PHYSICAL ACTIVITY STATUS, NUTRIENT INTAKE, MENSTRUAL AND BONE STATUS IN OVERWEIGHT AND OBESE WOMEN DURING THE COVID-19 PANDEMIC LOCKDOWN 2.0 IN MALAYSIA

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By

NUR DALILA ADILAH BT ABDUL RAOF

Thesis submitted in fulfilment of the requirements for the degree of

Exercise and Sport Science

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CERTIFICATE

This is to certify that the thesis entitled “PHYSICAL ACTIVITY STATUS, NUTRIENT INTAKE, MENSTRUAL AND BONE STATUS IN OVERWEIGHT AND OBESE WOMEN DURING THE COVID-19 PANDEMIC LOCKDOWN 2.0 IN MALAYSIA” is the bona fide record of research work done by of research work done by Ms “NUR DALILA ADILAH BT ABDUL RAOF” during the period from March 2020 to June 2021 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis to be submitted in partial fulfilment for the degree of Bachelor of Health Science (Honours) (Exercise and Sports Science).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

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"Nur Dalila Adilah Bt Abdul Raof"

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STATUS AKTIVITI FIZIKAL, PENGAMBILAN NUTRISI, STATUS MENSTRUAL DAN TULANG DALAM KALANGAN WANITA YANG MEMPUNYAI LEBIHAN BERAT BADAN DAN OBESITI SEPANJANG PERINTAH KAWALAN PERGERAKAN 2.0 PANDEMIK COVID-19 DI MALAYSIA

ABSTRAK

Objektif: Kajian ini mengkaji hubungan pengambilan nutrisi (Karbohidrat, Protein, Lemak, Gula, Vitamin C, Vitamin D, Vitamin K, Kalsium, Kalium, Fosforus), status aktiviti fizikal, status menstrual dan tulang [soal selidik aktiviti fizikal tulang sebelumnya bagi tempoh 12 bulan yang lepas (pBPAQ) dan soal selidik aktiviti fizikal tulang terkini (cBPAQ)] dalam kalangan wanita yang mempunyai berat badan berlebihan dan obesiti semasa Perintah Kawalan Pergerakan (PKP) 2.0 Pandemik COVID-19. Kaedah: Tiga puluh enam peserta wanita dari Universiti Sains Malaysia yang mempunyai berat badan berlebihan (umur: 24.1 ± 5.0 tahun; berat badan: 72.7 ± 11.2 kg; BMI: 28.8 ± 3.0 kg/m^2) direkrut dalam kajian ini. Peserta diminta menjawab beberapa borang soal selidik, iaitu Soal Selidik Kegiatan Kesediaan Aktiviti Fizikal (PAR-Q), Soal Selidik Sejarah Menstruasi, Soal Selidik Aktiviti Fizikal Tulang (BPAQ) dan mengisi 24 Jam rekod diet. Parameter antropometri peserta, tinggi, berat badan, indeks jisim badan (BMI) dan jisim bebas lemak (FFM) dicatatkan. Korelasi dan regresi bertahap digunakan untuk analisis statistik.Keputusan: Semasa PKP 2.0, jumlah kalori peserta adalah 1319.64 ± 562.16 kcal/day dan kebanyakan pengambilan makanan adalah menepati pengambilan nutrien yang disyorkan (RNI) kecuali karbohidrat, gula, Vitamin C, Vitamin D, kalsium, kalium dan fosforus. Peserta dilaporkan mempunyai

gaya hidup yang tidak aktif. pBPAQ skor peserta bagi 12 bulan lepas adalah 21.8 ± 28.6 manakala cBPAQ skor adalah 23.4 ± 38.9. Status tulang peserta bagi 12 bulan yang lepas dan status tulang terkini adalah kurang baik kerana skor BPAQ mereka kurang dari 40. Rata-rata peserta boleh dikategorikan sebagai eumenorea dan sihat. Secara keseluruhan, jisim bebas lemak mempunyai hubungan yang signifikan ($p < 0.001$) dengan jumlah pengambilan kalori. Jumlah pengambilan kalori mempunyai hubungan positif dengan status tulang terkini (cBPAQ) ($p < 0.001$) dan hari menstrual ($p < 0.05$). Walaupun begitu, hari diantara menstrual peserta mempunyai hubungan negatif yang signifikan dengan berat badan (kg) ($p < 0.05$) dan jisim bebas lemak (kg) ($p < 0.05$). Kekerapan tempoh menstrual (dalam tempoh 12 bulan yang lepas) juga mempunyai kaitan positif yang signifikan dengan pengambilan kalsium ($p < 0.05$) dan pengambilan fosforus ($p < 0.05$) sementara karbohidrat mempunyai hubungan yang signifikan dengan status tulang terkini (cBPAQ) ($p < 0.001$) dan hari menstrual ($p < 0.05$). Pengambilan protein dan kalsium mempunyai kaitan positif dengan kekerapan tempoh menstrual (dalam tempoh 12 bulan yang lepas ($p < 0.05$). Sementara itu, lemak mempunyai kaitan dengan status tulang terkini (cBPAQ) ($p < 0.05$) dan hari menstrual ($p < 0.05$). Tidak terdapat kaitan yang signifikan dalam mineral lain seperti gula dan mineral lain seperti Vitamin C, Vitamin D, Vitamin K dan kalium untuk semua parameter. Di samping itu, status tulang peserta bagi 12 bulan yang lepas (pBPAQ) menunjukkan hubungan yang signifikan dengan status tulang terkini (cBPAQ). Kesimpulan: Secara amnya, pengambilan nutrisi dan aktiviti fizikal kurang dari rekomendasi semasa PKP 2.0. Jumlah kalori peserta juga kurang dari rekomendasi serta masa yang dihabiskan untuk tingkah laku tidak aktif semakin meningkat. Kitaran menstrual yang normal didapati bergantung kepada jumlah pengambilan kalori, makronutrien (karbohidrat, lemak dan protein) dan juga mineral seperti kalsium dan fosforus. Di samping itu, penting untuk mengekalkan berat badan yang ideal (berat badan

