

**EFFECTS OF MODERATE-INTENSITY
TRAINING EXERCISE PROGRAM ON BODY
COMPOSITION AND METABOLIC MARKERS
AMONG OVERWEIGHT AND OBESE DENTAL
STUDENTS IN UNIVERSITI SAINS MALAYSIA**

NURSHARLINA BINTI SHARAN

UNIVERSITI SAINS MALAYSIA

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by

NURSHARLINA BINTI SHARAN

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for the degree of
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LIST OF ABBREVIATIONS

BW	Body Weight
BMI	Body Mass Index
BFP	Body Fat Percentage
CHOL	Cholesterol
FTO	Fat mass and obesity associated gene
HDL	High Density Lipoprotein
HIIT	High Intensity Interval Training
HR	Heart Rate
HRR	Heart Rate Reserve
IL-6	Interleukin-6
INS	Insulin
LDL	Low Density Lipoprotein
LM	Lean Mass
MIIT	Moderate Intensity Interval Training
PCOS	Polycystic Ovary Syndrome
RMR	Resting Metabolic Rate
ROS	Reactive Oxygen Species
RNI	Recommended Nutrient Intake
SD	Standard Deviation
TC	Total Cholesterol
TG	Triglyceride
VF	Visceral Fat
WHR	Waist-and-Hip Ratio

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**KESAN PROGRAM LATIHAN SENAMAN INTENSITI SEDERHANA
TERHADAP KOMPOSISI TUBUH DAN PENANDA METABOLIK DALAM
KALANGAN PELAJAR PERGIGIAN YANG BERLEBIHAN BERAT
BADAN DAN OBES DI UNIVERSITI SAINS MALAYSIA**

ABSTRAK

Pengenalan: Berat badan berlebihan dan obesiti adalah isu kesihatan global yang membahayakan individu dalam pelbagai profesion, termasuk pergigian. Pengamal pergigian sering menghabiskan masa yang lama dalam posisi duduk semasa merawat pesakit, menjadikannya berisiko untuk mengalami sakit belakang. Kajian secara konsisten melaporkan bahawa sakit belakang mempunyai korelasi yang kuat dengan berat badan berlebihan dan obesiti serta memberi kesan yang signifikan terhadap kualiti hidup. Oleh itu, adalah penting untuk meningkatkan kesedaran di kalangan pelajar pergigian tentang kepentingan mengekalkan indeks jisim badan (BMI) dan gaya hidup yang sihat untuk mencegah faktor-faktor yang menyumbang kepada sakit belakang semasa pengajian dan pekerjaan mereka pada masa depan. Objektif: Kajian ini bertujuan untuk menentukan kesan program senaman intensiti sederhana terhadap komposisi badan dan penunjuk metabolik di kalangan pelajar pergigian yang mengalami berat badan berlebihan dan obesiti di Universiti Sains Malaysia. Metodologi: Tiga puluh tiga pelajar pergigian yang berlebihan berat badan dan obes (kawalan, n=17 dan senaman, n=16) direkrut, dan komposisi badan dicatat dan sampel darah mereka diambil sebelum dan selepas intervensi. Peringatan diet 24 jam peserta direkodkan. Pelajar mengambil bahagian dalam pemanasan dinamik selama 10 minit, diikuti dengan latihan Tabata intensiti sederhana, yang dilakukan tiga kali seminggu selama 12 minggu, dengan peningkatan berperingkat dalam tempoh

latihan setiap empat minggu. Data dianalisis menggunakan ujian Independent T dan ujian T Sampel Berpasangan untuk data normal serta ujian Mann-Whitney U dan ujian Peringkat yang Ditandatangani Wilcoxon untuk data yang tidak normal. Keputusan: Selepas 12 minggu intervensi, kumpulan latihan menunjukkan peningkatan dalam kadar metabolisme rehat (RMR) 1524.1 ± 60.24 kcal/hari, sementara BMI mereka kekal stabil pada 27.8 ± 0.88 kg/m², menunjukkan tiada perubahan signifikan dalam komposisi badan. Sebaliknya, kumpulan kawalan menunjukkan perbezaan yang signifikan dalam BMI ($p < 0.034$) dimana terdapat peningkatan selepas intervensi (28.92 ± 3.87 kg/m²). Kedua-dua kumpulan menunjukkan tahap yang tinggi bagi kolesterol keseluruhan, trigliserid, HDL (high-density lipoprotein) dan LDL (low-density lipoprotein), insulin, dan IL-6 (interleukin-6) selepas intervensi. Selain itu, para peserta mengambil jumlah protein, lemak, dan natrium yang tinggi, melebihi pengambilan nutrien yang disyorkan (RNI). Kesimpulan: Kajian ini menunjukkan bahawa tiada perbezaan yang signifikan dalam komposisi badan antara kumpulan kawalan dan latihan. Walau bagaimanapun, BMI dalam kumpulan latihan yang tiada perubahan ketara menunjukkan hasil yang positif kerana peserta tidak mengalami penambahan berat badan semasa intervensi. Kajian ini juga mendapati peningkatan tahap kolesterol LDL, insulin, dan IL-6, sitokin pro-radang, dalam kumpulan latihan boleh dikaitkan dengan tisu adiposa yang berlebihan dan pengambilan kalori yang tinggi. Oleh itu, kajian masa depan dengan sekatan diet yang lebih ketat diperlukan untuk menentukan kesan latihan fizikal intensiti sederhana terhadap komposisi badan pelajar perguruan.

