Discriminating Metabolic Health Status in a Cohort of Nursing Students: A Cross-Sectional Study

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ABSTRACT

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Nurses have a vital role in counselling their patients towards healthier living. However, nurses tend to have poor metabolic health that may be influenced by lifestyle. Whether this begins during their nursing education is poorly understood. Undergraduate nursing (n=42) and biology (n=15) students had their metabolic health assessed through body measurements, fasting blood glucose and lipids. Lifestyle factors of physical activity, nutrition, stress, and sleep were assessed using questionnaires, accelerometry, diet logs, and heart rate variability. At an individual level, 31.0% of nursing students are at-risk of poor metabolic health. Results suggest that nursing students are sedentary, obtaining poor sleep quality, consuming elevated amounts of saturated fat, and perceiving themselves to be under mild stress. The implementation of lifestyle interventions should be considered for this cohort. However, few differences were found between nursing and biology groups, indicating that the results are potentially generalizable to a larger group of undergraduate students.

Keywords: metabolic health, lifestyle, physical activity, nutrition, psychological stress, sleep quality, nursing students

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LIST OF ABBREVIATIONS

Abbreviation	*Definition*
AHA	American Heart Association
ANS	Autonomic nervous system
BF%	Body fat percentage
BMI	Body mass index
BP	Blood pressure
CCSA	Canadian Centre on Substance Use and Addiction
CMA	Canadian Medical Association
CPM	Counts-per-minute
CSEP	Canadian Society for Exercise Physiology
CVD	Cardiovascular disease
DASS	Depression anxiety stress scale
EGIR	European Group for the Study of Insulin Resistance
ESC	European Society of Cardiology
HC	Hip circumference
HDL	High-density lipoprotein
HF	High frequency
HR	Heart rate
HRV	Heart rate variability
IDF	International Diabetes Foundation
IPAQ	International physical activity questionnaire

Abbreviation	***Definition***
kcals	Kilocalories
LDL	Low-density lipoprotein
LF	Low frequency
MAP	Mean arterial pressure
MAQ	Modifiable activity questionnaire
MET	Metabolic equivalent of task
MVPA	Moderate to vigorous physical activity
NASPE	North American Society of Pacing and Electrophysiology
NCEP	National Cholesterol Education Program
NCEP-ATP III	National Cholesterol Education Program-Adult Treatment Panel III
NHLBI	National Heart, Lung, and Blood Institute
NIH	National Institutes of Health
OC	Obesity Canada
PA	Physical activity
PHAC	Public Health Agency of Canada
PNS	Parasympathetic nervous system
PSQI	Pittsburgh sleep quality index
RN	Registered nurse
RPE	Rating of perceived exertion
RPN	Registered practical nurse
RQ	Research question

Abbreviation	*Definition*
SD	Standard deviation
SNS	Sympathetic nervous system
T2DM	Type 2 diabetes mellitus
TG	Triglyceride
WC	Waist circumference
WHO	World Health Organization
WHR	Waist-to-hip ratio

1 INTRODUCTION

1.1 Background

Obesity was first declared as a public health issue and global epidemic by the World Health Organization (WHO) in 1997 (Haththotuwa, Wijeyaratne, & Senarath, 2020). Since then, obesity rates have tripled, and an estimated 39% of the global population are considered overweight or obese (WHO, 2021). Obesity puts individuals at greater risk of developing many chronic diseases, including type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD), and certain cancers (Kyrou et al., 2018). Overweight/obesity, an abnormal or excessive accumulation of fat, is typically determined using body mass index (BMI) (WHO, 2021). BMI is an effective way of assessing obesity at a population level, however it does not account for fat distribution or muscle mass and therefore, on its own, it may not be an appropriate indicator of an individual’s personal health risk (Marchiondo, 2014; WHO, 2000). A more complete assessment of an individual’s risk for obesity associated chronic diseases is metabolic health (Kunzova et al., 2020). Metabolic health is a composite consideration of multiple risk factors including blood pressure (BP), fasting blood glucose, waist circumference (WC), and blood lipid measurements of triglycerides (TG) and high-density lipoprotein (HDL) (James et al., 2004; Kunzova et al., 2020). Poor metabolic health is also associated with increased risk of T2DM, CVD, and some cancers, and is thought to depict an individual’s risk of negative health outcomes more accurately (Kunzova et al., 2020; Kyrou et al., 2018; Somi et al., 2019).

Additionally, lifestyle factors including physical activity (PA), nutrition, sleep, and stress each influence individuals' health and can impact metabolic health status (Health Canada, 2019a; Nelson, Davis, & Corbett, 2022; Schneiderman, Ironson, & Siegel, 2005; Tremblay et al., 2011). It is widely accepted that engaging in regular, moderate-vigorous PA is associated with a reduced risk of all-cause mortality, CVD mortality, hypertension, T2DM, certain cancers (including breast and colon cancers), adiposity, and weight gain, along with an improved blood lipid profile, mental and cognitive health, sleep, and physical function (CSEP, 2020; Gerber et al., 2014; Kelley & Kelley, 2017; Kovacevic et al., 2018; Lavretsky & Abbott, 2018; WHO, 2020). Prolonged periods of psychological stress are associated with hypertension, CVD, decreased immunity, exacerbations of auto-immune diseases, along with depression and adverse effects on mental health (Schneiderman, Ironson, & Siegel, 2005). Poor sleep quality or quantity can lead to an increased risk of obesity, T2DM, metabolic syndrome, breast cancer, anxiety, depression, and mood disorders (Jehan et al., 2017; Nelson, Davis, & Corbett, 2022). Chronic diseases, such as CVD, T2DM, and colorectal cancer are also impacted by an individual's diet (Health Canada, 2019).

Nurses, the largest group of health care professionals, have an important role in managing and preventing obesity, poor metabolic health, and associated secondary diseases by acting as educators, role-models, and advocates to their patients (Almajwal, 2015; Bucher Della Torre et al., 2018; Groenewold et al., 2020; Reed et al., 2018; Rowen, 2009; WHO, 2016). This can be accomplished through providing patients with strategies to decrease caloric intake and increase PA, with the goal of improving clinical outcomes (Kraschnewski et al., 2013; Rabbitt, & Coyne, 2013). However, a nurse's personal lifestyle can influence how they counsel their patients; for example, nurses that engage in healthy eating habits and regular PA are more likely to educate their patients about its importance (Bakhshi et al., 2015; Marchiondo, 2014).

Unfortunately, research suggests that nurses have high levels of overweight and obesity and impaired metabolic health (Almajwal, 2015; Blake et al., 2021; Miller, Alpert, & Cross, 2008; Reed et al., 2018). Nurses are also highly sedentary, and most are not meeting the recommended PA guidelines (Almajwal, 2015; Iwuala et al., 2015; Reed et al., 2018). Compared to the general population, nurses often have elevated levels of psychological stress, anxiety, and depression due to the demanding nature of their job (Farquharson et al., 2013; Ghawadra et al., 2019; Letvak, 2013; Oates 2018; Trousselard et al., 2015). Nurses, particularly those working rotating and/or 12-hour shifts, report fatigue, insufficient sleep, and poor sleep quality (Geiger-Brown et al., 2012; Sveinsdóttir & Gunnarsdóttir, 2008). Nurses do not appear to be following recommended dietary guidelines; they tend to consume sugar-sweetened food or beverages at work, and shiftwork (often involved in the nursing profession) can cause an individual to eat excessively, potentially leading to obesity and metabolic syndrome (Jehan et al., 2017; Lin et al., 2019). This suggests that the increased knowledge about the importance of healthy lifestyle behaviours on health that nurses have, does not necessarily translate to their own lives and behaviours (Kyle et al., 2017). Not only is this problematic because of their role in patient treatment, but it is concerning to their own health as well.

Nursing students are a cohort of particular interest, since they are still engaged in education, therefore providing an opportunity to better inform them of the importance of lifestyle choices in relationship to their own health, and the health of their future patients

(Bakhshi et al., 2015; Camden, 2009; Marchiondo, 2014). Currently, there is limited research on the metabolic health and lifestyle of nursing students; there is particularly a lack of data objectively characterizing these aspects. From the literature that exists, like nurses, nursing students display poor PA and comparable rates of overweight/obesity in comparison to other university students (Adderley-Kelly & Green, 2000; Blake et al., 2021; Irazusta et al., 2016). More data objectively characterizing the metabolic health and lifestyle of nursing students would be essential in allowing us to better understand if nursing students are exhibiting the same behaviours observed in nurses.

1.2 Objectives

A pilot study was conducted in 2019 to address the gap in research characterizing the health and lifestyle of nursing students (West et al., 2019). The pilot study primarily focused on characterizing overweight/obesity status (i.e., BMI and waist-to-hip ratio [WHR]), along with objectively measured PA levels, and the results suggested that nursing students are highly sedentary and inactive (West et al., 2019). However, as previously mentioned, BMI alone is not the best measurement for assessing an individual's risk of negative health outcomes (WHO, 2000). A more thorough assessment of the metabolic health of nursing students can obtained by considering various components including BP, WC, fasting blood glucose, and blood lipid profile (Kunzova et al., 2020). In addition to PA levels, poor sleep and high stress may contribute to poor metabolic health outcomes in nursing students, and nutrition may also play a role since food intake is correlated with BMI and WHR in nurses (Amani & Gill, 2013; Gozal, Dumin, & Koren, 2016; Mesas et al., 2014; Zapka et al., 2009). It is likely that multiple lifestyle factors, including PA, nutrition, stress, and sleep, are associated with the metabolic health status of nursing students.

The current study is a follow-up to the pilot study (West et al., 2019), and will seek to objectively characterize the metabolic health and lifestyle of undergraduate nursing students. Therefore, the primary objectives this thesis aims to address are to:

1) Characterize the metabolic health and metabolic health status of undergraduate nursing students attending a Canadian university, objectively measured by BMI, WC, WHR, body fat percentage (BF%), fasting blood glucose, and blood lipid profile.
2) Characterize the lifestyle, specifically the PA, sleep, stress, and nutrition, of undergraduate nursing students attending a Canadian university.
3) Determine the correlation of components of metabolic health with lifestyle (PA, sleep, stress, and nutrition) in undergraduate nursing students attending a Canadian university.
4) Determine if the findings of the study are specific to undergraduate nursing students, compared to Canadian undergraduate students of other majors.

1.3 Research questions

Based on the objectives of the study, this thesis aims to answer the following questions:

1) What is the metabolic health status of undergraduate nursing students?

