UNIVERSITI PUTRA MALAYSIA

BONE RESORPTION MARKER AND ASSOCIATED FACTORS AMONG POSTMENOPAUSAL CHINESE WOMEN IN SENIOR CITIZEN CLUBS IN KUALA LUMPUR AND SELANGOR, MALAYSIA

LEIU KOK HONG

FPSK(m) 2019 3

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By

LEIU KOK HONG

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in fulfilment of the requirement for the Degree of Master of Science

January 2019

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

BONE RESORPTION MARKER AND ASSOCIATED FACTORS AMONG POSTMENOPAUSAL CHINESE WOMEN IN SENIOR CITIZEN CLUBS IN KUALA LUMPUR AND SELANGOR, MALAYSIA

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Chairperson : Chin Yit Siew, PhD
Faculty : Medicine and Health Sciences

Bone resorption is an ongoing process in the body that affects bone health status. Increased bone resorption reduces the bone mineral density (BMD) of women and lead to osteoporosis. Assessment of bone resorption using biomarkers gained attention recently due to its ability to detect bone loss earlier and more representative compare to BMD measured at only specific skeletal sites. Many of the previous studies have focused on factors that contribute to low BMD, but there were limited studies on bone resorption among postmenopausal Chinese women in Malaysia. Thus, the objective of current study was to determine the factors that contribute to bone resorption among postmenopausal Chinese women.

Anthropometric indices, namely body weight, height, waist circumference and body fat percentage of the respondents were measured. Respondents were interviewed by the researcher using a questionnaire, which comprised questions on socio-demographic characteristics, smoking behaviour, physical activity, sun exposure and dietary intake. Fasting blood samples of the respondents were collected for serum 25(OH)D and serum collagen type 1 cross-linked C-telopeptide (CTx-1) analysis. Stepwise multiple linear regression was utilised for the final analysis.

There were 214 respondents from seven consented senior citizen clubs in Kuala Lumpur and Selangor participated in the current study. The mean age of the respondents was 67.2 ± 6.6 years old, with an average 16.1 ± 7.8 year of menopause. Most of the respondents were married (77.6%), attained secondary education (40.7%), retired (49.5%) with low monthly household income (44.4%). Approximately two out of five respondents (38.8%) were overweight and obese, while nearly half of them (48.6%) had abdominal obesity (waist circumference ≥

80.0 cm). Most of the respondents (82.2%) had an unhealthy body fat percentage (≥ 32.0%). Almost all of the respondents (98.6%) were non-smokers, but one-quarter of them (24.3%) had second-hand smoke exposure either at home or work. More than half of the respondents were moderately active (58.9%) with a median sun exposure duration of 180.0 (60.0, 300.0) minutes per week. The respondents obtained a mean score of 66.9 ± 9.9 for their overall diet quality, which needs improvement. There were 33.2% and 49.5% of the respondents had deficient (<30.0 nmol/L) and inadequate (30.0 - <50.0 nmol/L) serum 25(OH)D level respectively, and their mean level of serum CTx-1 was 0.5 ± 0.2 ng/mL.

In stepwise multiple linear regression, 5.9% of the variances in serum CTx-1 was explained by younger age (B = - 0.006) and being moderately active (B = 0.065) ($F = 6.632$, $p < 0.01$). In conclusion, the present study reported younger age and being moderately active contributed to higher bone resorption among postmenopausal Chinese women. Further in-depth study is needed to explain the role of physical activity in bone health among postmenopausal women in consideration of the age factor.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENANDA PENYERAPAN TULANG DAN FAKTOR YANG BERKAITAN DALAM KALANGAN WANITA CINA SELEPAS MENOPAUS DI KELAB WARGA EMAS DI KUALA LUMPUR DAN SELANGOR, MALAYSIA