**EFFECTS OF MODERATE-INTENSITY TRAINING EXERCISE
PROGRAM ON BODY COMPOSITION AND METABOLIC MARKERS
AMONG OVERWEIGHT AND OBESE DENTAL STUDENTS IN
UNIVERSITI SAINS MALAYSIA**

ABSTRACT

Introduction: Overweight and obesity are global health issues that pose a threat to individuals in various professions, including dentistry. Dental practitioners often spend prolonged hours in a seated position while treating patients, placing them at a higher risk of developing low back pain. Studies have consistently reported that back pain has a strong correlation with overweight and obesity and significantly impacts the quality of life. Hence, it is crucial to raise awareness among dental students about the importance of maintaining a healthy body mass index (BMI) and lifestyle to prevent factors that contribute to back pain during their undergraduate studies and future dental practice. Objective: This study aimed to determine the effects of moderate-intensity training programs on body composition and metabolic markers among overweight and obese dental students of Universiti Sains Malaysia. Methodology: Thirty-three overweight and obese dental students (control, n=17 and exercise, n=16) were recruited, and their body composition and blood samples were collected pre- and post-intervention. Participants' 24-hour diet recalls were recorded. Students participated in 10 minutes of dynamic warm-up, followed by moderate-intensity Tabata exercise, carried out three times per week for 12 weeks, with an incremental increase in exercise duration every four weeks. Data was analysed using Independent T-test and Paired Sample T-test for normally distributed data and Mann-Whitney U test and Wilcoxon-Signed Ranked test for not normally distributed data. Results: After 12 weeks of

intervention, the exercise group showed no significant differences in resting metabolic rate (RMR) of 1524.1 ± 60.24 kcal/day ($p > 0.584$), while their BMI remained stable at 27.8 ± 0.88 kg/m², indicating no significant change in body composition. Conversely, the control group showed a significant difference in BMI ($p < 0.034$) which had increase in post-intervention (28.92 ± 3.87 kg/m²). Both groups exhibited increases pattern levels of total cholesterol, triglyceride, HDL (high-density lipoprotein) and LDL (low-density lipoprotein) cholesterol, insulin, and IL-6 (interleukin-6) post-intervention. Additionally, the participants consumed high amounts of protein, fats, and sodium, exceeding the recommended nutrient intake (RNI). Conclusion: This study revealed that there were no significant differences in body composition between the control and exercise groups. However, the maintenance of BMI in the exercise group represents a positive outcome as it indicates that participants did not experience weight gain during the intervention. The investigation also detected increases pattern levels of total cholesterol, triglyceride, HDL and LDL cholesterol, insulin, and IL-6, a pro-inflammatory cytokine, in both group, which could be associated with excessive adipose tissue and high caloric intake. Therefore, future studies with stricter dietary restrictions are needed to determine the effects of moderate-intensity physical exercise on dental students' body composition.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Overweight and obesity are global issues faced by many countries, especially Asian countries. The cutoff BMI for overweight in Asia is 23.0kg/m^2 to 27.4kg/m^2 , and for obesity, it is more than 27.5kg/m^2 (Misra et al., 2009). These cutoff points are lower compared to WHO guidelines, which consider a BMI of more than 25.0kg/m^2 as overweight and more than 30.0kg/m^2 as obese (WHO, 2021b). The differences in cutoff points between Asian and WHO guidelines are due to different ethnicities and localities.

The World Health Organisation (WHO) had attributed immense importance to the issue of obesity, which is considered an epidemic that threatens global health. According to their report, obesity is not only a problem predominantly seen in teenagers, but it has also become a universal concern for public health (WHO, 2021b). Rather than being a disease, obesity is considered a harmful phenomenon that is increasing at an alarming rate worldwide, as reported by the International Obesity Task Force (IOTF). Basdevant (2006) regards obesity as a serious consequence that affects human physical comfort, leading to emotional and social imbalances. Furthermore, it has impacts on multiple and sensitive stages of life, from childhood to old age (Basdevant, 2006). In this context, several well-established blood markers, such as blood glucose, total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL), and high-density lipoprotein cholesterol (HDL), and insulin resistance, are implemented as complementary tools for assessing health risk (Murakami et al., 2007).

One of the contributing factors deemed to be related to obesity is physical inactivity, especially among teenagers and students (Bertsias et al., 2003; Peltzer et al.,

2014). The definition of physical activity is any form of motion exerted by skeletal muscles which require energy expenditure (Caspersen et al., 1985). Physical activity and sports contribute not only to a healthy heart and respiratory system but also to overall health (Bertsias et al., 2003). Physical exercise may significantly reduce lipoprotein (Balagopal et al., 2005), which suggesting physical activity has a favourable effect on adiponectin concentrations in adolescents (Dai et al., 2009). It also improves psychological and social well-being, allowing students to better integrate into society, build healthy relationships with their colleagues, and experience other beneficial effects (Ten Hoor et al., 2016). The health benefits of regular physical activity are evident even among obese students, as reported by Ross et. al (Ross et al., 2000).

The best workout regimen for reducing body mass and lowering body fat in obese people has yet to be determined. Previously, moderate-intensity interval training was recommended as the major approach for losing body mass and body fat loss (Keating et al., 2015). The current study proposes moderate-intensity Tabata training as an ideal exercise prescription for this vulnerable group. In 1996, Izumi Tabata, a Japanese scientist who first coined Tabata training, defined this training as repeated sessions of moderate exercise interspersed with low-intensity recovery periods (Emberts et al., 2013). Since then, Tabata training has evolved further to include a wide range of exercises and workouts but still adhering to the original pattern—20 seconds of vigorous effort alternate with 10 seconds of rest.

