency of recycling oil used (*n* = 771)	Once	23	7.5	181	59.0	103	33.6	307	39.8	12.223	0.057
	Twice	18	5.5	163	49.7	147	44.8	328	42.5		
	Three times	6	5.6	49	45.8	52	48.6	107	13.9		
	More than three times	2	6.9	17	58.6	10	34.5	29	3.8		
Cooking practices compared to before COVID-19	Cooking more often	50	7.3	388	57.0	243	35.7	681	60.9	4.987	0.289
	Cooking less often	14	10.9	65	50.4	50	38.8	129	11.5		
	No difference	27	8.8	157	51.0	124	40.3	308	27.5		
Purchase of cooking oil as compared to before COVID-19	Buying more	23	6.8	193	56.9	123	36.3	339	30.3	2.595	0.628
	Buying less	13	7.1	99	54.1	71	38.8	183	16.4		
	No change	55	9.2	318	53.4	223	37.4	596	53.3		

*$p < 0.05$

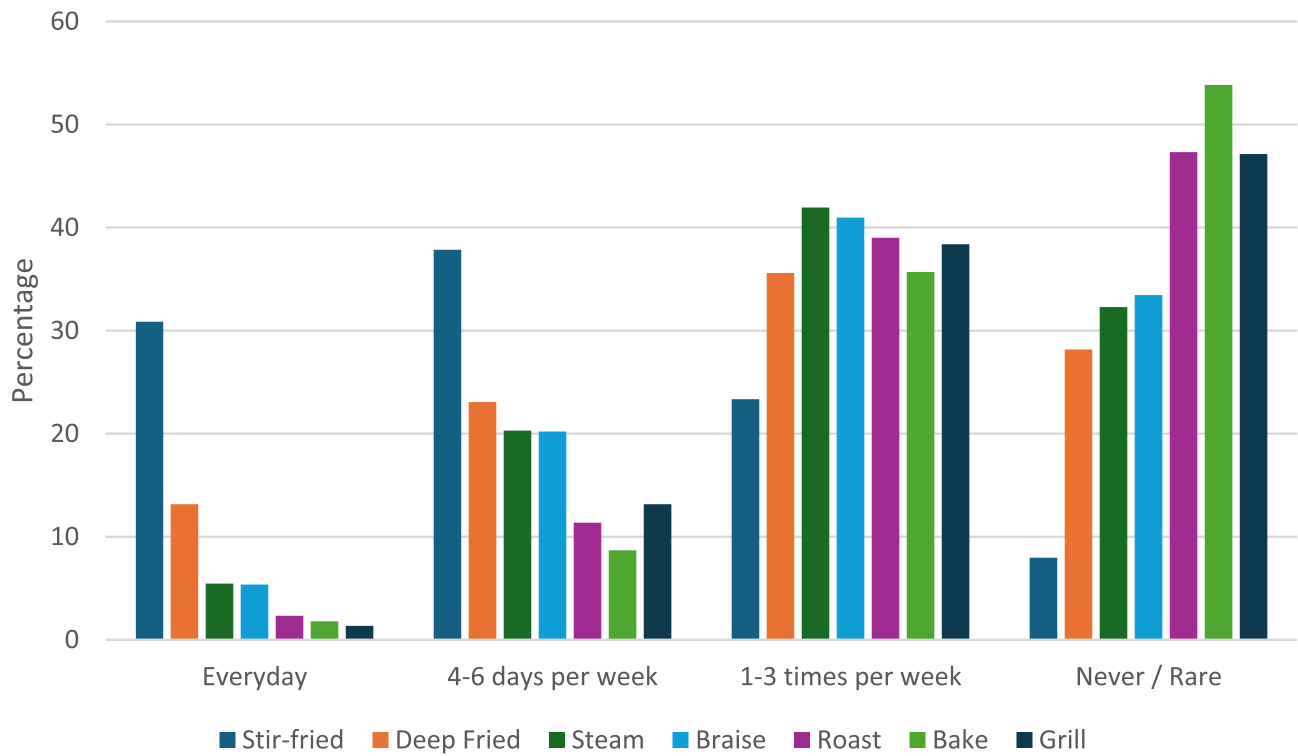

Fig. 1 Distribution of respondents according to cooking practices

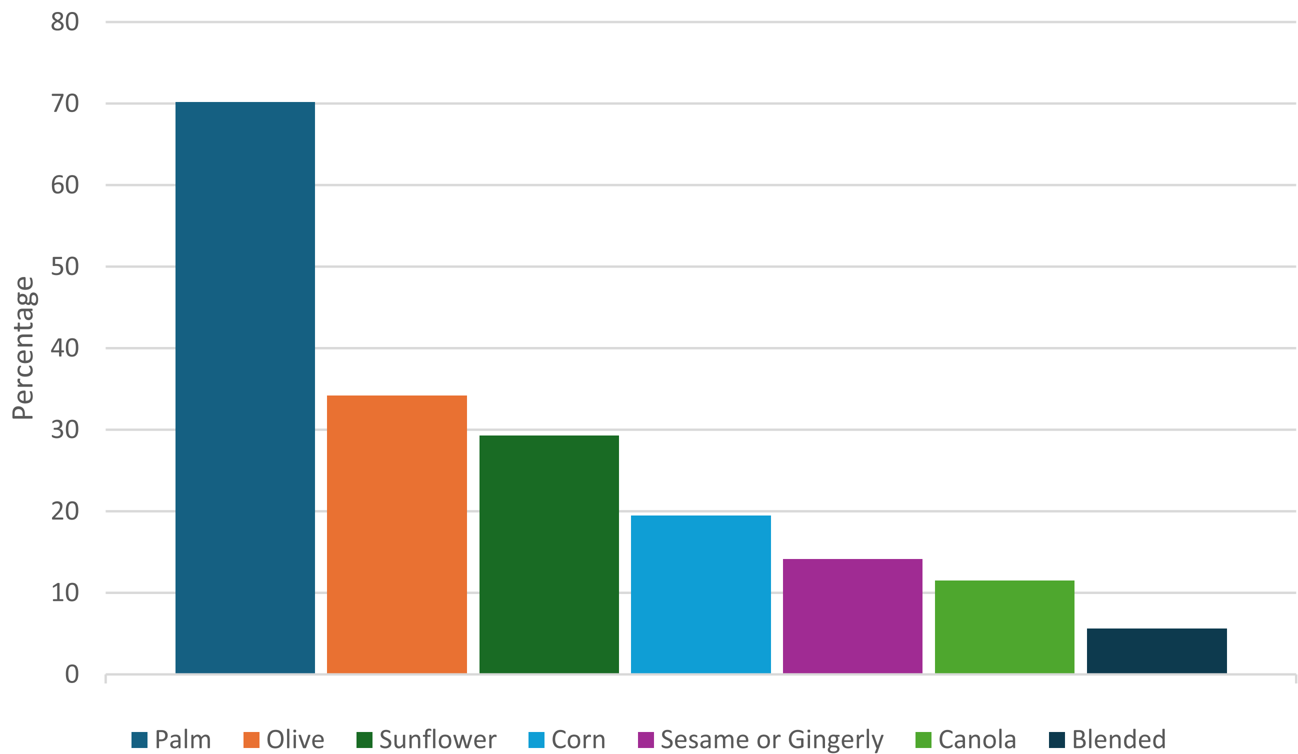

Fig. 2 Pattern of cooking oil use

36.6%. In contrast, palm oil was associated with a 71.9% increased risk of overweight and obesity compared to non-users. While the use of blended cooking oil did not affect the risk of overweight and obesity, it was associated with approximately 2.5 times higher risk of underweight compared to non-users. In contrast, using recycled cooking oil was associated with a 38.5% lower risk of being underweight. Interestingly, recycling cooking oil more than three times before discarding it was associated with a 39.4% higher risk of overweight and obesity when compared to those who only recycled it once. However, in the hierarchical multinomial regression analysis, none of the cooking oils had a significant influence on the risk of being overweight or obese.

Table 5 shows the hierarchical multinomial regression analysis to delineate the final model on factors influencing inappropriate body weight status, separated as underweight and overweight/obese, respectively. This model was computed and adjusted with a confounding variable (family income). The final model illustrated the total variance in underweight, overweight, and obesity associated with sociodemographic, lifestyle behaviour, and dietary practice characteristics. The risks of underweight and overweight/obese were multifaceted, including sociodemographic factors. In the best-fitting multilevel model that predicts the risk of being underweight, being female, Chinese, and in the younger age group (18–29 years) were the unmodifiable factors associated with higher odds of being underweight. High levels of perceived stress, habitually not exercising, seldom performing moderate or vigorous physical activity, and poor sleep quality increase the risk of being underweight. With regard to dietary behaviours, consuming milk and dairy products (e.g. yoghurt, cheese) less than 3 times per week dominated the risk. Baking exhibited a shared risk factor for both underweight and overweight / obesity. While baking at least once a month was the protecting factor for underweight, it was a risk factor for overweight and obesity. On the other hand, blended oil was a risk factor for underweight.