Oleh

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Proses penyerapan tulang merupakan proses berterusan di dalam badan yang mempengaruhi status kesihatan tulang. Peningkatan dalam proses penyerapan tulang akan mengurangkan kepadatan mineral tulang (BMD) dalam kalangan wanita dan menyebabkan osteoporosis. Penilaian bagi proses penyerapan tulang menggunakan penanda mendapat perhatian sejak kebelakangan ini kerana keupayaannya untuk mengesan kehilangan jisim tulang dengan lebih awal dan lebih jelas berbanding dengan BMD, yang dinilai hanya pada sebahagian rangka tulang yang spesifik. Banyak kajian sebelum ini memberikan tumpuan kepada faktor-faktor yang menyumbang kepada BMD yang rendah, namun kajian mengenai penyerapan tulang dalam kalangan wanita Cina yang menapos dalam Malaysia adalah terhad. Oleh itu, objektif kajian ini adalah untuk menentukan faktor-faktor yang menyumbang kepada proses penyerapan tulang dalam kalangan wanita Cina selepas menapos.

Indeks antropometrik, iaitu berat badan, ketinggian, lilitan pinggang dan peratusan lemak dalam badan bagi responden adalah diukur. Responden telah ditemu bual oleh penyelidik dengan menggunakan borang soal selidik yang merangkumi soalan mengenai latar belakang sosio-demografik, tingkah laku merokok, aktiviti fizikal, pendedahan kepada cahaya matahari dan pengambilan makanan. Sampel darah puasa bagi setiap responden telah dikumpulkan untuk analisis serum 25 (OH) D dan analisis serum kolagen C-telopeptida jenis 1 (CTx-1). Regresi linier berganda *stepwise* telah digunakan untuk analisis terakhir.

Terdapat 214 responden daripada tujuh buah kelab warga emas di Kuala Lumpur dan Selangor telah memberi persetujuan menyertai kajian ini. Purata umur responden adalah 67.2 ± 6.6 tahun, dengan purata 16.1 ± 7.8 tahun menapos. Kebanyakan responden telah berkahwin (77.6%), memperolehi

pendidikan di sekolah menengah (40.7%), telah bersara (49.5%) dengan pendapatan isi rumah bulanan yang rendah (44.4%). Lebih kurang dua daripada lima responden (38.8%) mempunyai berat badan berlebihan dan obes, manakala hampir separuh daripada mereka (48.6%) mempunyai obesiti abdomen (ukuran lilitan pinggang ≥ 80.0 cm). Kebanyakan responden (82.2%) mempunyai peratusan lemak badan yang tidak sihat (≥ 32.0%). Hampir kesemua responden (98.6%) tidak merokok, namun terdapat satu perempat daripada mereka (24.3%) terdedah kepada asap rokok sama ada di rumah atau di tempat kerja. Lebih daripada separuh responden adalah sederhana aktif (58.9%) dengan median tempoh pendedahan kepada matahari sebanyak 180.0 (60.0, 300.0) minit setiap minggu. Secara keseluruhannya, responden mendapat min 66.9 ± 9.9 bagi skor kualiti mereka, dan ini memerlukan penambahbaikan. Terdapat 33.2% dan 49.5% responden yang mempunyai tahap serum 25 (OH) D yang kurang (< 30.0 nmol/L) dan tidak mencukupi (30.0 - < 50.0 nmol/L) masing-masing, dan min tahap serum CTx-1 adalah 0.5 ± 0.2 ng/mL.

Analisis regresi linier berganda *stepwise* menunjukkan 5.9% daripada varians bagi serum CTx-1 dijelaskan oleh umur yang lebih muda (B = - 0.006) dan sederhana aktif (B = 0.065) (F = 6.632, p <0.01). Kesimpulannya, kajian ini melaporkan bahawa umur yang lebih muda dan tahap aktiviti fizikal yang sederhana aktif menyumbang kepada proses penyerapan tulang yang lebih tinggi di kalangan wanita Cina selepas menapos. Kajian yang lebih mendalam diperlukan untuk menjelaskan peranan aktiviti fizikal dalam kesihatan tulang di kalangan wanita menapos dengan pertimbangan faktor umur.