Few studies have shown that high-intensity interval training may improve health when practiced and performed over a period of time as it achieves a similar magnitude to regular moderate-intensity interval exercise, and this improvement is achieved due to increased cardiorespiratory fitness (Ciolac et al., 2010) and work

capacity (Burgomaster et al., 2005), increased muscle mitochondrial and GLUT-4 (Glucose Transporter type 4) levels (Little et al., 2010), and improved insulin sensitivity (Ciolac et al., 2010). Studies have shown that the high-intensity interval training enhanced fitness and insulin sensitivity in those who are overweight or obese, when compared to the effect of moderate-intensity interval exercise (Hood et al., 2011; Richards et al., 2010; Whyte et al., 2010).

The dynamic warm-up has also been introduced as one of the moderate exercises in a few previous studies. However, it took a long duration of 10 months (Santiago et al., 1995), 12 months (Jakicic et al., 2003), and 13 months (Hardman et al., 1992) to show a significant improvement. Regardless of the duration, initial treatment should aim to perform moderate-intensity at least 150 per week before activity and maintain before progressing to higher exercise levels as recommended by the Institute of Medicine's i.e. 60 minutes per day as appropriate. Combining moderate-intensity dynamic warm-up and Tabata training could provide a positive outcome.

Preventing, and identifying weight issues as well as providing advice to patients require training of healthcare professionals. This is to ensure that the right messages are delivered effectively in order to improve patients' motivation and understanding of weight loss (Bocquier et al., 2005; Jackson et al., 2013). As obesity is a major predisposing factor for oral diseases, it is important for dentists to counsel patients during their visits to dental hospitals and clinics to identify the underlying causes of obesity and carry out appropriate management and prevention procedures. Moreover, dentists should be aware of obesity complications as study has reported a close relationship between obesity and back pain (Shiri et al., 2010). The nature of work among dentists and dental auxiliaries may also predispose them to back pain,

particularly when practicing poor posture (Samat et al., 2011; Sharma and Golchha, 2011).

1.2 Problem statement

Dentists often spend periods sitting, rendering them more susceptible to a sedentary lifestyle compared to other professions. Consequently, back pain is a common issue among dentists, affecting 38% to 80% of them (Samat et al., 2011). Therefore, incorporating exercise into their daily routine can help alleviate back pain and improve posture. Tabata training involves repeated sessions of moderate exercise with low-intensity recovery periods (Emberts et al., 2013). While primarily used to enhance sports performance in athletes, a 10-week high-intensity Tabata program proved effective in improving body composition among overweight students (Domaradzki et al., 2020). However, there is limited information on the effects of moderate intensity Tabata exercise on metabolic marker, particularly in overweight and obese populations where metabolic syndrome is prevalent. To address this knowledge gap, a 12 weeks of a moderate intensity Tabata protocol is proposed for this study.

The risk of metabolic syndrome, prevalent among the overweight and obese population, can be prevented or reduced by maintaining a healthy diet and being physically active. In Malaysia, the Ministry of Health has introduced the ‘Quarter-Quarter-Half’ campaign, advocating for a balanced plate that includes proteins and carbohydrates, each contributing a quarter portion and half filled with vegetables (Ministry of Health Malaysia, 2016). To align with the government campaign, the participants dietary intake was assessed by using a 24-hour diet recall to identify their daily pattern.

1.3 Justification of the study

Based on previous studies, moderate-intensity exercise has been shown to bring about significant changes in body composition, such as body weight, BMI, body fat percentage, visceral fat, and resting metabolic rate. Specifically, moderate-intensity exercise has been found to effectively improve BMI and body fat percentage (Cao et al., 2021). In overweight and obese individuals, moderate-intensity exercise has been shown to have a significant impact on blood lipid profiles, as it leads to a decrement in adiposity. It has been found that the elevation of total cholesterol levels is associated with the elevation of triglycerides and saturated fat percentage of total energy intake (Rinaldi et al., 2012). Additionally, there are changes in inflammatory markers such as IL-6, as concentrations of IL-6 decrease after moderate-intensity exercise (Moghadam et al., 2021). Specifically, a 12-week moderate-intensity training program has been shown to result in decreases in TNF- α , IL-6, and leptin concentrations, while leading to an increase in IL-10 and adiponectin concentrations (Moghadam et al., 2021). Furthermore, it has been found that as the exercise intensity increases, there is an improvement in insulin sensitivity (Heiston et al., 2020). This indicates that moderate or high-intensity exercise training could be effective in improving insulin sensitivity.

Therefore, the purpose of this study is to observe the effects of moderate-intensity training program on body composition and metabolic markers among overweight and obese dental students at Universiti Sains Malaysia. The study will provide valuable information on the effectiveness of moderate intensity exercise in improving body composition and metabolic health among overweight and obese individuals, particularly in a young adult population. The findings of this study can be used to develop more effective exercise interventions for this population, ultimately

improving their overall health and well-being. In addition, this study will also benefit future dentists in reducing the risk of low back pain and musculoskeletal issues.

1.4 Research questions

1. Are there any significant differences in body weight, BMI, waist-and-hip ratio, body fat percentage, visceral fat, lean mass, resting metabolic rate (RMR) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks intervention?
2. Are there any significant differences in blood parameters (total cholesterol, high density lipoprotein, low density lipoprotein, triglyceride, insulin level and interleukin-6 (IL-6)) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks intervention?
3. Are there any differences between total calories in macronutrients and micronutrients intake and recommended nutrient intake (RNI) values in overweight and obese dental students?

1.5 Research hypotheses

H₀₁: There are no significant differences in body weight, BMI, waist-and-hip ratio, body fat percentage, visceral fat, lean mass, resting metabolic rate (RMR) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks intervention.