2) What is the lifestyle (PA, sleep, stress, and nutrition) of undergraduate nursing students?
3) Is metabolic health status, or any components of metabolic health, associated with lifestyle factors of PA, sleep, stress, or nutrition in undergraduate nursing students?
4) Are there any differences between the metabolic health or lifestyle (PA, sleep, stress, and/or nutrition) of undergraduate nursing students compared to undergraduate biology students (comparison group)?

1.4 Research hypotheses and predictions

Nursing is a demanding profession that often involves shiftwork and generates high levels of occupational stress, which can impact lifestyle and health (Lin et al., 2019). As nursing students engage in clinical placements throughout their degree, it is possible that some of these lifestyle habits, and the potential impact that they have on health, begins during their nursing education. Therefore, it is hypothesized that:

1) Undergraduate nursing students will have poor metabolic health, as seen through increased BMI, increased WC, increased WHR, increased BF%, increased fasting blood glucose, and suboptimal blood lipid profile.
2) Undergraduate nursing students will have poor lifestyle habits, as seen through poor PA levels, poor sleep quality, increased stress, increased food intake, and poor nutrition.

3) Poor PA participation, poor sleep quality, increased food intake, poor nutrition, and increased stress will be associated with worse metabolic health in full-time nursing students.
4) Undergraduate nursing students will display worse metabolic health and lifestyle habits in comparison to undergraduate biology students.

1.5 Significance

To our knowledge, this study is the first research study to examine the relationship between metabolic health status and multiple lifestyle factors (PA, sleep, stress, and nutrition) in undergraduate nursing students attending a Canadian university. Furthermore, the inclusion of undergraduate biology students as a comparison group will better inform us as to whether any characteristics of metabolic health or lifestyle are specific to undergraduate nursing students.

The results of this study may be the first step in determining the need for a lifestyle intervention for nursing students, targeting their physical and mental health. The intervention would address the most prominent factors associated with poor metabolic health status in nursing students, with the goal of improving their outcomes. Studies have supported the idea that lifestyle interventions in nursing students can positively impact their metabolic health status (Pawloski & Davidson, 2003). Furthermore, the intervention has the potential to not only impact nurses’ health, but also their practice (Bakhshi et al., 2015).

2 LITERATURE REVIEW

2.1 Introduction

The current literature review will explore the obesity epidemic and metabolic health by discussing how they are defined, their impacts on health, and the role that nurses can play in addressing these issues with their patients. It will then talk in detail about research on the relationship of physical activity (PA), stress, sleep, and nutrition with health, and the behaviour of nurses in relation to these lifestyle factors. Finally, it will conclude by focusing on nursing students, the cohort of interest for this thesis, by summarizing research that exists surrounding their health and lifestyle, and the pilot study from which the current study extends upon.

2.2 The obesity epidemic

2.2.1 What is obesity?

Obesity is recognized as a chronic disease by numerous medical and obesity organizations including the World Health Organization (WHO), Canadian Medical Association (CMA), and Obesity Canada (OC) (OC, 2023). Classifying obesity as a chronic disease is a somewhat controversial decision due to disagreement surrounding the definition of a disease; however, classifying obesity as a chronic disease emphasizes the seriousness of obesity and the need for prevention and treatment efforts, and could potentially lessen the stigma surrounding obese individuals (Rosen, 2014). Obesity is a complex and multifactorial disease with both genetic and environmental contributing factors, but in simple terms it is caused by an excess of kilocalories (kcals) consumed to kcals expended (Avila et al., 2015; Catenacci, Hill, & Wyatt, 2009; Swinburn et al., 2011; WHO, 2021). Overweight and obesity are defined as an abnormal or excessive accumulation of fat that has the potential to impair one's health (WHO, 2021). An individual's obesity or overweight status is commonly determined from a calculated body mass index (BMI); an index of weight-for-height that is determined by dividing an individual's weight in kilograms by their squared height in meters (WHO, 2021). The WHO defines that a normal BMI is between 18.5kg/m^2 and 24.9kg/m^2, a BMI between 25.0kg/m^2 and 29.9kg/m^2 is considered overweight, and a BMI greater than 30.0kg/m^2 is considered obese (WHO, 2000). The WHO overweight and obesity classifications are primarily based on the association between BMI and the relative risk of premature mortality (WHO, 2000).

2.2.2 Issues with body mass index

BMI is a crude, yet effective way of assessing obesity at a population level, however it does not account for the variation that can exist in fat distribution and may not be an appropriate indicator of an individual's personal health risk (WHO, 2000). As BMI is calculated using only an individual's height and weight, it does not provide any information about fat distribution throughout the body. While the risk for comorbidities and premature death increases with increasing BMI, the risk for premature mortality, particularly for BMIs between 25.0kg/m^2 and 29.9kg/m^2 (overweight/pre-obesity classification), appears to be mainly influenced by fat distribution (Kyrou et al., 2018). Independent of BMI, fat accumulation intra-abdominally or subcutaneously surrounding the abdomen is associated with a higher risk of cardiometabolic diseases, whereas fat accumulation subcutaneously surrounding the hips, thighs, or lower trunk are less harmful or even protective against cardiometabolic diseases (Kyrou et al., 2018). Additionally, since BMI is only reliant upon height and weight, it does not account for muscle mass and can be misleading when solely relying upon it for determining overweight and obesity status (Marchiondo, 2014). The limitations of BMI are especially important when one is considering the overall health of someone at an individual or small-scale level.

2.2.3 Health impacts of obesity

Obese individuals are at a high risk of developing many chronic diseases (Kyrou et al., 2018). These include type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD), hypertension, dyslipidemia, non-alcoholic fatty liver disease, as well as osteoarthritis, Alzheimer's disease, and certain types of cancers (including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon cancers) (Kyrou et al., 2018; Springer & Moco, 2019; WHO, 2021). For example, individuals with a BMI greater than 35.0kg/m^2 are 20 times more likely to develop T2DM than those with a normal BMI (Field et al., 2001). The risk for these associated chronic diseases increases with BMI, and therefore the risk is greater for obese individuals than overweight individuals (WHO, 2021). With the substantial number of comorbidities, it is not surprising that obesity is the fifth leading risk for global deaths, with over 2.8 million adults dying each year because of being overweight or obese (Avila et al., 2015; WHO, 2011).

While obesity is a major contributor to the global burden of chronic disease, it also has many social, emotional, and psychological impacts on individuals of all ages and socioeconomic statuses (Haththotuwa, Wijeyaratne, & Senarath, 2020; Rowen, 2009). Obesity and mental heath are suggested to have a bidirectional relationship (Avila et al., 2015). While individuals with a history of mental illness are at an increased risk of obesity, individuals with obesity have a 30% to 70% risk of developing a mental illness (Avila et al., 2015). There is also an association between obesity and the risk of developing a variety of psychological disorders, including depression, anxiety, mood, and personality disorders (Avila et al., 2015; Marchiondo, 2014). Obesity can have a variety of other psychological and social impacts, including altered body image, low self-esteem, feelings of shame and isolation, and stigmatization in social settings, including health care (Bucher Della Torre et al., 2018; Marchiondo, 2014; Rowen, 2009). Unfortunately, the impact obesity has on psychological health often enhances poor health behaviours, such as overeating, creating a perpetuating cycle (Djalalinia et al., 2015).

2.2.4 The obesity epidemic

In 1997 the WHO declared obesity as major public health issue and a global epidemic (Haththotuwa, Wijeyaratne, & Senarath, 2020). The most recent WHO global estimates from 2016 suggest that 1.9 billion adults (39% of the global adult population) are overweight, and 650 million of those individuals are considered obese (13% of the global adult population) (WHO, 2021). What is of greater concern is that obesity rates have tripled between 1975 and 2016, suggesting a continuing increase of overweight and obese individuals (WHO, 2021). It has been suggested that if the trends continue, most of the world's population will be either overweight or obese by 2030 (Haththotuwa, Wijeyaratne, & Senarath, 2020). Thus, it is of global necessity to reduce the burden of obesity (Avila et al., 2015; Mendenhall & Singer, 2019). Worldwide, there have been societal and environmental changes that have influenced both dietary and PA patterns of populations over time (Haththotuwa, Wijeyaratne, & Senarath, 2020; WHO, 2021). For example, increasing overweight and obesity rates are suggested to be caused by increased intake of energy-dense foods (i.e., foods high in fats and sugars) along with a decrease in PA due to urbanization and the sedentary nature of many careers (Springer & Moco, 2019; WHO, 2021). Both the increase of calories consumed through high-energy foods, and the decrease of energy expended through decreased PA could lead to an energy imbalance and eventually overweight or obesity.

It is clear that obesity is an identified epidemic with major public health concern, so the next important step is to highlight ways to address the obesity epidemic. There are many policy changes that governments and business must make to avoid creating the "obesogenic" environments that promote obesity in their populations (Swinburn et al., 2011). Implementation of various public policies by municipal, provincial, and federal governments that would broadly target social and environmental determinants of obesity are necessary (Public Health Agency of Canada [PHAC], 2011). Suggested obesity prevention policies include financial disincentives through taxes on "unhealthy" food and drinks, financial incentives that promote PA, reducing or regulating food and beverage marketing to children, food labelling that helps consumers better understand their food choices, along with improved transportation and urban planning that promotes active commuting and recreational PA (Novak & Brownell, 2012; PHAC, 2011).

Additionally, more community-based obesity prevention interventions can be implemented in businesses, workplaces, and schools to target specific groups of individuals (PHAC, 2011). Based on a systematic review of various initiatives that have been tested in the United States, the most promising approaches include; signage encouraging the use of stairs, workplace wellness programs, school-based interventions for children (e.g., increased frequency or duration of physical education classes), workplace and school policies encouraging healthy eating (e.g., regulating foods in vending machines), as well as menu and shelf labelling that encourages purchase of healthier options (PHAC, 2011).

Furthermore, individuals need to alter many of their own behavioural aspects that contribute to obesity development (Swinburn et al., 2011). At the individual level, key suggestions for reducing overweight and obesity, along with their associated comorbidities, are increasing PA levels along with limiting energy intake from fats and sugars (PHAC, 2011; WHO, 2021). Overall, these suggestions would address the general root cause of obesity by decreasing calorie intake and increasing energy expenditure.