ACKNOWLEDGEMENT

Without any hesitation, I would not be so successful without the generous support given by a number of individuals. Firstly, I would like to dedicate my sincere gratitude to my supervisor, Assoc. Prof. Dr Chin Yit Siew. I feel grateful to have her guidance, support, encouragement and supervision throughout the whole process. Undeniably, I have learned a lot from her, and she have enhanced my interest in research on community nutrition. Without all the advice, I would not be able to complete my research smoothly. Besides, my sincere gratitude goes to my co-supervisors, Assoc. Prof. Dr. Chan Yoke Mun for supporting my research with her grant as well as advice and constructive suggestions alongside with Prof. Zalilah Mohd Shariff.

Secondly, I would like to express my deepest gratitude to my family for their love and support. I feel thankful that they have been very supportive whenever I need them. The support and trust that they gave me has been one of the driving forces that motivate me to work hard to complete my research. Nevertheless, I would like to thank the presidents and respondents from the National Council of Senior Citizens Organisations Malaysia (NACSCOM). Their support and cooperation throughout the whole data collection period have been very crucial to me, as their contributions have directly led to the success of this master research.

Last but not least, I would like to acknowledge my teammates and friends who had directly or indirectly helped me throughout the whole process. Without all of you, this master research would not be a success. It has been great to be able to work with all of you. Thank you very much.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the supervisory committee were as follows:

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LIST OF ABBREVIATIONS

1,25(OH)2D3	1,25-dihydroxyvitamin D
25(OH)D	25-hydroxyvitamin D
AHEI	Alternative Healthy Eating Index
BMD	Bone mineral density
BMI	Body mass index
BMR	Basal metabolic rate
BMU	Basic multicellular unit
BSA	Body surface area
CSF-1	Colony stimulating factor-1
CTx-1	C-terminal telopeptide of type I collagen
DDS	Dietary Diversity Score
DEXA	Dual energy X-ray absorptiometry
DPD	Deoxypyridinoline
DQI	Dietary Quality Index
DQI-I	Dietary Quality Index International
DQI-R	Dietary Quality Index Revised
DVS	Dietary Variety Score
EFSA	European Food Safety Authority
FFQ	Food frequency questionnaire
FMP	Final menstrual period
GATS	Global Adult Tobacco Survey
GPAQ	Global Physical Activity Questionnaire
HEI	Healthy Eating Index
HEI-2005	Healthy Eating Index-2005
HEI-2010	Healthy Eating Index-2010
HRT	Hormone replacement therapy
IGF-1	Insulin-like growth factors
IL-11	Interleukin-11
IOF	International Osteoporosis Foundation
IQR	Interquartile range
MANS	Malaysian Adult Nutrition Survey
MDG	Malaysian Dietary Guidelines
MET	Metabolic equivalent

MOS	Malaysian Osteoporosis Foundation
NACSCOM	National Council of Senior Citizens Organisations Malaysia
NTX-1	N-terminal telopeptide of type I collagen
OPG	Osteoprotegerin
OSM	Oncostatin M
PGE2	Prostaglandin E2
PTH	Parathyroid hormone
PTHrP	Parathyroid hormone-related protein
RANK	Receptor activator of NF-KB
RANKL	RANK ligand
RFS	Recommended Food Score
RNI	Recommended nutrient intake
SEI	Sun exposure index
TRAP	Tartrate-resistant acid phosphatase
WHO	World Health Organisation

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Bone is an active and vital tissue in the human body. Bone provides three key functions, such as provides support and attachment sites for muscles, protects vital organs like bone marrow and brain, and acts as the primary storage for calcium and phosphate (Feng & McDonald, 2011). Bone undergoes remodelling, a complex process whereby old bone tissues are constantly replaced by new ones throughout life to perform all these functions (Hadjidakis & Androulakis, 2006). The remodelling process is managed by the basic multicellular unit (BMU), which comprises of osteoclasts (bone resorption cells), osteoblasts (bone formation cells), osteocytes within the bone matrix and osteoblast-derived lining cells that cover the bone surfaces (Sims & Gooi, 2008). When the balance between osteoclastic bone resorption and osteoblastic bone formation is achieved, the bone mass or quality is retained after every remodelling cycle (Feng & McDonald, 2011).