H_{A1}: There are significant differences in body weight, BMI, waist-and-hip ratio, body fat percentage, visceral fat, lean mass, resting metabolic rate (RMR) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks intervention.

H₀₂: There are no significant differences in blood parameters (total cholesterol, high density lipoprotein, low density lipoprotein, triglyceride, insulin level and interleukin 6 (IL-6)) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks intervention.

H_{A2}: There are significant differences in blood parameters (total cholesterol, high density lipoprotein, low density lipoprotein, triglyceride, insulin level and interleukin 6 (IL-6)) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks intervention.

H₀₃: There are no differences between total calories in macronutrients and micronutrients intake and recommended nutrient intake (RNI) values in overweight and obese dental students.

H_{A3}: There are differences between total calories in macronutrients and micronutrients intake and recommended nutrient intake (RNI) values in overweight and obese dental students.

1.6 Research objectives

1.6.1 General objectives

To determine the effects of moderate-intensity training programs on body composition and metabolic markers among overweight and obese dental students of Universiti Sains Malaysia.

1.6.2 Specific objectives

1. To compare body weight, BMI, waist-and-hip ratio, body fat percentage, visceral fat, lean mass, resting metabolic rate (RMR) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks of intervention.
2. To compare blood parameters (total cholesterol, high density lipoprotein, low density lipoprotein, triglyceride, insulin level and interleukin-6 (IL-6)) between and within control group (without dynamic warm-up and Tabata exercise) and exercise group (with dynamic warm-up and Tabata exercise) before and after 12 weeks of intervention.
3. To determine total calories intake in macronutrients and micronutrients and compare with recommended nutrient intake (RNI) in overweight and obese dental students.

CHAPTER 2

LITERATURE REVIEW

2.1 Overweight and obesity

2.1.1 Prevalence of overweight and obesity

Overweight and obese are defined as the abnormal or excessive fat accumulation that may impair health (WHO, 2021b). According to epidemiological studies, overweight and obesity are on the rise worldwide. Overweight and obese can strike anyone at any age. These two body weight issues have become more common in people and children of all ages, regardless of geographic location, ethnicity or financial status (Chooi et al., 2019). In 2015, a report showed that 1.9 billion adults were overweight and 609 million individuals were obese worldwide, accounting for nearly 39% of the global population (Haththotuwa et al., 2020). Young adult men were slightly more likely than women of the similar age group to be overweight (aged 20 to 44 years), but this trend reversed around the age of 45-49 years, probably due to menopause in women which occurs around the same time. (Ko and Kim, 2020). The rates of overweight and obesity grew with age, beginning at 20 years and peaked between 50 and 65 years, and fell slightly in the elderly (Chooi et al., 2019). Nowadays, overweight and obesity have been underestimated by people globally because of the perspective that those who are overweight or obese could be treated. Such a perspective should be changed because prevention is better than cure, and the trend could decrease slowly.

Chooi et al. (2019) discovered that between 1980 and 2015, the percentage of males with a BMI less than 25 kg/m² went from 25.4% to 38.5%, while the percentage of females with a BMI less than 25 kg/m² climbed from 27.8% to 39.4%. The authors noted that the proportion of males and females with a BMI less than 25 kg/m² decreased over the years, indicating an increased prevalence of overweight and obesity. In high-

income countries, obesity affects both sexes and all ages, being more common among disadvantaged groups, however, this problem was seen more in women of wealthy background in high-income countries (Swinburn et al., 2011).

According to the National Health and Morbidity Survey (NHMS) report (2019), one in every two persons in Malaysia is overweight or obese, with abdominal obesity being the most common type. Overweight or obese Malaysians account for around 50.1% of the adult population, which 30.4% are overweight and 19.7% are obese. Following that, 52.6% of adults suffer from abdominal obesity (Ministry of Health Malaysia, 2019). The trend for overweight, obesity, and abdominal obesity has been on the rise yearly since 2011. In year 2011, 29.4% were overweight, 15.1% were obese, and 45.4% had abdominal obesity, which percentage have increased in 2015 to 30.0%, 17.7%, and 48.6%, respectively. Furthermore, according to the NHMS report (2019), 29.8% of children aged 5 to 17 years have problems with increased weight, with 15.0% being overweight and 14.8% being obese (Ministry of Health Malaysia, 2019). By 2050, obesity is expected to affect up to 20% of the world's population.

Dentistry often involves long hours of sitting to perform dental procedures. This sedentary nature of the profession limits physical activity and may contribute to weight gain if the amount of caloric intake and expenditure are not balanced. When the caloric intake is higher than energy expenditure it leads to increase in body weight (Hill et al., 2012). Next, the demanding nature of dental practice, including back-to-back appointments and limited breaks, can lead to irregular eating patterns. Dentists may find it challenging to prioritize regular meals or may resort to quick, convenient, and often unhealthy food choices. Irregular eating can disrupt hunger and satiety cues, potentially leading to overeating or unhealthy snacking (Almoraie et al., 2021). Most dentists often prioritize their patients' oral health needs above theirs; this tendency to put others first

can lead to neglecting personal health, including proper nutrition, exercise and self-care practices.

Also, dentistry can be a high-stress profession with the pressure to provide quality care, manage patient expectations and run a practice efficiently which trigger emotional eating or unhealthy coping mechanism, such as turning to comfort foods high in sugar or fat which can contribute to weight gain over time. In addition to stress related to patient care, dentists may also face stressors associated with managing their dental practices, financial pressures and dealing with insurance companies. Chronic stress can impact hormonal regulation which leads to weight gain or difficulty in losing weight (Scott et al., 2012).