On the other hand, there appears to be a different set of factors influencing the risk of overweight and obesity. Among the non-modifiable sociodemographic factors, being male, Indian and other ethnicities and older people put an individual at risk of being overweight and obese. While the level of physical activity and perceived sleep quality were not influencing the risk of being overweight and obese, the presence of moderate difficulty in sleep duration increased individual risk of being overweight and obese. Dietary behaviours play a significant role in explaining the risk of overweight and obesity. These included higher frequency of lunch skipping (more than 3 days per week) and avoidance of starchy foods (more than 3 days per week), frequent consumption (4–7 days per week) of fried foods/high-fat foods and poor adherence to practice quarter-quarter half healthy eating concept for protein foods. As expected, increased frequency of having deep-fried foods was a risk factor for overweight and obesity. While sunflower oil demonstrated protective effects against overweight and obesity in our univariable multinomial analysis, the protective effect was diminished in the hierarchy multinomial analysis. Conversely, although palm oil showed a potential association with an increased risk of overweight and obesity in the univariable multinomial analysis, this effect was not significant in the final hierarchy multinomial analysis. These findings suggest that the relationship between dietary oils and weight outcomes is complex and may be influenced by various factors, warranting further exploration. Similarly, neither consumption of sugar-sweetened beverages nor sweet delicacies significantly predicts the risk of overweight and obesity.

Discussion

The COVID-19 pandemic has changed how things are carried out including the conduct of research, from physical or face-to-face data collection to online platforms. The findings of this research shed light on the concerning state of health-related behaviours among Malaysians. Consistent with the previous local studies conducted during the COVID-19 pandemic [11, 18] the present study reported that the issue of double burden of malnutrition remains a significant public health issue in Malaysia, whereby the prevalence of overweight and obesity is higher than the underweight problem before and during the COVID-19 pandemic. In comparison to NHMS 2019, about 50% were either overweight or obese [19]. This might be likely attributed to current study used online survey instruments which potentially restricted respondents to those proficient in digital technology and with internet access, diverging from the broader spectrum represented in prior national data.

