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DETERMINATION OF VITAMIN D DEFICIENCY PREVALENCE AND ITS RISK FACTORS AMONG MALAYSIAN ADOLESCENTS AGED 13 YEARS OLD

MUHAMAD NASRULLAH BIN NAZAHARUDIN

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BY

MUHAMAD NASRULLAH BIN NAZAHARUDIN

A project submitted as a partial fulfilment of the requirement for the degree of Bachelor of Science (Nutrition and Community Health) from the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia

SUPERVISOR SIGNATURE

This project entitled **— DETERMINATION OF VITAMIN D DEFICIENCY PREVALENCE AND ITS RISK FACTORS AMONG MALAYSIAN ADOLESCENTS AGED 13 YEARS OLD** was prepared by Muhamad Nasrullah Bin Nazaharudin and submitted to the Faculty of Medicine and Health Sciences as a partial fulfilment of the requirement for the degree of Bachelor of Science (Nutrition and Community Health) from the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia.

Received and examined by:

(ASSOC. PROF. DR. GEETA APPANNAH)

Senior lecturer

Department of Nutrition

Faculty of Medicine and Health Sciences

Universiti Putra Malaysia

(Supervisor)

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LIST OF ABBREVIATIONS

MyHeart	Malaysian Health and Adolescents Longitudinal Research Study
BMI	Body Mass Index
FFQ	Food Frequency Questionnaire
PAQ-C	Physical Activity Questionnaire for Older Children
PTH	Parathyroid hormone

ABSTRACT

DETERMINATION OF VITAMIN D DEFICIENCY PREVALENCE AND ITS RISK FACTORS AMONG MALAYSIAN ADOLESCENTS AGED 13 YEARS OLD

MUHAMAD NASRULLAH BIN NAZAHARUDIN

While vitamin D deficiency has been frequently reported in Malaysia, limited studies were conducted on the factors associated with this nutritional deficiency among healthy young people. This cross-sectional study was aimed to establish associations between socio-demographic characteristics, body mass index (BMI), abdominal obesity, dietary calcium intake, physical activity level and vitamin D deficiency among adolescents aged 13 years in three southern states of Peninsular Malaysia. A self-administered questionnaire was used to collect data on socio-demographic characteristics while anthropometry measurements including weight, height and waist circumference. BMI was estimated and classified according to WHO Growth Reference 2007. My UM Food Frequency Questionnaire (FFQ) was used to estimate dietary calcium intake and Physical Activity Questionnaire for Older Children (PAQ-C) questionnaire was used to measure physical activity level and venipunctures for blood sample was done by a certified phlebotomist to assess serum 25 hydroxyvitamin D 25(OH)D. Vitamin D status was classified as, < 12.5 nmol/L=severely vitamin D deficient; <37.5 nmol/L=vitamin D deficient; between 37.5 and 50 nmol/L=vitamin D insufficient; 250nmol/ L=sufficient vitamin D. A total of 585 adolescents [173 boys (29.6%)] participated in this study and the prevalence of both vitamin D deficiency in this study was 30.4% (n=102). Vitamin D deficiency was significantly higher in girls (OR=8.636; 95%Cl: 3.837-19.440) compared to males, Malay ethnic group (OR=10.951; 95%Cl: 3.732-32.132) compared to non-Malay ethnic group and in those adolescents whose mothers were highly educated (OR=8.964; 95%Cl: 2.1 69-37.042) compared to those whose mothers with lower education levels. No significant associations were observed between BMI and abdominal obesity, and vitamin D deficiency. Three out of ten adolescents were found to be vitamin D deficient. Being a female, Malay ethic group and those whose mothers were highly educated were more likely to be vitamin D deficient.

ABSTRAK

MENGENAL PASTI PREVALEN KEKURANGAN VITAMIN D DAN FAKTORNYA DALAM KALANGAN REMAJA BERUMUR 13 TAHUN DI MALAYSIA

MUHAMAD NASRULLAH BIN NAZAHARUDIN

Kekurangan vitamin D sering dilaporkan di Malaysia, namun kurang kajian dilakukan terhadap faktor-faktor yang berkaitan dengan kekurangan vitamin ini dalam kalangan remaja. Kajian keratan rentas ini bertujuan untuk mewujudkan hubungan antara ciri sosio-demografi, indeks jisim badan (IJT), obesiti abdomen, pengambilan kalsium harian, tahap aktiviti fizikal dan kekurangan vitamin D dalam kalangan remaja berusia 13 tahun di tiga negeri selatan Semenanjung Malaysia. Soal selidik yang dikendalikan sendiri digunakan untuk mengumpulkan data mengenai ciri sosio-demografi dan pengukuran antropometri termasuk berat badan, tinggi dan lilitan pinggang. BMI dianggarkan dan dikelaskan mengikut Rujukan Pertumbuhan WHO 2007. Soal Selidik Kekerapan Makanan UM (FFQ) digunakan untuk menganggarkan pengambilan kalsium dan soal selidik Aktiviti Fizikal untuk Kanak-kanak Tua (PAQ-C) digunakan untuk mengukur tahap aktiviti fizikal dan venepuncture untuk sampel darah dilakukan oleh phlebotomist yang diperakui untuk menilai serum 25hydroxyvitamin D 25 (OH) D. Status vitamin D dikelaskan sebagai, <12.5 nmol / L = kekurangan vitamin D teruk; <37.5 nmol / L = kekurangan vitamin D; antara 37.5 dan 50 nmol / L = vitamin D tidak mencukupi; 250nmol / L = vitamin D yang mencukupi. Sebanyak 585 remaja [173 lelaki (29.6%)] mengambil bahagian dalam kajian ini dan prevalensi kekurangan vitamin D dalam kajian ini adalah 30.4% (n = 1 02). Kekurangan vitamin D jauh lebih tinggi dalam kalangan perempuan (OR=8.636; 95%Cl: 3.837-19.440)) berbanding lelaki, kumpulan etnik Melayu (OR=10.951; 95%Cl: 3.732-32.132) berbanding kumpulan etnik bukan Melayu dan pada remaja yang ibu berpendidikan tinggi (OR = 8.964; 95% Cl: 2.1 69-37.042) berbanding mereka yang ibunya berpendidikan rendah. Tidak ada hubungan yang signifikan antara BMI dan obesiti abdomen, dan kekurangan vitamin D. Tiga daripada sepuluh remaja didapati kekurangan vitamin D. Sebagai perempuan, etnik Melayu dan mereka yang mempunyai ibu berpendidikan tinggi cenderung kekurangan vitamin D.

CHAPTER 1

INTRODUCTION

1.1 Background

Vitamin D is a fat-soluble vitamin, naturally found in some foods and added to others. Vitamin D is found in two forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Vitamin D2 is synthesized by plants, fungi, and yeasts from ergosterol by UVB, whereas vitamin D3 is produced in the skin by UVB (290–320nm) and converted from 7-dehydrocholesterol to cholecalciferol or obtained from food (Carlberg, 2019). Besides calcium, vitamin D has been recognized for bone health and maintenance (Sunyecz, 2008). Vitamin D supports calcium absorption in the gut and retains ample amounts of serum and phosphate, which allows for normal mineralization of the bones and avoids hypocalcemic tetanus, unintentional muscle contraction, leading to cramps and spasms (NIH, 2016). National Institute of Health, United Kingdom suggest that sufficiency of vitamin D avoids rickets in children and osteomalacia in adults meanwhile in older adults prevent osteoporosis in combination with calcium.

Vitamin D deficiency can increase the risk of chronic diseases such as type 2 diabetes mellitus, cancer and cardiovascular diseases especially among adults (Holick, 2003b; Wang et al., 2008). The relation of vitamin D deficiency among adolescents also increases the risk of osteoporosis as it prevents the acquisition of peak bone mass at the end of skeletal development and maturation (Quah et al., 2018b). Although clinical trial results are inconclusive, a growing body of evidence points to vitamin D deficiency as a global health issue linked to the development of a variety of diseases, including diabetes and cancer (Gabryanczyk et al., 2021)

Adolescence is a time of risk and resilience, when positive and negative pathways form (Dahl, 2004). According to the World Health Organization in 2018, human development has come to the fastest timeline during the adolescents' state. This period is also characterized by the release of pubertal hormones which activate the sexual maturation process, leading to a myriad of physical and biological changes including increased growth and metabolic rate, fat, muscle and brain alterations and the appearance of the secondary characteristics of the sex. At the same time, adolescents have marked social, emotional and cognitive processes which eventually allow them to achieve their roles and responsibilities as adults (Choudhury, 2009).

Globally, the state of adolescents is at risk with iron deficiency anaemia (World Health Organization, 2014). In a cross-sectional study near urban areas of Jhansi district in Uttar Pradesh, stated that the overall nutritional condition of adolescents was inadequate (Deka et al., 2015). The prevalence of vitamin D deficiency among adolescents in the United Kingdom is more than 44% and the prevalence also high in other European countries (Cashman, 2007). A cross sectional study in Singapore for adult populations reported that around 42% of the participants were deficient in vitamin D (Bi et al., 2016a). Malaysia faces the same statistics of vitamin D deficiency among adolescents compared to other regions although geographically as a tropical country (Khor et al., 2011). A local study included vitamin D deficiency during adolescence stage due to rapid skeletal development (Al-Sadat et al., 2016) A prospective study among adolescents in Malaysia namely the MyHeart study reported that gender, ethnicity and clothing style to be associated with vitamin D deficiency (Quah et al., 2018).

According to MyHeart study, the prevalence of vitamin D deficiency among Malaysian adolescents aged 15 years was 33% (Quah et al., 2018). Other than that, the overall dietary intake for vitamin D and calcium among majority of adolescents in Malaysia was below the

Recommended Nutrients Intake 2017 (Suriawati et al., 2016). In the same study, the researcher reported 98.8% unable to meet calcium recommendations and 91.7% do not meet vitamin D daily needs. According to the United State Endocrine Society, the condition of vitamin D deficiency happens when the level of vitamin D is <50 nmol/L (Holick et al., 2011). Other than that, in sunny Tropical regions, the high prevalence of vitamin D deficiency increases the need to understand that only sunlight is not the precursor for optimum vitamin D status (Bi et al., 2016a).

1.2 Problem Statement

There is a growing body of literature that recognizes the importance of vitamin D during adolescence and the consequences of long-term vitamin D deficiency. In tropical countries such as Vietnam, India and Indonesia, vitamin D insufficiency and deficiency were highly prevalent in healthy adults and youth (Chokephaibulkit et al., 2018; Kumar et al., 2015; Setiati, 2008; Tuyen et al., 2016).

It has previously been observed in the longitudinal local study, the most risk factors that lead to vitamin D deficiency are gender, ethnicity and clothing style (Quah et al., 2018). This study specifically reported that 15 years Malay and Indian adolescent girls have significant vitamin D deficiency. However, the previous finding in the same longitudinal study reported only 13 years of Indian adolescent girls were at risk of vitamin D deficiency (Al-Sadat et al., 2016). Another local cross-sectional study on children with epilepsy reported Indian girls and adolescents were at risk (Fong et al., 2016). As there are differences in ethnicity that are related with vitamin D deficiency in Malaysia, hence this study aimed to determine the association between ethnicity differences and vitamin D deficiency. However, all recent findings contradict when a cross sectional study in Indonesia reported that vitamin D status was not affected by skin tone, clothing style, sunblock use, and milk intake (Soesanti et al., 2013). Other than that, population-based study from the middle east, Lebanon that 33° N to the equator reported that gender is not causing the vitamin D deficiency among adolescents and supported by study in Italy 41° N that much distance from equator concluding the same findings (Arabi et al., 2010; Vierucci et al., 2014a). As there are mixed findings in gender difference, this study aimed to determine the association between gender and vitamin D deficiency.