2.1.2 Problem associated with overweight and obesity

Obesity and overweight are substantial risk factors for chronic noncommunicable diseases such as cardiovascular disease, diabetes, chronic kidney disease, and musculoskeletal disorders (Afshin et al., 2017). Hypertension and hypercholesterolemia are also associated with overweight and obesity. While certain factors such as family history, genetics, race, ethnicity, and gender cannot be changed, lifestyle and environmental changes can address other risk factors. By adopting healthier habits such as balanced diet and regular physical activity, individuals can reduce their risk of developing overweight and obesity and prevent associated health problems.

Dentists who are overweight or obese are at higher risk of suffering from health issues such as diabetes, cardiovascular disease, and musculoskeletal issues (Yamalik, 2006). These conditions can significantly impact their overall well-being and ability to perform their duties effectively, especially given the physical demands of dental profession, which requires dentists to maintain proper posture and use repetitive

motions, making them susceptible to musculoskeletal problems. Obesity can exacerbate these issues, making it more challenging for dentists to perform their daily tasks, leading to discomfort or increased risk of injury.

2.1.2(a) Hypertension and hypercholesterolemia

Hypertension or high blood pressure is a medical condition that negatively affects multiple organs especially the heart, brain, and kidney. Blood pressure is the force exerted by flowing blood on the walls of the arteries, and it is expressed in millimetres of mercury (mmHg) with two readings, the systolic (when the heart contracts or beats) and the diastolic (when the heart is resting between beats) (Tortora and Derrickson, 2012). Hypertension is diagnosed when the systolic reading is ≥ 140 mmHg, the diastolic reading is ≥ 90 mmHg on two different occasions (InformedHealth.org, 2010). Uncontrolled hypertension can lead to serious complications, such as stiffening of the arteries and reduce blood and oxygen flow to the heart, which can cause angina (chest pain), heart attack (when the heart's blood supply is cut off, heart muscle cells die from a lack of oxygen), heart failure (when the heart cannot pump enough blood and oxygen to other essential organs in the body), and irregular heartbeat, all of which can result in sudden death (WHO, 2021a). In Malaysia, the overall prevalence of hypertension among Malaysian adults was 30% in 2019, which showed a plateau result from 2011 (32.6%) and 2015 (30.3%) (Ministry of Health Malaysia, 2019).

In the United States, obesity has been demonstrated to be a better predictor of hypertension than other cardiovascular diseases including heart attack and stroke (Akil and Ahmad, 2011). In obese individuals, hypertension may result from the combination of adipokines production from adipose tissue with perivascular and microvascular inflammation (Chu et al., 2018). Higher cardiac outputs, glomerular filtration rates, and

salt retention in the kidneys are all associated with higher BMI level and can contribute to hypertension. Hypertension development may also be influenced by other processes linked to fat, such as insulin resistance, inflammation and neuropeptides such as leptin (Kotsis et al., 2010). Additionally, overweight and obesity with either abdominal or central obesity can contribute to hypertension. According to Chu et al. (2018), hypertension occurs more frequently in overweight and obese women than men due to the higher ratio of greater BMI in women. It is believed that weight gain leads to high blood pressure and increases the risk of cardiovascular disease and stroke.

Hypercholesterolemia, or elevated blood cholesterol is a well-known risk factor for cardiovascular, cerebrovascular, and peripheral vascular diseases (Al-Zahrani et al., 2021). All of the body's cells naturally contain cholesterol, a waxy, fatty-like substance. The body makes all the cholesterol it needs. Hypercholesterolemia can be contracted or passed down via the family. Eighty-five per cent of the hereditary causes are due to genetic abnormalities in the LDL receptor gene (Al-Zahrani et al., 2021). Other genetic causes include a defective apolipoprotein B, a gain-of-function mutation in the proprotein convertase subtilisin/kexin type 9 gene, a mutation in the LDL receptor adaptor protein, and polygenic HC (Sturm et al., 2018). Medical problems such as hypothyroidism, diabetes mellitus, nephrotic syndrome, and cholestasis are examples of the acquired causes. Drugs such as cyclosporine and thiazide, high dietary cholesterol intake, and smoking have also been associated with an elevated risk of hypercholesterolemia (Al-Zahrani et al., 2021). Hence, if an individual has high cholesterol in the blood, a plaque (sticky deposit) will form against the artery wall, eventually narrowing the blood vessel. This narrowing of blood vessels will disrupt blood circulation to the brain, heart, and other vital organs. Blood cells can adhere to plaque which later can break off and form clots. If the clot is large enough, it can reduce

or block the blood flow through an artery and cause a heart attack or ischemic stroke (Eljamay, 2020).

The normal range for total blood cholesterol is between 140 and 200mg/dL of blood. A high-density lipoprotein (HDL), known as “good cholesterol” and low-density lipoprotein (LDL), known as “bad cholesterol”. Triglycerides can also be found in cholesterol (Eljamay, 2020). An individual with hypercholesterolemia has low HDL and high LDL and triglycerides, which increases the risk of cardiovascular disease. However, high cholesterol can be prevented by adopting a healthy lifestyle, such as engaging in physical activity or exercise and consuming a healthy diet. Eljamay (2020) states that BMI and serum cholesterol levels are positively correlated. Obese people are more likely to develop hypercholesterolemia than overweight people in their early middle years. After age 35, the risk of hypercholesterolemia increases in overweight males, but there is no statistically significant association between BMI and hypercholesterolemia in women (Veghari et al., 2013). Other studies have found no association between BMI and blood cholesterol levels in postmenopausal women (Veghari et al., 2013).

