



**UNIVERSITI PUTRA MALAYSIA**

***IMPACT OF WEIGHT CHANGES ON CARDIOMETABOLIC MARKERS  
AMONG LOW SOCIOECONOMIC OVERWEIGHT AND OBESE WOMEN  
IN A COMMUNITY LIFESTYLE INTERVENTION***

**LIYANA BINTI AHMAD ZAMRI**

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By

**LIYANA BINTI AHMAD ZAMRI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
Malaysia, in Fulfilment of the Requirements for the Degree of  
Master of Science**

**July 2019**

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

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**July 2019**

**Chair : Geeta Appannah, PhD**  
**Faculty : Medicine and Health Science**

Weight loss has been linked to improvements in multiple cardiometabolic risk factors, including lipid profiles, glucose and insulin sensitivity. However, weight loss intervention and its health benefits among low-income women, a group with a higher risk of obesity, have received little attention, particularly in the local setting. The current study utilised the secondary outcomes of a community-based lifestyle intervention namely My Body is Fit and Fabulous at Home (MYBFF@home) to investigate the impact of weight changes on cardiometabolic risk markers among low socioeconomic women in three different study phases (i.e., overall 12 months (baseline to 12 months), weight loss intervention phase (baseline to 6 months) and weight loss maintenance phase (6 to 12 months). This study also further explored the association between weight changes and improvements in those risk markers.

MYBFF@home was a quasi-experimental study of overweight and obese women living in low-cost flats in Klang Valley. The intervention group underwent a 6-month lifestyle intervention that included individual diet counselling, moderate-intensity physical activities, and self-monitoring skills (using a pedometer, diet, and physical activity diaries), after which they were followed up at 12 months. The control group attended group seminars on women's health during follow-up visits. In the current study, 243 participants (129 in the intervention group and 114 in the control group) were included in the analysis on an intention-to-treat basis. Anthropometric measurements (i.e., weight and waist circumference (WC) and blood samples were assessed at baseline, six months, and one year. Fasting plasma glucose (FPG), insulin, insulin resistance marker (HOMA-IR), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides, adiponectin, high-sensitivity C-reactive protein (hs-CRP) and tumour necrosis factor- $\alpha$  (TNF- $\alpha$ ) were measured in the blood samples. The participants were also stratified according to the change in body weight; 1) loss 5 to 20%, 2) loss > 2 to < 5%, 3) maintained  $\pm$  2% and 4) gained > 2%.

Repeated measures ANCOVA revealed a significant intervention effect (Time x Group) on TC ( $F(2, 236) = 3.131, p = 0.046$ ) and hs-CRP ( $F(2,288) = 4.129, p = 0.017$ ) after 12 months controlling for age and baseline weight while no evidence found in other risk markers. The magnitude of weight change in the intervention group after 12 months was significantly correlated to improvement in WC ( $r(125) = 0.366, p < 0.001$ ), FPG ( $r(125) = 0.228, p = 0.010$ ), insulin ( $r(113) = 0.247, p = 0.008$ ) and HOMA-IR ( $r(113) = 0.290, p = 0.002$ ) after controlling for age and baseline weight. Participants in the intervention group who lost between 5 to 20% of their body weight showed highest reduction of WC (-5.67 cm [95% CI:-7.98,-3.36]), insulin (-4.27  $\mu\text{U/mL}$  [95% CI:-7.35,-1.19]) and TC (-0.59 mmol/L [95% CI:-0.99,-0.19]) as compared to other weight change categories. Those who lost > 2 to < 5% of body weight also showed reduction in WC (-4.24 cm [95% CI:-5.44,-3.04]) and insulin (-0.36  $\mu\text{U/mL}$  [95% CI:-1.95, 1.24]) but not in TC. No evidence of association was found during the maintenance period in both study groups. For overall 12 months, a step-wise association in the changes of WC, FPG and insulin was observed in the intervention group but not in the control group except for WC.

In conclusion, in the context of low socioeconomic communities, this study supports that weight loss-related lifestyle modifications over 6 months could improve selected cardiometabolic risk markers including TC, hs-CRP and markers of glycaemic control in overweight and obese women even with minimal weight loss (> 2% from initial body weight).