In terms of parental educational levels, no association was reported with vitamin D deficiency during adolescence by the local longitudinal study (Quah et al., 2018b). In contrast to what was reported by Quah et al.(year), a survey in the United States population around 2011-2012 suggested that parents' education level increased vitamin D deficiency awareness in children (Parva et al., 2018a). Finding by the previous National Health and Nutrition Survey, United States concerned that educated parents will low the vitamin D deficiency prevalence among adolescents (Bowering & Clancy, 1986). Further research should be undertaken to investigate the potential of this parents' education factor to be the risk of vitamin D deficiency during adolescence.

The school location within urban and rural areas can be the risk factors for vitamin D deficiency. A local study, approving the findings of urban areas, may have significant vitamin D deficiency, not only for the adolescents but also for the children (Al-Sadat et al., 2016b). A cross-sectional retrospective study in Ireland concluded differently, that vitamin d deficiency is affected by age, lower daily sunshine hours, male gender, rural address and season (Griffin et al., 2020). Further work through this research is required to establish the viability of current local findings on urban factors to the vitamin D deficiency.

Besides, obesity is repeatedly being reported in studies that it can lead to vitamin D deficiency, both Malaysia and United States support this risk and need to be considerate as it also increases the prevalence of non-communicable diseases (Al-Sadat et al., 2016; Parva et al., 2018; Quah et al., 2018). However, studies in Indonesia and Thailand stated that there is no association between body mass index among adults with vitamin D deficiency (Chokephaibulkit et al., 2018; Soesanti et al., 2013). Although in Malaysia, there are studies on the association of obesity with Vitamin D deficiency, there are still limited findings especially regarding the adolescent's population in Malaysia as recent study focusing on Selangor, Perak and Kuala Lumpur. So, this study aims to contribute to this growing area of research by exploring more validated data of Malaysia's adolescent's population in other states.

According to NIH 2016, less active adolescents are more likely to be at the risk of vitamin D deficiency as they have less exposure to the sunlight. Adolescents who are less active and have a sedentary lifestyle are significant in having low vitamin D (Manios et al., 2018; Parva et al., 2018a). Among Malaysian adolescents, NHMS 2017 reported that only 45% of adolescents are physically active. However, there is limited study on the association between physical activity and vitamin D deficiency, particularly in Malaysia. Longitudinal study in Malaysia reported only gender, ethnicity and clothing style had significant vitamin D deficiency (Quah et al., 2018). This study intends to determine the physical activity level factor will significantly correlate with vitamin adolescents in Malaysia.

Calcium consumption factors may be factors determining vitamin D deficiency. No study in Malaysia includes this factor as a contribution for vitamin D deficiency. The factors found to be influencing vitamin D deficiency have been explored in study in Istanbul where, those with high dairy products, calcium food sources will have sufficient vitamin D level (Erol et al., 2015). Moving back to a more previous study in Beijing reported the same, that usually dietary patterns that lack calcium food sources can lead to this issue (Du et al., 2001). To add up, adolescents in Malaysia have lower intake of calcium in their daily food intake (Suriawati et al., 2016). Due to a longer period of study and not much current study focusing on dietary lack of calcium, this study will look up the calcium sources as one of factors that can contribute to vitamin D deficiency.

The researchers began systematically to study vitamin D deficiency predictors and to what degree they affect the condition of adolescents. There have been very few studies to date that investigated adolescent factors linked to vitamin D deficiency in Malaysia. The goal of this study is to help clarify factors by analyzing these possible vitamin D deficiency predictors. In conclusion, what type and to what extent are sociodemographic properties of vitamin D in adolescents, a body mass index, waist circumference, calcium intake and physical activity? How are these factors impacting Vitamin D status in the short and long term?

1.2.1 Research Purpose

To determine the factors associated with vitamin D deficiency and its prevalence among adolescents aged 13 years old.

1.2.2 Research Question

1. What is the prevalence of vitamin D deficiency among adolescents in this study?
2. What are the factors associated with vitamin D deficiency during adolescence?

1.3 Significance of the Study

There were two established study findings from the MyHeart longitudinal study on adolescents that literally focus on vitamin D deficiency during adolescence. This study is unable to encompass the entire Malaysian adolescent's population. To enhance the field, this new study will contribute more to the findings and support previous study especially on the vitamin D status for adolescents in Malaysia.

Apart from that, this study may suggest common factors faced by adolescents that can be used for future policy interventions that can be implemented by the policy maker such as government, scientist and nutritionist in preparing healthy adolescents for the future nation.

Besides, this study can act as a foundation of the concept for future studies and the results can also be used as baseline data for future similar studies to compare with. Lastly, this study will be different from the currently ongoing longitudinal study MyHeart on adolescents and comparison can be done to sum up the current condition of adolescents in Malaysia with bigger perspectives and study coverage.

1.4 Objectives

1.4.1 General Objective

To determine the factors associated with vitamin D deficiency during adolescence including socio-demographic factors such as gender, race, number of siblings, parents' education, school location and state of living, body mass index measurements, waist circumference, physical activity and calcium intake.

1.4.2 Specific Objectives

1. To assess adolescent socio-demographic factors including gender, ethnicity, parents' education level, and school location.
2. To measure the body mass index (BMI) and waist circumference (WC) measurements in adolescents.
3. To assess physical activity level in adolescents.
4. To assess dietary calcium intake in adolescents.
5. To determine the association between socio-demographic, BMI, WC, physical activity, calcium intake and vitamin D deficiency in adolescents.

1.5 Hypothesis

1. Socio-demographic factors such as gender, ethnicity and parents' education, school location will be associated with serum vitamin D level.
2. Body mass index and waist circumference will be associated with serum vitamin D level.
3. Physical activity level factor will be associated with serum vitamin D level.
4. Calcium intake will be associated with serum vitamin D level.

1.6 Conceptual Framework

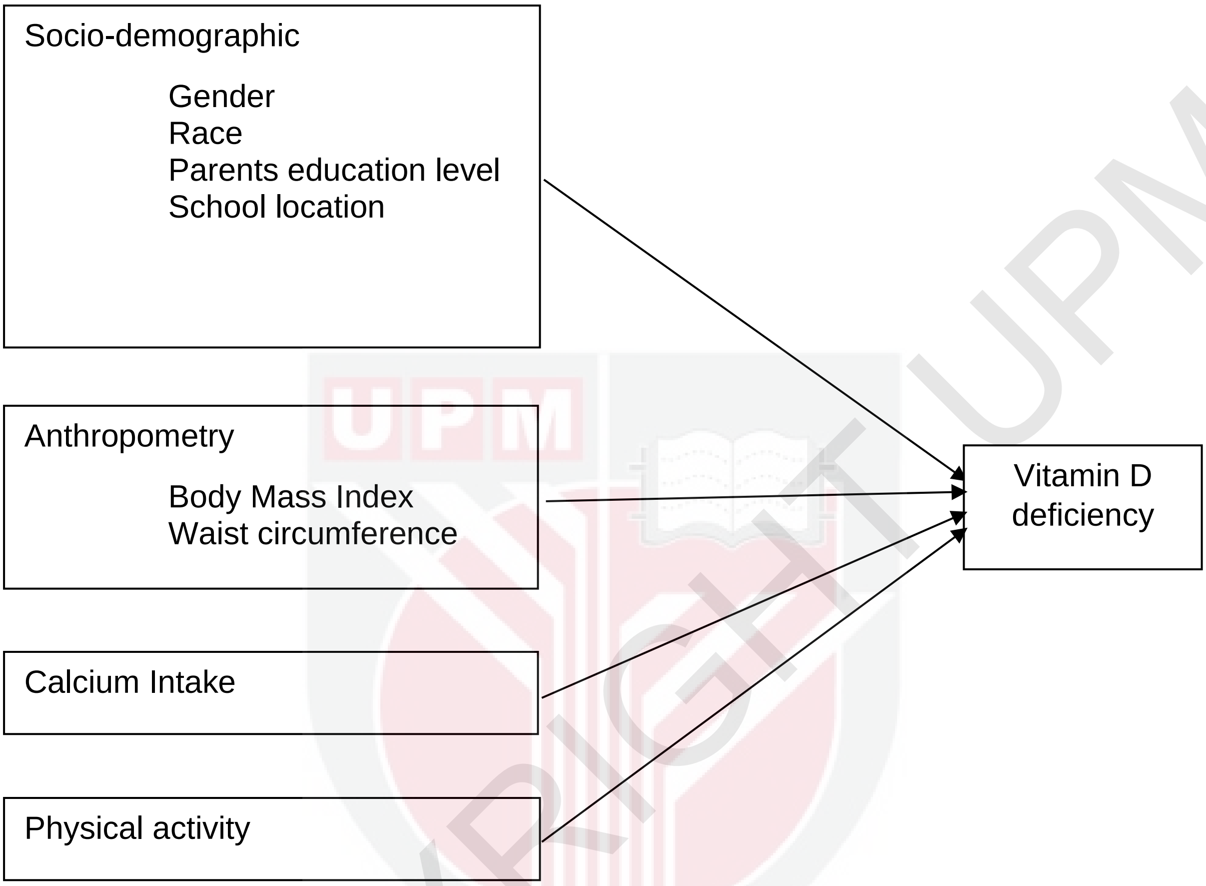

Figure 1.1 Conceptual Framework

This figure 1.1 showed the conceptual framework of this study, the independent variables which are socio-demographic (gender, ethnicity, parents' education and place of living, body mass index, waist circumference, calcium intake and physical activity with the dependent variable, vitamin D deficiency. Based on this framework, study will be conducted to identify the link of all the independent variables stated with the dependent variable.

CHAPTER 2

LITERATURE REVIEW

Vitamin D is known as calciferol is a fat-soluble vitamin that is naturally present, added to others and available as a dietary supplement in a few foods (NIH, 2016). Vitamin D derived from exposure to the sun, foods, and supplements are biologically inert and have to be activated by two hydroxylations in the body. The first hydroxylation that takes place in the liver transforms vitamin D to 25-hydroxyvitamin D[25(OH)D], also known as "calcidiol" meanwhile the second hydroxylation takes place mainly in the kidney and forms 1,25-dihydroxyvitamin D[1,25(OH)2D], also known as "calcitriol," which is physiologically active (Calcium et al., 2011). Calcium (2011) also mentions that vitamin D is essential for osteoblast and osteoclasts for bone growth and remodelling. Bones may become thin, scratchy or mis-formed without enough vitamin D. Sufficiency of vitamin D prevents childhood rickets and adult osteomalacia. Vitamin D helps to protect older adults against osteoporosis in conjunction with calcium.

Vitamin D deficiency can occur in people who have a lower normal intake over time, have minimal exposure to sunlight, unable to transform 25(OH)D into active form in kidneys, and are unable to absorb vitamin D in their digestive tract (NIH, 2016). Vitamin D-low diets are more popular in people with dairy or lactose intolerances and those who eat an ovo-vegetarian or vegetarian diet (Calcium et al., 2011). Vitamin D deficit is expressed in children as rickets, a disorder that is characterised by bone tissue failure to adequately mineralize and leads to soft bones and skeletal defects (C. J. Elder & Bishop, 2014). Extreme rickets problem in children may cause non-completion, developmental delay, hypocalcaemia, tetanus spasm and cardiomyopathy as well as dental malformances in addition to bone deformities and pain (Aguiar et al., 2016; Uday & Högler, 2017).