The current study builds upon the MyNutriLife COVID-19 online survey [11] initially conducted during the MCO 1.0 lockdown period. Despite initial health concerns during the first national lockdown, the present study reveals that similar unhealthy eating patterns and lifestyle behaviours persisted during the subsequent nationwide lockdown. Respondents' views on body image vary widely, with one-third were dissatisfied whereas one-fourth expressed satisfaction with their body weight status. Moreover, more than 80% of respondents attempted to manage their weight during MCO 2.0, which was consistent with Tan et al. (2022) [18] our findings reveal a higher proportion of weight gain (42.8%) during the extended MCO 2.0 period (spanning 15 months of full lockdown) compared to the initial MCO 1.0 lockdown (encompassing the first 3 months of

Table 5 Factors associated with body weight status according to hierarchical multinomial regression

	Model 0- Sociodemographic factors						Final model					
	Underweight			Overweight and obese			Underweight			Overweight and obese		
	AOR	95% CI for OR		AOR	95% CI for OR		AOR	95% CI for OR		AOR	95% CI for OR	
		LB	UB		LB	UB		LB	UB		LB	UB
Age group (years)												
18–29	5.144	0.642	41.231	0.367*	0.205	0.659	2.719	0.317	23.304	0.318*	0.165	0.614
30–39	3.408	0.436	26.660	0.857	0.520	1.414	2.340	0.280	19.551	0.759	0.437	1.320
40–49	2.185	0.245	19.489	1.161	0.676	1.994	1.985	0.207	18.997	1.180	0.652	2.134
≥ 50	Ref						Ref					
Marital status												
Single/Divorced/Widowed	2.382*	1.116	5.082	0.930	0.645	1.341	3.627*	1.576	8.349	0.996	0.668	1.484
Married	Ref						Ref					
Gender												
Male	0.344*	0.161	0.733	2.040*	1.510	2.757	0.406	0.164	1.003	2.245*	1.588	3.175
Female	Ref						Ref					
Ethnicity												
Chinese	1.942*	1.208	3.123	0.304*	0.225	0.410	1.807	0.888	3.677	0.404*	0.273	0.597
Indian and others	0.803	0.336	1.916	0.942	0.647	1.371	0.702	0.237	2.078	1.209	0.777	1.881
Malay	Ref						Ref					
	Model 1- Anthropometric factors						Model 1- Anthropometric factors					
Satisfaction on body weight status												
Satisfied	0.895	0.534	1.500	0.694*	0.507	0.950	0.745	0.405	1.372	0.739	0.514	1.064
In Between Satisfied and Dissatisfied	0.863	0.524	1.421	0.977	0.735	1.297	0.709	0.392	1.283	1.135	0.817	1.577
Dissatisfied	Ref						Ref					
	Model 2- Lifestyle factors						Model 2- Lifestyle factors					
Perform moderate/vigorous - intensity aerobic exercise for at least 30 min/day												
Everyday	0.658	0.079	5.470	0.907	0.443	1.856	1.215	0.130	11.329	1.568	0.697	3.530
5–6 days/week	1.586	0.500	5.026	0.853	0.477	1.527	2.320	0.652	8.248	0.902	0.463	1.756
1–2 days/week	3.321*	1.529	7.216	1.192	0.836	1.699	4.567*	1.818	11.475	1.368	0.899	2.080
Never/less than one per week	3.890*	1.762	8.584	1.209	0.842	1.736	3.895*	1.510	10.051	1.371	0.889	2.115
3–4 days/week	Ref						Ref					
Exercise pattern compared to before COVID-19 pandemic												
Exercise more	0.932	0.508	1.708	0.760	0.534	1.082	0.719	0.351	1.472	0.744	0.497	1.112
Exercise less	0.522*	0.319	0.854	0.825	0.620	1.098	0.403*	0.227	0.715	0.752	0.541	1.047
No different	Ref						Ref					
Sleep duration												
> 7 h	1.679*	1.044	2.700	0.754	0.546	1.041	1.202	0.685	2.111	0.978	0.672	1.425
5–6 h	0.440	0.192	1.010	1.337	0.960	1.861	0.617	0.250	1.523	0.931	0.636	1.364
less than 5 h	0.819	0.315	2.130	0.688	0.381	1.241	0.967	0.301	3.106	0.617	0.317	1.204

Table 5 (continued)