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

**KESAN PERUBAHAN BERAT BADAN TERHADAP PENANDA  
KARDIOMETABOLIK DI KALANGAN WANITA BERLEBIHAN BERAT  
BADAN DAN OBES DALAM KAJIAN INTERVENSI GAYA HIDUP KOMUNITI**

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Penurunan berat badan telah dikaitkan dengan penambahbaikan pelbagai faktor risiko kardiometabolik termasuk profil lipid, glukosa dan sensitiviti insulin. Namun, intervensi penurunan berat badan dan faedah kesihatannya di kalangan wanita berpendapatan rendah, sebuah kumpulan dengan risiko obesiti yang tinggi menerima perhatian yang sedikit terutamanya dalam penyelidikan tempatan. Kajian ini menggunakan hasil sekunder sebuah intervensi gaya hidup komuniti iaitu *My Body is Fit dan Fabulous at Home* (MYBFF@home) untuk mengkaji kesan perubahan berat badan terhadap penanda risiko kardiometabolik dalam kalangan wanita yang mempunyai sosioekonomi rendah di dalam tiga fasa kajian yang berbeza (iaitu, keseluruhan 12 bulan (garis dasar hingga 12 bulan), fasa penurunan berat badan (garis dasar hingga 6 bulan), fasa pengekalan berat badan (6 hingga 12 bulan). Kajian ini juga meneroka lebih lanjut tentang hubung kait di antara perubahan berat badan dan penambahbaikan penanda risiko tersebut.

MYBFF@home adalah kajian kuasi-eksperimen di kalangan wanita berlebihan berat badan dan obes yang tinggal di rumah pangsa kos rendah di Lembah Klang. Kumpulan intervensi menerima intervensi gaya hidup selama 6 bulan yang terdiri daripada kaunseling diet individu, aktiviti fizikal berintensiti sederhana dan kemahiran pengawasan sendiri (menggunakan alat pengukur langkah, diari untuk diet dan fizikal aktiviti) dan disusuli dengan lawatan pada bulan ke-12. Kumpulan kawalan menghadiri seminar yang berkaitan dengan kesihatan wanita semasa lawatan susulan. Sebanyak 243 peserta (129 orang di dalam kumpulan intervensi dan 114 orang di dalam kumpulan kawalan) dimasukkan ke dalam analisis berdasarkan pada niat untuk merawat. Pengukuran antropometrik (iaitu berat dan lilitan pinggang (WC)) dan sampel darah diperiksa pada peringkat garis dasar, 6 dan 12 bulan. Sampel darah diukur untuk plasma glukosa (FPG), insulin, penanda rintangan insulin (HOMA-IR), kolesterol total (TC), kolesterol lipoprotein berketumpatan tinggi (LDL-C), kolesterol lipoprotein berketumpatan rendah (HDL-C), trigliserida, adiponektin, C-reaktif protein bersensitiviti tinggi (hs-CRP) dan faktor nekrosis tumor- $\alpha$  (TNF- $\alpha$ ). Peserta turut dikelaskan mengikut

perubahan berat badan; 1) pengurangan berat 5 hingga 20%, 2) pengurangan berat > 2 hingga < 5%, 3) pengekalan berat  $\pm$  2% dan 4) peningkatan berat > 2%.

Analisis berulang ANCOVA menunjukkan kesan intervensi yang signifikan (Masa x Kumpulan) terhadap paras TC ( $F(2, 236) = 3.131, p = 0.046$ ) dan hs-CRP ( $F(2,288) = 4.129, p = 0.017$ ) selepas 12 bulan dengan mengawal faktor umur dan berat garis dasar, sementara tiada bukti ditemui untuk penanda risiko yang lain. Magnitud perubahan berat badan oleh kumpulan intervensi selepas 12 bulan berkorelasi secara signifikan dengan penambahbaikan pada WC ( $r(125) = 0.366, p < 0.001$ ), FPG ( $r(125) = 0.228, p = 0.010$ ), insulin (113) = 0.247,  $p = 0.008$ ) dan HOMA-IR ( $r(113) = 0.290, p = 0.002$ ) selepas mengawal faktor umur dan berat garis dasar. Peserta di dalam kumpulan intervensi yang kehilangan antara 5 ke 20% berat badan semasa fasa intervensi menunjukkan pengurangan tertinggi WC (-5.67 cm [95% CI:-7.98,-3.36]), insulin (-4.27  $\mu$ U/mL [95% CI:-7.35,-1.19]) dan TC (-0.59 mmol/L [95% CI:-0.99,-0.19]) berbanding dengan kategori penurunan berat badan yang lain. Penurunan berat badan sebanyak > 2 hingga < 5% juga menunjukkan penambahbaikan pada WC (-4.24 cm [95% CI:-5.44,-3.04]) dan insulin (-0.36  $\mu$ U/mL [95% CI:-1.95, 1.24]) tetapi tidak bagi TC. Tiada bukti hubungan yang sama ditemui semasa tempoh pengekalan berat badan. Untuk keseluruhan 12 bulan, terdapat hubungan secara berperingkat yang signifikan di antara perubahan berat badan dan perubahan WC, FPG dan insulin di dalam kumpulan intervensi tetapi tidak di dalam kumpulan kawalan kecuali WC.