Other than that, vitamin D deficiency can cause osteomalacia in adults and adolescents in which established bones are deficiently or incompletely mineralized during remodelling, resulting in weak bones (Uday & Högler, 2017). Osteomalacia's signs and symptoms are similar to ricketing and include bone and pain defects, hypocalcaemia, tetanus spasms, and dental abnormalities (Aguiar et al., 2016). Vitamin D-risk individuals are at greater risk in groups such as breast-feeding babies, the elderly persons with decreased exposure to sunlight, people with dark skin, those with a fat-resistant disease and obese or postoperative gastric bypasses (NIH, 2016). How about the adolescent’s population?

WHO describes 'adolescents' as people between the ages of 10 to 19 years old. According to the National Health Morbidity Survey in 2017 there were about 5.5 million adolescent’s population in Malaysia. With regard to growth, adolescence is both a challenging and an exciting period. The bodies of adolescents are maturing physically. They start thinking in new ways cognitively about the environment. Socially, evolving relationships with families and peers play a central role. This is when the need for their nutrients such as vitamins and minerals also become a demand. As vitamin D plays a role in bone development (Sunyecz, 2008), the phase of adolescents is very important to improve the status of vitamin D. According to Malaysia Recommended Nutrient Intake 2017, both boys ages 10-18 years old and girls ages 10-18 years old need 15 ug (600 IU) per day. However, deficiency of vitamin D has been identified as a generalised pandemic and is the most popular global nutritional deficit (Holick, 2010). Study in the Malaysian adolescent’s population, reported a 33% prevalence of vitamin D deficiency among 15 years old adolescents selected for a prospective study (Quah et al., 2018). In the same study reported since children the prevalence of vitamin D deficiency is range between 47-75% (Quah et al., 2018), they concluded the risk factors were the gender, ethnicity and dressing style.

The studies on the status of vitamin D in adolescence are contradictory and the available data from various studies are not easily comparable due to the use of different age groups, ethnic, screening seasons, latitudes, analytical screening techniques and most of all, the use of different cut off thresholds specifying the deficiency (Patseadou & Haller, 2020).

2.1 Sociodemographic Characteristics

2.1.1 Gender

Two cross-sectional studies from Malaysia and the United Arab Emirates reported the prevalence of vitamin D deficiency will be much higher in girls (Al-Sadat et al., 2016; Muhairi et al., 2013). A longitudinal study in Malaysia named MyHEART supported the findings, they explain this higher risk may be attributed to 57% females wearing hidden clothing that only reveals their hands and legs, compared to 11% males (Quah et al., 2018). However, there are contradictory findings in a northern European country cross-sectional study regarding gender differences as boys in Copenhagen area in Denmark also have the prevalence to be the factors of vitamin D deficiency during late adolescence stage (Tønnesen et al., 2016). Nearby country, which is Singapore, in a cross-sectional study for adults, significant difference between vitamin D status and HOMA-IR were reported for both male and female participants when the male and female participants were independently analysed in the study (Bi et al., 2016a). The issue has grown in importance in light of recent to nearer country to equator, when a population-based study from middle east, Lebanon reported that gender is not causing the vitamin D deficiency among adolescents and supported by study in Italy concluding the same findings (Arabi et al., 2010; Vierucci et al., 2014a). The mechanisms of gender that underpin association are not fully understood as every region concluded contradict findings.

2.1.2 Ethnicity

Human skin has an immense capacity to manufacture vitamin D3. From experimental data, exposure of the body in a bathing suit which was almost 100% of body surface area to sunlight that induces a minimal erythematous dose (MED) was equal to taking 10,000-25,000 IU of vitamin D orally (Holick, 2003a). We need to know MED for each type of skin at the specific latitude and time to bring this technique into practise. Generally, exposure of arms and legs for 5 to 30 min depending on the time of day, season, latitude and pigmentation of the skin between 10 a.m. or at 3 p.m. and twice a week is always enough (Holick, 2003a). Asians have skin type 4 or 5 comparable to Caucasians mostly skin type 2 or 3. With the same amount of MED, people with dark skin need more exposure time than their light-skinned counterparts to synthesise comparable vitamin D3 levels (Nimitphong & Holick, 2013). Three main Malaysian ethnicities are Malays, Indians and Chinese. The prevalence of vitamin D deficiency is the highest among 13 years old Malays and Indian adolescents according to the cohort study conducted (Al-Sadat et al., 2016). A few years later, the findings in the cohort study concluded Indian girl adolescents had four times higher risk compared to Malay girls 3 times higher than Chinese girl adolescents' population (Quah et al., 2018). A cross sectional study in Indonesia, reported that skin tone and clothing style were not related with the vitamin D status and a retrospective study among adolescent idiopathic scoliosis in line with similar findings, non-whites population higher risk to have deficient vitamin D (Kiebzak & Neal, 2019; Soesanti et al., 2013) As the ethnicity factor confounder with skin type pigmentation, more research needs to be done to observe the consistency of the association in Malaysia population when clothing style may be another confound in Malaysian ethnicity.

2.1.3 Parental education level

Awareness and education of the nutrients in foods with respect to their roles in the maintenance, development, reproduction, wellbeing and prevention of human disease is important in human life. A modified study regarding educational attainment of children emphasize that the level of education of both parents influences the educational achievements of children living with both parents and that the effect of the level of education of mothers and the father is not statistically different and to precise, the findings indicate that the maternal effect on education of children in households not involving both parents is comparatively higher compared with the father's educational level (Christensen, 2020). Theoretically, a high level of parental education will increase the awareness of nutrients important for their family development. A cross-sectional study in Portuguese reported, educated parents will encourage supplementation of vitamin D to avoid vitamin D deficiency among their children (Cabral et al., 2016). Findings by the National Health and Nutrition Survey, United Stated also support the findings that educated parents will lower the vitamin D deficiency prevalence among adolescents (Bowering & Clancy, 1986). However, a study in the Southeast, Guangzhou, China found a different finding where the education level of the parents was not significant to the vitamin D deficiency (Tang et al., 2020a). Malaysia longitudinal study also reported the same in the latest findings for adolescents aged 15 years (Quah et al., 2018). Instead, the relationship between parental education level is still lacking in study, although some studies already indirectly relate the factor with vitamin D deficiency during adolescence.

2.1.4 Rural and urban (School location)

The area around a city is an urban area. There are non-agricultural jobs for most residents in urban areas. Urban areas are very developed, which means that human structures such as homes, commercial buildings, roads, bridges, and railways are densely dense (J. Elder, 2011). The word "Urban area" can apply to cities, towns, and suburbs. As well as the surrounding areas, an urban area comprises the city itself.

The opposite of urban areas is rural areas. Low population density and large quantities of undeveloped land in rural areas, also called the 'country' (J. Elder, 2011). The distinction between a rural and an urban area is generally obvious. Both locations will eventually have schools for the education purpose. Schools differ widely in racial or ethnic structure, concentration of poverty, performance of students, scale, density and administrative organisation (Burdick-Will & Logan, 2017).

A cross-sectional study in the Boston area, reported there was a significant correlation between urban school location with vitamin D deficiency (Sacheck et al., 2011). The finding is supported by a Korean study where, not only the urban location but with low socioeconomic status will increase the risk of vitamin D deficiency (Kim, 2019). Latest cross-sectional study in Guangzhou, found 44.4% prevalence of vitamin D deficiency among children and adolescents in Guangzhou City (Tang et al., 2020a). These results are similar to a follow up study in India, where the prevalence of vitamin D deficiency is higher in the south Indian population, well developed in India (Jayashri et al., 2020). These findings were supported by

Thailand in their cross-sectional study, urban populations in all regions of Thailand have shown lower vitamin D status than rural ones (Chokephaibulkit et al., 2018).

This interpretation contrasts with study in Ireland and Morocco. A cross-sectional retrospective study in Ireland concludes that vitamin D deficiency is affected by age, lower daily sunshine hours, male gender, rural address and season (Griffin et al., 2020). Rural address was also significant with vitamin D deficiency in a double-blind study among rural Moroccan school-aged children during winter (Benjeddou et al., 2019). There is a growing body of literature regarding urban and rural location to vitamin D deficiency factor as many current studies still contradict findings.

2.2 Anthropometry

2.2.1 Body Mass Index (BMI) and waist circumference

The Body Mass Index (BMI) is the weight of a person in kilogrammes divided into metres by a square in height. BMI being used to classify weight categories which are obesity, overweight, normal and underweight. Obesity rises are occurring globally and according to the World Health Organization the escalating global epidemic of overweight and obesity – "globesity" – is spreading across many parts of the world and now being considered by many health professionals. This includes the study into vitamin D deficiency caused by obesity and high waist circumference. In the Malaysia longitudinal study named MyHeart, the reported results had obesity significant for 13 years and 15 years adolescents and among the 13 years adolescents both normal and high waist circumference had high percentage of vitamin D deficiency, 75.5% and 86.2% respectively (Al-Sadat et al., 2016; Quah et al., 2018) A retrospective study among children and adolescents in Turkey stated that insufficient vitamin

D were high in overweight and obese status (Andiran et al., 2012). A survey from the United States also finds the similarity when 42.5% of vitamin D deficient participants falling under the category of obese among their population >20 years and above in year 2011-2012 (Parva et al., 2018b). Besides, a cross-sectional study in China among obesity children and adolescents without other cardiovascular risk factors proves low vitamin D status was found only associated with general obesity (Tang et al., 2020a). Throughout those similarities, Indonesia reported that between obese and non-obese adults will not affect the vitamin D status (Soesanti et al., 2013). It is now well established that obesity and significant with vitamin D deficiency but the evidence for this relationship is inconclusive among adolescents as most of the study is focusing children and adults. Besides, the waist circumference level is still less attention and the findings still uncertain between normal and high waist circumference will affect the Vitamin D deficiency.

2.3 Calcium Intake

According to the National Institute of Arthritis and Musculoskeletal and Skin Diseases, calcium is needed for our heart, muscles, nerves to function properly, blood to clot and need Vitamin D to enhance the absorption of calcium in the human body. Recommended Nutrient Intake 2017 for Malaysia, intake for calcium among adolescents is 1300mg/day. Adolescents in Malaysia have lower intake of calcium in their daily food intake (Suriawati et al., 2016). In addition, calcium intake may be factor determination for vitamin D deficiency. A systematic review regarding vitamin D in adolescents, suggests that adequate calcium intake will decrease the risk of insufficient vitamin D (Patseadou & Haller, 2020). At this point, there is no study in Malaysia that includes this factor as a contribution for vitamin D deficiency.

The factors found to be influencing vitamin D deficiency have been explored in study in Istanbul where, those with high dairy products, calcium food sources will have sufficient vitamin D level (Erol et al., 2015). Moving back to more previous study in Beijing reported the same, that usually dietary pattern that lacks calcium food sources can lead to this issue (Du et al., 2001). Study in adults, risk of vitamin D deficiency will decrease as the calcium intake increases (Weaver, 2007). A cross-sectional study in Saudi and Korea reported a similar association where children in Saudi with >800mg calcium intake and adults in Korea with >1200mg calcium intake can be elevated vitamin D deficiency (Al-Musharaf et al., 2012a; Choi et al., 2015). However, a randomized placebo control study among adults in the UK found there was no evidence that increased calcium intake will modify vitamin D status in the body (Cashman et al., 2014). Instead, the relationship between calcium intake and vitamin D deficiency was rarely observed, which indirectly may relate to vitamin D deficiency.