It is unlikely that a single societal, environmental, or behavioural change will solve the rising prevalence of obesity; rather, a comprehensive and multisectoral approach is needed (PHAC, 2011). A combination of a variety of these suggestions at a public policy, community-specific (business, workplace, and school), and individual level are necessary in addressing the obesity epidemic (PHAC, 2011).

2.3 Metabolic health

2.3.1 Considering metabolic health vs. obesity

As previously discussed in section 2.2.2, BMI may be misleading as it does not account for fat distribution or muscle mass (Kyrou et al., 2018; Marchiondo, 2014; WHO, 2000). A more accurate or complete assessment of an individual's risk for developing obesity associated chronic diseases comes from an individual's metabolic health status (Kunzova et al., 2020). Metabolic health can be defined as a composite consideration of multiple factors including blood pressure (BP), fasting blood glucose, waist circumference (WC), and blood lipid measurements of triglycerides (TG) and high-density lipoprotein (HDL). Good metabolic health status is defined as having ideal measurements of these various risk factors (including BP ≤120/80mmHg, fasting blood glucose 3.9-5.5 mmol/L, TG <1.7mmol/L, and HDL >1.5mmol/L) that are associated with the development of metabolic diseases (James et al., 2004; Kunzova et al., 2020). In contrast, poor metabolic health status, which may be clinically diagnosed as metabolic syndrome, occurs when measurements of these risk factors are outside of the ideal ranges, thus increasing the risk of the development of metabolic diseases (IDF, 2006; Kunzova et al., 2020). Chronic diseases associated with poor metabolic health include T2DM, CVD, and cancer; many of the same chronic diseases associated with obesity (IDF, 2006; Kyrou et al., 2018; Somi et al., 2019).

Considering an individual's metabolic health, rather than just their overweight/obesity status, gives a more accurate depiction of their risk of developing associated chronic diseases (Kunzova et al., 2020). Along with the previously mentioned issue of BMI not accounting for fat distribution, it is suggested that while obese individuals are more likely to suffer from impaired metabolic health, not all individuals within the same BMI category have equivalent risk (Kunzova et al., 2020; E. Rhee et al., 2014; Somi et al., 2019). An estimated 10-22% of normal BMI (18.5-24.9kg/m^2) adults are considered metabolically unhealthy, despite not being overweight or obese according to their BMI (Kunzova et al., 2020). Metabolically unhealthy normal BMI individuals have a 3-times greater risk of all-cause mortality and cardiovascular events than metabolically healthy normal BMI individuals (Kunzova et al., 2020). Additionally, obese individuals who are metabolically healthy do not have a greater risk than metabolically healthy normal BMI individuals of all-cause mortality and cardiovascular events (Kunzova et al., 2020). This further suggests that BMI alone is not sufficient when determining an individual's risk of negative health outcomes (E. Rhee et al., 2014).

2.3.2 Defining metabolic health in the literature

There appears to be a lack of consistency in the literature surrounding how poor metabolic health (i.e., metabolic syndrome) is defined and which measurements should be considered (Kyrou et al., 2019). In the literature, the International Diabetes Federation (IDF) guidelines for metabolic syndrome are used frequently in studies evaluating metabolic health status of their participants (Kunzova et al., 2020). Current IDF guidelines for poor metabolic health identify central obesity (increased waist circumference) as the hallmark of metabolic syndrome, with additional considerations for BP, fasting blood glucose, plasma levels of TGs, and HDL levels (Kyrou et al., 2019).

The IDF guidelines were designed to create a consensus for defining and diagnosing poor metabolic health, as prior to their release there were various proposed guidelines by prominent organizations including the WHO in 1999, the European Group for the Study of Insulin Resistance (EGIR) in 1999, and the National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) in 2001 (Kyrou et al., 2019). However, previous guidelines differed from each other slightly in terms of diagnostic criteria and therefore limited the comparability between studies due to different guidelines being used (Kyrou et al., 2019). Differences were mainly in the cut-offs used for systolic BP, diastolic BP, fasting blood glucose, TG, and HDL, and whether central obesity (defined based on WC) was a prerequisite for diagnosis (Kyrou et al., 2019).

Despite the goal of the IDF to create guidelines that formed a consensus on defining poor metabolic health, there are still studies published within the last decade that are using previous guidelines, particularly NCEP-ATP III guidelines, to distinguish metabolically healthy and unhealthy participants (Mahjoub et al., 2012; Scuteri et al., 2015; Somi et al., 2019; van Vliet-Ostaptchouk et al., 2014). A further attempt to resolve disagreement surrounding the definition of poor metabolic health was made in 2009 in a joint statement from the American Heart Association (AHA)/National Heart, Lung, and Blood Institute (NHLBI) and the IDF (AHA/NHLBI/IDF) (Alberti et al., 2009; Kyrou et al., 2019). The AHA/NHLBI/IDF guidelines harmonized the previous IDF and NCEP-ATP III guidelines and agreed that central obesity is not a prerequisite for metabolic syndrome (Alberti et al., 2009; Kyrou et al., 2019). The differences between these 3 sets of guidelines are outlined in Appendix A (Table 10).

To account for the lack of consistency in the literature, some studies have opted to include multiple classification guidelines for poor metabolic health or modify the existing guidelines and create their own (Kuk & Ardern, 2009; E. Rhee et al., 2014). Despite the various guidelines that are used, there does appear to be a consensus that considering the various components encompassing metabolic health is a better predictor of development of chronic disease than overweight/obesity status alone (Kyrou et al., 2019; E. Rhee et al., 2014).

For the purpose of this thesis, poor metabolic health will be defined using the 2009 consensus AHA/NHLBI/IDF guidelines. Thus, from this point onwards, poor metabolic health will be defined as the presence of at least 3 of the following: WC ≥ 102cm (males) or ≥88 cm (females), TG ≥ 1.7mmol/L, HDL ≤ 1.03mmol/L (males) or ≤ 1.29mmol/L (females), systolic BP ≥ 130mmHg, diastolic BP ≥ 85mmHg, or fasting blood glucose ≥ 5.6mmol/L (Alberti et al., 2009).

2.3.3 Resting blood pressure

Resting BP provides information on the pressure in the blood vessels when the heart beats (systolic) and the pressure in the blood vessels between beats (diastolic) (WHO, 2021). Normal resting BP is when the systolic BP is equal to or less than 120mmHg, and the diastolic BP is equal to or less than 80mmHg (WHO, 2021). Systolic and/or diastolic BP readings above those values are generally considered to be elevated, with hypertension typically being diagnosed when systolic BP is greater than or equal to 140mmHg and/or diastolic BP is greater than or equal to 90mmHg (WHO, 2021), and elevated BP and hypertension significantly increases the risk of CVD (WHO, 2021). Hypertension increases the workload on the heart and can create negative structural and functional changes in the left ventricle, left atrium, and coronary arteries (Tackling & Borhade, 2022).

An additional measure that can be considered is mean arterial pressure (MAP). MAP is the average arterial pressure through one cardiac cycle and is commonly calculated as diastolic BP plus one third of the difference between systolic BP and diastolic BP (DeMers & Wachs, 2022). Similar to systolic and diastolic BP, MAP is thought to be associated with all-cause mortality and CVD risk (M. Liu et al., 2021).

2.3.4 Fasting blood glucose

Impaired fasting blood glucose is one of the major risk factors for T2DM (DeFina et al., 2012). Fasting blood glucose levels can be divided into categories: normoglycemia (3.9-5.5mmol/L), mild hyperglycemia (5.6-6.0mmol/L), and intermediate hyperglycemia (6.1-7.0mmol/L), with fasting blood glucose levels greater than 7.0mmol/L typically being diagnosed as T2DM (DeFina et al., 2012). Elevated fasting blood glucose levels suggest insulin resistance, or a reduced ability of tissues to take up glucose from the blood (Sasaki et al., 2020). The resulting hyperglycemia leads to a fluid shift from intracellular to extracellular compartments, resulting in increased plasma volume and increased BP (Sasaki et al., 2020). Chronically elevated circulating blood glucose (hyperglycemia) that is left untreated can cause damage to the heart, kidneys, eyes, nerves, and vascular system (Mouri & Badireddy, 2022).

2.3.5 Lipid profile

When characterizing an individual's lipid profile, various lipids within the blood serum of a fasting individual are considered (National Institutes of Health [NIH], 2002). Total serum cholesterol levels below 5.18mmol/L are desirable, with levels between 5.18 and 6.18mmol/L being borderline high, and above 6.18mmol/L being high (NIH, 2002). Total cholesterol can be further broken down into low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol. LDL, often considered "bad" cholesterol, is the lipoprotein most strongly associated with CVD (NIH, 2002). Optimal LDL levels are below 2.6mmol/L, with 2.6 to 3.3mmol/L being near optimal, 3.4 to 4.1mmol/L borderline high, 4.1 to 4.9mmol/L high, and above 4.9mmol/L very high (NIH, 2002). HDL cholesterol, often considered "good" cholesterol, is thought to have a protective effect against CVD (NIH, 2002). Optimal HDL levels are above 1.5mmol/L, and poor HDL levels are below 1.0mmol/L (NIH, 2002). Another type of lipid in found in the blood are TGs (NIH, 2002). TG levels in the blood can be considered, as there appears to be a positive relationship between serum TGs and risk of CVD (NIH, 2002). Optimal TG levels are below 1.7mmol/L, with levels between 1.7 and 2.2mmol/L being borderline high, 2.3 to 5.6mmol/L high, and above 5.6mmol/L very high (NIH, 2002).

An imbalance of any of these levels is a form of dyslipidemia. Dyslipidemia is defined as an imbalance of TG, HDL, LDL, and/or total cholesterol, and it increases the risk of CVD and adverse health outcomes (Limbu et al., 2008). Dyslipidemia is thought to specifically be associated with atherosclerotic CVD through circulating lipids being deposited into the tunica intima of artery walls and subsequently being involved in atherogenesis (Hedayatnia et al., 2020).

2.3.6 Waist-to-hip ratio and body fat percentage

As previously discussed, there are issues when relying on BMI alone when considering metabolic health and/or obesity status, as it does not account for fat distribution or muscle mass (Kyrou et al., 2018; Lee & Giovannucci, 2018; Marchiondo, 2014). These elements of an individual's body composition can be better assessed by considering waist-to-hip ratio (WHR) and body fat percentage (BF%).