	Model 0- Sociodemographic factors						Final model					
	Underweight			Overweight and obese			Underweight			Overweight and obese		
	AOR	95% CI for OR		AOR	95% CI for OR		AOR	95% CI for OR		AOR	95% CI for OR	
		LB	UB		LB	UB		LB	UB		LB	UB
6–7 h	Ref						Ref					
Perception of stress level												
Low	0.323*	0.144	0.724	1.210	0.699	2.095	0.240*	0.088	0.655	1.019	0.536	1.938
Moderate	0.406*	0.216	0.763	1.084	0.662	1.773	0.347*	0.163	0.740	0.977	0.558	1.711
High	Ref						Ref					
	Model 3- dietary variables						Model 3- dietary variables					
Consumption of fruits												
4–6 days/week	1.511	0.855	2.672	1.129	0.827	1.542	1.476	0.784	2.778	1.207	0.853	1.709
1–3 days/week	2.188*	1.262	3.794	0.878	0.626	1.233	1.602	0.842	3.048	1.230	0.834	1.815
Never	1.076	0.337	3.442	0.694	0.358	1.347	0.320	0.064	1.603	0.935	0.434	2.014
Everyday	Ref						Ref					
Disordered Eating												
Yes	0.379*	0.178	0.808	1.839*	1.368	2.471	0.315*	0.132	0.748	1.799*	1.289	2.510
No	Ref						Ref					
Complied to QQH concept for meat and legumes												
For all main meals (everyday)	0.851	0.388	1.867	0.586*	0.355	0.966	0.920	0.350	2.418	0.577	0.327	1.017
Lunch and dinner only (everyday)	0.850	0.413	1.750	0.449*	0.279	0.723	0.813	0.328	2.014	0.414*	0.242	0.708
Lunch or dinner only (everyday)	0.578	0.229	1.454	0.860	0.511	1.447	0.438	0.143	1.338	0.815	0.455	1.459
4–6 days/week	0.699	0.313	1.564	0.694	0.422	1.142	0.733	0.272	1.972	0.610	0.350	1.062
1–3 days/week	0.529	0.226	1.238	0.910	0.563	1.473	0.596	0.217	1.639	0.732	0.425	1.260
Never	Ref						Ref					
Consumption pattern of lunch												
4–6 days/week	0.710	0.359	1.406	1.050	0.727	1.518	0.719	0.327	1.580	0.944	0.628	1.419
1–3 days/week	0.716	0.242	2.120	1.994*	1.223	3.250	0.656	0.200	2.148	2.125*	1.226	3.683
Never	1.501	0.163	13.840	2.078	0.596	7.244	0.779	0.075	8.091	1.904	0.446	8.133
Everyday	Ref						Ref					
Consumption pattern of fried foods/high fat foods												
4–6 days/week	1.004	0.476	2.115	1.213	0.816	1.803	1.390	0.572	3.374	1.270	0.811	1.989
1–3 days/week	1.118	0.578	2.164	0.694	0.479	1.006	0.841	0.349	2.022	0.812	0.519	1.269
Never	0.745	0.288	1.927	0.582*	0.341	0.992	0.693	0.213	2.259	0.807	0.420	1.548
Everyday	Ref						Ref					
	Model 4- cooking methods						Model 4- cooking methods					
Consumption pattern of Deep-fry foods												
4–6 days/week	1.004	0.405	2.488	0.699	0.457	1.069	0.830	0.293	2.349	0.771	0.480	1.238
1–3 days/week	1.005	0.431	2.344	0.573*	0.384	0.857	0.872	0.304	2.497	0.948	0.583	1.543

Table 5 (continued)

	Model 0- Sociodemographic factors						Final model					
	Underweight			Overweight and obese			Underweight			Overweight and obese		
	AOR	95% CI for OR		AOR	95% CI for OR		AOR	95% CI for OR		AOR	95% CI for OR	
		LB	UB		LB	UB		LB	UB		LB	UB
Rare/Never	1.556	0.678	3.570	0.390*	0.253	0.602	1.421	0.471	4.291	0.815	0.468	1.421
Everyday	Ref						Ref					
Practiced Roasting in cooking												
4–6 days/week	0.297	0.049	1.794	0.425	0.162	1.115	0.316	0.043	2.330	0.385	0.135	1.099
1–3 days/week	0.440	0.085	2.267	0.410	0.164	1.028	0.396	0.064	2.450	0.428	0.158	1.161
Rare/Never	0.514	0.101	2.618	0.309*	0.123	0.776	0.349	0.056	2.187	0.323*	0.118	0.882
Everyday	Ref						Ref					

* $p < 0.05$

the full lockdown), as reported by Chin et al. (2022) [11]. This trend highlights the escalating issue of overweight and obesity in Malaysia, emphasizing the critical need to determine nutritional and lifestyle influences on body weight status within relatively short durations.

Similar to previous local studies, during the COVID-19 pandemic [11, 18, 20] a notable prevalence of overall unhealthy lifestyle behaviours was evident. Throughout MCO 2.0, a majority of Malaysian adults encountered reduced physical activity (~ 40%), poor sleep quality (~ 60%), and high stress levels (~ 70%), collectively highlighting the substantial impact on well-being during this period. Furthermore, a significant number of Malaysian adults heavily relied on outside food sources and frequently used food ordering apps, showing a preference for convenient food choices over home-cooked meals. This trend aligned with a notable consumption of sugar-related foods and beverages, along with insufficient adherence to recommended fruit, and vegetable intake, and balanced meals encompassing starchy foods, protein sources, milk and milk products, and legumes. The common practices of frequent snacking and meal skipping raised concerns as approximately one in four individuals were at risk of eating disorders. This is consistent with a recent systematic review demonstrated that there was an increase in disordered eating behaviours during COVID-19 pandemic [21]. Respondents demonstrated diverse cooking methods and oils preferences. Deep-frying and stir-frying were the most favoured cooking methods while grilling, roasting, and air-frying were less commonly preferred. Palm olein was the most preferred cooking oil while blended oil was least preferred. Cooking methods and oil preferences reflect different approaches to healthy eating and could significantly impact the dietary behaviours and nutritional status of the individuals.