2.4 Physical activity

People are physiologically adapted to produce vitamin D, especially UVB radiation, in response to sun exposure (Baggerly et al., 2015). Increase of physical activity will increase the time being exposed to the sunlight. According to NIH 2016, less active adolescents are more likely to be at the risk of vitamin D deficiency as they have less exposure to the sunlight. Adolescents who are less active and have a sedentary lifestyle are significant in having low vitamin D (Manios et al., 2018; Parva et al., 2018a). Among Malaysian adolescents, NHMS 2017 reported that only 55% of adolescents are physically less active. In a multivariate linear regression model of plasma 25 (OH) D concentrations among Adolescents in Al Ain, Saudi reported significant findings for physically less active adolescents during the cross-sectional study (Muhairi et al., 2013).

However, there is limited study on the association between physical activity and vitamin D deficiency, particularly in Malaysia. Longitudinal study in Malaysia reported the results of physical activity or active time under sun show no significant maybe due to other confounding factors (Quah et al., 2018). Physical activity is an important aspect of Vitamin D as only being active will increase the duration being exposed outside under the sunshine.

CHAPTER 3

METHODOLOGY

This study will be based on secondary data collected by a research team led by Assoc Prof Dr Geeta Appannah in UPM. The decision to use secondary data in this final year project was merely due to the challenges in collecting data in the field due to the current pandemic COVID-19. Furthermore, social distancing practice and preventing mass gathering publicly are the priority to avoid the spreading of the virus (Mat et al., 2020).

3.1 Study Design

This is a cross-sectional study among a total of 933 adolescents. Details on the study were previously described (Emi et al., 2020). Briefly, 930, 793, 585 and 507 adolescents were provided with anthropometric, physical activity, dietary assessment and biochemical measurement information, respectively.

This secondary data analysis was evaluated associations between socio-demographic characteristics (gender, ethnicity, school location and parents' education level), body mass index, waist circumference, physical activity level and calcium intake with Vitamin D deficiency assessed as 25(OH)D among adolescents in southern region of Peninsular Malaysia.

3.2 Study Location

This study was carried out from August to November 2016, in a total of 21 public secondary schools that were randomly selected within three states in the southern region of Peninsular Malaysia namely Negeri Sembilan, Melaka and Johor.

3.3 Sample Size Determination

A total of 933 adolescents from selected public high schools in Melaka, Negeri Sembilan and Johor were recruited. The response rate was 93% after a total of 1,000 adolescents were predicted for this previous study, considering the 20% response rate and the design effect of 2.

Sample size in the previous study was determined by a single cross-sectional survey formula. The minimum sample size estimate was based on a prevalence of child obesity of 20.9% (Serene Tung et al., 2011).

3.4 Sampling Design

A probability proportionate sampling design by Aday & Cornelius in 2006) was employed for the selection of schools. This was achieved by having a full list of public secondary schools as the sampling frame from the Malaysia's Ministry of Education (MOE). Out of a total of 24 that were initially randomly selected, 21 schools agreed to participate in the study.

3.5 Participants

Adolescents aged 13 years were selected as participants in the previous study. Adolescents will enter secondary school at this age, several challenges such as physical characteristics and social changes will emerge from the transition from primary to secondary school, proper preparation will ensure that those involved are well prepared to face these challenges (Coffey, 2013). Adolescents who had met the inclusion criteria were invited to take part in the previous study. Based on the inclusion and exclusion criteria set, all the adolescent participants aged 13 years were screened. The participants were carefully selected by a dietitian, a medical doctor, and two research enumerators. The inclusion criteria were specific for adolescents aged 13 years and able to read and understand either Malay language or English language. Meanwhile, adolescents who were unable to read and understand either Malay or English language and had limitations of physical activity including physical disability and in a state of chronic condition were excluded.

Table 3.1 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
13 years old adolescents	Limitation of physical activity (physical disability and in state of chronic condition)
Able to read and understand Malay/English	

3.6 Study Instruments

Socio-demographic characteristics, anthropometry measurements, dietary intake, physical activity and calcium intake were assessed using self-administered questionnaires and related validated questionnaires.

3.6.1 Self-Administered Socio-Demographic Factor Questionnaire

A self-administered questionnaire was completed by the adolescent participants to determine their gender, ethnicity, school location and parents' educational level in this study. Other characteristics were also included, such as family structure, household income and parents' occupational level and were filled by their parents.

3.6.2 Anthropometry Data

3.6.2.1 Body Mass Index (BMI)

Weight was measured using Tanita HD319, Japan to the nearest 0.1 kg while height was measured using Body SECA, 206 Germany to the nearest 0.1 cm. Both measurements were taken with caution to achieve correct reading and to prevent any error. In addition, all measurements were repeated twice to obtain a mean value which was then used in the study. Subsequently, BMI was estimated using the following formula:

$$BMI = Weight\ (kg) / Height\ (m^2)$$

Body Mass Index were categorized based on Z-Scores BMI for ages growth chart for 5 to 19 years old by the World Health Organization. The classifications were tabulated and concluded as in table 3.2 in the next page.

Table 3.2 Classifications of BMI-for-age

SD	Indicator
Below -3	Severe thinness
-3 to -2	Thinness
-2 to 1	Normal
1 to 2	Overweight
Above 2	Obese

3.6.2.2 Waist Circumference

Waist circumference was measured by a study dietitian. In order to measure the adolescent waist circumference (WC) at the mid-point between their bottom rib border and their top pelvic border, a measurement tape (Seca 201, Germany) was used. Besides, to obtain a mean value for every variable which was then used in the study, all measurements were repeated twice. The reference for the categorisation of waist circumference (Table 3.3) was done according to the waist circumference percentile curves for Malaysian children and adolescents aged 6.0-16.9 years (Poh et al., 2011). The waist circumference cut off points will be 90 cm in boys and 80 cm in girls according to the Asian populations (World Health Organisation (WHO), 2008). The percentiles will be classified into two categories which are normal waist circumference and abdominal obesity that can be refer in Table 3.3.1. Percentiles from 3rd until 90th percentiles will be classified as normal and 90th percentile will be classified as abdominal obesity.

Table 3.3 Percentile values of WC (cm) by sex and age.

Sex	Age (years)	*n*	Percentiles								
			3rd	5th	10th	25th	50th	75th	90th	95th	97th
Boys	10	1197	48.3	49.2	50.8	54.1	58.7	65.3	74.5	83.1	91.1
	11	1024	49.5	50.5	52.3	55.8	60.8	67.9	77.7	86.6	94.8
	12	611	50.9	52.0	53.9	57.6	63.0	70.5	80.7	90.0	98.3
	13	644	52.7	53.9	55.9	59.7	65.3	73.2	83.8	93.3	101.8
	14	570	54.7	55.8	57.8	61.8	67.5	75.5	86.4	96.1	104.9
	15	474	56.5	57.6	59.7	63.7	69.4	77.5	88.5	98.4	107.4
	16	414	58.1	59.3	61.4	65.4	71.1	79.2	90.2	100.2	109.3
Girls	10	1206	46.6	47.5	49.2	52.3	56.7	62.5	69.8	75.6	80.4
	11	1040	48.1	49.2	51.0	54.4	59.2	65.5	73.3	79.6	84.6
	12	614	50.1	51.2	53.1	56.7	61.7	68.4	76.5	83.0	88.2
	13	656	52.0	53.1	55.1	58.8	63.9	70.6	78.8	85.2	90.3
	14	603	53.4	54.6	56.6	60.4	65.6	72.2	80.1	86.1	90.8
	15	437	54.3	55.6	57.6	61.5	66.7	73.2	80.7	86.3	90.5
	16	396	54.6	55.9	58.0	62.0	67.2	73.7	80.8	85.9	89.7

Adapted from Poh et.al.

Table 3.3.1 Percentiles cut-off points

Percentiles	**Category**
≤90th	Normal
>90th	Abdominal obesity

3.6.3 Calcium Intake

To assess calcium intake in this research, a semi-quantitative food frequency questionnaire, namely the MyUM Adolescent Food Frequency Questionnaire (MyUM Adolescent FFQ) was used. The MyUM Adolescent FFQ is a validated method to use because it not only captures the normal diet of Malaysian adolescents, but also determines their consumption of micronutrients (Mohamed et al., 2018). Portion sizes and the level of intake for a total of 195 food items over the previous 12 months were obtained by using this questionnaire. The MyUM Adolescents FFQ presented common options that were acceptable for Malaysian adolescents, meanwhile for food frequency and serving sizes and the food options were based on the Malaysian Food Composition data. Information obtained from MyUM Adolescent FFQ was then computed into the Nutritionist ProTM Diet Analysis (Axxya System, USA) software to measure the dietary intake of adolescents for a day.

Step-by-step instructions on how to fill in the questionnaires were given to all participants by the study researchers before administering the FFQ. A flipchart on household measurements was presented to the participants as an aid in estimating food intake by the study dietitians. During the past year the average frequency of consumption of each food item was reported as 'never',' 1-3 times a month',' one time a week',' 2-4 times a week',' 5-6 times a week',' one time a day',' 2-3 times a day',' 4-5 times a day or '6 times a day'. Before the submission, the study researchers reviewed all the questionnaires to ensure all fields were filled in to ensure that all fields have been filled in A standard conversion factor for estimating daily food intake based on the level of food consumption was used to manually convert the FFQ raw data to daily energy and other nutrient (Norimah et al., 2008). In order to measure nutrient intake, information obtained from the MyUM Adolescent FFQ was then computed into the Nutritionist

ProTM Diet Analysis (Axxya System, USA) software. Daily requirement of calcium for adolescents is 1300mg/day. The values lower than 1300mg/day were considered low meanwhile calcium intake of equal or greater than 1300mg/day was considered to have met the daily requirement.

3.6.4 Vitamin D Status 25(OH)D

The assessment of vitamin D status will be based on the serum 25-hydroxyvitamin D. 25(OH)D is the most stable and abundant vitamin D metabolite in human serum with a half-life of approximately 3 weeks, making it the most appropriate vitamin D status indicator (Thacher & Clarke, 2011). After an overnight fast or at least 8 hours, biochemical parameters were gathered by a certified phlebotomist. All the biochemical samples were sent to Pantai Premier Pathology Laboratory to be analysed using standard methods. Results of 25(OH)D level will be the indicator of vitamin D status.

Table 3.4 Classification of Vitamin D Status by 25(OH)D Concentration

25(OH)D Concentration, nmol/L (ng/mL)	Classification
≤12.5 (5)	Severe deficient
≤37.5 (<15)	Deficient
37.5-50.0 (15-20)	Insufficient
50.0-250.0 (20-100)	Optimal

According to Table 3.4, the classification is based on 25(OH)D level guidelines that maximally suppresses parathyroid hormone (PTH) secretion (Kennel et al., 2010; Misra et al., 2008; Pludowski et al., 2018) and recommended for adolescent cut off (Harel et al., 2013). As the blood test result is in nmol/L, the conversion of ng/mL to nmol/L is multiplied by 2.496. Vitamin D status is deficient when equal and lower than 37.5nmol/L (≤15ng/ml), insufficient if the results between 37.5-50.0nmol/L (15-20ng/mL) and optimal level when equal and greater that 50.0-250.0 nmol/L (20-100ng/mL).