2.1.2(b) Diabetes

Diabetes mellitus (DM) is a chronic disease marked by high glucose levels in the blood. DM is caused by either reduced insulin secretion by pancreatic β -cells of the islets of Langerhans or reduced insulin sensitivity to glucose. DM is classified into Type 1 diabetes and type 2 diabetes (Al-Goblan et al., 2014), the former is a genetic disorder that often presents early in life while the latter is primarily lifestyle-related and develops over time.

According to Al-Goblan et al. (2014), although type 1 diabetes is more commonly observed in children, it can also affect adults, particularly those in their late

thirties and early forties. Patients with type 1 diabetes are usually not severely overweight and often present with diabetic ketoacidosis, a life-threatening condition. The causes of type 1 diabetes may include damage to pancreatic cells due to infections or environmental factors. When the immune system detects changes in β -cells or the molecules within that are identical to viral proteins, it triggers an immunological response that attacks these β -cells (Al-Goblan et al., 2014). Indeed, autoimmunity has been proposed to be the most critical factor in the pathogenesis of type 1 diabetes.

Unlike type 1 diabetes, type 2 diabetes affects adults and the elderly who have pancreatic β -cell failure or impaired insulin secretion capacity, as well as peripheral insulin resistance (Kasuga, 2006). Insulin resistance is induced by an increase in fatty acids in the blood as a result of increased fat metabolism, as well as impaired glucose transport into muscle cells, resulting in increased hepatic glucose production. Dysfunction of β -cells is a significant element in the progression of prediabetes to diabetes in type 2 diabetes. Postprandial blood glucose levels rise first in people who go from normal to impaired glucose tolerance.

Fasting hyperglycaemia may develop if hepatic gluconeogenesis inhibition fails (Porte, 1991). Furthermore, insulin resistance in the presence of lipid and thrombotic abnormalities, as well as atherosclerotic risk factors (such as smoking, a family history of cardiovascular disease, and hypertension), all contribute to a patient's cardiovascular risk. Even before acute hyperglycaemia develops, cardiovascular risk is related with the development of insulin resistance (Al-Goblan et al., 2014).

Baum et al. were the first to investigate the relationship between weight gain and type 1 diabetes in 1975. Baum et al. (1975) discovered that overfeeding was linked to hormone instability (Baum et al., 1975). Wilkin (2001) hypothesised that gaining weight at a young age increases the risk of developing type 1 diabetes. Moreover, type

1 diabetes may be diagnosed earlier in young children who experience weight gain, and greater weight gain may accelerate insulin resistance, resulting in the development of type 1 diabetes (Wilkin, 2001). Insulin resistance is linked to both obesity and type 2 diabetes. However, most obese individuals do not have hyperglycaemia due to the normal release of insulin by pancreatic β -cells. The absence of esterified fatty acids (NEFAs) being secreted by adipose tissue suggests a possible link between insulin resistance and β -cell dysfunction (Al-Goblan et al., 2014).

According to the National Health and Morbidity Survey (2019), the prevalence of diabetes among Malaysian adults is on the rise. In 2011, 11.2% of the adult population was diagnosed with diabetes mellitus, followed by 13.4% in 2015 and 18.3% in 2019. According to Chu et al. (2018), obese people are more likely to develop type 2 diabetes than people of average weight. However, the risk of type 2 diabetes in obese people are differed between studies (Chu et al., 2018). Thus, overweight and obese individuals are at a higher risk of developing type 2 diabetes.

2.1.2(c) Musculoskeletal issues

The musculoskeletal system is composed of bones, muscles, ligaments, tendons, cartilage, nerves, and blood vessels (Yamalick, 2006). The American Dental Association has identified several risk factors for musculoskeletal issues, including repetitions, force, mechanical stressors, posture, vibration, cold temperature and extrinsic stress (Kawtharani et al., 2023). Repetitive actions can result in muscle overuse and overextension, leading to muscle fatigue and injury. Additionally, these symptoms often affect opposing muscle groups and tendons. Force is the physical effort required to perform a series of movements to complete a task.

Dentists frequently work in a forward-leaning position while treating patients, which can strain the muscles in the neck and shoulders over time, leading to muscle

imbalances, stiffness, and pain. Prolonged sitting, often in a twisted or hunched position, can also strain the lower back, and inadequate lumbar support and ergonomics in the dental operatory can contribute to the development of back pain. Sitting in awkward positions for extended periods can also put stress on the hips and knees. Moreover, dentists perform repetitive tasks and use specific hand and wrist movements during procedures, which can lead to conditions like carpal tunnel syndrome, tendonitis, or other overuse injuries affecting the hands and wrists. The combination of maintaining static positions and performing fine motor movements for extended periods can lead to muscular fatigue, reducing muscle support and stability and increasing the risk of developing musculoskeletal issues (Statham et al., 2010).

2.2 Body composition

2.2.1 Body shape for overweight and obese

Bone structure, genetics, age, fat distribution, muscle mass, and lifestyle all contribute to body shape. Individual body shape can be made by taking anthropometry measurements of the chest, waist, and hip. According to Wang et al. (2015), body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-stature ratio (WSR) are all recommended markers for chronic diseases in adults. However, Gažarová et al. (2019) stated that although waist circumference is widely regarded as an indicator of fat distribution, it does not differentiate between subcutaneous fat and visceral fat mass (Gažarová et al., 2019). Body shape is typically categorised into five distinct categories—apple, pear, hourglass, ruler, and inverted triangle—based on the overall body fat distribution. Wang et al (2015) associated body fat distribution with body shape using four distinct types of fruits that resemble most body shapes, such as apple, pear, pear-apple, and chilli (S. Wang et al., 2015). Of these five categories, the

apple shape has the highest risk for health issues. For example, a large waist circumference indicates a high risk of cardiovascular disease and type 2 diabetes. Therefore, WC and WHR are widely used to screen for these conditions by measuring abdominal fat in the community and clinical practice.