normal dan jisim bebas lemak yang tinggi) kerana pengaruhnya terhadap kitaran menstrual dan pengambilan makronutrisi kerana mempengaruhi status tulang. Aktiviti fizikal yang berkaitan dengan latihan berimpak tinggi juga bermanfaat untuk mempengaruhi status tulang dalam kehidupan seterusnya.

PHYSICAL ACTIVITY STATUS, NUTRIENT INTAKE, MENSTRUAL AND BONE STATUS IN OVERWEIGHT AND OBESE WOMEN DURING THE COVID-19 PANDEMIC LOCKDOWN 2.0 IN MALAYSIA

ABSTRACT

Objective: This study investigated the relationship between physical activity status, nutrients intake (Carbohydrate, Protein, Fats, Sugar, Vitamin C, Vitamin D, Vitamin K, Calcium, Potassium, Phosphorus), menstrual and bone status [previous bone physical activity questionnaires in the past 12 months (pBPAQ) and current bone physical activity questionnaires (cBPAQ)] in overweight and obese women during the COVID-19 Pandemic Lockdown 2.0. Methods: Thirty-six female participants from Universiti Sains Malaysia who are overweight and obese women (age: 24.1 ± 5.0 years old; weight: 72.7 ± 11.2 kg; BMI: 28.8 ± 3.0 kg/m^2) were recruited in this study. Participants were required to answer several questionnaires, i.e. Physical Activity Readiness Questionnaire (PAR-Q), Menstrual History Questionnaire, Bone Physical Activity Questionnaire (BPAQ) and 24-Hours Diet Recall. Participant's anthropometry parameters, body height, body weight, body mass index (BMI) and fat free mass (FFM) were recorded. Correlation and stepwise regression were used for statistical analysis. Results: During lockdown 2.0, the total calories intakes of the participants was 1319.64 ± 562.16 kcal/day and most of the dietary intake met the recommended nutrient intake (RNI) except for carbohydrate, sugar, Vitamin C, Vitamin D, calcium, potassium and phosphorus. Participants were reported to have sedentary lifestyle. Past BPAQ score of the participants is 21.8 ± 28.6 while current BPAQ score is 23.4 ± 38.9. Both past and current bone status of the participants are considered as poor as their BPAQ scores were less than

40. On average, participants were categorised as eumenorrhea and healthy. Overall, fat free mass had a significant relationship ($p < 0.001$) with total calories intakes. The total calories intakes had a positive correlation with current bone status cBPAQ ($p<0.001$) and menses days ($p<0.05$). Nevertheless, participants' days between menses had a significant negative association with body weight (kg) ($p<0.05$) and fat free mass (kg) ($p<0.05$). Frequency of menses (in the past 12 months) also had a significant positive association with calcium ($p<0.05$) and phosphorus intakes ($p<0.05$) respectively, while carbohydrate had a significant correlation with current bone status (cBPAQ) ($p<0.001$) and menses days ($p<0.05$). Protein and calcium intakes had a positive association with frequency of menses (in the past 12 months) ($p<0.05$). Meanwhile, fats had a correlation with current bone status (cBPAQ) ($p<0.05$) and menses days ($p<0.05$) respectively. No significant association found in sugar and other minerals like Vitamin C, Vitamin D, Vitamin K and potassium for all parameters. In addition, bone status in the past 12 months (pBPAQ) showed a significant relationship with current bone status (cBPAQ). Conclusion: Generally, nutrient intake and physical activity was lower than recommended during this pandemic during lockdown 2.0. Total calorie of the participants also lower than recommended, and the time spent on sedentary behaviours was increased. Normal menstrual cycle was found to be depending on total calories intake, macronutrients (carbohydrate, fat and protein) and also minerals such as calcium and phosphorus. In addition, it is important to maintain ideal body weight (normal body weight and high of fat free mass) as it influences menstrual cycle, and macronutrients intakes as it influences bone status. Physical activity that related with high impact exercises also could be beneficial to affect bone status in later life.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

A continuous occurrence of an unknown acute respiratory tract infection was reported in Wuhan City, Hubei Province, China, since 12th of December 2019, originating from the Hunan South China Seafood Market. On the 7th of January 2020, Chinese scientists isolated the unknown viral sample from an infected person and sequenced its genome using the next gene sequencing tool. They reported that the virus had 96.3% genetic similarity with a Yunnan bat coronavirus RaTG13 and 70% homology with severe acute respiratory syndrome coronavirus (SARS-CoV). On the 12th of January 2020, the World Health Organization (WHO) announced the cause of this epidemic outbreak was a novel coronavirus discovered in 2019 (2019-nCoV) or SARS-CoV-2 and named the disease as coronavirus disease 2019 (COVID-19). However, the answer to the origin of SARS-CoV-2 remains to be determined (Elengoe, 2020).