About 16% of respondents adopted healthier eating habits through the QQH concept, while 15.5% did not embrace the concept, probably attributed to their low awareness or doubts about health benefits. The low level of awareness of the healthy eating concept observed in our study is consistent with the recent national survey [22]. In the above study, approximately 80% of Malaysian adults had never heard of the healthy plate concept, despite its nationwide promotion since 2016. These findings, together with our study results, suggest that more strategic efforts including the implementation of more effective communication strategies are needed to improve the visibility and adoption of QQH among Malaysians.

Our study identified five key factors, namely sociodemographics, body weight perceptions, lifestyle behaviours, dietary habits, and cooking methods, that contributed to addressing both underweight and

overweight/obesity issues during the COVID-19 pandemic. To the best of our knowledge, this is the first study to report two distinct comprehensive factorial models for underweight and overweight/obese, respectively. We found that both similarities and differences in these key factors affect both ends of the weight spectrum. Therefore, to effectively combat these health challenges, we need to understand these shared and unique factors well before devising comprehensive strategies. This was supported by a nationally representative community-based study that suggested that incorporating sociodemographic, lifestyle, and health status risk factors for both underweight and overweight or obesity can assist in developing intervention strategies that target these conditions [23].

In the present study, single respondents were more prone to being underweight. This finding coincides with a global study which demonstrated that those who live alone have a reduced likelihood of gaining weight [24]. Similarly, a previous study conducted in the United Kingdom revealed that being single, divorced, or widowed was associated with irregular eating habits during national lockdowns [25]. It is conceivable that single people might not have the same support system as married people, which could make them feel more stressed. On the other hand, during the COVID-19 pandemic, being in a relationship seems to reduce the likelihood of experiencing stress, anxiety, or depression symptoms [26]. The experience of stressful life events has been associated with a consistent decrease in food intake. However, our research was unable to definitively determine whether depression was the primary driver of emotional eating or if it served as a coexisting symptom alongside the psychological challenges individuals were facing.

Contrary to common assumptions, the study's unexpected conclusion was that people who reported being sedentary were more likely to be underweight. However, it is imperative to acknowledge the limitations inherent in self-reported data and the cross-sectional design of the study, necessitating cautious interpretation of the findings. Several research has consistently linked low physical activity to underweight status [27, 28]. This association may be explicated by the profound impact of exercise on lean body mass. Physical activity has a dual effect on body weight, increasing fat-free mass while decreasing fat mass, as demonstrated in experimental studies [29]. Additionally, physical activity plays an important role in skeletal muscle development, increasing lean body mass [27]. Notably, a study reveals that inactive individuals exhibit a diminished total body lean mass compared to those adhering to average or active lifestyles [30]. Besides, Weiss et al. (2017) suggested that modest, calorie restriction-induced weight loss in overweight sedentary adults decreases whole body and lower extremity lean mass, suggesting skeletal muscle atrophy, and reduces absolute aerobic capacity, suggesting catabolic activity on the cardiovascular system [31]. However, dietary intake was not assessed in this study and therefore we cannot exclude partial confounding and/or mediation by a low energy intake, which would require further research to establish.

Another concerning trend highlighted in our study was that males are more likely to be overweight compared to females, which contrasts with the Malaysia National Health and Morbidity Survey (NHMS 2019) that reported higher prevalence of overweight and obesity among Malaysian women [32]. However, our finding aligns with two earlier Malaysian studies among young adults, both of which observed a greater risk of overweight and obesity in males [33, 34] and another study that reported an increase of BMI among males during the lockdown period compared to females [35]. In addition, in our current study population, a significantly lower proportion of male participants reported adhering to healthy eating practices such as the 'Quarter-Quarter-Half' guideline and consumed fewer fruits and vegetables compared to females (data not shown). These dietary behaviours are known to influence weight outcomes and may partly explain the observed sex differences. Besides, there have been varied reports on how men and women were affected by weight gain, particularly during periods of lifestyle disruption such as the COVID-19 pandemic. While men tend to have a greater likelihood of weight gain or obesity [36, 37] due to higher visceral fat [38] a recent systematic review found that both sexes experienced weight gain during the pandemic [38]. These inconsistencies suggest that multiple factors are likely to shape sex-based differences in weight gain, including behavioral, environmental, and psychosocial influences. These findings highlight the necessity for specified interventions addressing overweight and underweight conditions based on gender-specific factors, especially during public health crises such as the COVID-19 pandemic. Furthermore, these interventions should consider the multifaceted nature of these issues, including biological, environmental, and socioeconomic determinants; thereby, we can effectively mitigate the adverse health outcomes associated with malnutrition.

The present study reveals a notable trend whereby individuals below 30 years old are less likely to be overweight as compared to those aged more than 50. The result was contradicted by previous studies, which often suggested a negative correlation between age and weight gain, positing factors such as declining appetite and energy intake with increasing age [18, 24]. On the contrary, an earlier study suggested younger adults may face a heightened risk of obesity due to their susceptibility to an obesogenic environment [39] characterised by a screen-based sedentary lifestyle and energy-dense diet, which is attributed to

cohort-effect of obesity, with inconsistency in the findings have been reported [40]. As a global epidemic, obesity has particularly afflicted older adults and has seen a steady increase over the past decades [41]. The ageing process is typically marked by significant loss of muscle mass, reduced physical activity and basal metabolic rate with a preference for oxidizing carbohydrates instead of fat [42]. These age-related changes are commonly associated with increased susceptibility to obesity. However, it is important to note that the findings should be interpreted cautiously, as weight and height were self-reported by respondents, which may cause certain biases and inaccuracies in estimating weight, height as well as BMI.