Kesimpulannya, dalam konteks komuniti dengan sosioekonomi yang rendah, kajian ini menyokong bahawa penurunan berat badan melalui modifikasi gaya hidup selama tempoh 6 bulan dapat menambah baik penanda risiko kardiometabolik yang terpilih seperti TC, hs-CRP dan penanda kawalan glisemik di kalangan wanita berlebihan berat badan dan obes walaupun dengan penurunan berat badan yang minimum (> 2% dari berat badan awal).

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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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## Declaration by Members of Supervisory Committee

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- the research conducted and the writing of this thesis was under our supervision;
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## LIST OF ABBREVIATIONS

BMI	body mass index
CVD	cardiovascular diseases
FFA	free-fatty acid
FPG	fasting plasma glucose
g	gram
GNP	gross national product
GWG	gestational weight gain
HbA1c	glycated haemoglobin
HDL-C	high density lipoprotein-cholesterol
HOMA-IR	homeostatic model assessment-insulin resistance
hs-CRP	high-sensitivity c-reactive protein
HR	hazard ratio
IHD	ischemic heart disease
kg	kilogram
LDL-C	low density lipoprotein-cholesterol
mmol/L	milimoles per litre
MYBFF@home	My Body Is Fit And Fabulous At Home
Mets	metabolic syndrome
N	sample size
PA	physical activity
PHP	people's housing project
RCTr	reverse cholesterol transport
SD	standard deviation
SEA	South East Asia



SES	socioeconomic status
SMM	skeletal muscle mass
SPSS	statistical package for social science
T2DM	type 2 diabetes mellitus
TC	total cholesterol
TNF- $\alpha$	tumour necrosis factor-alpha
USA	United States of America
USD	us dollars
WHO	World Health Organization
WC	waist circumference
WtHR	waist-to-hip ratio

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

In less than 20 years, the prevalence of overweight and obesity among Malaysian adults has increased at an unprecedented rate, and Malaysia was the fattest nation in South East Asia (SEA) (World Health Organization, 2011). While obesity is significantly higher among Malaysian women than men, housewives are one of the subpopulations with a high obesity predisposition. (Institute for Public Health, 2011, 2015). In addition, Malaysia's low socioeconomic population, generally measured by income and education, is vulnerable to both under- and over-nutrition issues. Previous national health and morbidity survey found that the poorest income bracket (< RM400) has significantly higher rates of overweight (28.9%) and obesity (14.7%) than the brackets above (e.g., RM400 - RM699 = 26.0% overweight, 13.6% obesity) (Institute for Public Health, 2011). Moreover, a Malaysian observational study on factors influencing body mass index (BMI) among multi-ethnic groups discovered that individuals with lower education have a higher tendency to become obese than those with higher education. (Tan, Yen, & Feisul, 2012).

Obesity is also strongly associated with an increased risk of non-communicable diseases (NCD) including type-2 diabetes mellitus (T2DM), cardiovascular diseases (CVD) and several types of cancers in women, including endometrial cancer, ovarian cancer, and breast cancer. As reported in the previous national survey, the comorbidities were now emerging in the low-income group or known as the Bottom 40% (B40) (Institute for Public Health, 2015). Furthermore, a study of low-income urban dwellers in Kuala Lumpur predicted that one out of five people will develop CVD within ten years (Su et al., 2015). CVD remains the leading cause of death worldwide (Naghavi et al., 2015) as well as in Malaysia (Department of Statistics Malaysia, 2017). As a result, the direct and indirect cost of obesity in Malaysia totalled up to 10 to 19% of national healthcare spending (Economist Intelligence Unit, 2017). Hence, combating obesity in low-income women is critical to lowering the morbidity and mortality rate as well as the economic burden of obesity.