On average, a person undergoes a period of net gain in bone mass since birth until the age of 30 to 40 years old, then followed by a plateau in bone mass for a few years before undergoing a period of net loss in bone mass after the age of 45 years old (Christenson, 1997). The rationale behind this is the bone formation process requires at least three months, whereas the bone resorption process requires only two to three weeks, and these processes naturally contribute to a consistent net bone loss, especially in later life (Christenson, 1997; Harada & Rodan, 2003). Both men and women undergo similar bone remodelling process and should have similar bone mass. However, women are more susceptible to age-related bone loss, especially after menopause. This is possibly due to the decline in ovarian function after menopause for 5 to 10 years, which triggers a quick reduction in oestrogen levels and thus triggers rapid bone loss in women (Feng & McDonald, 2011; Khosla & Riggs, 2005; Sowers et al., 2013).

Besides age and sex, certain pathological conditions such as hyperparathyroidism may trigger an imbalance between bone resorption and bone formation, and lead to the development of bone disorders. Examples of bone disorders are osteoporosis, rickets, Paget's disease, renal osteodystrophy and osteopetrosis (Feng & McDonald, 2011; Sims & Gooi, 2008). Among all these bone disorders, osteoporosis is recognised as one of the major global health issues. Osteoporosis reduces bone mass and deteriorates bone structure, then increases the risk of bone fractures at hip, spine and other sites that lowers the quality of life of an individual (Khashayar, 2017). There are about one out of three women and one out of five men aged 50 years old and above projected to sustain an osteoporotic fracture globally (Svedbom et al., 2013).

The national prevalence of osteoporosis in Malaysia is not well documented, but a recent local study in Kuala Lumpur reported about 8.0% of females and 10.6% of males aged 50 years and above had osteoporosis (Chin, Kamaruddin, Low, & Ima-Nirwana, 2016). Similarly, there was no latest data on osteoporotic hip fractures other than a local study conducted in 1997, whereby the incidence rate was 65 per 100 000 for men and 141 per 100 000 for women aged 50 years and above (Lee & Khir, 2007). Besides, Chinese women had the highest hip fracture rates (220 per 100 000) compared to Indian (200 per 100 000) and Malay (40 per 100 000) (Lee & Khir, 2007). Malaysia is predicted to have an approximate triple growth in the number of osteoporotic hip fracture from 3908 in 2018 to 14 264 in 2050 among female aged 50 years and above (Cheung et al., 2018).

Despite that, bone health is still lack of recognition or to be given priority compared to other chronic diseases, for example coronary heart disease, hypertension and diabetes mellitus in Malaysia (Mithal, Ebeling, & Kyer, 2013). Based on the data from the Malaysian Osteoporosis Foundation (MOS), the average treatment cost for each osteoporotic hip fracture case was USD 6000.00 (Mithal et al., 2013), which is almost twice the median treatment cost of USD 2943.74 in the Asian region (Mohd-Tahir & Li, 2017). This high treatment cost will be a huge burden to the patient, the hospital, as well as the country in the long term.

There are several tools in determining bone health status, and dual energy X-ray absorptiometry (DEXA) has been the gold standard among all (Christenson, 1997). However, DEXA is unable to capture the anticipated rate of bone resorption within a short duration, which can affect the predictability of osteoporosis and fractures, then delay the window of opportunity for treatment (Bonnick & Shulman, 2006; Demers & Kleerekoper, 1994). Thus, another approach is introduced by measuring the biomarkers that are discharged into the urine or blood through bone resorption (Looker et al., 2000). These biomarkers reflect the overall bone resorption rate in the body and complement the information on bone mineral density (BMD) to predict osteoporotic fracture risk (Khashayar, 2017; Ross & Knowlton, 1998).

There are many bone resorption biomarkers, such as serum C-terminal telopeptide of type I collagen (CTx-1), N-terminal telopeptide of type I collagen (NTX-1), Deoxypyridinoline (DPD) and Tartrate-resistant acid phosphatase (TRAP) 5b (Eastell et al., 2018). CTx-1 has been recommended by the International Osteoporosis Foundation (IOF) and the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) as the standard reference marker for bone resorption in clinical studies (Vasikaran et al., 2011). The justification from IOF and IFCC is CTx-1 more bone specific and the CTx-1 assay used is widely accessible, cheap and simple handling procedure compared to other markers (Eastell et al., 2018).