Increased abdominal adiposity is associated with an increased risk of CVD, T2DM, and all-cause mortality (WHO, 2008). Abdominal obesity is defined as a WHR of 0.85 or greater in women, and 1.0 or greater in men (Marchiondo, 2014; WHO, 2000). It has also been suggested that a measurement of waist circumference (WC) alone is sufficient in predicting the risk of CVD (WHO, 2000). WC has a good correlation with abdominal adiposity, and strong association with cardiovascular mortality (Chen et al., 2021). The recommended WC cut-offs differ by sex and ethnicity due to different body sizes; the recommendations are summarized in Appendix A (Table 11) (Chen et al., 2021). WC and WHR are thought to be better indicators of obesity-associated T2DM than BMI (Gómez-Ambrosi et al., 2012; WHO, 2008). For the purpose of this thesis, the Health Canada WC guidelines of less than 102cm for males and less than 88cm for females will be used (Alberti et al., 2009).

Additionally, considering body composition through estimating body fat is useful, as high body fat is associated with increased all-cause and cardiovascular mortality (Gómez-Ambrosi et al., 2012; Lee & Giovannucci, 2018; Silveira et al., 2020). Using skinfold measurements is an ideal way to estimate body fat percentage due to the strong relationship between the amount of subcutaneous fat and total body fat (Silveira et al., 2020).

2.4 Managing the obesity epidemic and metabolic health

Health care professionals, including registered nurses (RNs), play a critical role in addressing the obesity epidemic and poor metabolic health (Bucher Della Torre et al., 2018; Rowen, 2009). The current thesis will focus more specifically on RNs and the role they play in addressing the obesity epidemic, since nurses are the largest group of health care professionals in Canada (48%) and are essential to the infrastructure of virtually all health care settings (Groenewold et al., 2020; Reed et al., 2018; WHO, 2016).

RNs have a role in managing their patients' obesity and associated secondary diseases, however they also have the capability of managing and preventing obesity by acting as educators, role-models, and advocates for their patients (Almajwal, 2015; Bucher Della Torre et al., 2018; Rowen, 2009). RNs can educate their overweight and obese patients by providing them with nutritional advice, along with offering strategies to decrease caloric intake and increase PA; these forms of weight-related counselling have been shown to help reduce weight and improve clinical outcomes in patients (Kraschnewski et al., 2013; Rabbitt, & Coyne, 2013). A RN's personal behaviours and habits can also influence how they counsel their patients (Bakhshi et al., 2015; Marchiondo, 2014). They are more likely to educate their patients about healthy eating and PA when they engage in it themselves (Marchiondo, 2014). RNs may also act as advocates of their patients by pushing for the creation of policies and funding that support a comprehensive plan to address the obesity epidemic (Rowen, 2009). RNs are leaders in initiating action for social health change; for example, they have had large impacts in educating their communities about the consequences of smoking as well as been at the forefront of community activities raising awareness for breast cancer (Marchiondo, 2014). They could also have the same impact in addressing the obesity epidemic (Marchiondo, 2014; Miller, Alpert, & Cross, 2008).

2.5 Health of nurses

2.5.1 Metabolic health of nurses

Past international research agrees that a large proportion of RNs are overweight or obese (Almajwal, 2015; Blake et al., 2021; Miller, Alpert, & Cross, 2008). A study of 335 RNs from the United States found that more than half of their participants were overweight (34.1%) or obese (23.4%) (Ross et al., 2018). Comparably, a study from the United Kingdom found that nurses had higher rates of overweight (35.67%) and obesity (25.1%) than other health care professions, with obesity rates comparable to that of non-health related careers (23.5%) (Kyle et al., 2017). In comparison, the most recent statistics for the general adult population in Canada suggests that 36.3% were overweight and an additional 26.8% were obese; these are very similar proportions to what is being seen in RNs from the United States and United Kingdom (Statistics Canada, 2019). A study of 410 RNs and registered practical nurses (RPNs) from Canada found that participants had an average BMI of $27.1\pm5.4 kg/m^2$ which places them into the overweight category (Reed et al., 2018). Of the Canadian nurses that participated, 58%

were overweight/obese, 24% had elevated WCs associated with health risks, 7% had high BP, 4% were taking medication for high cholesterol, and 2% for diabetes (Reed et al., 2018). In comparison, for Canadian women in the general population, >50% are overweight/obese, 41% have high risk WCs, 17% have high BP, 16% have high LDL levels, and 6% have diabetes (Reed et al., 2018). These results suggest that Canadian nurses may have worse metabolic health compared to the general Canadian population. Overall, research suggests that nurses have high levels of overweight and obesity and impaired metabolic health. This suggests that their knowledge about the importance of healthy lifestyle behaviours on health does not necessarily translate to their own lives and behaviours (Kyle et al., 2017).

2.5.2 Absenteeism and concerns for future health

Nurses are essential to the infrastructure of virtually all health care settings (Groenewold et al., 2020; Reed et al., 2018; WHO, 2016). However, there appears to be high rates of absenteeism from scheduled shifts among nurses, with more than 9% (24,000) of Canadian nurses being absent each week in 2016 from personal illness or injury (Jacobson Consulting Inc, 2017). This rate of absenteeism among nurses is substantially larger than the national average rate of work absenteeism (6%) of all other occupations in Canada (Jacobson Consulting Inc, 2017). In 2016, absenteeism among Canadian nurses cost an estimated $989 million (Jacobson Consulting Inc, 2017). High incidence of absenteeism, along with "presenteeism" (being at work but not functioning at full capacity) in RNs can disrupt patient care and increase the workload of remaining nurses (Ross et al., 2018). The rate of absenteeism has likely increased since the COVID-

19 pandemic, as a study on Brazilian nurses found the rate of absenteeism significantly increased from 13.9% to 18.6% between 2019 and 2020 (Alves et al., 2022).

The particularly high incidence of absenteeism from personal illness or injury, together with the apparent increased rates of overweight and obesity and poor metabolic health among Canadian nurses is concerning, as it suggests that nurses are putting their own health at risk, and potentially being at greater risk of developing negative health outcomes (Reed et al., 2018). Additionally, there could be a negative impact on the ability of nurses to effectively perform their job. Some studies have suggested that the high rates of overweight and obesity among nurses, discredits them as role models and educators to their patients (Blake et al., 2021; Marchiondo, 2014). Overweight and obese nurses perceive themselves as having reduced performance, being less likely to promote health to their patients, and feeling as though the public may be less likely to trust their health promotion messages (Blake et al., 2021; Miller, Alpert, & Cross, 2008; Stanulewicz et al., 2020).

Nursing is an inherently challenging profession, often involving physically- and psychologically demanding tasks, irregular shift rotations, and long shift durations; all of which can potentially negatively impact health (Chappel et al., 2017; d'Ettorre et al., 2020; van Amelsvoort, Schouten, & Kok, 1999). The impact of the nursing profession on psychological and physical health has been emphasized by the increased demands of the COVD-19 pandemic on nurses (Murphy et al., 2022). There is an unusually high number of RNs leaving their positions, the profession, or expressing their intent to retire early; this further exacerbates the nursing shortage and leads to chronic understaffing becoming the norm in the profession (Murphy et al., 2022). Getting optimal PA, sleep, and nutrition, along with reducing stress levels, are all key factors in combating the negative impacts that the nursing profession can have on an RN's health (Chappel et al., 2017; d'Ettorre et al., 2020). The apparent poor metabolic health of nurses in Canada suggests that one or more of these factors is lacking (Reed et al., 2018).

2.6 Physical activity and sedentary behaviour

2.6.1 Current physical activity guidelines

In 2011 the Canadian Society for Exercise Physiology (CSEP), with support of ParticipACTION and the PHAC, published new PA guidelines to promote healthy living for Canadians (Tremblay et al., 2011). The guidelines for healthy adults aged 18-64 are at least 150 minutes of moderate-to-vigorous PA (MVPA) per week, performed in bouts of 10 minutes or more (Tremblay et al., 2011). Classification of PA intensity is typically defined using multiples of the metabolic equivalent of task (METs), with a MET of 1 being the rate of energy expenditure while at rest (MacIntosh et al., 2021). Moderate intensity exercise is 3 to 6 METs, and vigorous intensity exercise is greater than 6 METs (MacIntosh et al., 2021). This typically is not a useful or convenient way of describing exercise intensity to the general population, so it is often described using a rating of perceived exertion (RPE) measured on a 10-point scale (MacIntosh et al., 2021). Moderate intensity exercise is described as an RPE of 5 to 6, and vigorous intensity exercise with an RPE of 7 to 8 (MacIntosh et al., 2021). Some examples of moderate PA include brisk walking, dancing, and gardening, and examples of vigorous PA include jogging, running, fast cycling, and fast swimming (MacIntosh et al., 2021). It is recommended to incorporate a variety of activities of various intensities into your routine (CSEP, 2020). It is also recommended to incorporate muscle and bone strengthening exercises using the major muscle groups at least 2 times per week (Tremblay et al., 2011). Examples of muscle and bone strengthening activities include lifting weight, jumping rope, running, strength training, and resistance training (ParticipACTION, 2020). These guidelines are irrespective of gender, race, and socioeconomic status (Tremblay et al., 2011). The Canadian PA guidelines are also comparable to the WHO guidelines for PA in adults (WHO, 2020). More recently, CSEP has released 24-hour movement guidelines. In addition to the PA guidelines published in 2011, they provide recommendations on sleep and sedentary behaviour (CSEP, 2020). These guidelines give individuals a better idea on how to integrate activities throughout the day and emphasize the need to reduce sedentary time in addition to getting sufficient PA (CSEP, 2020). As stated on the guidelines, adults aged 18-64 should include several hours of light PA (e.g., standing, and slow walking) into each day, break up prolonged periods of sitting, and should limit sedentary time (excluding sleep) to no more than 8 hours per day (CSEP, 2020; ParticipACTION, 2020).

2.6.2 Impact of physical activity and inactivity on health

It is widely accepted that engaging in regular PA is a preventative measure for many health risks across all ages, genders, races, and ethnicities (Knapen et al., 2014; Ruegsegger & Booth, 2017; Tremblay et al., 2011). Following CSEP’s 24-hour movement guidelines and getting the recommended amount of PA per week is associated with a reduced risk of all-cause mortality, CVD mortality, hypertension, T2DM, certain cancers (including breast and colon cancers), adverse blood lipid profile, adiposity, and weight gain, along with improved mental and cognitive health, sleep, and physical function (CSEP, 2020; Gerber et al., 2014; Kelley & Kelley, 2017; Kovacevic et al., 2018; Lavretsky & Abbott, 2018; WHO, 2020). Unsurprisingly, the health outcomes of being sedentary (physically inactive) are the opposite of those associated with regular PA (WHO, 2020).