Evidence suggests that lifestyle modification consisted of key components such as diet, physical activity (PA), and behaviour therapy promotes weight loss in overweight and obese individuals. Even modest weight loss (of at least 5%) resulted in clinically meaningful health benefits such as improved insulin sensitivity and decreased intra-abdominal and intra-hepatic fat and higher improvement in those risk markers seen with greater weight losses (Magkos et al., 2016). Additionally, 5% of weight loss among obese individuals receiving either diet-only or diet plus exercise intervention improved triglycerides (TG), total cholesterol (TC) and high sensitivity C-reactive protein (hs-CRP) concentration (Fayh, Lopes, da Silva, Reischak-Oliveira, & Friedman, 2012). Brown and colleagues (2016) confirmed the findings, stating that 5 to 10% of initial weight loss among overweight and obese adults enrolled in a behavioural weight loss

programme significantly reduced fasting glucose, TG, and TC, with greater weight losses (> 10%) associated with larger improvement. Likewise, 21 non-diabetic obese women in a 12-week light exercise and caloric restriction programme significantly improved BMI, insulin, fasting glucose, hs-CRP, leptin and visfatin, migration inhibitor factor as well as activated proinflammatory cytokines expression in circulating mononuclear cells with an average weight loss of  $4.0 \pm 0.4$  kg ( $5.0 \pm 0.3\%$ ) (Sheu et al., 2008).

However, the long-term sustainability of such interventions is less reported following a successful weight-loss programme. The amount of weight lost also has a different effect on each cardiometabolic risk marker. Dow et al. (2013) looked at the long-term effects of weight loss on cardiometabolic risk factors in 417 overweight and obese American women. After two years, there was a significant reduction in LDL-C, CRP, insulin, and TG if they lost 10% of their body weight. TC and non-high-density lipoprotein cholesterol concentrations, on the other hand, decreased significantly regardless of weight loss. Beavers and colleagues (2012) discovered that postmenopausal women who regained some of their lost weight one year after losing 11.4 kg of their weight had an increase in TC, TG, glucose, insulin, and HOMA-IR, an indicator of insulin resistance. Some of the risk markers were also higher at follow-up than at baseline, whereas those who maintained their weight loss showed improvement in those risk markers.

Although weight loss and weight loss maintenance in women have been well described in the literature (Bajerska et al., 2018; Beavers et al., 2012; Dow et al., 2013; Lavoie et al., 2013; Palau-Rodriguez et al., 2019; Travier et al., 2018; Van Dammen et al., 2018), the low-income group has been less targeted, resulting in limited evidence on the feasibility, efficiency and effectiveness of the programme to promote and sustain weight loss in this high-risk population. Low-income women face numerous obstacles to achieving and maintaining a healthy weight, including family responsibilities, stress, a lack of social support, limited finances that influence food choices, environmental factors, and a lack of supportive resources (Chang, Nitzke, Guilford, Adair, & Hazard, 2008; Pampel, Krueger, & Denney, 2010; Skowron, Stodolska, & Shinew, 2008; Wiig Dammann & Smith, 2009). A tailored weight loss intervention could be used to reduce barriers and eliminate health disparities among women in this group.

Hence, the current study utilised and explored secondary data from the My Body is Fit and Fabulous at home (MYBFF@home), a community-based lifestyle intervention consisting of increased PA, dietary counselling and self-monitoring skills (using a pedometer, diet and PA diary) among overweight and obese non-working women or housewives living in low-cost flats in Kuala Lumpur (Mohamad Nor et al., 2016). This study investigates the impact of weight changes on the cardiometabolic risk markers and also aimed to answer the following research questions:

- 1) Is the community-based lifestyle intervention effective for the improvement of cardiometabolic risk markers including glucose homeostasis, lipid profiles and inflammatory markers in low-income overweight and obese women after 6 and 12 months?
- 2) Are positive improvements sustained during the weight-loss maintenance phase?
- 3) Is the amount of weight loss resulting from the lifestyle intervention associated with clinically relevant changes in cardiometabolic risk markers?