In short, there is a need to recognise elevated bone resorption as one of the risk factors for poor bone health status among postmenopausal Chinese women in

(Department of Statistics Malaysia, 2017a), and the percentage of people aged 60 years or over above is anticipated to rise from 9.2% in 2015 to 14.7% in 2050 (UN, Department of Economic and Social Affairs, Population Division, 2015).

1.2 Problem Statement

Bone remodelling happens in the human body continuously, but bone resorption starts to increase gradually when a person gets older (Christenson, 1997; Harada & Rodan, 2003). This gradual increase of bone resorption affects women more commonly in relation to their genetically smaller body stature and shorter period of menarche, which contribute to lower BMD as compared to men (Gordon et al., 2017; Heaney et al., 2000). In addition, women after menopause have lower oestrogen production and their bodies are unable to suppress the osteoclast activity, so it contributes to even higher rates of bone resorption and increase their susceptibility of osteoporotic fractures (Zhao et al., 2007). Therefore, it is important to focus more on postmenopausal women regarding bone resorption.

Aside from biological factor, there are other factors that influence bone resorption in the body. One of the factors is body mass index (BMI), whereby many past studies reported an inverse relationship between BMI and bone resorption among women (Hapidin, Mahmood, & Harith, 2013; Laroche et al., 2017; Puntus, Schneider, Meran, Peterlik, & Kudlacek, 2011; Ravn et al., 1999), especially during the perimenopause period (Sowers et al., 2013). However, BMI is just a proxy for body composition, and it cannot differentiate either fat mass or lean mass contributes to the fluctuations in bone resorption (Sowers et al., 2013). Aging also alters the percentage and distribution of fat and lean mass in older adults (Kuk, Saunders, Davidson, & Ross, 2009; St-Onge & Gallagher, 2010), which further increases the complexity of the link between BMI and bone resorption. Therefore, the inclusion of three different anthropometric indices such as BMI, body fat percentage and waist circumference are necessary in the current study to determine their associations with bone resorption.

Besides, the daily activities of older adults, such as physical activity, smoking behaviour and sun exposure affects bone resorption. Previous studies reported that having moderate intensity physical activity for half an hour or more every day is beneficial to BMD at various sites among postmenopausal women (Kim, Shin, Lee, Myung, & Kim, 2012; Muir, Ye, Bhandari, Adachi, & Thabane, 2013). Physical activity helps to transfer the load to the bone, strengthens the muscles and improves the balance of an individual, then maintains BMD (Schwarz, 2004). Despite that, there were inconsistent findings between physical activity and bone resorption (Ardawi, Rouzi, & Qari, 2012; Bergstrom, Parini, Gustafsson, Andersson, & Brinck, 2012), which might be due to metabolic acidosis after physical activity and mechanical loading created during physical activity that affected bone resorption (Maimoun & Sultan, 2011). Besides, it is unclear regarding the way different types of physical activity, especially weight-bearing activities such as brisk walking and climbing stairs (Abrahamsen, Brask-

Lindemann, Rubin, & Schwarz, 2014) affects bone resorption. Therefore, the type and duration of physical activities should be included in determining the link between physical activity and bone resorption among postmenopausal women.

Smoking is another lifestyle factor related to bone resorption. Previous longitudinal studies reported that smokers who smoke more than one pack per day have higher possibility of having osteoporosis compared to those former and non-smokers (Brook, Balka, & Zhang, 2012; Thorin, Wihlborg, Akesson, & Gerdhem, 2016). Based on the national health survey in Malaysia, there were more males (43.0%) who are current smokers compared to females (1.4%) (Institute for Public Health, 2015b). However, there were more non-smoking females (31.3%) who were exposed to tobacco smoke at home compared to their counterparts (17.1%) (Institute for Public Health, 2015b). Regardless of direct or indirect smoking, smoking may lower oestrogen level and reduce calcium absorption and retention in the body, which leads to increased bone resorption (Yoon, Maalouf, & Sakhaee, 2012). With the high prevalence of second-hand smoke exposure among females, there are limited published studies in Malaysia that associate smoke exposure with bone resorption among females, especially after menopause.