The previously mentioned CSEP guidelines of 150 minutes of MVPA per week are based on the best evidence available for when substantial health benefits occur, however, a dose-response relationship exists between PA and health benefits (Tremblay et al., 2011; WHO, 2020). Therefore, even if the PA guidelines are not met, some PA will still provide some health benefits, and exceeding the PA guidelines (within reason) may also provide additional health benefits (CSEP, 2020; Tremblay et al., 2011; WHO, 2020).

2.6.3 Physical activity and sedentary behaviour in nurses

Nursing is a physically demanding job that involves prolonged standing and walking (Stolt et al., 2018). Despite this, research indicates that RNs are highly sedentary, and most are not meeting the recommended PA guidelines (Almajwal, 2015; Iwuala et al., 2015; Reed et al., 2018). During leisure time, RNs predominantly engage in low- and moderate-PA, and a systematic review of fifteen studies determined that while working, RNs' PA consisted predominantly of light-intensity PA, interspersed with moderate-intensity PA (Chappel et al., 2017). A study that examined 364 Canadian nurses (RNs and RPNs) working in a hospital setting found that based on accelerometer data, nurses performed an average of 96±100 minutes per week of MVPA in bouts of 10 minutes or more, and only 23% of nurses met the recommended PA guidelines (Reed et al., 2018). Similarly, 80.1% of sampled US RNs (n=305) were sedentary (sitting for 3 or more hours per day) (Ross et al., 2018). From the same study, RNs engaged in a mean 60 minutes of vigorous PA per week (n=309) and 45 minutes of moderate PA per week (n=306) (Ross et al., 2018). Combined, this data indicates that the average RN is not meeting the recommended 150 minutes of MVPA per week.

Overall, research suggests that RNs are not meeting the recommended PA guidelines (Reed et al., 2018). A lack of adequate PA in nurses may be related to whether the RN has rotating or fixed shifts, whether they work full- or part-time, and what department they work in (Reed et al., 2018). For example, emergency room nurses had significantly less sedentary time and light PA than outpatient, mental health, and imaging nurses (Reed et al., 2018). Due to the high stress nature of the nursing profession, obtaining adequate PA is even more important due to the established stress-reducing properties of PA (CSEP, 2020).

2.7 Stress and psychological health

2.7.1 Impact of stress on health

Stress can be defined as a state of threatened homeostasis caused by exposure to extrinsic or intrinsic stressors (disturbing forces) (Chrousos & Gold, 1992). Stress can either be acute (short-lived; minutes, hours, or days) or chronic (prolonged; weeks, months, years) (Won & Kim, 2016). The autonomic nervous system (ANS) is one of the major pathways activated by stressors (Won & Kim, 2016). The ANS has two main divisions; the sympathetic nervous system (SNS), and the parasympathetic nervous system (PNS) (Won & Kim, 2016). The SNS is typically referred to as the "fight or flight" system as its activation contributes to high arousal and active states, whereas the PNS is often referred to as the "rest and digest" system since its activation is involved in relaxation and restorative processes (Weissman & Mendes, 2021). Generally, the SNS system will activate in response to a stressor, and the PNS system will activate once the stressful situation is alleviated (Won & Kim, 2016). However, in chronic stress, the SNS is constantly active without the normal counteraction from the PNS (Won & Kim, 2016).

Psychological stressors have a major influence on mood, behaviour, sense of well-being, and health (Schneiderman, Ironson, & Siegel, 2005). While acute stress has little negative impact on health and potentially plays an adaptive role, chronic or prolonged periods of stress have many negative impacts on health (Schneiderman, Ironson, & Siegel, 2005). Chronic stress is associated with hypertension, CVD, decreased immunity, exacerbations of auto-immune diseases, along with depression and adverse effects on mental health (Schneiderman, Ironson, & Siegel, 2005).

2.7.2 Stress in the nursing profession

RNs often have high levels of occupational and psychological stress, anxiety, and depression compared to the general population due to the demanding nature of their job (Farquharson et al., 2013; Ghawadra et al., 2019; Letvak, 2013; Oates 2018; Trousselard et al., 2015). For RNs, being physically inactive may worsen mental health; even after adjusting for age and job demands, among other factors, and leisure-time physical inactivity was associated with psychological distress in these individuals (Malinauskiene et al., 2018). Stress in RNs has been linked to reduced physical and psychological health, poorer job performance, increased absenteeism, and decreased job satisfaction (Farquharson et al., 2013). Stress in RNs appears to have a concerning impact on both their own health and potentially their ability to effectively perform their duties (Letvak et al., 2012).

The COVID-19 pandemic has likely amplified both the occupational and psychological stress, anxiety, and depression of RNs (Al Maqbali, Al Sinani, & Al-Lenjawi, 2021; Jahrami et al., 2021). Of front-line health care workers during the COVID-19 pandemic, 85% had moderate-to-severe levels of stress (Jahrami et al., 2021). The high infection rate of SARS-CoV-2 increased the workload of RNs, along with fears of being infected by their patients (Al Maqbali, Al Sinani, & Al-Lenjawi, 2021). This same impact on stress levels and psychological health in RNs is likely to occur during any future public health threats (Al Maqbali, Al Sinani, & Al-Lenjawi, 2021; Jahrami et al., 2021).

2.8 Shiftwork and sleep habits

2.8.1 Current sleep guidelines

The current CSEP 24-hour movement guidelines state that adults aged 18-64 should obtain 7-9 hours of sleep per night (CSEP, 2020). In addition, individuals should practice good sleep hygiene to obtain good sleep quality, which includes consistent sleep and wake times (CSEP, 2020). Other components of sleep quality include sleep latency (how long it takes to fall asleep), sleep waking (how many times you wake up during the night), wakefulness (how long spent awake during the night after first falling asleep), and sleep efficiency (how much time spent actually sleeping while in bed) (Nelson, Davis, & Corbett, 2022). The ideal measure for sleep latency is less than 30 minutes; for sleep waking is 0 to 1; for wakefulness is less than 20 minutes; and for sleep efficiency is greater than 85% (Nelson, Davis, & Corbett, 2022). Obtaining good sleep quality typically results in individuals feeling rested, restored, and energized upon waking (Nelson, Davis, & Corbett, 2022).

2.8.2 Impact of poor sleep on health

Disturbances to sleep can alter an individual's circadian rhythm. Circadian rhythms are mediated by the suprachiasmatic nucleus in the hypothalamus and regulate an individual's sleep-wake cycles (Jehan et al., 2017). Circadian rhythms typically repeat every 24 hours, but can be disrupted; for example, by shiftwork (working outside of typical 9am to 5pm hours) (Jehan et al., 2017). Circadian rhythm disturbance from poor sleep quality or quantity can lead to hormonal disturbance of melatonin and cortisol, leading to an increased risk of obesity, T2DM, metabolic syndrome, breast cancer, and decreased immunity (Jehan et al., 2017; Nelson, Davis, & Corbett, 2022). Numerous prospective studies have found that insufficient (<7 hours) and/or long (>9 hours) sleep each night is associated with an increased risk of all-cause mortality (Gozal, Dumin, & Koren, 2016). Additionally, difficulty falling asleep, regardless of sleep duration, was associated higher frequency of metabolic syndrome; however, this study found no other relationships between other components of sleep quality and metabolic syndrome (Mesas et al., 2014). Poor sleep and disruptions to the circadian rhythm can also impact psychological health, impacting daily function, cognitive abilities, and being associated with increased risk for anxiety, depression, and mood disorders (Jehan et al., 2017).

2.8.3 Sleep of nurses

Due to the 24-hour nature of many health care settings, shiftwork is typically a component of nursing, with the majority of RNs engaging in rotating shifts (Chappel et al., 2017). This means that RNs rotate between day/evening and night shifts that are 8 to 12 hours in length which can disrupt sleep (Chappel et al., 2017; Fang & Li, 2015). Nurses, particularly those working 12-hour shifts, report fatigue, insufficient sleep, and poor sleep quality (Geiger-Brown et al., 2012). Studies looking at quality of sleep surrounding shift work in nurses indicates that nurses working rotating shifts (rather than fixed shifts) have worse sleep quality (Sveinsdóttir & Gunnarsdóttir, 2008).

The relationship between shiftwork and metabolic health has been of increasing interest. A study of shift working Malaysian manufacturing workers found that night-shift work was independently associated with a two-fold increase in the risk of metabolic syndrome (Lim et al., 2018). Night-shift workers also reported significantly poorer sleep quality, longer sleep latency, shorter sleep duration, sleep disturbances, and daytime dysfunction (Lim et al., 2018). A study on Taiwanese shift workers found that fixed night shifts was associated with short sleep duration (<7 hours per day) and increased prevalence of insomnia (Cheng & Cheng, 2017).

Due to the often-unavoidable shift working component of nursing, there is reason to the believe that the sleep quality and quantity that many RNs are obtaining is suboptimal, and potentially negatively impacting their health (Almajwal, 2015; Costa et al., 2014; d'Ettore et al., 2020). Cumulative night shift work in nurses has significant associations with BMI (increasing by 0.477kg/m^2 per 1000 night duties), WC, HC, and WHR (increasing respectively by 1.089cm, 0.72cm, and 0.007 per 1000 night duties) (Peplonska, Bukowska, & Sobala, 2015). Of additional concern, disturbed sleep impairs daily functioning, leading to reduced quality of life and cognitive impairment; potentially affecting a RNs ability to effectively perform their duties (Jehan et al., 2017). More than half of a sample of nurses (56%) in one study reported being sleep deprived, and nurses that were sleep deprived made more patient care errors (Johnson et al., 2014).

The COVID-19 pandemic also appears to have impacted the sleep quality of health care workers (Al Maqbali, Al Sinani, & Al-Lenjawi, 2021; Jahrami et al., 2021; Salari et al., 2020). A study conducted in April 2020 reported that 75% of health care workers had poor sleep quality; a higher prevalence than what was reported in many pre-pandemic studies on sleep quality (Jahrami et al., 2021). Additionally, female sex and the nursing profession were predictors of poor sleep quality in this study (Jahrami et al., 2021). It is suspected that increased workload and stress during the COVID-19 pandemic, as well as in any previous or future public health threats, has an impact on the sleep of RNs (Al Maqbali, Al Sinani, & Al-Lenjawi, 2021; Salari et al., 2020).