The SARS-CoV-2 spread rapidly to other countries including South Korea, Taiwan, Thailand, Singapore, Japan, Italy, Iran, Spain, USA, UK and was classified by the WHO as a pandemic on 12th of March 2020. As of the 17th of April 2020, there are a total of 2,230,439 cases of COVID-19; 150,810 cases of deaths and 564,210 recovered cases have been reported throughout the world (Elengoe, 2020).

On the 25th of January 2020, the first case of COVID-19 was detected in Malaysia and traced back to 3 Chinese nationals who previously had close contact with an infected person in Singapore. The number of positive cases increased beyond 553 cases on the 16th of March 2020, hence the Prime Minister of Malaysia announced a Movement Control Order (MCO). Social distancing was implemented for 14 days (18th to 31st of March 2020) to reduce the rapid spread of COVID-19 (Elengoe, 2020).

In a special announcement on 11 Jan 2021, Prime Minister Tan Sri Muhyiddin Yassin began by stressing how bad the COVID-19 third wave is affecting Malaysia, with daily 4-digit cases being recorded since end November, even reaching a new high of 3,027 cases just a few days ago. He says that hospitals across Malaysia and the nation's healthcare system is under tremendous pressure, and unprecedented measures will have to be taken to prevent the situation from getting worse (Eunis, 2021).

With that being said, he announced that the Movement Control Order 2.0 similar to the one we all faced in March 2020 will be implemented for 14 days from 13th to 26th of January 2021 in 6 states across Malaysia which are Penang, Selangor, Wilayah Persekutuan (KL, Labuan & Putrajaya), Melaka, Johor, and Sabah. Meanwhile, 5 states which are Pahang, Perak, Negeri Sembilan, Kedah, Terengganu and Kelantan will be placed under Conditional MCO, while Perlis and Sarawak will be under the Recovery MCO (Eunis, 2021).

The coronavirus (COVID-19) outbreak has led to unprecedented hazards to lifestyle, mental health and threatened the overall well-being of the population (Xiong *et al*., 2020). Along with uncertainties and even fear associated with the virus outbreak, citizens

have to cope with the distressing experience of the loss of freedom and separation from family members and friends due to lockdowns (Brooks *et al*., 2020).

Apart from the impact on mental health, the COVID-19 pandemic has led to a global economic crisis due to lockdowns and yielded negative economic growth, with massive public health and social safety costs (Rahman *et al*., 2020). The disruption caused by the COVID-19 pandemic has also resulted in food insecurity among many people (Zurayk, 2020). Food insecurity is a disruption in food intake or eating patterns with limited access to sufficient, nutritious food due to a money problem and other resources (Hendriks, 2015). Numerous surveys have documented the unprecedented levels of food insecurity since the start of the pandemic (Coleman-Jensen *et al*., 2014). Food insecurity is a stressful experience and has been associated with numerous detrimental physical and mental health outcomes, and it thus becomes a major concern (Gundersen *et al*., 2015). In addition, those impacted by poverty or food insecurity are likely to experience additional resource-related hardships that in turn, contribute to poor nutrition, health, and disease management (Liu *et al*., 2014).

Nutrition, physical activity, and socialization are important contributors to the enhancement of physical and mental resilience, especially among women. However, the COVID-19 pandemic has disturbed all these factors due to physical distancing and social activities restriction, leading to physical frailty, sarcopenia, and malnutrition (Nakayama, 2020). Social isolation can expose women to increase nutritional risk due to factors such as socioeconomic insecurity, which could affect food acquisition and the needs for support in daily tasks and meal preparations (Ceolin *et al*., 2020).

Obesity and lack of fitness are emerging as risk factors for developing more severe symptoms and complications if one were to become infected with COVID-19 (Carter *et al*., 2020). For example, hospitalized obese COVID-19 patients under 60 years of age were two times more likely to be admitted to acute and critical care than similar patients who were not obese (Lighter *et al*., 2020). Dietz and colleagues (2020) also speculate that because obesity increased mortality risk with other respiratory illnesses (e.g., H1N1) it may similarly increase mortality risk during the COVID-19 pandemic. Despite the obstacles created by the pandemic, attempt to maintain recommended physical activity behaviour put forth by the World Health Organization of 150 min/week of moderate-intensity physical activity or 75 min/week of vigorous-intensity physical activity (Foster *et al*., 2018). Recommendations to meet these thresholds include home-exercises such as cycling on the ergometer, running on the treadmill, or exercise on the rowing machine, walking/jogging in the house or outside if the exerciser can maintain a distance of ≥1m from other individuals, playing physically active video games, and using video- or app-guided equipment-free aerobics or strength training (Carter *et al*., 2020). However, some individuals may have obstacles (e.g., lack of equipment, space) to exercise at home. Furthermore, prior research has indicated that adherence to home-based exercise programs may be poor (Jack *et al*., 2010).