Next, sun exposure is another lifestyle factor that is linked with bone resorption. According to past literature (Holick, 2004), exposure to sunlight helps to activate vitamin D in the human body for maintenance of calcium metabolism that influences bone resorption. Theoretically, Malaysians should have sufficient sun exposure and a good vitamin D status because Malaysia is blessed with an abundance of sunlight. However, low serum vitamin D among Malaysians are evident, especially among postmenopausal women (Chee et al., 2010; Rahman, Chee, Yassin, & Chan, 2004; Shafinaz & Moy, 2016) and is related to higher bone resorption compared to those with high vitamin D status (Hernandez et al., 2013; Kuchuk, van Schoor, Pluijm, Chines, & Lips, 2009; Napoli et al., 2014). Therefore, it is crucial to include sun exposure into the current study and determine its strength in affecting bone resorption among postmenopausal women.

Last but not least, having an optimal diet quality is equally important, especially to women after menopause with high bone resorption. Diet quality focuses on the overall quality of dietary intake in terms of variety, balance and moderation (Waijers, Feskens, & Ocke, 2007; Wirt & Collins, 2009), as highlighted in the Malaysian Dietary Guidelines (MDG) 2010 (National Coordinating Committee on Food and Nutrition, 2010). Previous studies in Malaysia (Chee, Suriah, Chan, Zaitun, & Chan, 2003; Chee et al., 2002) reported that postmenopausal women failed to achieve the daily recommended intake of milk and dairy products (National Coordinating Committee on Food and Nutrition, 2010). Moreover, only one out of 10 adults aged 50 years and above achieved the recommended intake of three servings of vegetables and two servings of fruits, based on the data from NHMS 2015 (Institute for Public Health, 2015a). These results showed that postmenopausal women in Malaysia are having inadequate intake of milk, dairy products, fruits and vegetables, which contain essential nutrients, for instance

calcium, potassium and magnesium that are required for good bone health status (Byberg, Bellavia, Orsini, Wolk, & Michaelsson, 2015; Tucker et al., 2002). With this worrying situation on diet quality among postmenopausal women, it is also important to investigate whether they have an adequate intake from a variety of food groups like cereals, poultry, meat, fish, seafood, legumes, and how does the overall diet quality contribute towards bone resorption.

To conclude, previous studies have shown the associations between anthropometric indices, lifestyle factors (physical activity, smoking behaviour and sun exposure), vitamin D and diet quality with bone resorption, respectively. However, there is no study that reports on the contribution of anthropometric indices, lifestyle factors, vitamin D and diet quality towards bone resorption. Hence, this study aims to determine the contribution of anthropometric indices, lifestyle factors, vitamin D and diet quality towards bone resorption among postmenopausal women. There are two research questions to be answered in this study:

i. What is the mean level of bone resorption marker (CTx-1) among postmenopausal women?
ii. What is the contribution of socio-demographic characteristics, anthropometric indices, lifestyle factors (physical activity, smoking behaviour & sun exposure), vitamin D and diet quality towards bone resorption among postmenopausal women?

1.3 Significance of the Study

The current study provides an overview on the mean level of bone resorption marker (CTx-1) among postmenopausal Chinese women in Kuala Lumpur and Selangor. Besides, the current study determines the factors that associated with bone resorption markers, such as socio-demographic characteristics, anthropometric indices (BMI, waist circumference and body fat percentage), lifestyle factors (physical activity, smoking behaviour and sun exposure), serum vitamin D and diet quality. Furthermore, the present study determines the factors that significantly contribute to bone resorption marker (CTx-1) while filling in the knowledge gap in this area of interest. These findings may serve as important references for the researchers and health care professionals in understanding the factors that associated with bone resorption marker among women.

The findings of the current study can provide the latest data on vitamin D status of postmenopausal Chinese women in Kuala Lumpur and Selangor. With that, researchers and healthcare professionals can recognise where Malaysia stands in combating vitamin D deficiency compared to other countries, and generate new ideas through partnership with government organisations and food industries to further reduce the prevalence of vitamin D deficiency. The reduction of vitamin D deficiency can alleviate the chance of having high level of bone resorption markers in the body among the postmenopausal Chinese women.