## 1.2 Problem Statement

Malaysia has experienced rapid urbanisation and socioeconomic advancement over the last two decades, altering the population's lifestyle. Malaysian women, particularly those living in urban communities with lower socioeconomic status (SES), are much affected by these changes because they were less likely to engage in PA (Cheah & Poh, 2014) and had poor dietary practices (Karupaiah, Swee, Liew, Ng, & Chinna, 2013). Consequently, a poor lifestyle has resulted in an exponential rise in the prevalence of obesity and NCD. It was found that low-income adults in Kuala Lumpur had a high prevalence of cardiovascular risk factors such as obesity (54.8%), hypercholesterolaemia (51.5%), and hypertension (39.3%) (Amiri et al., 2014). Despite compelling evidence on the obesity problem, research on obesity intervention is still lacking in Malaysia, particularly among low-income women in urban communities. So far, no research has been published on the effects of lifestyle intervention on weight loss and cardiometabolic risk markers in this population.

Housewives in Malaysia are more overweight and obese than other job categories (Institute for Public Health, 2008, 2011), making them an important target population, particularly among low-income women. Housewives are also the nutritional gatekeepers in the average household, influencing diet, food choices, and attitudes toward food control within a family. Household gatekeepers with higher food skills confidence were more likely to have a lower BMI, understand the importance of fresh foods, including vegetables in meals, use product information, meal planning, perceived behavioural control, and overall diet satisfaction. Those with less confidence, on the other hand, were more likely to report perceived barriers to healthy eating, time constraints, impulse purchases, and greater use of convenience ingredients (Burton, Reid, Worsley, & Mavondo, 2017). Furthermore, low-income women with limited nutritional knowledge are less likely to engage in healthy weight loss practices (Laz, Rahman, Pohlmeier, & Berenson, 2015). As a result, improving dietary housewives' abilities may result in positive health benefits for them and their families.

Furthermore, being a woman, particularly a housewife living in an urban area, is linked to physical inactivity (Chan et al., 2014). According to a previous study, nearly one out of every five low-income urban residents in Kuala Lumpur were physically inactive (< 600 MET-min/week), and the prevalence increased with age and in those with chronic diseases (Su et al., 2018). Women's low participation in PA was due to a variety of factors, including a lack of leisure time, motivation, absence of parks and playgrounds, and embarrassment about being physically active in public (Oli, Vaidya, Pahkala, Eiben, & Krettek, 2018; Sharifi, Mahdavi, & Ebrahimi-Mameghani, 2013). They also feared that part-time PA would jeopardise family responsibilities and expectations (Alvarado, Murphy, & Guell, 2015). Home-bound activities such as child care and housework seem to be insufficient for housewives to meet the recommended daily PA levels. Furthermore, technological advancements in most household appliances may reduce PA among these women, leading them to engage in sedentary activities such as watching television or browsing the internet. According to the findings, housewives should engage in a more intense home-based activity or exercise to increase their daily PA level without compromising their role as caregivers.

### 1.3 Significance of Study

There is currently no local study reporting on the impact of lifestyle intervention on multiple cardiometabolic outcomes among low-income women. Previous studies were conducted on individuals with comorbidities, short-term, in primary care or for academic purposes. As such, the current study may provide empirical evidence on the effects of weight loss on cardiometabolic risk markers resulting from a community-based lifestyle intervention. It would be beneficial for stakeholders, policymakers, and health facilitators to improve the current weight management programme among women in the community, particularly those from low-income families.

Furthermore, low-income overweight and obese women who were apparently 'healthy' (i.e., no diagnosed comorbidities based on self-report) and lived in urban areas are the key target population for obesity intervention as they have a significantly increased risk of NCD. They represent an understudied population in terms of health-related needs. They also reported many barriers that contributed to excess weight problems, such as attitude, support, environment, safety, finance, and health issues (Abdul Aziz, Mohd Zaki, & Mohamad Nor, 2016), which must be addressed in order to eliminate health disparities. Furthermore, reaching out to women in this demographic is critical because they are less likely to be health-conscious and receive fewer benefits from available healthcare services (Pampel et al., 2010).

In 2017, Malaysia's obesity problem accounted for 13.3% of total health costs, amounting to US dollars (USD)1.7 billion, the highest in the ASEAN region (Economist Intelligence Unit, 2017). In comparison to other ASEAN countries, Malaysia has the highest number of productive years lost due to obesity among obese women (between 7 and 12 years) and the second-highest for males (between 6 and 11 years). Furthermore, metabolic diseases such as diabetes mellitus, whose prevalence is increasing year after year, incur a significant annual cost in Malaysia. The total cost of T2DM in both the public and private sectors was estimated to be RM2.04 billion per year (for 2011), with the government incurring RM1.40 billion per year (Mustapha et al., 2017). Community interventions that promote lifestyle modifications for weight loss may be a useful measure for increasingly constrained healthcare resources as the approach has the potential to reduce the financial burden of obesity attributed to direct and indirect costs in a year.