Obesity was strongly associated with an energy imbalance, characterized by increased food intake and decreased energy expenditure. Therefore, the dietary patterns play critical roles in obesity development and its associated comorbidities (Lee *et al*., 2006). Traditionally, obesity has been considered a disease of "overnutrition" because it often resulted an excessive caloric intake. Most an obese individual ate diets that consist of a high amount of products riches in saturated fat, sugars, and sodium, and poorer in fibre. Moreover,

the consumption of green vegetables and fruits has decreased by 20% (Monteiro *et al*., 2011) which were energy-dense and micronutrient-poor. During the past few years, evidence has been shown that obesity also can be associated with micronutrient deficiencies, considering the Dietary Reference Intakes (DRI) for daily supply of vitamins and minerals (Monteiro *et al*., 2011). Recent studies point to an insufficient dietary micronutrient intake of vitamins A, C and D, folate, iron, zinc, and calcium in obese individuals (Monteiro *et al*., 2011). Deficiencies of essentials micronutrients influence day-to-day performance, behaviour, and emotional state, as well as intellectual and physical activity (Kaidar-Person *et al*., 2008). This deficiency could lead to further weight gain or development of obesity-associated comorbidities (Kaidar-Person *et al*., 2008).

The prevalence of obesity was increasing rapidly worldwide. According to the World Health Organization, nearly two billion people were overweight, of which 600 million were obese. In Malaysia, The NHMS reported the prevalence of overweight among adult was 30.0% while obesity prevalence was 17.7%. The prevalence of obesity in Malaysia were 11.4% in males and 16.7% in females (Chan *et al*., 2017).

Other than that, several studies had shown that obese women were more likely to experience menstrual cycle irregularity than non-obese women (Castillo-Martinez *et al*., 2003). Most women had a menstrual every 28 days or so, but it is common to have a slightly shorter or longer cycle than this (from 21 to 40 days). Some women did not always had a regular menstrual cycle. Their menstrual might be earlier or later from the exact count, and how long it lasts and how heavy it was may vary each time. Similarly, being overweight also might produce an excessed amount of estrogen, one of the hormones that regulated the

reproductive system in women. Excess estrogen could affect how often menstrual and could also cause menstrual to stop (NHS, 2020).

It was once thought that carrying some extra weight helped build stronger bones (Tarkan, 2017). The theory suggested that those bones get stronger when the body bear with weighted training. For example, when individuals involved in weight bearing exercises, strength training or jumping exercise. But more recently, studies had revealed that being obese could actually lead to an increased risk of low bone density and fractures (Tarkan, 2017*)*.

1.2 PROBLEM STATEMENTS

Investigators have disseminated information outlining the potential negative impacts the pandemic may have upon health behaviors (Carter *et al*., 2020). These preliminary studies indicate that stay-at-home orders (strict to lenient) have the potential to limit physical activity and promote sedentary behaviour. While the benefits of physical activity and problems associated with excessive sedentary behaviour are well documented, remaining active during the COVID-19 pandemic may be particularly important (Warburton *et al*., 2006).

Overweight and obese people tend to have improper nutrition intake such as consume an excess amount of energy; and their diet is deficient in elements necessary for proper normal growth, development, and ageing, helps to maintain a healthy body weight, and reduces the risk of chronic disease leading to overall health and well-being. Besides, snacking highly processed and calorie-rich foods between meals eating in front of the TV screen, skipping breakfasts, drinking sugar-sweetened beverages, "eating out" frequently and "emotional eating". Those of the bad eating behaviors are crucial factors for the development of obesity (Kuźbicka and Rachoń., 2013). In addition, obese women often had abnormal menstrual cycles (Kim., 2009). Obesity could cause irregular periods that were unpredictable, catching women unprepared at inopportune times. It might affect fertility and difficulty to get pregnant. This study concerned on how nutrient intake, menstrual status and physical activity affect bone health. With the increase in obesity and osteoporosis statistic worldwide, an important discussion had developed and focused on the probability of having poor bone density later in life. Both fat and bone cells originate from the same bone marrow stem cells (Rosen *et al*., 2009) and physical inactivity and aging induces both obesity and osteoporosis

(Kim *et al*., 2009). It was well documented that physical activity began to decline in adolescence with concomitant increased in weight. Whether these trends continue in the transitional period from adolescence to adulthood, a time critical for the development of obesity, was not clear (Parsons *et al*., 2006). The relationship between physical inactivity in adolescence and obesity in adulthood has been weak or non-existent in the few published longitudinal studies.

1.3 OBJECTIVES

1.3.1 General objective:

The main objective of this study was to assess correlation between physical activity status, nutrients intake, menstrual, and bone status among overweight and obese women during the COVID-19 Pandemic Lockdown 2.0 in Malaysia.

1.3.2 Specific objectives:

1. To assess nutrients intake (Carbohydrate, Protein, Fats, Sugar, Vitamin C, Vitamin D, Vitamin K, Calcium, Potassium, and Phosphorus), menstrual status, bone status and physical activity status in overweight and obese women during the COVID-19 Pandemic Lockdown 2.0 in Malaysia.