Ethnicities are proven to play a role in body weight status. Our finding reveals a lower risk of overweight among Chinese, in contrast to Malays respondents. This finding was consistent with previous national population surveys [32, 43] and studies in Singapore [44, 45]. In a recent age-period-cohort analysis based on four serial population-based National Health and Morbidity Surveys of Malaysia, Chinese have less profound BMI and waist circumference increases across the life course and birth cohorts than other ethnic groups [46]. The observed differences in dietary patterns across ethnic groups might explain this trend [47, 48]. Abdullah et al. (2016) hypothesized the greater preference for healthy-based over the Western-based (high in fat, sugar, and salts) food pattern among Chinese adolescents than their Malay counterparts may likely explain healthier BMI and waist circumference trajectories among the Chinese, particularly those born more recently [47]. Besides dietary patterns, genetic predisposition may also contribute to ethnic differences. In a sample of Adult Americans in California, the multiethnic study had unequivocally reported that the Chinese have lower odds of obesity compared to Japanese, Filipino and Whites [49].

Meal frequency has been frequently reported as a dietary determinant for overweight or obese [50]. Among the three main meals, the association between breakfast frequency and overweight or obesity has been the most extensively studied. Two recent systematic reviews confirmed that skipping breakfast increased the risk of overweight or obesity among adults, respectively [51, 52]. Besides breakfast, few studies have previously reported the association between skipping dinner and overweight or obesity among adults. In a cross-sectional study in Spain, dinner skipping in women increased their risk of obesity by 76%, while there was no increased prevalence of obesity among men who skipped dinner [53]. This was supported by a more recent retrospective cohort study in Japan whereby skipping dinner predicted the incidence of weight gain and overweight or obesity in university students [54]. The British birth cohort including 1416 young adults reported dinner skipping at the age of 36 years increased the risk of overweight or obesity (waist circumference and body mass index) 17 years later [55]. Notwithstanding our findings were in contrast with the above studies whereby breakfast or dinner skipping was not associated with risk of overweight or obesity, lunch skipping among the current cohort subjects increased their risk of overweight or obesity. Studies concerning the clinical impacts of lunch skipping on overweight/obesity were relatively scarce, attributed to a relatively lower percentage of lunch skipping. Similarly, lunch skipping was much less prevalent than skipping breakfast or dinner in the present study.

Compared to studies on skipping breakfast or dinner, there has been less research on the effect of skipping lunch on the likelihood of being overweight or obese. This could be because skipping breakfast or supper is more common. However, recent research of Korean children clarifies the possible repercussions of skipping lunch [56]. They reported that children who skipped lunch were 2.5 times more likely to have central obesity and to be obese besides 1.9 times more likely to be overweight, compared to their peers who did not skip lunch. This compelling evidence underscores the need for more extensive and in-depth prospective studies to unravel the causal relationship between lunch skipping and the development of obesity. Through this, researchers could provide more valuable insights into the specific mechanism of skipping lunch and weight-related outcomes. This can gain a comprehensive understanding of the role of meal timing towards overall health. One plausible explanation is skipping lunch may involve an upregulation of appetite, resulting in an elevated overall energy intake. This hypothesis is supported by an earlier study whereby extending the interval between meals significantly increases the likelihood of consuming more calories [57]. This was supported by a recent study confirming skipping a meal, whether it be breakfast or lunch, leads to greater energy intake at subsequent meals [58].

Meal skipping has been consistently linked not only to an increased risk of overweight and obesity but also to a decline in overall diet quality [57, 58]which can have negative implications for long-term health. With diet quality refers to a diversified, balanced and healthy diet that provides energy and all essential nutrients for growth, leading to a healthy and active life, poor quality diets are often high in fats and sugars, primarily composed of discretionary calories from cakes, pastries, and sugary beverages, which are not nutrient-dense. Excessive consumption of foods high in fat and sugar can cause heightened activity in the brain's reward system and disrupt homeostatic mechanisms, which increases the risk of overweight and obesity [59]. Studies conducted on a variety of populations have consistently shown that people who skip meals have poorer food quality than those

who are non-skippers [60–64]. The analysis of data from the five waves of the US National Health and Nutrition Examination Survey (NHANES 2007–2016) further highlighted the impact of meal skipping on diet quality. On the other hand, the type of meal skipped, whether it be breakfast, lunch, or dinner, was found to influence diet quality differently [58]. Skipping lunch or dinner was associated with a reduction in fruit and vegetable intake while skipping breakfast was associated with a lower intake of whole grains and milk products. This showed the importance of taking into account the meal missed when analysing its impact on eating patterns.

Notably, a comprehensive systematic review focusing on children and adolescents revealed that eating breakfast was associated with an overall improvement in dietary quality. This positive impact included a decreased intake of sugar-sweetened beverages, saturated fats, and added sugars, indicative of healthier food choices [65]. Unfortunately, there is a paucity of information regarding the skipping of other main meals, such as lunch or dinner, among adults. While evidence among adolescents suggests lower dietary quality for those skipping lunch [64] comparable information for adult populations remains limited. Further research in this area is warranted to better understand the implications of meal skipping on adult dietary habits and health outcomes.