3.6.5 Physical Activity

To assess the physical activity of adolescents, the Physical Activity Questionnaire for Older Children (PAQ-C) was used. PAQ-C is a 7-day, self-administered recall questionnaire that measures involvement in various physical activities, as well as physical education class and activities done during lunch break, after-school, evening and weekend. This questionnaire consisted of 8 items and was graded between 1 (low) and 5 (high physical activity) and the overall PAQ score is the mean score of all items (Voss et al., 2017).

Table 3.6.5.1 Physical Activity Mean Score Classification.

Type of Physical Activity Level	Classification
Low	<2.33
Moderate	2.33-3.66
Active	>3.66

3.7 Data Collection

The primary data collection was collected from August to November 2016 in 21 public high schools located in three southern states of Peninsular Malaysia. Anthropometric measurements were obtained by the study dietitians.

3.8 Study Approval

Full ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects (JKEUPM) of Universiti Putra Malaysia (UPM) (Reference number: FPSK (EXP16) P031). Approval to conduct this study in the selected schools were obtained from the Ministry of Education Malaysia, state education departments and selected schools.

3.9 Statistical Analysis

Data will be analysed using the Windows version 25 Statistical Package for Social Sciences (SPSS) to generate descriptive statistics summarising questionnaire data with a significance level of $P < 0.05$. To summarise continuous variables, standard deviation and mean will be used while frequency (n) and percentage (%) for categorical variables. The relations between the categorical data will be calculated using the Chi-square statistics.

Logistic regression model will be used in the study. Measurement of the impact (odd ratio, OR) and 95% confidence interval (95% CI) between the possible risk factors and the outcome of the vitamin D deficiency will be determined by conducting univariate logistic regression. Respective risk factors with p-value <0.25 will be further evaluated using multivariable logistic regression (Bursac et al., 2008). All statistical tests will be performed at a 5% significance stage. The confounding variables such as gender, race, mother education level, school location and BMI will be used to predict the influence of each variable on the association. This test will be similar with current findings in Malaysia (Quah et al., 2018b) to compare the factors associated with vitamin D deficiency and observe the new findings.

CHAPTER 4

RESULTS

This research was based on secondary data gathered by a team of researchers at UPM lead by Assoc Prof Dr Geeta Appannah. Anthropometric, physical activity, dietary assessments, and biochemical measurement data were provided by 930, 793, 585, and 507 adolescents, respectively. Data used in this study is described in figure 1.

The intended data analysis will examine relationships between socio-demographic variables (gender, ethnicity, parental education level and school location), body mass index, waist circumference, calcium intake, physical activity level and serum Vitamin D deficiency as measured by 25(OH)D among adolescents in Peninsular Malaysia's southern states, Melaka, Johor, and Negeri Sembilan.

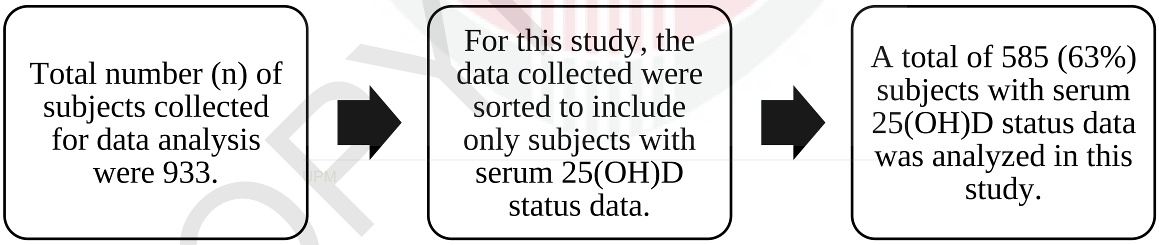

Figure 4.1 Number of dependent data (serum 25(OH)D included in this study.

4.1 Socio-demographic background

Socio-demographic data of 585 subjects who provided serum 25(OH)D data was presented in Table 4.1. Most of the subjects were girls (70.4%) and followed by boys (29.6%). The Malay race group was predominant in this study (83.9%) as compared to non-Malay (16.1%). Non-Malay consisted of Chinese (10.1%), Indian (5.3%), and others (0.7%). As for the parental education level, most of both mothers and fathers attained education at secondary school level (73.3%, 72.4%) respectively.

Meanwhile, fathers and mothers with no formal or with primary school education level were (11.1%, 15.3%) respectively, and for higher education level fathers and mothers were (15.6%, 15.3%) in this study. Lastly, more than half of the subjects were from rural school locations (54.4%) compared to urban school locations (45.6%).

Table 4.1 Socio-demographic background of the study subjects (n=585)

Characteristics	Frequency (n)	Percent (%)
Gender		
Boy	173	29.6
Girl	412	70.4
Race		
Malay	491	83.9
Non-Malay	94	16.1
Chinese	59	10.1
Indian	31	5.3
Others	1	0.7
Parents education level		
Mothers		
No formal education/primary	57	11.1
Secondary school	377	73.3
Higher education	80	15.6
Fathers		
No formal education/primary	59	12.3
Secondary school	346	72.4
Higher education	73	15.3
School location		
Urban	267	45.6
Rural	318	54.4

4.2 Anthropometry measurements

The summary of BMI and waist circumference of the subjects were presented in Table 4.2. Based on BMI-for-age growth chart by WHO, most of the subjects involved in this study had normal BMI (63.0%) while others were either underweight (5.7%), overweight (15.1%) or obese (16.3%). The mean+SD of BMI for all 585 subjects was 20.57±5.042kg/m^2. Based on the waist circumference cut-off points of Asian populations, almost all the subjects had normal waist circumference (89.0%) and a small group of subjects with abdominal obesity (11.0%). The mean+SD of the waist circumference was 65.38±11.543cm.

Table 4.2. BMI and waist circumference status of subjects (n=585)

	Frequency (n)	Percent (%)	Mean ± SD
BMI (kg/m^2)			20.57±5.042
Underweight	33	5.7	
Normal	367	63.0	
Overweight	88	15.1	
Obese	95	16.3	
Waist Circumference (cm)			65.38±11.543
Normal [a]	518	89.0	
Abdominal obesity [b]	64	11.0	

[a]3rd percentile-90th percentile [b]95th percentile and above (Poh et al., 2011).

4.3 Calcium intake

Calcium intake of the subjects was tabulated in Table 4.3. Subjects with low calcium intake (74.7%) were higher compared to the subjects with optimum calcium intake (25.3%). The mean±SD calcium intake of the subjects was 1003.23±868.156mg.

Table 4.3 Calcium Intake of the subjects (n=585)

Variables	Frequency (n)	Percent (%)	Mean±SD
Calcium intake (mg)			1003.23±868.156
Low calcium intake	437	74.7	
Optimum calcium intake	148	25.3	

4.4 Physical activity level

The total score of physical activity was categorized into three groups and tabulated into Table 4.4. The mean±SD for total score was 2.47±0.636 which represents that the subjects were moderately active. Subjects with low physical activity and moderate physical activity recorded almost the same value of 45.7% and 48.7% respectively while there were only 5.6% subjects were physically active.

Table 4.4 Physical Activity level of the subjects (n=585)

Variables	Frequency (n)	Percent (%)	Mean±SD
Physical activity			2.47±0.636
Low (<2.33)	229	45.7	
Moderate (2.33-3.66)	244	48.7	
Active (>3.66)	28	5.6	

4.5 Serum Vitamin D status

The assessment of vitamin D status using 25(OH)D indicator was tabulated in Table 4.5. More than half of the subjects had optimal serum vitamin D status (69.6%), meanwhile 30.4% of the subjects were found to be vitamin D deficient. The Vitamin D deficiency group consisted of severe deficient (0.3%), deficient (7.7%) and most of them were insufficient (12.8%). The mean±SD of serum vitamin D status was 61.10±17.427 nmol/L.

Table 4.5 Serum Vitamin D 25(OH)D status (n=585)

Blood Sample	Frequency (n)	Percent (%)	Mean ± SD (nmol/L)
Vitamin D 25(OH)D (nmol/l)			61.10±17.427
Deficiency	**102**	**30.4**	
Severe deficient (≤12.5)	1	0.3	
Deficient (≤37.5)	26	7.7	
Insufficient (37.5-50.0)	75	22.3	
Optimal (50.0-250.0)	**234**	**69.6**	

4.6 Hypothesis testing

4.6.1 Hypothesis testing using Chi-Square Test

4.6.1.1 Association between Socio-demographic characteristics with serum vitamin D deficiency.

The associations between socio-demographic characteristics and vitamin D deficiency using chi-square test were tabulated in Table 4.6. Girls were significantly associated with higher vitamin D deficiency in this study compared to boys with 28.3% (n=95) girls having vitamin D deficiency while boys only 2.1% (n=7) persons. The Malay group had a significant association with vitamin D deficiency. Malay ethnicity showed higher proportion for both sufficient and deficiency of vitamin D as compared to non-Malay (Chinese, Indian and others).

Adolescents with vitamin D deficiency had significant results (X^2=8.592, p=0.014) when their fathers had secondary education level (21.1%) and higher education level (8.5%). The result of vitamin D deficiency is also significant (X^2=10.101, p=0.006) among adolescents' mothers secondary education level (23.2%) and higher education level (6.8%). There was no association between the school location, urban or rural location with vitamin D deficiency.

Table 4.6 Unadjusted association between socio-demographic factors with serum vitamin D deficiency among adolescents

Variables	Sufficient vitamin D (%)	Deficient vitamin D (%)	X^2	p-value
Gender			35.266	0.000
Boy	91 (27.1)	7 (2.1)		
Girl	143 (42.6)	95 (28.3)		
Race			27.947	0.000
Malay	164 (48.8)	98 (29.2)		
Non-Malay	70 (20.8)	4 (1.2)		
Parents education level				
Mothers			10.101	0.006
No formal education/primary	31 (10.0)	3 (1.0)		
Secondary school	152 (49.0)	72 (23.2)		
Higher education	31 (10.0)	21 (6.8)		
Fathers			8.592	0.014
No formal education/primary	27 (9.5)	5 (1.8)		
Secondary school	139 (48.9)	60 (21.1)		
Higher education	29 (10.2)	24 (8.5)		
School location			0.000	0.986
Urban	103 (30.7)	45 (13.4)		
Rural	131 (39.0)	57 (17.0)		

4.6.1.2 BMI, abdominal obesity, calcium intake, physical activity level with serum vitamin D deficiency.

Table 4.7 Unadjusted associations between BMI, waist circumference, calcium intake, physical activity level with serum Vitamin D deficiency

Variables	Sufficient vitamin D (%)	Deficient vitamin D (%)	X^2	p-value
BMI			5.156	0.161
Underweight	11 (3.3)	9 (2.7)		
Normal	155 (46.3)	56 (16.7)		
Overweight	31 (9.3)	15 (4.5)		
Obese	36 (10.7)	22 (6.6)		
Waist circumference type			2.751	0.097
Normal	211 (63.0)	86 (25.7)		
Abdominal obesity	22 (6.6)	16 (4.8)		
Calcium intake			1.846	0.174
Low calcium intake	177 (52.7)	84 (25.0)		
Optimum calcium intake	57 (17.0)	18 (5.3)		
Physical activity			0.580	0.446
Less active	202 (67.3)	83 (27.7)		
Active	12 (4.0)	3 (1.0)		

The associations between BMI, waist circumference, calcium intake, physical activity and vitamin D deficiency using chi-square test were tabulated in Table 4.7. There were no associations between BMI, waist circumference (normal, abdominal obesity), calcium intake and physical activity level with vitamin D deficiency.