Besides, the present study emphasise on the diet quality of postmenopausal Chinese women to assess whether they are following the recommendations based on the MDG (National Coordinating Committee on Food and Nutrition, 2010). The current findings also help to determine which food groups are essential in reducing bone resorption, which can lead to osteoporosis later in life. By knowing the current diet quality of this targeted population, strategies or efforts in promoting the benefits of each food group can be strengthened and thus provide alternatives for those who lack accessibility to these foods.

Health professionals in both public and private sectors able to utilise the findings of the present study as a foundation to develop intervention programmes in reducing bone resorption. The intervention programmes can include promotion of "variety, balance, adequate and moderate diet" based on MDG and the importance of physical activity as part of the efforts to reduce or maintain bone resorption rates. As a result, these intervention programmes can reduce the burden of osteoporosis and fractures among postmenopausal women in the country.

1.4 Objectives

1.4.1 General Objective

To determine the factors associated with bone resorption marker (CTx-1) among postmenopausal Chinese women.

1.4.2 Specific Objectives

i. To determine the socio-demographic characteristics, anthropometric indices (BMI, waist circumference and body fat percentage), lifestyle factors (smoking behaviour, sun exposure and physical activity), vitamin D and diet quality of postmenopausal Chinese women.
ii. To determine the mean level of bone resorption marker (CTx-1) among postmenopausal Chinese women.
iii. To determine the contribution of socio-demographic characteristics, anthropometric indices (BMI, waist circumference and body fat percentage), lifestyle factors (smoking behaviour, sun exposure and physical activity), vitamin D and diet quality towards bone resorption marker (CTx-1) among postmenopausal Chinese women.

1.5 Research Hypothesis

There are contributions from socio-demographic characteristics, anthropometric indices, lifestyle factors, serum vitamin D and diet quality towards bone resorption marker (CTx-1) among postmenopausal Chinese women.

1.6 Conceptual Framework

Figure 1.1 shows the five groups of independent variables related to bone resorption in the current study, which includes socio-demographic characteristics anthropometric indices, lifestyle factors, serum vitamin D and diet quality. The dependent variable is bone resorption marker (CTx-1).