The adverse effects of meal omission extend beyond concerns related to body weight. A recent study revealed that adults who skipped breakfast, lunch and dinner had 40%, 12% and 16% of higher rates of cardiovascular disease mortality or all-cause mortality [66]. In contrast, Park, Shin & Lee (2023) presented nuanced results, indicating that while skipping breakfast increased the risk of elevated fasting blood glucose levels and triglycerides by 18% and 19%, women who skipped dinner exhibited a 26% lower risk of elevated fasting blood glucose levels [67]. In a systematic review involving 11 randomised controlled trials and prospective cohort studies, while breakfast omission significantly decreased body weight, it was concurrently associated with an increased level of serum low-density lipoprotein cholesterol [68]. These divergent outcomes highlight the absence of a conclusive stance on the overall impact of meal skipping on health outcomes, highlighting gaps in the existing body of literature. While it is important for more robust evidence to facilitate a clearer understanding of the intricate interplay between meal skipping and health outcomes, individuals are advised to refrain from skipping meals. Practising a balanced and regular meal pattern is advisable to promote overall well-being including an appropriate body weight.

Respondents who ate roasted foods daily were associated with overweight and obesity risk. However, it is crucial to interpret this data cautiously, considering the small percentage of respondents who reported daily consumption of roasted foods. Malaysian roasted cuisines differ from those of Caucasian cultures. Our Malaysian cuisine is a great blend of cultural variety, shaped by Malay, Chinese, and Indian cuisines. In Malaysia, popular roasted dishes like *satay* and *ayam percik* are widely enjoyed and easily accessible, forming an integral part of the country's diverse culinary landscape. However, these dishes used ingredients such as sweet soy sauce, sugars, peanut sauce and coconut milk adding layers of flavour but also increasing their calorie content. While delicious, the traditional methods of preparing these dishes tend to be rich and indulgent, which may contribute to the rising rates of overweight and obesity in the country. Similar issues have been reported with regard to the preparation of vegetable dishes in local cuisine, where stir-frying or cooking with water and coconut milk was found to offset the nutritional benefits of vegetables [69]. Coconut milk, a prominent ingredient, is extensively used in cooking as a thickening and emulsifying agent due to the presence of phospholipids, enhancing stability in various foods. While this culinary practice contributes to the unique and delicious flavours of Malaysian cuisine, it also establishes coconut milk as a primary source of culinary fat in the Malaysian diet. The COVID-19 pandemic has further shaped culinary trends in Malaysia. Movement restrictions and a shortage of workforce led to an increased demand for coconut-based products, including culinary coconut milk. The market size for culinary coconut milk surged from 67.3 to 71.9 USD million from 2021 to 2022 in Malaysia [70] underscoring the extensive use of coconut milk in Malaysian cuisine, including during the roasting of dishes like *satay* and *ayam percik*. Understanding the dual role of coconut milk as a cultural staple and a significant contributor to culinary fat in the Malaysian diet is crucial for promoting awareness about dietary choices. Efforts to balance traditional flavours with healthier cooking practices could contribute to mitigating the unintended consequences of calorie-dense ingredients, thus fostering a healthier eating culture in Malaysia. This cultural nuance emphasises the importance of understanding regional variations in dietary habits and cooking methods when interpreting health-related findings.

Our study found a low adoption of the Healthy Plate concept among Malaysians. In particular, respondents practising the Healthy Plate concept specifically during lunch and dinner, exhibited a 23% lower risk of being overweight compared to those who did not embrace this concept. Our findings align with a recent study in Malaysia, indicating that a 10-week diet intervention employing the Healthy Plate concept led to a 1.5-unit reduction in BMI and a 4.8% decrease in body weight [71]. On the other hand, our data, however, must be interpreted with caution considering the significance was applied to the adoption of healthy eating concepts for protein-rich

recommendations only. In the previous study, the correlation between protein intake and its impact on weight management exhibits inconsistencies. Despite the widespread recommendation for high protein intake to curb weight gain and aid individuals dealing with obesity, the long-term findings from observational studies and various randomized controlled diet interventions do not consistently validate the presumed beneficial effects of high protein intake on body weight or metabolic health. Contrary to conventional expectations, a high-protein diet over time has been associated with obesity and a higher risk of cardiometabolic disorders [72, 73]. This observation is particularly salient in regions where protein-rich foods in local cuisine are frequently prepared using high-fat cooking methods, such as deep frying or cooking in coconut milk. Despite the acute satiating effect and the greater thermic effect of feeding associated with protein, the evidence underscores the necessity for a nuanced approach to comprehend the intricate interplay between protein intake, dietary practices, and their lasting impact on weight and metabolic outcomes.

One of our key findings reveals that embracing the recommended amount of protein foods as outlined in the Healthy Plate concept (a quarter of the healthy plate should comprise protein-rich foods) can effectively mitigate the risk of being overweight. Intriguingly, studies conducted in Malaysia consistently indicate a prevalent trend of high protein intake among Malaysians. A systematic review and meta-analysis including 15 small-scale studies and 5 nationwide studies revealed Malaysians had an average excess of protein of approximately 2 exchanges over the mean recommended nutrient intake (RNI) for both sexes across all age groups [74]. This comparison emphasises the significance of adopting the healthy eating concept, particularly the need for consuming protein in a well-balanced and mindful approach. In light of the escalating rate of obesity in Malaysia, it becomes particularly noteworthy to encourage the practice of the healthy eating concept as a proactive measure in addressing this pressing health concern.

The Healthy Plate Concept is recognised as a practical nutrition education tool and extensively incorporated in many national dietary guidelines across the globe [75]. Despite widespread promotion in various settings, such as health clinics, schools, and grocery markets, through mass media and an online application [76] awareness of the Healthy Plate Concept remains low among Malaysians [22]. Recognising the growing evidence of its positive impact on overweight and obesity, there is a pressing need for effective strategies to promote the widespread adoption of this user-friendly concept in the community and the nation.