4.6.2 Hypothesis testing using binary logistic regression model

4.6.2.1 Socio-demographic characteristics (gender, race, school location and parents' education level).

The associations between socio-demographic characteristics and vitamin D deficiency after adjusting for gender, race, mother education level, school location and BMI were tabulated in Table 4.8. Girls' gender will have higher odds of suffering vitamin D deficiency (OR: 8.636 95% CI 3.837 to 19.440). Next, the Malay race also had greater odds of suffering vitamin D deficiency during adolescence (OR: 10.591 95% CI 3.732 to 32.132) than non-Malay.

Other than that, based on mother's education level, adolescents with their mother's education level start during secondary school showed higher odd being vitamin D deficient (OR: 5.298 95% CI 1.437 to 19.054) and the association become more significant with greater odd when their mothers had high education level (OR: 8.964 95% CI 2.169 to 37.042). It was found that Malay adolescents' girls with highly educated mothers are having greater odds of being vitamin D deficient in this study.

Table 4.8 Adjusted odd ratios (AOR) and 95% confidence intervals (95% CI) for associations between socio-demographic characteristics and vitamin D deficiency

Variables	Vitamin D Deficiency AOR (95% CI)	p-value
Gender		
Boy	REF[1]	
Girl	8.636 (3.837-19.440)	0.000
Race		
Malay	10.951 (3.732-32.132)	0.000
Non-Malay	REF[2]	
Parents education level		
Mothers		
No formal education/primary	REF[3]	
Secondary school	5.298 (1.473-19.054)	0.011
Higher education	8.964 (2.169-37.042)	0.002
Fathers		
No formal education/primary	REF[2]	
Secondary school	1.598 (0.523-4.887)	0.411
Higher education	3.410 (0.974-11.947)	0.055
School location		
Urban	0.970 (0.550-1.710)	0.916
Rural	REF[4]	

[1]*Adjusted by race, mother education level, school location and BMI.*
[2]*Adjusted by gender, mother education level, school location and BMI.*
[3] *Adjusted by gender, race, school location and BMI.*
[4] *Adjusted by gender, race, mother education level and BMI.*

4.6.2.2 BMI and waist circumference.

Table 4.9 Adjusted odd ratios (AOR) and 95% confidence intervals (95% CI) for associations between BMI, waist circumference and vitamin D deficiency

Variables	**Vitamin D Deficiency** AOR (95% CI)	**p-value**
BMI		
Underweight/Normal	REF	
Overweight/Obese	1.006 (0.561-1.806)	0.983
Waist circumference type		
Normal	REF	
Abdominal obesity	1.122 (0.500-2.514)	0.780

Adjusted by gender, race, mother education level, school location.

The association between BMI, waist circumference and vitamin D deficiency after adjusting for gender, race, mother education level, school location were tabulated in Table 4.9. After adjusting for above mentioned potential covariates, no significant associations were found between BMI and waist circumference.

4.6.2.3 Calcium Intake

Table 4.10 Adjusted odd ratios (AOR) and 95% confidence intervals (95% CI) for associations between calcium intake and vitamin D deficiency

Variables	**Vitamin D Deficiency** AOR (95% CI)	**p-value**
Calcium intake		
Low calcium intake	1.722 (0.861-3.442)	0.124
Optimum calcium intake	REF	

Adjusted by gender, race, mother education level, school location and BMI.

The association between calcium intake and vitamin D deficiency after adjusting for gender, race, mother education level, school location and BMI were tabulated in Table 4.10. After adjusting for above mentioned potential covariates, low calcium intake showed no significant associations in this study.

4.6.2.4 Physical Activity Level

Table 4.11 Adjusted odd ratios (AOR) and 95% confidence intervals (95% CI) for associations between physical activity level and vitamin D deficiency

Variables	Vitamin D Deficiency AOR (95% CI)	p-value
Physical activity		
Less active	0.294 (0.51-1.707)	0.173
Active	REF	

Adjusted by gender, race, mother education level, school location and BMI.

The association between physical activity level and vitamin D deficiency after adjusting for gender, race, mother education level, school location and BMI were tabulated in Table 4.11. After adjusting for above mentioned potential covariates, less physical activity showed no significant associations in this study.

Chapter 5

DISCUSSION

Vitamin D has a wide range of benefits, from bone health and calcium homeostasis to immune system and cell proliferation outside of the skeletal system. Deficiency of vitamin D has been numerous reported around the world according to published research worldwide (Tang et al., 2020b) and also reported among children and adolescents (Çelik et al., 2021a; Holick, 2017; Turer et al., 2013). Vitamin D insufficiency in youngsters has become more common in recent years all around the world (Koyama et al., 2020). While severe vitamin D deficiency causes rickets (Wagner & Greer, 2008), lower levels of vitamin D deficiency can cause a reduction in peak bone mass (Gudmundsdottir et al., 2020).

Adolescents are the stages where both macronutrients and micronutrients become crucial to support the growth of adolescents. Vitamin D deficiency may affect the growth of adolescents and studies also reported that low levels of vitamin D had significance with several chronic diseases including cardiovascular disease (Barbarawi et al., 2019; Manson et al., 2019). Effective interventions can be planned to reduce the prevalence of vitamin D deficiency among adolescents if information on the factors associated with vitamin D deficiency are ruled out.

This study provided results between socio-demographic characteristics (gender, race, parents education level and school location), body mass index (BMI), waist circumference, calcium intake and physical activity among adolescents aged 13 years old in Melaka, Negeri Sembilan, and Johor. The assessment of the vitamin D status was based on the serum 25(OH)D, and it was further categorised into two groups: deficient and optimal vitamin D status. The mean of serum 25(OH)D in this study was 61.10 nmol/L which was in line with the optimal level of the vitamin D status. The prevalence of vitamin D deficiency in this study was 30.4% (n=102) and more than half of the subjects, 69.6% (n=234) had optimal vitamin D status. The prevalence in this study is consistent with other previous studies and Malaysia also being located at latitude 3.13°N, 101.7°E with sufficient sun exposure (Quah et al., 2018a). Meanwhile, a study among 2680 children and adolescents aged 7-18 years in China reported that Vitamin D insufficiency and inadequacy were found to be prevalent in 7.5% and 44.4% of adolescents aged 14 to 18 (Tang et al., 2020c). Besides, a study in Indonesia among adolescents in urban settings reported that Vitamin D deficiency (25-hydroxyvitaminD serum 37.5 nmol/L) was found in 62.5% of the study population (Prafiantini & Thia, 2019).

5.1 Socio-demographic characteristics

In this study, girls were significantly associated with deficient vitamin D (28.3%), 8 times higher risk compared to the boys (2.1%). Vitamin D insufficiency or deficiency was far more common in adolescent girls and young adult women than in other age groups, similar to the trend reported in other Asian countries (Jang et al., 2019). In Malaysia, as for Muslim girls, they tend to have loose and cover up clothes with scarf when they were outside due to religion beliefs. Other than that, girls in Asia prefer to use sunscreen and sunshade clothing when they are outside. Other than that, in this study, most of the subjects were moderate physical activity (48.7%) and had low physical activity level (45.7%). This indicates that they may reduce their exposure time under the direct sunlight and as for girls, the risk can be higher.

A study among Japanese girls, they reported that girls in Japan will apply their sunscreen before having an outdoor event and this results in lower UV exposure (Koyama et al., 2020). A Brazilian cross-sectional study, they observed that during the early stage of adolescence, the levels of 25(OH)D will decrease and it will fluctuate back to stabilize during adulthood. The occurrence was more prevalent among girl adolescents during their pubertal period due to hormone changes. To explain more, a decrease in serum 25(OH) D levels has been widely reported in girls, suggesting that this stage could be a risk for hypovitaminosis D presentation, which, when severe menstrual cycle for a long time, can have detrimental repercussions for both linear development and peak bone mass changes (Leão et al., 2021).

Findings in this study also reported that Malay ethnicity were 10 times higher risk of vitamin D deficiency compared to non-Malay. In the MyHEART study, Malay girls aged 15 years old, particularly had 5.5 times higher risk to develop vitamin D deficiency as culturally Malay girls adolescents wore concealing clothes (Quah et al., 2018a). A previous MyHEART study, adolescents aged 13 years old reported Indian subjects had four times the risk of developing Vitamin D deficiency compared to Malay and Chinese. However, this study classified the race into only two groups, Malay and non-Malay as the non-Malay subjects were very small (16.1%) with 10.1% were Chinese, 5.3% were Indians and 0.7% of other ethnic groups. Study by Canadian Laboratory Initiative on Paediatric Reference Intervals (CALIPER) cohort of healthy children and adolescents reported that ethnicity difference (Black, Caucasian, East Asian and South Asian) and Caucasian ethnicity had significant association with vitamin D biomarkers and other few biomarkers such as amylase, ferritin, follicle-stimulating hormone (FSH), immunoglobulin A (IgA), immunoglobulin G (IgG) and immunoglobulin M (IgM). However, they conclude that more research is needed to confirm their findings since the study was the first comprehensive Canadian paediatric study examining ethnic-specific differences in common biomarkers (Tahmasebi et al., 2020).

This study attributes to other findings where parental education level had significant association with their adolescent's vitamin D deficiency. In unadjusted association (chi square test), both fathers and mothers with at least secondary school education level will influence the risk of their adolescents being vitamin D deficient. Further analysis using logistic regression reported that after being adjust by gender, race, school location and BMI, mothers start with secondary education level will have 5 times risk (OR: 5.298 95% CI 1.437 to 19.054) of their adolescents suffering vitamin D deficiency and the odd become greater, 8 times risk (OR: 8.964 95% CI 2.169 to 37.042) when the mothers had higher education level compared to mothers without formal education or primary only.

In this finding, there will be many growing points of speculations and points of arguments that need to be discussed. In a point of current situation or population influenced by technology, since young, when parents do not want to be disturbed while working, or when they want their children to be quiet and calm, they may encourage their children gadgets so that they can play at home and not go anywhere and still can be monitor in front of them, allowing them to finish their jobs or routines without interruption from their children (Perbowosari & Sudarsana, 2019) and this can promote sedentary lifestyle and reduce sun exposure (Roberts et al., 2017). The routine may be a habit until their children reach adolescence period and this life pattern was predicted by a study in Finland where, the relationship between childhood physical activity and adult physical activity exists in response to changes in physical activity throughout life (Kari et al., 2021). However, children of highly educated parents in another point of view, for example, may be encouraged to be physically active, or they may have more opportunities to do so with their parents' knowledge and awareness (Kari et al., 2021). Future studies requiring larger sample sizes and informative datasets covering, for example, health endowments, personality, and cognitive ability are required to investigate the potential mechanisms underlying the findings of this study.

This study shows no significant associations between school location and vitamin D deficiency even after adjusting for gender, race, mother education level and BMI (OR;0.970; 95% CI: 0.550-1.710). A study among the Italian population reported the same that either urban or rural location will not affect the vitamin D status to the population because of their location was less dense concentration of buildings that limit the sun exposure (Vierucci et al., 2014b). Besides, a previous local study showed that urban area subjects had lower mean vitamin D level compared to the rural area (Quah et al., 2018a).