Body shape in an obese person can indicate cardiovascular risk, and the combination of BMI, WC and hip circumference is the best measurement for quantifying body shape and detecting the relationship between body shape and hypertension (S. Wang et al., 2015). The apple body shape in obesity has a higher risk of health problems than the pear body shape because fat distribution around the waist affects important organs in the upper body, such as the heart and liver. Fats around the capillaries surrounding the heart and narrowed blood vessels can lead to ischemic stroke and hypertension and disrupt insulin production in the liver, causing the individual to have type 2 diabetes. Populations with a normal BMI and larger waist circumference have also been linked to an increased risk of cardiovascular mortality (Chen et al., 2019). A few other studies have also shown that pear body shape or gynoid fat is associated with a decreased risk of cardiovascular disease (Lanfer et al., 2014; Zong et al., 2016). Therefore, overweight and obese individuals with an apple body shape have a higher risk of cardiovascular diseases than individuals with a pear body shape.

2.2.2 Body mass index and waist-and-hip ratio

According to WHO (2021), obesity and overweight are characterized as abnormal or excessive fat accumulations that can have negative impacts on one's health. Body mass index (BMI) is a simple weight-for-height index that is often used to identify whether a person is overweight or obese. It is calculated by dividing a person's weight in kilograms by the square of his/her height in metres (kg/m^2). Overweight and obesity are defined differently in Asian populations, with cutoff BMIs of 23.0-27.5 kg/m^2 for

overweight and greater than 27.5kg/m^2 for obesity. However, BMI does not directly measure the body fat, but it is correlated with direct measures of body fat obtained from methods such as skinfold thickness measurements, bioelectrical impedance, underwater weighing, dual energy x-ray absorptiometry (DXA), and others.

Excess fat mass can also be an indicator of a risk factor for chronic disease and early death. BMI can be used to measure body fatness because it measures excess body weight. However, several studies reported waist circumference (WC) is a better predictor of overweight-related factors than BMI (Janssen et al., 2004; Y. Wang et al., 2005). WC and hip circumference (HC) have been used for other markers in abdominal obesity with large WC is related to morbidity and premature death while large HC is protective for these same outcomes (Cameron et al., 2020). The suggested WC cutoff point in Malaysia for abdominal obesity men is 92.5 cm and above while for women is 85.5cm and above (Ahmad et al., 2016). The waist-to-hip ratio (WHR) is calculated by dividing WC (cm) by HC (cm) and is an indicator of abdominal obesity. The cutoff point for WHR in Caucasians is greater than 1.0 in men and more than 0.85 in women. In contrast, the cutoff points for WHR in Asians are 0.95 for men and 0.80 for women, which are much smaller than those for Caucasians.

2.2.3 Influence of lifestyle on body composition

Overweight and obesity have become a universal problem among the adult population, largely due to an imbalance between food intake and physical activity. Many adults can be categorised as sedentary if they engage in less than 150 minutes of physical activity per week. In the modern era, the availability of motorized vehicle, technological products, and home delivery services have made everything seem easier, resulting in individuals responding normally to obesogenic environments. Obesogenic environments refer to the conditions of life that promote obesity in individuals and the

population as a whole (Lake and Townshend, 2006). Moreover, modernization has led to sedentary lifestyles, with people spending long hours sitting on the sofa watching TV or playing games, without worrying about food procurement, as they can order food online and have it delivered to their doorstep with ease. Many applications and sources provide food delivery services, which benefits both consumer and business. Consumers receive the foods while businesses make profits.

Developing countries have been predicted to experience the fastest rate of increase in overweight and obesity. Over the past two decades, these countries have seen a higher growth in overweight and obesity prevalence compared to developed countries. Prior to the early 1980s, obesity was not a major public health issue in economically developing countries until socioeconomic and nutritional conditions improved (Chu et al., 2018). According to Swinburn et al. (2011), an estimated 1.46 billion adults worldwide were overweight (body-mass index (BMI) $>25 \text{ kg/m}^2$) and 502 million adults were obese (BMI $>30 \text{ kg/m}^2$) by 2008 (Finucane et al., 2011). The increase in prevalence is due to an improvement in food availability and a decrease in physical activity. As countries become more developed, access to food, especially fast-food such as McDonald's, KFC, Marrybrown and other fast-food franchises providing drive-thru and delivery 24 hours a day, increases. Most fast-food options are small portions but with hidden high amounts of calories, and a sedentary lifestyle exacerbate the risk of overweight and obesity. An imbalance of energy availability, where there is high calorie intake but low energy expenditure, leads to positive energy availability and ultimately overweight and obesity. Additionally, top franchise companies always have promotions and seasonal menus to attract customers to buy their products. For developing countries, affordable prices and the trendy food options make them popular among population.

Other than that, people who are overweight and obese can be influenced by having ultra-processed food in their daily meals. Ultra-processed foods, such as chocolate candy, ice cream, sweetened breakfast cereals, chicken nuggets, and fries, go through multiple processes (extrusion, moulding, milling and other) and contain many added ingredients, such as salts, sugar, artificial colour, and fats. The consumers of these food are at high risks of developing cardiovascular disease and increased blood pressure. Cookies and candies are examples of ultra-processed food that have been associated with increased overall dietary energy intake and weight gain that may lead to positive energy balance (Tucker et al., 2021).