2. To evaluate the correlation between nutrients intake (Carbohydrate, Protein, Fats, Sugar, Vitamin C, Vitamin D, Vitamin K, Calcium, Potassium, and Phosphorus), menstrual status, bone status and physical activity status in overweight and obese women during the COVID-19 Pandemic Lockdown 2.0 in Malaysia.

3. To identify the best factor to predict physical activity level, nutrient intake, menstrual and bone status.

1.4 HYPOTHESES OF THE STUDY

H_O: There are no correlation between nutrients intake (Carbohydrate, Protein, Fats, Sugar, Vitamin C, Vitamin D, Vitamin K, Calcium, Potassium, and Phosphorus), menstrual status, bone status and physical activity status in overweight and obese women during the COVID-19 Pandemic Lockdown 2.0 in Malaysia.

H_A: There are correlation between nutrients intake (Carbohydrate, Protein, Fats, Sugar, Vitamin C, Vitamin D, Vitamin K, Calcium, Potassium, and Phosphorus), menstrual status, bone status and physical activity status in overweight and obese women during the COVID-19 Pandemic Lockdown 2.0 in Malaysia.

1.5 SIGNIFICANCE OF THE STUDY

An international research on the effects of the COVID-19 outbreak on lifestyle behaviours, (Ammar *et al*., 2020) highlighted that food consumption and meal patterns (type of food, eating out of control, snacks between meals, and number of main meals) were unhealthier during this pandemic. The findings of this present study could educate the participants to improve their dietary habits include consuming balanced diet with appropriate portion sizes to meet their energy requirement. This awareness could reduce the mortality rate, improve quality of life and create positive environment in nation. Other than that, Overweight and obese individuals were not protected against osteoporosis and fracture. Most important, obesity had been associated with compromised bone quality, which can lead to bone structural damaging and increased fracture risk. Low bone mineral density (BMD) is a major risk factor for osteoporosis and its related fractures. The findings of this study will acknowledge and redound to the population of overweight and obese considering that physical activity, nutrition intake, menstrual status might affect bone strength status. Thus, these outcomes would acknowledge overweight and obese participants to change their physical activity status and eating pattern with healthy dietary intake.

CHAPTER 2

LITERATURE REVIEW

2.1 COVID-19 affecting social activity and food intake among society.

The coronavirus disease 2019 (COVID-19) pandemic caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) raised several questions about public health, economic, and political crisis (Cotula, 2021). After the initial outbreak, which occurred in December 2019 in Wuhan, China, the virus rapidly spread across China and reached Europe and both Americas (Holshue, 2020) and finally across the world. The first recorded case in Latin America was in São Paulo, Brazil, on February 26, 2020 (Rodriguez-Morales, 2020) In the following month (March, 2020), several measures to control and contain the virus spread were taken by government institutions and health authorities in Brazil (Aquino, 2020).

In the second half of March, schools and parks were closed and, commercial activities and non-essential services were suspended (Aquino, 2020). All these measures were taken in order to implement physical distancing among people to contain the spread of SARS-CoV-2, which has been considered a fundamental method to contain the virus spread (Woods *et al*., 2020) As a consequence, these measurements of social distancing also may negatively impact the daily physical activity of the population (Ammar *et al*., 2020).

Physical inactivity has been considered a global pandemic since 2012 (Kohl *et al*., 2012) and it was estimated that 28% of the world population (1.4 billion people) remain physically inactive (Guthold *et al*., 2018). This scenario is extremely worrying because physical inactivity is one of the leading causes of cardiovascular diseases, diabetes, obesity, and premature mortality in the world (Guthold *et al*., 2018). Therefore, if the population's physical activity levels further decrease during this physical distancing period, it will be an even greater challenge for public health agencies, as this condition may further complicate the pandemic scenario since the presence of diabetes, obesity, hypertension, and other comorbidities associated with physical inactivity can worsen the COVID-19 prognosis (Siordia, 2020).

Encouraging or mandating that people should remain within their homes with discontinued daily life activities may unintentionally increase sedentary behaviour, decrease general PA, and inflict negative health consequences. Decreased PA will lower mechanical load, metabolic rate, and energy expenditure, which may result in a decline in physical fitness and an energy surplus. All are well-known risk-factors for future disease manifestations, imposing further economic burden on tomorrow's society (Owen *et al*., 2010).

The effects of COVID-19 on patients with obesity is yet to be well-described, however, several reports identified obesity as a risk factor for hospitalization (Dietz and Santos-Burgoa, 2020). This new condition may compromise maintaining a healthy and varied diet, as well as a regular physical activity. For example, limited access to daily grocery shopping may lead to reduce the consumption of fresh foods, especially fruit, vegetables and

fish, in favour of highly processed ones, such as convenience foods, junk foods, snacks, and ready-to-eat cereals, which tend to be high in fats, sugars, and salt.