2.9 Nutrition

2.9.1 General nutritional guidelines

Health Canada has a set of dietary guidelines designed to promote healthy eating and reduce the risk of developing chronic diseases that are impacted by diet, such as CVD, T2DM, and colorectal cancer (Health Canada, 2019a). Canada's most recent dietary guidelines recommends that fruits, vegetables, and whole grains are consumed regularly, and foods that contain mostly saturated fat should be replaced with those that contain mostly unsaturated fat (Health Canada, 2019a). These guidelines are designed to help increase fibre intake, lower the risk of CVD, and decrease LDL-cholesterol (Health Canada, 2019a). They also state that water should be the beverage of choice, and to not consume sugary drinks, confectionaries, and sugar substitutes regularly, to avoid adding excess kcals and free sugars to the diet (Health Canada, 2019a). Recommended caloric intake varies by individual, and is dependent upon factors including sex, height, weight, and age, but typically ranges from 1,750 to 2,350 kcals for women and 2,200 to 3,000 kcals for men (McCrory et al., 2016). Energy (caloric) intake that exceeds an individual's energy expenditure results in weight gain in the form of body fat, whereas energy intake that is less than an individual's energy expenditure results in weight loss (McCrory et al., 2016). Being aware of your necessary energy intake is important in maintaining a health body weight and avoiding diet-impacted chronic diseases (McCrory et al., 2016).

2.9.2 Nutrition habits of nurses

The nutrition habits of RNs are likely influenced by various factors, including rotating shift work, occupational stress, and workload (Lin et al., 2019). Hospital nurses may cope with fatigue by consuming sugar-sweetened food or beverages at work, and shiftwork can cause an individual to eat excessively, potentially leading to obesity and metabolic syndrome (Jehan et al., 2017; Lin et al., 2019). A Taiwanese study found that most nurses (57.6%) consumed sugar-sweetened beverages as meal replacements, which was associated with high workloads (Lin et al., 2019). Additionally, nurses who consumed these beverages as meal replacements were more likely to be obese (Lin et al., 2019).

Shift workers may be at a greater risk for increased BMI and T2DM due to the meal-timing associated with those shifts (Lopez-Minguez, Gómez-Abellán, & Garaulet, 2019). Eating late in the day and/or in misalignment with the typical sleep-wake cycle (i.e., during the night) may impair weight loss (Garaulet et al., 2013). Eating later in the day has been found to decrease glucose tolerance and resting energy expenditure compared to eating earlier in the day (Almoosawi et al., 2016; Bandín et al., 2014; Lopez-Minguez, Gómez-Abellán, & Garaulet, 2019). Many studies also suggest that shift workers show higher frequency of meal intake or poor-quality nutrition when compared to consistent dayworkers (Amani & Gill, 2013).

While Health Canada's most recent dietary guidelines no longer follow a prescriptive food guide, their previous document, *Eating Well with Canada's Food Guide*, recommends that adults get 7 to 10 servings of fruits and/or vegetables a day (Heart & Stroke Foundation, 2013). However, RNs do not appear to be consuming sufficient fruits and/or vegetables, as only 47.2% of RNs (n=335) consumed 5 or more servings of fruits and/or vegetables per day (Ross et al., 2018). This generally indicates that shift working, including for RNs, negatively impacts nutrition and health, and that RNs are not following the recommended dietary guidelines.

2.10 Nursing students as a cohort of interest

Nursing students are a cohort of interest as they are future RNs that will be working with unprecedented rates of obesity and poor metabolic health in their patients (Camden, 2009). As these individuals are still completing their education, there is the opportunity to better integrate teachings regarding the importance of lifestyle choices for both themselves, and their future patients, since we know that an RN's own behaviour influences their practice (Bakhshi et al., 2015; Marchiondo, 2014).

There is a paucity of published research on the metabolic health of nursing students. However, these few studies suggests that, like RNs, nursing students also display poor PA behaviours (Adderley-Kelly & Green, 2000; Irazusta et al., 2016). Furthermore, despite having education on public health and health promotion, health care students (including nursing and midwifery) appear to have similar or higher rates of overweight and obesity compared to other university students (Blake et al., 2021). However, most of the published studies examining obesity and PA of nursing students relies on self-reported data which may be inaccurate or biased, leaving a lack of data objectively characterizing aspects of metabolic health and lifestyle in nursing students (Blake et al., 2021). More data, along with more objective data, will allow us to better understand if the metabolic health and lifestyle behaviours observed in RNs is also present before entry to the workforce (during nursing school).

2.11 Pilot study

To address the gap in research characterizing metabolic health of nursing students, a pilot study was completed in 2019 on a group (n=43) of full-time nursing students attending a Canadian university (West et al., 2019). The pilot study primarily focused on characterizing the overweight and obesity status in the nursing student cohort, along with their PA levels. Measures collected from the nursing students included BMI and WHR for overweight/obesity status, and 7-day accelerometry data for PA levels (West et al., 2019). The data was classified based on year of study in the nursing program; first year (n=13), second year (n=10), and upper-year (third/fourth year) (n=20) nursing students (West et al., 2019).

Mean body weight, BMI and WHR were all higher in second year and upper-year nursing students (West et al., 2019). BMI was significantly higher in second year (23.7±1.9kg/m^2) and upper-year students (25.4±2.5kg/m^2) compared to first-year students (20.3±2.3kg/m^2; p=0.005) (West et al., 2019). Mean WHR was also significantly higher in upper-year students (0.81±0.06cm) compared to first-year students (0.77±0.04cm; p=0.04) (West et al., 2019). When looking at PA levels, regardless of year of study, nursing students were highly sedentary, with mean time spent sedentary being 81.7±4.4% (West et al., 2019). The cohort of nursing students also engaged in only an average of 9.9±8.8 minutes of vigorous activity per day (West et al., 2019). Overall, the pilot study results suggest that the metabolic health of upper-year students, based only on BMI and WHR, is worse than first- and second-year students, and that nursing students are highly sedentary and inactive. This also suggests that the physical inactivity we see in RNs may be beginning before they are entering the workforce, and that while they are receiving their nursing education may be a critical point in informing them about the influence their lifestyle has on their health.

While the pilot study results show that nursing students (like RNs) are highly sedentary, PA is likely not the only factor contributing to the metabolic health of nursing students. As previously mentioned, poor sleep and high stress may contribute to poor metabolic health outcomes in nursing students (Gozal, Dumin, & Koren, 2016; Mesas et al., 2014). Nutrition may also play a role as food intake is correlated with BMI and WHR in RNs, and shift workers show increased food intake and poor nutrition quality (Amani & Gill, 2013; Zapka et al., 2009). It is likely that multiple lifestyle factors, including PA, nutrition, stress, and sleep, are associated with the metabolic health status of nursing students.

The pilot study only considered overweight and obesity status, along with WHR, in nursing students. However, at an individual level, BMI alone is not the best measurement for assessing an individual's risk of negative health outcomes (WHO, 2000). The current thesis also examines fasting blood glucose, BP, BF%, and blood lipid measurements to allow for a more thorough view of the metabolic health status of nursing students. Additionally, this thesis will expand upon the pilot study by including a cohort of undergraduate students majoring in biology from the same university to act as a comparison group. This comparison group allows us to better determine whether any of our findings are unique to nursing students.

2.12 Conclusion

To summarize, this literature review discussed the definitions of obesity and metabolic health and their impacts on health. We then detailed the relationships that the lifestyle factors of PA, sleep, nutrition, and psychological stress has with health. We also discussed the metabolic health and lifestyle of nurses, along with the role they can play in addressing these issues in their patients. Finally, we focused on nursing students, our cohort of interest for this thesis, by summarizing research that exists surrounding their health and lifestyle, as well as the results of the pilot study from which this study is based off of.

3 METHODS

3.1 Introduction

This was a cross-sectional study that examined metabolic health and lifestyle (PA, sleep, nutrition, and stress) in full-time undergraduate nursing students and biology students. This study received research ethics approval from the Trent University Research Ethics Board (REB#27872).

3.2 Participants

Students enrolled in a full-time undergraduate nursing program at Trent University through the 2022-2023 academic year were invited to participate in this study. Nursing students who were enrolled in the collaborative (4-year program) and compressed (accelerated 28-month program for individuals with previous post-secondary experience) programs were included. Additionally, full-time undergraduate students enrolled in a biology program at Trent University through the 2022-2023 academic year were invited to participate in the study as part of the comparison group. Participants were recruited on a rolling basis through the regular academic year (September 2022 to February 2023) through classroom announcements, emails, online learning system posts, posters, and word of mouth. Researchers involved in recruitment had no influence over the students' academics. Interested participants would reach out to the graduate student (primary researcher) via email to learn more about the study, ask any questions, and receive the consent form for review (Appendix B). If they were still interested, a study visit was scheduled, the consent form was reviewed again in person at the study visit, and written informed consent was obtained. To encourage participation from all students, a $10 gift card for a restaurant found on campus was provided to study participants.

Specific participant inclusion criteria were: (1) enrolled in full-time studies in nursing or biology at Trent University, (2) ≥17 years of age, and (3) signed informed consent.

3.3 Study visit procedure

Once written informed consent was obtained, there were two main components of the study that participants completed: (1) a study visit in the laboratory, and (2) a second visit to the laboratory to return completed accelerometer and diet logs. The study outline is further detailed in Figure 1.

The initial study visit was 60 to 90 minutes in length, and always began between 8am and 10am during the regular academic week (Monday to Friday). At the study visit, the various metabolic health measurements, R-R intervals (to later assess heart rate variability [HRV]), and various lifestyle questionnaires were completed. Participants also completed a demographic questionnaire related to their academic history, general health, and other health-related habits (i.e., smoking and alcohol consumption). At the end of the study visit, participants were given an accelerometer to wear on their hip, along with papers to complete a diet log for three days.