Few more study supported the findings found in the current where in Cambodia, despite being generally close to the equator, children in urban areas had 43% higher rate of vitamin D insufficient (OR; 1.434; 95% CI: 1.007; 2.041)(Smith et al., 2016) and in Greece, children's residence in major metropolitan and semi-urban areas was linked to an elevated risk of vitamin D insufficient (OR;2.88; 95% CI: 1.28;6.51) and deficiency (OR; 1.49; CI: 1.16;1.93) (Manios et al., 2017). As Malaysia is near to the equator with abundant sunlight all over the country, the risk may be slightly less compared to other countries in a lower latitude and lower sun exposure (Song et al., 2021). Unfortunately, other underlying factors may contribute to the prevalence of vitamin D deficiency in this study. In this study the population also had lower physical activity reported and may reduce sun exposure.

5.2 Body mass index and waist circumference

In this study, both BMI and waist circumference do not have significant association with vitamin D deficiency among adolescents. Of the 585 subjects who participated in this study, 15.1% and 16.3% were overweight and obese, respectively meanwhile half of the subjects were normal in BMI category (63%). A small number of adolescents (11%) were classified as abdominal obesity and the other 89% of subjects had normal waist circumference. Other studies may have been influenced, such as study among adolescents in Italy, BMI had significant association with risk of vitamin D deficiency (OR 1.50) and hypovitaminosis D (OR 3.89) (Vierucci et al., 2014c).

Obesity may be associated with hypovitaminosis D, which is likely due to decreased vitamin D bioavailability due to vitamin D deposition in body fat compartments (Walker et al., 2014). Study by a Singaporean researcher explained that obesity may influence vitamin D deficiency status, but it appeared that body fat percentage indicated a much stronger predictor compared to BMI, and furthermore studies needed to be done among Asian population (Bi et al., 2016b). Furthermore, adiponectin has been identified as a key plasma protein linking vitamin D deficiency to paediatric obesity (Wortsman et al., 2000).

In MyHEART study, obesity had been significant with vitamin D deficiency during the adolescents were 13 years old and 15 years old (Al-Sadat et al., 2016; Quah et al., 2018), and during the adolescents were 13 years old, both normal and abdominal obesity had high percentage of vitamin D deficiency (15.5%, 86.2% respectively). Recently, a study suggested that when assessing vitamin D levels in obese adolescents, the free or bioavailable form of 25(OH)D is not preferable to the total form (Çelik et al., 2021b). The study also observed that the 25(OH)D threshold for vitamin D deficiency was lower in obese adolescents (23.5nmol/l) than in non-obese controls populations because the data imply that obese adolescents have a lower threshold for total vitamin D status than nonobese adolescents for PTH elevation, which is linked to bone resorption. In this study the threshold for vitamin D deficient was set up at <12.5 nmol/l according to the guidelines that maximally suppresses parathyroid hormone (PTH) secretion (Kennel et al., 2010; Misra et al., 2008; Pludowski et al., 2018) and recommended for adolescent cut off (Harel et al., 2013). This study, however, is unable to compare non-obese group threshold values. Age, sex, statistical methodologies, latitude, race, nutritional intake, and genetic factors are all confounding variables for determining the cut-off 25(OH)D level for vitamin D deficiency (Çelik et al., 2021b).

5.3 Calcium Intake

Lower intake of calcium was reported among adolescents in Malaysia (Suriawati et al., 2016). On average, this study also found out that 74.7% of the subjects did not meet the recommended nutrient intake 2017 (RNI) for calcium. The mean intake of calcium in this study was only 1003.23±868.156mg and below the daily recommendation level of 1300mg/day. Vitamin D is a nutrient that helps the body regulate calcium and bone metabolism (Song et al., 2021). Low calcium intake also can increase the risk of nutritional rickets in children besides lack of vitamin D (Gentile & Chiarelli, 2021).

It was found that children and adolescents in urban Saudi had the highest vitamin D status when their calcium intake was >800 mg/day (Al-Musharaf et al., 2012b). However, no association was found in this study between calcium intake X^2=1.846, p=0.174 with vitamin D deficiency. The test continued by adjusting with other covariates (sex, gender, ethnicity, mother's education level, school location and BMI) [(OR;1.722; 95% CI:0.861-4.442) (p=0.124)] (p<0.005) with vitamin D deficiency also do not have significant association found. Our results share a similar finding with healthy adolescents in Italy that the amount of calcium consumed in the diet had no influence on vitamin D levels (Vierucci et al., 2014b). Different with a systematic review regarding Vitamin D supplementation among children with cancer, they conclude that in clinical cases vitamin D supplementation must support calcium supplementation. This is because low levels of 25(OH)D reduce calcium and phosphate absorption, causing a rapid rise in parathyroid hormone (PTH) and bone resorption to release calcium (Atteveld et al., 2021). Other than that, other micronutrients such as phosphorus may also contribute and affect the dietary calcium intake but not being study in this research to look up for the association with vitamin D deficiency. Vitamin D plays a key role in calcium homeostasis and bone mineralization by regulating calcium mobilisation and renal reabsorption, as well as calcium and phosphorus absorption in the intestine (Reyer et al., 2021). Sufficient dietary supply of calcium (Ca) and phosphorus (P) is very important to ensure various biological processes such as bone formation, blood clotting, cell proliferation, and energy metabolism (Reyer et al., 2021). Future study may include other minerals (potassium, zinc, etc.) and vitamins (A, C, and K), vitamin D and calcium are significant dietary components that regulate bone mass (Polzonetti et al., 2020)

The evidence from this study regarding low calcium intake however suggests that intervention is needed to increase the calcium intake among adolescents in their daily diet. Increasing calcium intake through childhood and adolescence helps to improve bone health and avoid osteoporosis (Nguyen, 2021). It should be noted that calcium intake was recommended from daily diet and calcium supplement should be avoided as acute gastrointestinal symptoms, hypercalciuria, kidney stones, and myocardial infarction are all possible side effects of excessive calcium supplementation (Song et al., 2021).

5.4 Physical activity level

According to the National Health and Medical Survey of Malaysian Adolescents (NHMS 2017), 55% of Malaysian adolescents are physically inactive. Our study is in line with the previous data as almost half of the subjects 45.7% were less active and surprisingly, not more than 10%, only 5.6% of the subjects were physically active. That left 48.7% remaining of the subjects moderately active.

It has been discovered that increasing the duration of outdoor activities increases exposure to sunlight, which in turn increases vitamin D synthesis (Chen et al., 2007). A previous local study concluded that more than 7 hours per week of physical activity will at least increase 22% higher serum 25(OH)D (Gordon et al., 2004). MyHEART study reported that less exposure to the sunlight due to sedentary lifestyle among obese children will lower the vitamin D level (Quah et al., 2018a). Besides, a study in Italy among 427 adolescents concluded that subjects who exercised outside for less than 3 hours per week will have a higher risk of developing vitamin D deficiency (Vierucci et al., 2014b).

The association between physical activity level and vitamin D was tested and also adjusted by gender, race, mother education level, school location and BMI in this study and no association was found. Physical activity and vitamin D deficiency have no clear relationship; however, growing literature review already reported that both physical activity and vitamin D status may influence bone mineral density that may lead to early prognosis of osteoporosis (Alghadir et al., 2015; Zhu et al., 2017).

Although the associations between physical activity and vitamin D deficiency was not found in this study and differ to some extent compared to other studies, the prevalence of less active adolescents reported in this study need to be monitored and intervention must be planned to avoid practice of sedentary lifestyle. Optimum physical activity level during late adolescence will lower the risk of hypertension, type 2 diabetes, obesity, osteoporosis, colon cancer, breast cancer, anxiety, and depression (Fernberg et al., 2021).

CHAPTER 6

CONCLUSION

6.1 Limitations

This study may have some limitations. The first is, the race distribution of the 585 subjects with serum 25(OH)D data were majority from Malay race 83.9%. Further data collection is needed among adolescents around Malaysia including other states to clearly justify the finding for national references regarding vitamin D status among adolescents in Malaysia. Self-reporting questionnaires may contribute to bias data as the subjects answer the question to their personal understanding and honesty. Over or misreporting also may occur when answering the questionnaires. Furthermore, the smaller sample size for the analysis (933 to 585 serum 25(OH)D) may have altered the strength of associations between the various factors being studied and vitamin D deficiency. Other than that, this study was focused on calcium intake only, other micronutrients such as phosphorus may also affect the calcium absorption and vitamin D deficiency.

6.2 Strengths

This study included a large number of adolescents aged 13 years old from different states in southern Malaysia, Negeri Sembilan, Johor and Melaka. The subjects in this study also had a balanced background from rural and urban areas of staying. This study used similar statistical analysis (logistic regression model) with other nearest Malaysian findings for vitamin D deficiency among adolescents.

6.5 Recommendation

In the future study, further data collection is needed among adolescents around Malaysia including other states to clearly justify the finding for national references regarding vitamin D status among adolescents in Malaysia. In order to create successful health promotion activities, national policies, national guidelines and references, more longitudinal research is necessary to strengthen the finding variables and other possible risk factors of vitamin D deficiency in young people.

6.4 Conclusion

This study has explained vitamin D deficiency in adolescents aged 13 years in Malaysia is influenced by factors such as gender, race, and mother education level. This study showed that mothers' education level from secondary level to high education will increase the risk of vitamin D deficiency in their adolescents 5 to 8 times more compared to mothers with no education or only with primary education. Malay ethnicity also had significant association with 10 times higher risk of vitamin D deficiency compared to non-Malay during adolescence. Besides, this study found that girls will have 8 times higher risk being vitamin D deficient compared to the boys. This study found out the prevalence of lower calcium intake and less active among adolescent subjects can be used as reference for further studies and intervention.

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APPENDICES

Self-administered Questionnaire

1. Students Part (Part A: FFQ)

No. Rujukan/ *Reference no.* :

FAKULTI PERUBATAN DAN SAINS KESIHATAN
JABATAN PEMAKANAN DAN DIETETIK
FACULTY OF MEDICINE AND HEALTH SCIENCES
DEPARTMENT OF NUTRITION AND DIETETICS

SOAL SELIDIK
Questionnaires

(Untuk diisi oleh PELAJAR sahaja)
(To be completed by students only)

TAJUK KAJIAN / ***RESEARCH TITLE:***

PUTRA-Adol

KAJIAN SUSULAN BERKAITAN CORAK PEMAKANAN DISLIPIDEMIA REMAJA DAN KAITANNYA DENGAN PENYAKIT HATI BERLEMAK BUKAN ALKOHOL (NAFLD), KETEBALAN INTIMA MEDIA ARTERI KAROTID (CIMT) DAN SINDROM OVARIUM POLISISTIK (PCOS).

TRACKING OF A DIETARY PATTERN LINKED TO DYSLIPIDEMIA AND ITS PROSPECTIVE RELATIONSHIP WITH NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD), CAROTID INTIMA-MEDIAL THICKNESS (CIMT) AND POLYCYSTIC OVARY SYNDROME DURING ADOLESCENCE

PENYELIDIK/*RESEACHER* : **DR. GEETA APPANNAH**

TARIKH PENGUMPULAN DATA :
DATE OF DATA COLLECTION:

Semua maklumat yang diberikan di sini adalah dirahsiakan dan hanya digunakan untuk tujuan akademik sahaja. Kejayaan kajian ini amat bergantung kepada kerjasama pihak tuan/puan dalam menjawab kesemua soalan yang dikemukakan. Segala kerjasama yang tuan/puan berikan saya didahului dengan ribuan terima kasih.