Eating habits and lifestyle modification may threaten our health. Maintaining a correct nutrition status is crucial, especially in a period when the immune system might need to fight back. In fact, subjects with severe obesity (BMI $\geq$ 40 kg/m^2) are one of the groups with the higher risk for COVID-19 complications (Panahi and Tremblay, 2018). Obesity is an expansion of the adipose tissue, which produces cytokines and contributes to a proinflammatory milieu (Hauner, 2005).

It was expected that during the quarantine, there would have been a reduction of the consumption of fresh food, accompanied by vitamins and minerals deficiency, including vitamin C and vitamin E and beta-carotene with antioxidants and anti-inflammatory properties. The deficiency of these micronutrients is associated with both obesity and impaired immune responses, thus making more susceptible to viral infections (Garcia *et al*., 2009).

2.2 Macronutrient Intake

2.2.1 Carbohydrate intake and overweight/obesity

Carbohydrates are an important source of energy in human diets comprising some 40 – 80% of total energy intake. Carbohydrates are one of the three main building blocks, also known as macronutrients, that make up all food. It could be further split into three groups: Sugar, Starch and Dietary fibre. Sugars are simple short-chain compounds (monosaccharides and

disaccharides) found in fruit like apples and the ubiquitously demonized white sugar. They taste sweet and tend to be highly palatable. Starch is a longer chain of sugar compounds (polysaccharides). This type includes things such as bread, pasta, grains, and potatoes and dietary fibre is the odd one out. It is also a polysaccharide, but the gut cannot digest it.

Carbohydrates are among the macronutrients that provide energy and can thus contribute to excess energy intake and subsequent weight gain but there was still no clear evidence that altering the proportion of total carbohydrate in the diet had an important determinant of energy intake (Van Dam and Seidell, 2007). However, there was an evidence that sugar-sweetened beverages did not induce satiety to the same extent as solid forms of carbohydrate, and that increases in sugar-sweetened soft drink consumption were associated with weight gain. Findings from studied on the effect of the dietary glycemic index on body weight has not been consistent. Dietary fibre was associated with fewer weight gain in observational studies. In trials with strictly controlled energy intakes, macronutrient composition of the diet did not substantially affect body weight or fat mass (Golay *et al*., 1996).

In the study by Baron *et al*. (1986), no difference in weight loss between the high- and the low-carbohydrate diets was observed. The authors reported that weight loss differed much more by weight loss club than by macronutrient composition of the diet. Lean *et al*. (1997) compared two diets with a 23-energy percent difference in targets for the carbohydrate content of the diet. No difference in weight loss between the high- and low-carbohydrate diet was observed after 6 months among obesity population. One of the studies conducted by Jebb stated that a higher proportion of carbohydrates in unrestricted diets did not increase obesity

levels (Jebb, 1997). Some studies shown that the quality of carbohydrates, rather than quantity, determines whether a person gained weight and becomes obese. Food with high glycaemic index such as white bread, pasta, chips, processed foods, cakes and cookies causes a sudden increased in blood sugar. This increased blood sugar, if not utilized by the body, builds up as fat. Similarly, processed carbohydrates or high calories sugars predispose to the development of diabetes and cardiac diseases, besides causing obesity (Foster *et al*., 2003).

In the population nutrient intake goals recommended by (WHO, 2003) for the prevention of diet-related chronic diseases, intake of total carbohydrate has been suggested to be from 55% to 75% of total energy. The FAO/WHO (1980) highlighted that the minimal amount of carbohydrate in the human diet that needed to avoid ketosis was 50 g/day in adults. The government's healthy eating advice, illustrated by the Eatwell Guide, recommended that just over a third of human diet should be made up of starchy foods, such as potatoes, bread, rice and pasta, and over another third should be fruit and vegetables. This means that over half of our daily calorie intake should come from starchy foods, fruit, and vegetables (Public Health England, 2016).

2.2.2 Sugar intake and overweight/obesity

Sugars have been classified into intrinsic and extrinsic sugars (Department of Health, 1991). Extrinsic sugars are defined as those that are not present within the cellular structure of food when consumed, which were divided into milk sugars and nonmilk extrinsic sugars (NMES). NMES refers to all mono- and disaccharides added to foods by manufacturing, cooking, and consumers, in addition to sugars that were naturally present in honey, syrup, and unsweetened fruit juice. Under these specifications, lactose is excluded, since it was naturally present in milk and milk products (Farajian *et al*., 2016). Studies have shown that diets high in NMES could result in poor diet quality, such as high energy density (Kant, 2000). Noteworthily, the term "NMES" is broadly synonymous with free sugars, and these terms have been adopted in research worldwide (Kelly *et al*., 2005). In 2015, the WHO recommended that the daily consumption of free sugars should not exceed 10% of total energy intake (TEI) (Department of Health, 1991).

Recent studies have shown that soft drinks, confectioneries, biscuits, and cakes were the main sources of free sugars in Europe in all age group (Azaïs-Braesco *et al*., 2017). Free sugars intake has been proposed as one of the dietary contributors to obesity development in children, especially in the form of sugar-sweetened beverages (SSB) (Vartanian *et al*., 2007). Malaysians' consumption of sugary drinks has increased dramatically over the past 15 years, in tandem with rising incomes. More than one third (36%) of students had sugary drinks at least once a day, and the average daily sugar intake for adolescents has increased from seven teaspoons in 2012 to 10 teaspoons in 2017 which that is more than the recommended limit for adults. On average, Malaysians consumed

around 3kg of sugar per year in the form of sugary drinks. (Marianne, 2019). Excessive unhealthy food and sugars-sweetened soft drink consumption has been linked to weight gain, as it provides a major and unnecessary source of calories with little or no nutritional value. 4 studies have examined the relation between the intake of sugar-sweetened beverages and weight gain in adults.