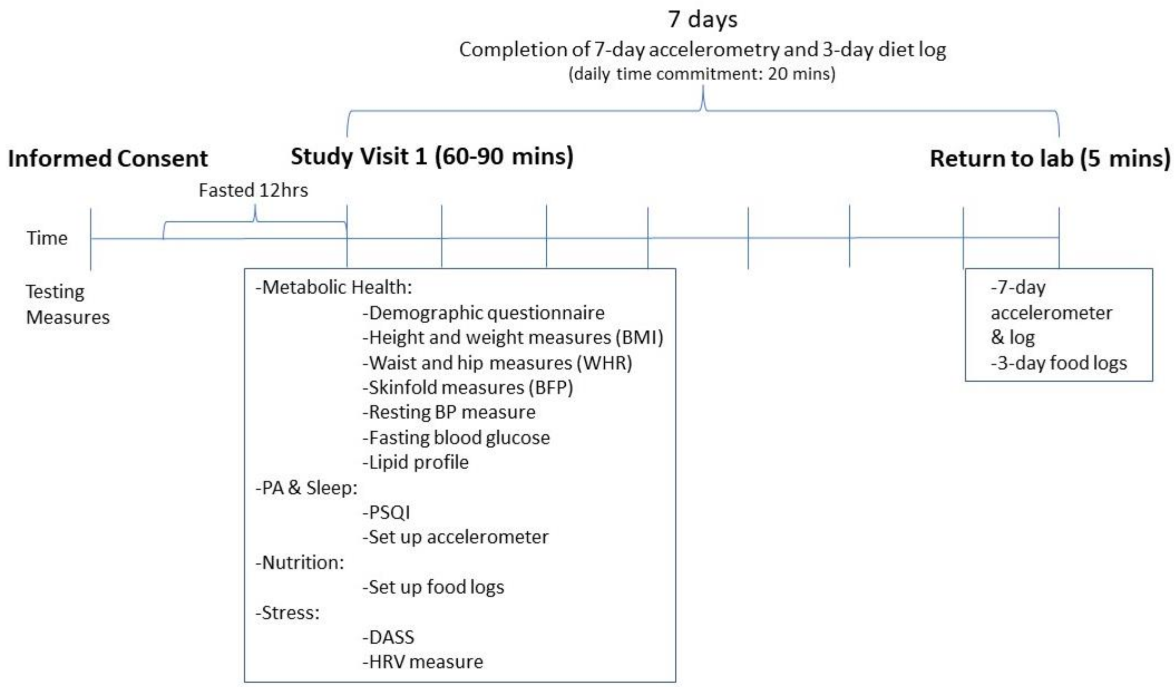

Figure 1: Illustration of study outline

BF%: body fat percentage; BMI: body mass index; BP: blood pressure; DASS: Depression Anxiety Stress Scale; HRV: heart rate variability; PA: physical activity; PSQI: Pittsburgh Sleep Quality Index; WHR: waist-to-hip ratio.

Participants were given the accelerometer for approximately seven days, with it being worn for a slightly longer or shorter period if conflicts with the participant's class or work schedule, or extenuating circumstances occurred. Completing the diet log along with keeping a log of when the accelerometer was removed (e.g., for showering) required a daily time commitment of less than 20 minutes per day. When the participant returned to the lab to drop-off their accelerometer and diet logs, they were given their gift card for participation in the study.

3.4 Metabolic health assessments

Metabolic health was assessed by measuring obesity (BMI, WC, WHR, BF%), BP, fasting blood glucose, and lipid profile (total cholesterol, HDL, LDL, and TGs), which are all associated with metabolic health (DeFina et al., 2012).

3.4.1 Body mass index

Participant height was measured using a stationary research-grade stadiometer (Health o meter® Professional) to the nearest tenth of a centimeter, and participant weight was measured using a scale (Health o meter® Professional, model: 349KLX) to the nearest tenth of a kilogram. The measurements were used to calculate the participant's BMI by dividing their weight (kg) by their height squared (m^2) (WHO, 2000).

3.4.2 Waist-to-hip ratio

Participants had their waist and hip circumferences measured to the nearest tenth of a centimeter with a tape measure. The tape measure was snug, but not constricting, and measurements were taken at the end of a normal exhale (WHO, 2008). Any excess bulky clothing was removed prior to the measurements being taken. WC measurements were taken at the narrowest part of the waist, generally above the hip bones and below the ribs, often 1 inch above the navel (WHO, 2008). HC measurements were taken at the widest point, generally around the hips and buttocks (WHO, 2008). Each of the measurements was taken twice, and repeated if there was more than 1 centimeter of difference between the two measurements. The average WC and HC measurements were used to calculate the WHR by dividing the average WC (cm) by the average HC (cm) (WHO, 2008).

3.4.3 Body fat percentage

Body fat percentage was assessed using skinfold measurements, as they are a simple and non-invasive way of estimating body composition (Silveira et al., 2020). Skinfold measures were obtained to the nearest millimeter using a Slim Guide® skinfold caliper (Creative Health Products). All measurements were taken on the right side of the body (Figure 2). Skinfold measurements were taken at the triceps (vertically on center of back of upper arm), biceps (vertically on center of front of upper arm), subscapular (below shoulder blade on a 45-degree angle), and suprailiac (above iliac crest on a 45-degree angle) regions. BF% was calculated according to the participant's skinfold measurements, sex, and age using Durnin and Womersley (1974) equations (Durnin & Womersley, 1974; Silveira et al., 2020). Individuals who did not consent to researchers having access to their subscapular or suprailiac skinfold sites had their BF% estimated according to their triceps skinfold measurement, sex, and age (Donoghue, 2009). In cases where the triceps skinfold could not be accessed, the participant did not have their BF% included in the results.

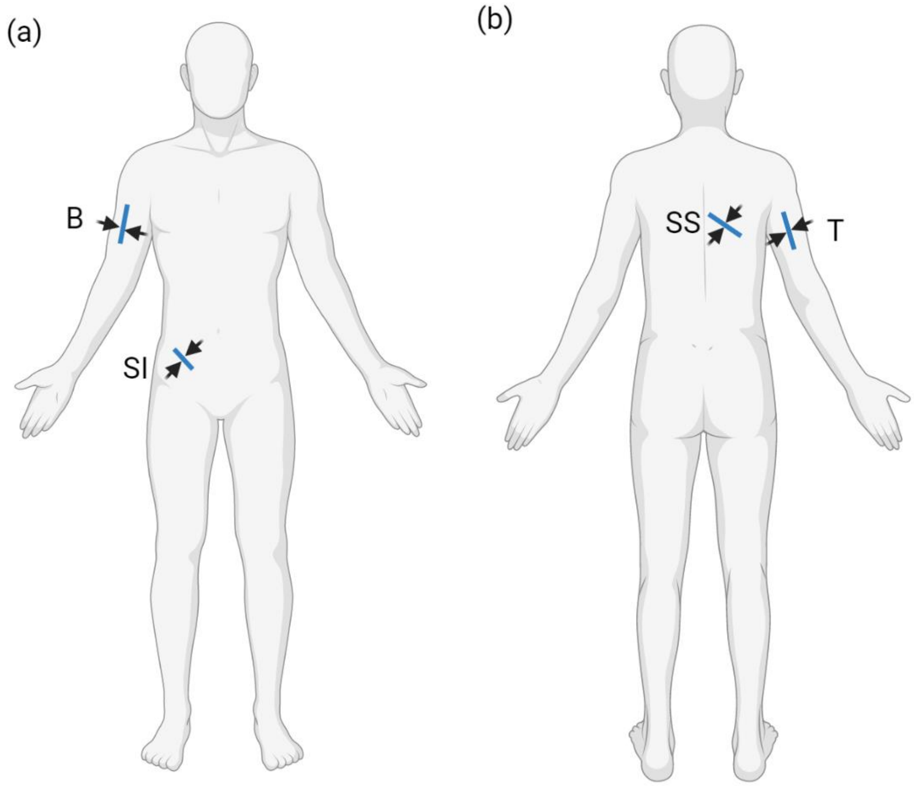

Figure 2: Skinfold measure sites (a) anterior view; (b) posterior view. Arrows indicate where skin is pinched, and blue line indicates how the skinfold would form.

B: Biceps; SI: Suprailiac; SS: Subscapular; T: Triceps

3.4.4 Resting blood pressure

Resting BP was measured using an automated oscillatory device (BIOS Diagnostics, model: BD350) placed on the nondominant upper arm, approximately 1 inch above the elbow. Participants were in a seated position for approximately 5 minutes prior. BP was taken two times for an average resting BP to be calculated. There was break between the readings (a minimum of 60 seconds between the two readings); participants completed the demographic questionnaire between the readings.

3.4.5 Fasting blood glucose

To obtain fasting blood glucose measurements, participants were asked to fast (i.e., to consume no food or drink other than water) for 12 hours prior to their study visit. Participants had a finger on their non-dominant hand lanced with a single-use lancet to obtain blood. Blood was collected on a Contour Next (Ascencia Diabetes Care) blood glucose test strip and analyzed with a Contour Next One glucose monitoring system (Ascencia Diabetes Care). Blood glucose was measured in mmol/L.

3.4.6 Lipid profile

Lipid profile was analyzed using a CardioChek PA Analyzer (PTS Diagnostics). The CardioChek PA Analyzer is a validated device that provides clinically equivalent lipid profile information including total cholesterol, HDL, LDL, TGs, and the ratio of total cholesterol to HDL (Bastianelli, Ledin, & Chen, 2017; Gao et al., 2016). Blood was collected from the same lanced finger used for the fasting blood glucose measurement, using a 40 microlitre capillary tube (PTS Diagnostics) and applied to the lipid panel test strips (PTS Diagnostics) inserted into the CardioChek PA Analyzer. If sufficient blood was not obtained using the first lanced finger, a second finger on their non-dominant hand was lanced upon the participant’s consent. Blood lipid levels were measured in mmol/L.

3.5 Physical activity assessment

Participants had their PA objectively measured with an accelerometer. At the study visit, participants were given an accelerometer (wGT3X-BT, ActiGraph LLC), initialized with a sampling rate of 60Hz, to quantitatively measure activity and sleep. The accelerometer measures movements across the x-, y-, and z-axes. It is a valid PA measurement tool that has been used to quantify PA in nurses and nursing students (Migueles et al., 2017; Oyeyemi et al., 2017; Reed et al., 2018). Participants were to wear the accelerometer on their nondominant hip for seven consecutive days (Ellis et al., 2014; Sadeh, 2011; Slater et al., 2015). Participants were instructed to maintain their regular activity and sleep habits and to wear the device during all waking and sleeping hours, only removing the device during a shower or water-based activities. Participants were given an activity log that was used for periods of time when the accelerometer was removed (e.g., while showering).