Your personal information given in this questionnaire is for research purpose only. It will be kept strictly confidential. I would be very grateful if you could help me by completing this questionnaire

Arahan: Soal selidik ini mengandungi 2 bahagian. Sila baca soalan dengan teliti dan jawab semua soalan secara jujur yang mungkin. Jawapan bagi soalan-soalan tersebut tiada betul atau salah.
Instructions: This questionnaire consists of 2 sections. Please read the questions carefully and answer all the questions honestly. There is no right or wrong answer.

No. Rujukan/ *Reference no.* :

BAHAGIAN B / *SECTION B*

<u>Diari pemakanan/ *Food diary*</u>

SILA BACA MAKLUMAT BERIKUT SEBELUM MULA MENGISI DIARI ANDA
PLEASE READ THROUGH THESE PAGES BEFORE STARTING YOUR DIARY

Kami ingin mendapatkan maklumat pemakanan anda selama tiga hari daripada diari ini. Sila sertakan semua makanan dan minuman yang diambil di rumah dan di luar rumah i.e. di sekolah atau restoran. Sila pastikan anda tidak mengubah tabiat makan dan minum anda sepanjang mengisi diari ini. Sila kekalkan tabiat makanan biasa anak anda seperti biasa.

We would like you to keep this diary of everything you eat and drink over 3 days. Please include all food and beverages consumed at home and outside the home e.g. school or restaurants. It is very important that you do not change what your normally eat and drink just because you are keeping this record. Please keep to your usual food habits.

<u>Hari dan Tarikh / Day and Date</u>
Sila menulis hari dan tarikh di bahagian atas halaman setiap kali anda memulakan hari baru rekod.
Please write down the day and date at the top of the page each time you start a new day of recording.

<u>Slot masa / Time Slots</u>
Sila catatkan masa makan dalam setiap ruang yang disediakan.
Please write down the time of each eating occasion into the space provided.

<u>Di mana? / Where?</u>
Bagi setiap masa makan, sila beritahu kami apa bilik atau bahagian rumah anak anda berada apabila makan, contohnya dapur, ruang tamu. Jika anak anda makan di luar contohnya, kantin sekolah, restoran, restoran rantaian makanan segera atau dalam kereta, sila tulis lokasi tersebut.
For each eating occasion, please tell us what room or part of the house your child were in when eating, e.g. kitchen, living room. If your child ate at the school canteen, a restaurant, fast food chain or car, write that location down.

<u>TV buka? / TV on?</u>
Kami ingin tahu adakah anak anda menonton televisyen sambil makan. Bagi mereka yang

2

2. Student Part (Part B: Physical Activity)

Rujukan/ *Reference no.* :

FAKULTI PERUBATAN DAN SAINS KESIHATAN
JABATAN PEMAKANAN DAN DIETETIK
FACULTY OF MEDICINE AND HEALTH SCIENCES
DEPARTMENT OF NUTRITION AND DIETETICS

SOAL SELIDIK (BUKU SOALAN)
Questionnaires (QUESTIONS BOOKLET)

TAJUK KAJIAN / *RESEARCH TITLE*:

KAJIAN SUSULAN BERKAITAN CORAK PEMAKANAN DISLIPIDEMIA REMAJA DAN KAITANNYA DENGAN PENYAKIT HATI BERLEMAK BUKAN ALKOHOL (NAFLD), KETEBALAN INTIMA MEDIA ARTERI KAROTID (CIMT) DAN SINDROM OVARIUM POLISISTIK (PCOS).

TRACKING OF A DIETARY PATTERN LINKED TO DYSLIPIDEMIA AND ITS PROSPECTIVE RELATIONSHIP WITH NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD), CAROTID INTIMA-MEDIAL THICKNESS (CIMT) AND POLYCYSTIC OVARY SYNDROME DURING ADOLESCENCE

PENYELIDIK/*RESEACHER* : **DR. GEETA APPANNAH**

TARIKH PENGUMPULAN DATA :
DATE OF DATA COLLECTION:

Semua maklumat yang diberikan di sini adalah dirahsiakan dan hanya digunakan untuk tujuan akademik sahaja. Kejayaan kajian ini amat bergantung kepada kerjasama pihak tuan/puan dalam menjawab kesemua soalan yang dikemukakan. Segala kerjasama yang tuan/puan berikan saya didahului dengan ribuan terima kasih.

Your personal information given in this questionnaire is for research purpose only. It will be kept strictly confidential. I would be very grateful if you could help me by completing this questionnaire

Arahan: Soal selidik ini mengandungi 8 bahagian. Sila baca soalan dengan teliti dan jawab semua soalan secara jujur yang mungkin di dalam kertas jawapan yang telah disediakan. Jawapan bagi soalan-soalan tersebut tiada betul atau salah.
Instructions: This questionnaire consists of 8 sections. Please read the questions carefully and answer all the questions honestly in the answer sheet provided by the researcher. There is no right or wrong answer.

No. Rujukan/ *Reference no.* :

BAHAGIAN A / *SECTION A:* *Sila bulatkan satu pilihan jawapan yang sesuai*

<u>Butiran Maklumat Aktiviti Fizikal/*Information on Physical Activity*</u>

1. Adakah anda telah melakukan sebarang aktiviti yang berikut pada 7 hari yang lepas (minggu lepas)? Jika Ya, berapa kali? (Bulatkan sekali sahaja untuk setiap baris)
Have you done any of the following activities in the past 7 days (last week)? If yes, how many times? (Mark only one circle per row.)

No	**Aktiviti** *Activity*	**Tidak** *No*	**1 – 2 kali** *1-2 times*	**3 – 4 kali** *3-4 times*	**5 – 6 kali** *5-6 times*	**Lebih daripada 6 kali** *More than 6 times*
1	Melompat *Jumping*	1	2	3	4	5
2	Berjalan untuk senaman *Walking for exercise*	1	2	3	4	5
3	Mengayuh basikal *Bicycling*	1	2	3	4	5
4	berjoging atau berlari *Jogging or running*	1	2	3	4	5
5	Senaman aerobic *Aerobics*	1	2	3	4	5
6	Berenang *Swimming*	1	2	3	4	5
7	Besbol, Sofbol *Baseball, softball*	1	2	3	4	5
8	Menari *Dance*	1	2	3	4	5
9	Bola Sepak *Football*	1	2	3	4	5
10	Badminton *Badminton*	1	2	3	4	5
11	bola tampar *Volleyball*	1	2	3	4	5
12	bola keranjang *Basketball*	1	2	3	4	5
13	lain-lain:__________ *Others*	1	2	3	4	5

2. Parent Part

No. Rujukan/ Reference no. :

FAKULTI PERUBATAN DAN SAINS KESIHATAN
JABATAN PEMAKANAN DAN DIETETIK
FACULTY OF MEDICINE AND HEALTH SCIENCES
DEPARTMENT OF NUTRITION AND DIETETICS

SOAL SELIDIK
Questionnaires

(Untuk diisi oleh IBU/BAPA/PENJAGA sahaja)
(To be completed by mother/father/guardian only)

TAJUK KAJIAN / *RESEARCH TITLE:*

KAJIAN SUSULAN ANTARA CORAK PEMAKANAN DISLIPIDEMIA DAN KAITANNYA DENGAN PENYAKIT HATI BERLEMAK BUKAN ALKOHOL (*NAFLD*), KETEBALAN INTIMA MEDIA ARTERI KAROTID (*CIMT*) DAN SINDROM OVARI POLISISTIK (*PCOS*)

TRACKING OF A DIETARY PATTERN LINKED TO DYSLIPIDEMIA AND ITS PROSPECTIVE RELATIONSHIP WITH NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD), CAROTID INTIMA-MEDIAL THICKNESS (CIMT) AND POLYCYSTIC OVARY SYNDROME DURING ADOLESCENCE

PENYELIDIK/*RESEACHER* : **DR. GEETA APPANNAH**

TARIKH PENGUMPULAN DATA :
DATE OF DATA COLLECTION:

Semua maklumat yang diberikan di sini adalah dirahsiakan dan hanya digunakan untuk tujuan akademik sahaja. Kejayaan kajian ini amat bergantung kepada kerjasama pihak tuan/puan dalam menjawab kesemua soalan yang dikemukakan. Segala kerjasama yang tuan/puan berikan saya didahului dengan ribuan terima kasih.

Your personal information given in this questionnaire is for research purpose only. It will be kept strictly confidential. I would be very grateful if you could help me by completing this questionnaire

Arahan: Soal selidik ini mengandungi 3 bahagian. Sila baca soalan dengan teliti dan jawab semua soalan secara jujur yang mungkin. Jawapan bagi soalan-soalan tersebut tiada betul atau salah.
Instructions: This questionnaire consists of 3 sections. Please read the questions carefully and answer all the questions honestly. There is no right or wrong answer.

No. Rujukan/ Reference no. :

Sila isikan butiran berikut dan tandakan "√" pada yang ruang berkenaan.
Please fill in the following details and mark "√" in the relevant column.

BAHAGIAN A / *SECTION A*

Maklumat Peribadi Ibu Dan Bapa atau Penjaga/ Father and Mother's or Guardians' Personal Information

		Bapa / Penjaga Lelaki *Father / Guardian*	Ibu / Penjaga Perempuan *Mother / Guardian*
1.	Umur *Age*	_____tahun/year	_____tahun/year
2.	Status Bekerja *Working status*	☐Bekerja *Working* ☐Tidak bekerja *Not working*	☐Bekerja *Working* ☐Tidak bekerja *Not working*
3.	Jenis Pekerjaan *Occupation type*	☐Pengurusan *Managers* ☐Profesional *Professionals* ☐Juruteknik dan separa profesional Technicians and associate professionals ☐Staf sokongan/Perkeranian *Clerical support workers* ☐Staf perkhidmatan & staf jualan *Service & sales workers* ☐Staf berkemahiran pertanian, perhutanan & perikanan *Skilled agricultural, forestry & fishery worker* ☐Perdagangan/perniagaan *Craft and related trade workers* ☐Operator pemasangan/ pengendali mesin *Plant and machine-operators & assemblers* ☐Pekerjaan asas *Elementary occupations* ☐Pegawai bersenjata (tentera/polis dan lain-lain) *Armed forced occupations*	☐Pengurusan *Managers* ☐Professional *Professionals* ☐Juruteknik dan separa profesional Technicians and associate professionals ☐Staf sokongan/Perkeranian *Clerical support workers* ☐Staf perkhidmatan & staf jualan *Service & sales workers* ☐Staf berkemahiran pertanian, perhutanan & perikanan *Skilled agricultural, forestry & fishery worker* ☐Perdagangan/perniagaan *Craft and related trade workers* ☐Operator pemasangan/pengendali mesin *Plant and machine-operators & assemblers* ☐Pekerjaan asas *Elementary occupations* ☐Pegawai bersenjata (tentera/polis dan lain-lain) *Armed forced occupations*
4.	Taraf Pendidikan Tertinggi *Highest Education level*	☐Tiada pendidikan formal *No formal education* ☐Sekolah rendah *Primary school* ☐Sekolah menengah *Secondary school*	☐Tiada pendidikan formal *No formal education* ☐Sekolah rendah *Primary school* ☐Sekolah menengah *Secondary school*

1

3. MyUM Adolescents FFQ reference.

Kekerapan Pengambilan Makanan Remaja di Malaysia (UM)

(MyUM Adolescent Food Frequency Questionnaire)

Nama: ______________________ ID: ______________________

No Kad Pengenalan: ______________________ Tarikh: ______________________

Nama Sekolah: ______________________

4. Plagiarism check (Turnitin).

FYP Draft Thesis 1

ORIGINALITY REPORT

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