A recent study by Schulze *et al*. (2004) evaluated the effect of the intake of sugar-sweetened beverages on weight gain and the incidence of type 2 diabetes in a large cohort of young and middle-aged women during 2 consecutive follow-up periods of 4 years. Kvaavik *et al*. (2005) assessed the association between long-term consumption of soft drinks and body weight. After an 8-y follow-up, the authors found slightly higher odds of overweight and obesity in long-term high consumers of soda than in long-term low consumers of soda (both groups made up of both men and women). Most of the cross-sectional studies, especially the large ones, found a positive association between the consumption of sugar-sweetened beverages and body weight. Three prospective studies that included repeated measures of both soft drinks and weight found that an increase in the consumption of sugary soft drinks was significantly associated with greater weight gain and greater risk of obesity over time in both children (Kvaavik *et al*., 2005) and adults (Schulze *et al*., 2004). Furthermore, the Scientific Advisory Committee on Nutrition (SACN) reviewed randomised control trials, which indicated that consumption of sugars-sweetened beverages, as compared with non-calorically sweetened beverages, results in weight gain and an increase in BMI in children and adolescents. Prospective cohort studies also generally confirmed the link between sugars-sweetened beverages and increased obesity (Luger *et al*., 2017).

Among higher quality studies, results have shown that there was no evidence to associate sugars, such as fructose, with obesity or diabetes. Additionally, the researchers noted that it is much more likely that excessive intake of calories, and not specifically sugar, was to blame for poor health outcomes such as obesity. They also stated that, "if there were any adverse effects of sugar, they were due to entirely to the calories it provides, and therefore indistinguishable from any other caloric food."

Other studies have found an inverse relation between dietary sugars intake from milk and fruits and overweight and obesity in children and adolescents, especially in females (Ha *et al*., 2016). In the same vein, it was observed that free sugars from liquid sources resulted in higher body mass index (BMI), while solid foods sources alone did not have any adverse impact on obesity parameters in adults (Ahmad *et al*., 2019). In Korean studied (Ha *et al*., 2016) children and adolescents, only total sugars intake from milk and fruits was inversely associated with overweight and obesity among females. However, in (Sondos *et al*., 2020) studied, total free sugar residuals were used as a confounding variable, and no significant associations were found between free sugar from different food sources and BMI. Different foods have different content of free sugars, and for this reason, they may have a different impact on obesity development. Moreover, in (Sondos *et al*., 2020) studied, female consumers of "fruit and vegetables juices" had higher tendency toward obesity. Recent meta-analyses have reported that high intake from sugar-sweetened beverages (SSB) was positively associated with weight gain and obesity development (Morenga *et al*., 2012). The main explanation of this result was that SSB may lead to weight gain due to their high added sugar content (on average, it contains about 140–150 calories and 35.0–37.5 g of sugar per 12 oz serving) and low satiety effect. Also, after intake of liquid calories, incomplete

reduction in energy intake was compensated during subsequent meals (Malik *et al*., 2006). In addition, studies have shown that fructose from any source promotes visceral adiposity development and ectopic fat deposition (Teff *et al*., 2009).

2.2.3 Protein intake and overweight/obesity

Protein is the major component of body tissues. It is the essential nutrient for growth. The body is in a dynamic state, with protein and other nitrogenous compounds being degraded and resynthesized continuously. More protein is turned over daily in the body than is ordinarily consumed in the diet. Proteins are large molecules made up of amino acids bonded together by peptide linkages. They provide the essential amino acids, which are the initial materials for tissue synthesis and constituent of tissue protein. Thus, it was often referred to as the "currency" of protein nutrition and metabolism (Young, 2001). The maintenance of body tissue was essential because the body is constantly undergoing wear and tear, and proteins and amino acids provide continuous repairs. Some of the important physiological functions of proteins were summarised below.

Proteins are important for the formation of regulatory compounds. Some hormones, all enzymes, and most other regulatory materials in the body are proteins substances. Proteins defend the body against disease. When the body detects invading antigens, it manufactures antibodies, giant protein molecules designed specifically to combat them. The antibodies worked so swiftly and efficiently that in normal, healthy individual, most diseases never have a chance to get started (Young, 2001). The body's fluids are contained within the cells (intracellular) and outside the cells (extracellular). Extracellular

fluids are found either in the spaces between cells (interstitial) or within blood vessels (intravascular). Wherever proteins are, they attract water, and this helps to maintain the fluid balance in their various compartments. In addition, proteins help maintain the balance between acids and bases within the body fluids by accepting and releasing hydrogen ions. Even though proteins are needed for growth, maintenance, and repair, they will be used to provide glucose when the need arises. Nutritional experts do not advocate consumption to exceed the recommended daily amount (Young, 2001).