As evidenced in the WISEWOMEN study, a lifestyle programme aimed at reducing CVD risk among low-income women in the United States of America (USA), the intervention was cost-effective, with USD470 per percentage point reduction in CVD risk or USD4400 per discounted life-year gained, particularly if the improvements in risk factors were sustained after the programme ended (Finkelstein, Khavjou, & Will, 2006). The study's cost-effectiveness was comparable to other public health interventions aimed at improving CVD risk factors (Wolf et al., 2007). Furthermore, a study predicted that 30 cardiovascular and 22 diabetes events and USD1.99 million medical costs could be avoided over 5 years with lifestyle intervention consisting of weekly group coaching to achieve reduced calorie intake, increased fruit and vegetable intake, and physical activity of  $\geq 2,000$  kcal/week (Gotthelf et al., 2018).



Achieving substantial weight loss through lifestyle intervention is difficult while maintaining it is even a greater challenge. There is evidence that shows the benefits of losing weight even in small amounts (i.e. < 5%), which leads to longer-term sustained weight loss and improvements in cardiometabolic risk factors (Neiberg et al., 2012). Furthermore, Gaesser and colleagues (2011) investigated the significant improvements in cardiometabolic risk profiles of overweight and obese people following exercise and diet intervention, even in the absence of clinically significant weight loss (i.e.,  $\geq 5\%$ ). It was also demonstrated in an animal model, where exercised mice fed a high-fat diet improved skeletal muscle membrane abnormalities and insulin resistance when compared to sham-exercised mice with no loss of body mass (Ambery, Tackett, Penque, Brozinick, & Elmendorf, 2017). The findings suggest that exercise can help improve or prevent diabetes regardless of weight loss. This should be emphasised in public to shift the focus away from the specific weight-loss goal and toward continuously increasing PA and improving diet quality. The advocates for health benefits of smaller weight losses may motivate individuals to achieve weight-loss goals that are attainable in a short term. Hence, this research is essential in supporting the evidence on the benefits of modest weight loss (at least 5%) in improving cardiometabolic risk markers through lifestyle changes among women in the population.

#### **1.4 Study Objectives**

##### **1.4.1 Main Objective**

To examine the impact of weight changes on cardiometabolic risk markers among low socioeconomic overweight and obese women in a community-based lifestyle intervention study in Klang Valley, Malaysia.

##### **1.4.2 Specific Objectives**

- i. To compare the baseline sociodemographic, anthropometric and cardiometabolic risk markers characteristics between the intervention and control groups.
- ii. To determine and compare the distribution of the participants by weight change categories (i.e., 1) gain > 2%, 2) Maintain  $\pm 2\%$ , 3), small weight loss > 2 to < 5%, 4) and weight loss 5 to 20%) in both study groups for overall 12 months period (baseline to 12 months) and at the end of the weight-loss intervention phase (baseline to 6 months) and weight-loss maintenance phase (6 months to 12 months).
- iii. To determine the changes in cardiometabolic risk markers (i.e. fasting plasma glucose, insulin, HOMA-IR, lipid profiles, TNF- $\alpha$ , hs-CRP and adiponectin) within and between study groups for an overall 12 months period and at the end of the weight-loss intervention phase and weight-loss maintenance phase.
- iv. To determine the correlation between weight change (in percentage) achieved for overall 12 months and changes in cardiometabolic risk markers in the intervention and control group.

- v. To determine the association between body weight change categories and changes of cardiometabolic risk markers for the overall 12 months period and at the end of the weight-loss intervention phase and weight-loss maintenance phase.