Sedentary lifestyle or behaviour develops due to lack of health literacy in the population. People may think that physical activity is the least priority as they are healthy, but being physically active can prevent individuals from the risks of chronic diseases such as cardiovascular disease, type 2 diabetes, and others. Nowadays, many young adults are involved in e-sports, which is playing video games as their sports. However, the accelerated growth in e-sports is accompanied by increased time spent sitting while playing. The increased screen time is associated with a high prevalence of obesity and unhealthy lifestyle behaviours in adults (Trotter et al., 2020). Besides that, e-sports players also do not meet the WHO physical activity guidelines for the general population, whereby adults should have at least 150 minutes of physical activity per week. Physical activity is defined as any voluntary bodily movement produced by skeletal muscles that require energy expenditure. Therefore, e-sports players can be categorized as sedentary because they are not practicing physical activities.

2.3 Metabolic markers

2.3.1 Association of insulin, lipid profile and interleukin-6 (IL-6) with overweight and obesity

Overweight and obesity are major risk factors for cardiovascular disease and type 2 diabetes. People with overweight and obesity are often associated with high blood pressure, high blood cholesterol, impaired glucose tolerance, or high glucose levels. These high blood pressure, abnormal levels of blood cholesterol, and high blood glucose levels increase the risk for heart disease. Therefore, blood markers such as fasting lipid profile (cholesterol, triglycerides, LDL and HDL) and fasting glucose are carried out in this high-risk group to detect the risk of cardiovascular disease and type 2 diabetes (Mezghanni et al., 2012). Fasting lipid profile is a set of blood tests used to detect lipid abnormalities such as cholesterol, LDL, HDL, and triglycerides, while fasting glucose measures the glucose level in the plasma upon fasting. Another marker to look for in overweight and obese people is interleukin-6 (IL-6). IL-6 is a pro-inflammatory cytokine that has a role in controlling the inflammatory response. The increased levels of IL-6 in obese people may raise the risk of cardiovascular complications, insulin resistance, and type 2 diabetes (El-Mikkawy et al., 2020).

Insulin resistance occurs when cells in muscles, fat, and liver do not respond adequately to insulin and are unable to use glucose from the blood as an energy source. In overweight and obesity, the probability of having insulin resistance is higher compared to normal weight. Insulin sensitivity also seems to decrease naturally across the natural life cycle, such as during pregnancy, puberty, and ageing. Changes in insulin sensitivity are associated with increased carbohydrate intake and decreased physical activity (Al-Goblan et al., 2014). For example, when carbohydrate intake is high but physical activity is low, it will increase the risk of insulin resistance. According to Al-

Goblan et al. (2014), another important element that influences insulin sensitivity is body fat distribution. At a certain level of weight increase, insulin resistance is linked to body mass index. Due to variations in body fat distribution, insulin sensitivity appears to vary among lean people. Insulin sensitivity is higher in those with peripheral fat distribution than in people with central fat distribution in the abdomen and chest area. For instance, skeletal muscle tissues cannot break down glucose in response to insulin when people are physically inactive. Moreover, abdominal fat is expected to be more lipolytic than subcutaneous fat and does not respond well to insulin's antilipolytic activity, making intra-abdominal fat more essential in generating insulin resistance and hence diabetes (Al-Goblan et al., 2014).

High adiposity is associated with high blood lipid levels and body fat percentage, as suggested by Rinaldi et al. (2012). For overweight and obese people, the triglyceride level is high due to excess adiposity. Besides, the elevation of total cholesterol level is positively associated with full-fat dairy products, the elevation of triglycerides levels and the saturated fat percentage of total energy intake (Rinaldi et al., 2012). So, the higher the intake of high-fat dairy products such as whole milk, full-fat cheese, heavy cream, and butter with 80% butterfat, the higher the total cholesterol level. Full-fat dairy products are good for development and growth. However, the intake of the full-fat dairy products should be minimised or changed to skim dairy products. Nevertheless, the small amount of full-fat dairy serving still has high cholesterol level which is the main source of saturated fat that increases the visceral adipose tissue which could lead to dyslipidaemia.

The excess of macronutrients stored in adipose tissue stimulates the release of inflammatory adipokines such as interleukin-6 (IL-6), tumour necrosis factor α (TNF- α), monocyte chemoattractant protein-1 (MCP-1), and resistin, leading to a state of

chronic inflammation in overweight and obese individuals (El-Mikkawy et al., 2020). IL-6 levels are known to increase in obese individuals with chronic inflammatory conditions and abnormalities in serum lipid concentration. Therefore, increasing IL-6 levels in obese individuals may increase the risk of cardiovascular disease, insulin resistance, and type 2 diabetes. According to El-Mikkawy et al. (2020), positive associations have been described between BMI and IL-6 levels in postmenopausal women. Additionally, the high level of IL-6 is also due to the presence of high adipose tissue in individuals with abdominal obesity. Furthermore, obesity-induced chronic inflammation plays an important role in the mechanisms of insulin resistance, as it leads to an increase in biochemical inflammatory markers such as IL-6 and TNF- α (Chow et al., 2021).

2.4 Exercise prescription

2.4.1 Intensity of exercise

Exercise needs to be planned, structured, and repetitive to improve one or more health-related components. Examples of exercise include walking, jogging, swimming, cycling, dancing, and others. The level of intensity can be divided into a few levels which are low, moderate, and vigorous based on the heart rate reserve (HRR) of each individual. The American College of Sports Medicine (ACSM) recommends that adults aged between 18 to 64 years old should do at least 150 minutes of moderate-intensity of aerobic exercise per week or at least 75 to 150 minutes of vigorous-intensity of aerobic exercise per week, or an equivalent combination of moderate- and vigorous-intensity per week (WHO, 2016).

Furthermore, intensity classifications are ranked according to the energy demands and represent the gradient in metabolic and neurohumoral responses during