The RNI for protein for adults were based on the 1985 FAO/WHO/UNU recommendations of 1.00 g protein/kg body weight/day after adjusting for 80% protein quality (FAO/WHO/UNU, 1985). The reference body weights for Malaysian adult men and women are 62 kg and 55 kg respectively. Consuming high amounts of any nutrient for a long period of time typically comes with risks, as could be the case with protein. Overconsumption may lead to an increased risk of certain health complications, according to research (Wu *et a*l., 2000). One large study published in 2015 in the Clinical Nutrition Journal found that people whose diets were made up of more than 20 percent protein especially animal protein were significantly more likely to gain more than 10 percent of their body weight compared to people whose diets had less than 15 percent protein (Hernández-Alonso *et al*., 2016). A 2016 study found that weight gain was significantly associated with diets where protein replaced carbohydrates, but not when it replaced fat.

There were some research revealed potential benefits to a high-protein diet for otherwise healthy people. However, it was important to understand the health concerns related to excess protein in the body, especially if they followed an excessively high-protein

diet for an extended period (Keller, 2011). High-protein diets may tout weight loss, but this type of weight loss might only be short-term. Excess protein consumed is usually stored as fat, while the surplus of amino acids is excreted. This could lead to weight gain over time, especially if they consumed too many calories while trying to increase their protein intake.

Protein was also essential for weight loss, especially in the obese, as it helps to stabilize blood sugar, curb hunger and potentially increase the number of calories burned through digestion. Protein also supported exercise efforts and kept from losing too much muscle mass as a person created a calorie deficit to lose weight (Paddon-Jones *et al*., 2008).

A 2008 paper in an issue of the American Journal of Clinical Nutrition reported that a higher protein intake might help people reduce overall food consumption, even when they were not on a diet (Douglas *et al*., 2008). A 2007 study published in Obesity showed that obese women who were restricting their calories reported greater pleasure from food and higher feelings of satiation when their diet consisted of 30 percent protein (Leidy *et al*., 2007). A 2016 edition of Clinical Nutrition published a study suggesting that about 0.55 grams of protein per pound of body weight daily helped obese people trying to lose weight, when combined with a low-calorie diet and resistance training (Weijs and Wolfe, 2016). Plenty of other research suggested that to go higher in protein to lose, not gain. (Ganesan *et al*., 2018).

In contrast, one of the largest prospective studies conducted so far with a total of 89,432 subjects from the EPIC cohort and a mean follow-up of 6.5 years failed to find any association between high intake of energy as protein and weight loss. However, it did report

a positive relationship between consumption of animal protein and weight gain (Halkjær *et al*., 2011). Similarly, a higher intake of total protein or animal protein was associated with a greater risk of overweight and obesity in men after 7-years of follow-up (Bujnowski *et al*., 2011).

Some research suggests that a diet high in protein could help women who are overweight and obese lose fat while retaining lean muscle mass (Josse *et al*., 2011). Diets that were high in protein help to decrease hunger, increase satiety, boost metabolic rate, and preserve muscle mass. In general, a high-protein diet recommends getting more than 20% of our total calories from protein. That typically means eating fewer calories from carbohydrates or fats to keep our calories in balance.

2.2.4 Fats intake and overweight/obesity

Dietary fats perform important functions in our body. They provide the essential fatty acids [linoleic acid (LA) and alpha (α)-linolenic acid (ALA)] which are required for the synthesis of "local hormones" called eicosanoids which regulate metabolism. Fats provide the fatty acids (FA) which form structural components of biological membranes. This macronutrient allowed "piggy-rides" for the fat-soluble vitamins (A, D, E and K) during absorption and distribution to body tissues. In addition, fats impart taste and texture to foods (Hayes, 2002).

Fat was the major determinant of the energy density of diets, providing a high 9.0 kcal/g compared with the much lower 4.0 kcal/g for carbohydrate and protein. As such, people who consumed high-fat diets (>35% energy) coupled with a sedentary lifestyle, would

likely put on weight as they took in more calories than what they actually needed (FAO/WHO, 1994).

There were four major dietary fats in the foods we eat: Saturated fats, *Trans* fats, Monounsaturated fats, and Polyunsaturated fats. The four types have different chemical structures and physical properties. The bad fats, saturated and *trans* fats, tend to be more solid at room temperature (like a stick of butter), while monounsaturated and polyunsaturated fats tend to be more liquid (like liquid vegetable oil). Fats can also have different effects on the cholesterol levels in your body. The bad fats, saturated fats and *trans* fats raise bad cholesterol (LDL) levels in your blood. Monounsaturated fats and polyunsaturated fats can lower bad cholesterol levels and are beneficial when consumed as part of a healthy dietary pattern.

According to the National Health and Morbidity Survey of 2015 (NHMS, 2015), obese Malaysians make up 17.7% of the population while those categorized as overweight make up 30%. A study found that there are many factors that influence obesity for example environment factors, culture, exercise and food intake (Kopelman, 2000). Despite the overwhelming tendency to associate obesity with higher fat intake, conclusive association between obesity and fat intake in the Malaysian population is not evident. In fact, the mean fat intake of the Malaysian population is reported to be <30% total energy intake (TEI) (Mirnalini *et al*., 2008).