## 1.5 Research Hypotheses

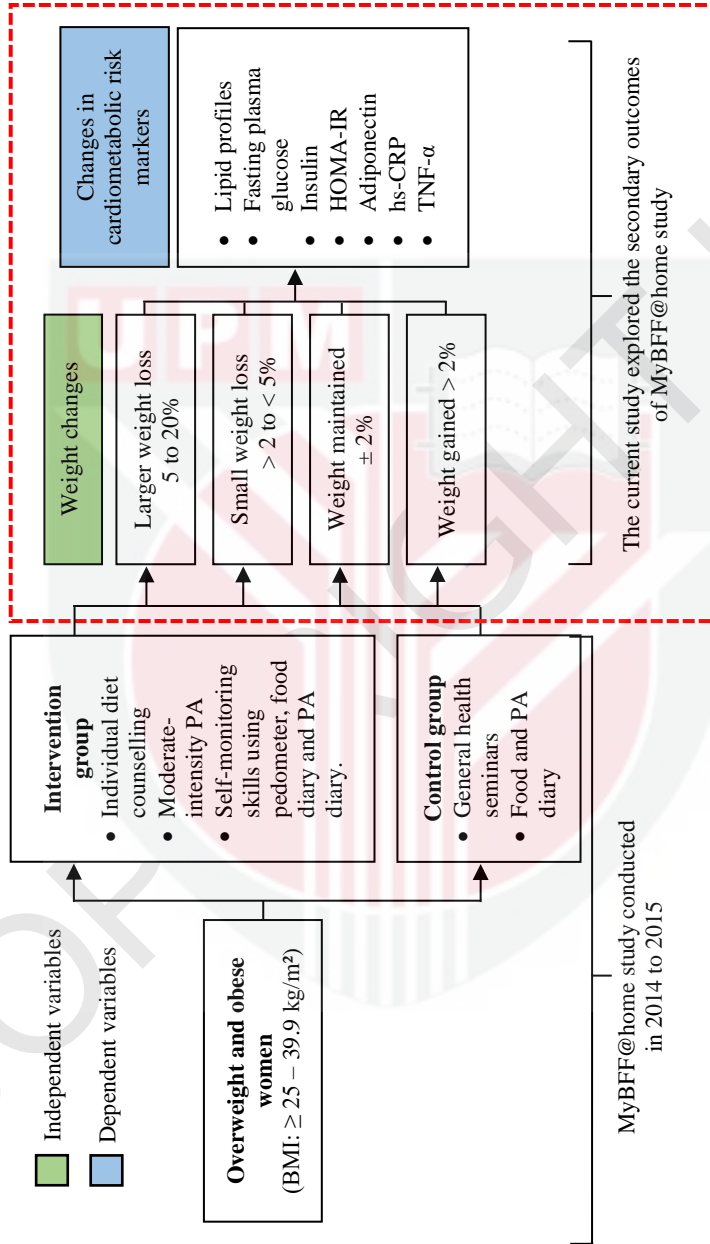
The hypotheses are:

- i. There will be no statistical difference in the baseline characteristics of sociodemographic, anthropometric and cardiometabolic risk markers between intervention and control groups.
- ii. There will be more participants in the intervention group losing  $\geq 5\%$  of body weight compared to the control group after 12 months and at the end of the weight-loss intervention phase and weight-loss maintenance phase.
- iii. There will be significant improvements in cardiometabolic risk markers in individuals in the intervention group for an overall 12 months period and at the end of the weight-loss intervention phase and weight-loss maintenance phase compared to the control group.
- iv. There will be a significant correlation between weight change at 12 months and changes in cardiometabolic risk markers in individuals in the intervention group compared to the control group.
- v. Weight loss of at least 5% is associated with significant improvements in cardiometabolic risk markers.

## 1.6 Conceptual Framework

The benefits of modest weight loss and maintenance on health outcomes continue to be underreported, particularly in Malaysia. This study was based on the guideline recommendation of a modest weight loss of 5 to 10% of the initial weight in order to obtain cardiovascular health benefits (Jensen et al., 2014; North American Association for the Study of Obesity, National Heart, Lung, 2000). A combined diet and physical activity intervention are likely to result in an appreciable amount of weight loss that improves cardiometabolic risk factors (Butryn, Webb, & Wadden, 2011; Nicklas, You, & Pahor, 2005).

The MYBFF@home intervention promotes increased PA, a healthy diet, and self-monitoring skills in order to achieve a target weight loss of at least 5% loss of the initial body weight. Whereas, during the follow-up visits, the control group received general women's health seminars. The current study conceptualised the changes in cardiometabolic risk markers as the dependent variables. Figure 1.1 illustrates the weight changes resulting from lifestyle intervention. Weight changes were stratified into weight loss ( $> 2$  to  $< 5\%$  and 5 to 20% of initial body weight), weight maintenance ( $\pm 2\%$ ) and weight gain ( $> 2\%$ ) and served as independent variables whose effect on biomarkers were investigated in this study.



**Figure 1.1 : Conceptual Framework of The Impact of Lifestyle Intervention on Weight Change And Cardiometabolic Risk Markers**



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