Strength and limitations of study

To the best of our knowledge, MyNutriLifeCOVID-19 is the first online study to investigate the associations between lifestyle behaviours and body weight changes among Malaysian adults during the COVID-19 pandemic lockdown. The use of an online survey enabled the efficient recruitment of a large sample, making it a practical and timely research tool during movement restrictions. A key strength of this study lies in its nationwide coverage, capturing responses from all five regions of Malaysia and achieving a substantial sample size of 1,182 participants, thus enhancing the generalisability of the findings. A significant strength of this study lies in its application of hierarchical multinomial regression, which identifies critical risk factors for weight status while highlighting the intricate interplay between sociodemographic, lifestyle, and behavioural variables. This methodological rigor enables a deeper understanding of how these factors interact, providing essential insights into the challenges of maintaining healthy weight during a public health crisis.

Several limitations in the present study should be taken into consideration. First, the respondents self-reported all information, including anthropometric data and lifestyle behaviours, which may be subject to recall bias. Self-reported measures are often used in extensive population health studies due to limitations in funding and resources; however, research comparing self-reported height and weight data with clinical data generally finds discrepancies between the two sets of measurements, with specific groups of people over-reporting height and/or under-reporting weight [77]. On the other hand, a Malaysian study has shown substantial agreement between self-reported and measured anthropometric data, with BMI classifications demonstrating strong concordance [13] supporting the validity of self-reported measures in this context. Nonetheless, fluctuations in body weight could not be accounted for by recent nutritional intake, menstrual cycles, or transient fluctuations since the timing of self-reported weight was not specified. The results of this investigation should, therefore, be regarded cautiously. One of the limitations of this study is the use of convenience sampling and online data collection, which may have led to underrepresentation of certain vulnerable populations, particularly older adults with limited internet access or digital literacy. While these methods were necessary during the COVID-19 pandemic due to movement restrictions and safety concerns, we recognize that this approach may have introduced sampling bias. Future studies should consider using mixed-method approaches, including offline data collection, to ensure more inclusive and representative sampling across diverse population groups. Longitudinal studies with

more robust study designs are needed to ascertain our findings.

Conclusion

The findings of the present study revealed a diverse spectrum of weight-related challenges during Malaysia's second lockdown, with the prevalence of overweight and obesity remains a significant public health concern. Furthermore, a notable proportion of the population continues to grapple with underweight issues, highlighting the double burden of malnutrition within the population. Despite the majority attempting weight management, insufficient physical activity, prevalent poor sleep quality and unhealthy dietary behaviours were found in the present study. Additionally, the hierarchical multinomial regression analysis highlighted multifaceted risk factors for both underweight and overweight/obesity, emphasizing the importance of addressing sociodemographic, lifestyle, and dietary factors in comprehensive public health strategies. As we navigate through successive phases of the pandemic, it is imperative to prioritize public health interventions that target the root causes of unhealthy behaviours. Effective combating of these challenges necessitates targeted interventions aimed at high-risk demographics and the promotion of healthier lifestyle habits through community-oriented initiatives.

AOR: Adjusted odd ratio; Ref: reference; CI: Confidence Interval; LB: Lower Boundary; UB: Upper Boundary * $p < 0.05$.

Nagelkerke Residuals: Model 0-21.7%; Model 1-0.7%; Model 2-6.6%; Model 3-10.6%; Model 4-5.5%; Model Final model-32.6%.

Final model: Intercept for Underweight: -−2.220(1.626); Overweight and obese: 1.556(0.717); Stepwise variable selection method was used. Adjusted with confounding variable (family income), classification percentage: 65.5%, AIC: 1804.183, BIC: 2224.746, −2log likelihood value: 350.660, $p < 0.001$.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-23699-9.

Supplementary Material 1.

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Authors' contributions

YMC and YSC equally conceptualised the study, prepared the manuscript, responsible for communications with other co-authors and accepts full responsibility for the work and/or the conduct of the study. MA, NBMY, PYL, RL and KRS participated in the design of the study, data collection and review of the manuscript in several stages. PYL performed the statistical analysis.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from Ethics Committee for Research Involving Human Subjects of Universiti Putra Malaysia, with reference number JKEUPM-2020-163. As the study was conducted online during the COVID-19 pandemic, informed consent was obtained electronically from all participants prior to their participation in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Faculty of Medicine and Health Sciences, Strategic Health & Advanced Prevention for Excess Weight & Obesity (PUTRA-SHAPE), Universiti Putra Malaysia, Serdang, Selangor 43400, Malaysia
[2]Research Centre of Excellence on Nutrition and Non-communicable Diseases, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, Selangor 43400, Malaysia
[3]Department of Community Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, Selangor 43400, Malaysia
[4]Faculty of Sports Science & Recreation, Universiti Teknologi MARA, Shah Alam, Selangor 40450, Malaysia
[5]Department of Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, Selangor 43400, Malaysia
[6]Nutrition Unit, Division of Product Development and Advisory Services, Malaysian Palm Oil Board, No. 6, Persiaran Institusi, Bandar Baru Bangi, Kajang, Selangor 43000, Malaysia
[7]Promoting Resilience and Innovation in Multidisciplinary Ageing Excellence (PrimAGE), Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, Selangor 43400, Malaysia

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