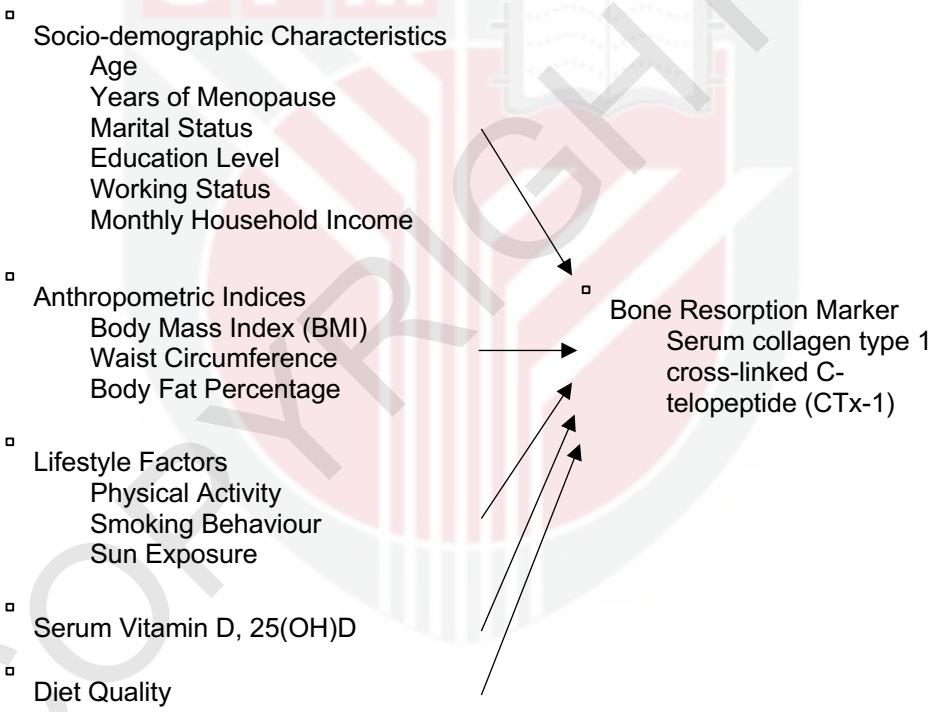

Figure 1.1. Conceptual Framework of the Study

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Leiu Kok Hong was born on 9th September 1991 in Kuala Lumpur. He received his primary education at Sekolah Jenis Kebangsaan (Cina) Yu Hua in Kajang, Selangor. He continued his secondary and pre-university education, Form 6 at Sekolah Menengah Jenis Kebangsaan Yu Hua in Kajang, Selangor. After completing Form 6, he continued his tertiary education at Universiti Putra Malaysia. He was granted Bachelor of Science in Nutrition and Community Health with first class honour. He also received an award as one of the best oral presenters in the final year project seminar under the social science category.

He had various experiences in research, for example he was an enumerator in Universiti Putra Malaysia for a nationwide research project on healthy eating and physical activity among children in boarding school. He was also a research assistant in International Medical University (IMU) for a pioneer project collaborated with Ajinomoto (Malaysia) Sdn. Bhd. on reduction of sodium consumption among institutionalised elderly. Besides, he had many experiences in health promotion activities with different target populations, such as primary school children, indigenous people and institutionalised elderly. He participated in various nutrition events, for instance Nutrition Month Malaysia and Milo Breakfast Day as a nutrition counsellor.

He attended various scientific conferences at the local level, such as Nutrition Society Malaysia (NSM) Conference and Malaysian Association for the Study of Obesity (MASO) Conference as poster presenter as well as international level, such as Southeast Asia Public Health Nutrition (SEA-PHN) Conference and Asia-Pacific Academic Consortium of Public Health (APACPH) Conference as oral presenter. He also managed to receive a fellowship from SEAMEO RECFON to attend a training in Jakarta, Indonesia.

He is currently pursuing his postgraduate study in Master of Science in Community Nutrition in University Putra Malaysia. He is also an active member in NSM as well as MASO. He is accredited as Level One anthropometrist by the International Society for the Advancement of Kinanthropometry (ISAK).

PUBLICATIONS

Leiu, K. H. & Chin, Y. S. (2019). Comparison of Paternal and Maternal Attributes between Healthy Weight and Overweight or Obese Primary School Children. *Malaysian Journal of Medicine and Health Sciences* (Q4)

PROCEEDINGS

Leiu, K. H. & Chin, Y. S. (2015). *Comparison of parental influences and dietary practices between normal weight and overweight or obese primary school children in Hulu Langat district, Selangor*. Paper presented at the 30th Scientific Conference of the Nutrition Society of Malaysia, Kuala Lumpur. **(Poster)**

Leiu, K. H., Chin, Y. S., Chan, Y. M. & Zalilah, M. S. (2017). *Body composition and vitamin D status among Chinese postmenopausal women.* Paper presented at the Malaysian Association for the Study of Obesity (MASO) 2017 Scientific Conference, Kuala Lumpur. **(Poster)**

Leiu, K. H., Chin, Y. S., Chan, Y. M., Zalilah, M. S., Chan, K. S. & Lim, S. Y. (2018). *Factors contributing to bone resorption among postmenopausal Chinese women in Kuala Lumpur and Selangor*. Paper presented at the 33th Scientific Conference of the Nutrition Society of Malaysia, Kuala Lumpur. **(Poster)**

Leiu, K. H., Chin, Y. S., Chan, Y. M., Zalilah, M. S., Chan, K. S. & Lim, S. Y. (2018). *Diet quality and its contribution towards bone resorption among postmenopausal Chinese women in Kuala Lumpur and Selangor*. Paper presented at the 50th Asia-Pacific Academic Consortium of Public Health (APACPH) Conference, Kota Kinabalu. **(Oral)**

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