After the 7-day period, the participants returned the accelerometer and activity log. Accelerometer data was downloaded with a 60-second sampling epoch using ActiLife software (version 6.13.4, ActiGraph LLC), with data further exported to Excel. Wear-time validation was done manually, by examining the hourly kcals and/or steps for each hour and day of wear. If the hourly kcals and/or steps suggested the device was not being worn for a significant portion of the day (i.e., unaccounted for non-wear time for any period greater than two full hours outside of the period they were sleeping), that day would be removed from analysis. When necessary, activity logs and hourly analysis of the accelerometer data were referred to, and days with unaccounted reasons for the device not being worn were excluded. After the manual wear-time validation, a minimum of four days of accelerometer wear was required for data to be considered valid, and participants who did not meet this requirement were excluded from the accelerometer results (Colley et al., 2011; Trost et al., 2005).

Accelerometer data provided information on total kcals expended per day and per hour, amount of time engaged in sedentary, light-, moderate-, vigorous-, and very vigorous-intensity PA per day and steps per day (Sadeh, 2011). PA intensity was determined by counts-per-minute (CPM) using the Freedson Adult (1998) algorithm; these intensity cut-offs were used in the pilot study and another study that examined PA via accelerometry in nursing students (Freedson et al., 1998; Oyeyemi et al., 2017; West et al., 2019). The intensity cut-offs used were sedentary: 0-99CPM, light PA: 100-1951CPM, moderate PA: 1952-5724CPM, vigorous PA: 5725-9498CPM, and very vigorous PA: 9499CPM and above (Freedson, Melanson, & Sirard, 1998).

Total kcals expended per day and per hour, the amount of time spent in each intensity of PA per day, and the number of steps per day were averaged for valid days the accelerometer was worn. Average MVPA per week for each participant was calculated by adding their average moderate-, vigorous-, and very vigorous-intensity PA per day and multiplying it by 7 (to get a weekly average). Average MVPA was converted to minutes per week to assist in comparing it to CSEP's MVPA guidelines.

3.6 Sleep quality assessment

Participants completed the Pittsburgh Sleep Quality Index (PSQI) to assess their sleep quality. The PSQI is composed of 18 self-rated questions that were completed at the study visit. It is a commonly used questionnaire to measure sleep quality (Zhang et al., 2016). The questions on the PSQI are related to the individual's perceived sleep over the past month, and are related to their sleep duration, sleep disturbance, sleep latency, day dysfunction due to sleepiness, sleep efficiency, use of sleep medicine, and overall sleep quality. The evaluated questionnaire produces a score ranging from 0 (better) to 21 (worse), with a score ≤ 5 associated with good sleep quality, and a score > 5 associated with poor sleep quality.

3.7 Nutrition assessments

Participants completed a 3-day diet log by recording all food intake, including two weekdays and one day of the weekend, during the same period as their accelerometry data collection. 3-day diet logs are a commonly used dietary assessment tool (Schröder et al., 2001; Yang et al., 2010). Participants were asked to choose days that most resemble their typical eating habits, and to be as specific as possible in their diet log by including brands, restaurants, and quantities of foods consumed when applicable.

The diet logs were analyzed for multiple outcomes, including total kcal intake, macronutrient content (carbohydrates, protein, total fat, saturated fat, cholesterol, dietary fibre), and sodium intake, using Nutritionist Pro software (Axxya Systems).

3.8 Stress and psychological health assessments

Stress was assessed using 2 methods: (1) the Depression Anxiety Stress Scale (DASS); and (2) resting measures of heart rate variability (HRV).

3.8.1 Depression anxiety stress scale

The DASS is a 42-question scale that was completed at the study visit. The DASS is a widely used tool that has been validated in many populations to assess the emotional states of depression, anxiety, and stress (Crawford & Henry, 2003; Lovibond & Lovibond, 1995). The DASS has also been shown to be a good fit and have good internal consistency (reliability) when used in university student cohorts, with a Cronbach's alpha coefficient of 0.77 for depression, 0.70 for anxiety, and 0.74 for stress (Talwar et al., 2016). The questionnaire has 14 questions associated with each of the three traits, and the participant's DASS scores for each trait were compared to reference values to interpret the score for each. Possible interpretations for each trait are, normal, mild, moderate, severe, and extremely severe. The DASS is not intended to measure clinical outcomes, but rather the emotional states the individual had felt over the past week.

3.8.2 Heart rate variability

HRV, the variation in time between consecutive R-R intervals, is a non-invasive method that has been used as an objective measure of stress (Alcantara et al., 2020; Lim & Kim, 2014). HRV indicates change in ANS activity on a beat-to-beat basis; it varies based on the interaction of sympathetic and parasympathetic influences on the heart's sinoatrial node (Akselrod et al., 1985; Akselrod et al., 1981; Alcantara et al., 2020). For HRV analysis, participants had their heart rate monitored for 10 minutes in supine position and 10 minutes standing using a GPS sports watch (Polar Vantage V2). The Polar Vantage V2 sports watch has been determined to accurately measure both heart rate (HR) and HRV at rest (Nuuttila et al., 2022). The watch was placed on their right wrist, with a heart rate sensor (Polar H10) secured snugly around the chest, directly against the skin. Participants were instructed to relax, and to stand in place (vs. walking around) for the 10 minutes of standing.

The data was downloaded using Flowsync software (Polar) and further analyzed using Kubios HRV Standard software (version 3.5.0, Kubios Oy). The Kubios HRV software performed a fast Fourier transformation to determine autonomic balance (Douzi et al., 2018). The beat-correction threshold was set to low as it is the recommended correction level for young adults (Alcantara et al., 2020). From the corrected data, the best 5-minute interval (i.e., fewest outliers and/or corrected beats) was used for analysis of both the supine and standing positions (Alcantara et al., 2020).

Kubios HRV analysis provided both time- and frequency-domain measures of the selected intervals (Kim et al., 2018; Task Force of the European Society of Cardiology [ESC] & the North American Society of Pacing and Electrophysiology [NASPE], 1996). Since this study is analyzing HRV over a short period of time (i.e., 5 minutes), frequency-domain measurements were used, as time-domain measurements are generally reported for longer periods (i.e., 24 hours) (Task Force of the ESC & the NASPE, 1996). Recorded frequency-domain measures in both the supine and standing position were low frequency (LF; 0.04-0.15Hz) power, high frequency (HF; 0.15-0.5Hz) power, and total power; all measured in milliseconds squared (ms^2) (Kim et al., 2018; Shaffer & Ginsberg, 2017; Task Force of the ESC & the NASPE, 1996). LF power is believed to reflect both parasympathetic and sympathetic activity, and HF power reflects parasympathetic activity (Akselrod et al., 1981; Task Force of the ESC & the NASPE, 1996). The ratio of LF to HF serves as an indicator of SNS activity (related to increased stress levels), and the ratio of HF to total power is reflective of PNS activity (related to relief from stress) (Brenner et al., 2020; Nakayama et al., 2018; Task Force of the ESC & the NASPE, 1996).

3.9 Statistical analysis

Demographic characteristics of participants were analyzed using descriptive statistics. All metabolic health and lifestyle variables were tested for normality within the nursing and biology student subgroups using the Shapiro-Wilk test for normality. For metabolic health and lifestyle variables that were not normally distributed, nonparametric tests were used to examine differences. HRV measurements were also log-transformed for comparisons by program of study and metabolic health risk.

To address research question (RQ) 1, as outlined in section 1.3, descriptive statistics were used to characterize the individual components of metabolic health (BMI, WC, WHR, BF%, fasting blood glucose, blood lipid profile) in nursing students. Descriptive statistics were also used to characterize the lifestyle (PA, sleep, nutrition, and stress) of nursing students (RQ 2).

Additionally, for RQ 1, the metabolic health of each participant was determined using the AHA/NHLBI/IDF 2009 definition of metabolic syndrome (Appendix A; Table 1) with the Health Canada guidelines for WC (Appendix A; Table 11). More specifically, the presence of 3 of more of the following: increased WC (≥ 102cm [males] or ≥ 88cm [females]), increased TG (≥ 1.7mmol/L), decreased HDL (≤ 1.03 mmol/L [males] or ≤ 1.29mmol/L [females]), increased BP (systolic ≥ 130mmHg or diastolic ≥ 85mmHg), or increased fasting blood glucose (≥ 5.6mmol/L). As a limited number of our participants met the AHA/NHLBI/IDF 2009 guidelines, we modified the definition to better indicate the percentage of nursing students that are **at risk** of having poor metabolic health or being diagnosed with metabolic syndrome in the future. We first amended the AHA/NHLBI/IDF criteria for metabolic syndrome by changing the increased WC criterion to increased body size. For the increased body size criterion to be met, individuals would need to meet at least one of the following: increased WC (≥ 102cm [males] or ≥ 88cm [females]), increased BMI (≥ 25.0kg/m^2), increased WHR (≥ 1.0 [males] or ≥ 0.85 [females]), and/or increased BF% (≥ 25.8% [males] or ≥ 37.1% [females]) (Alberti et al., 2009; Macek et al., 2020; WHO, 2000). As well, to better indicate participants who were **at risk** of having poor metabolic health, we examined the number of individuals who had 2 risk factors. The amended guidelines for identifying individuals who are at risk of poor metabolic health are summarized in Appendix A (Table 12). Therefore, the resulting two groups created from the amended criteria are "low-risk of poor metabolic health" (meet 0 or 1 criteria) and "at-risk of poor metabolic health" (meet 2 or more criteria). These groups will simply be referred to as "low-risk" and "at-risk" from this point forward.

To answer RQ 3, the strength and direction of association between metabolic health variables (BMI, WC, WHR, BF%, fasting blood glucose, blood lipid profile) and lifestyle variables in nursing students were examined using Spearman's rank correlations.

For comparisons between nursing and biology students (RQ 4), Mann-Whitney U tests were conducted to determine if any differences exist for the metabolic health or lifestyle variables between the groups. Pearson's chi-squared test was used to determine if the distribution of low-risk and at-risk groups differed between nursing vs. biology students.

The statistical level of significance for all tests was set at $p<0.05$ (two-tailed). Unless otherwise noted, data is presented as means±standard deviations (SD) for continuous variables and counts (n) and percentages for categorical data. We did not adjust for multiple comparisons. All data were analyzed using IBM SPSS Statistics for Windows (version 29; IBM Corp.).

4 RESULTS

4.1 Introduction

The results of this study will be presented according to the 4 RQs this thesis aims to answer, as outlined in section 1.3. It will first outline the participant demographics, and then report findings surrounding the characterization of metabolic health in nursing students (RQ 1). RQ 2 will then be addressed by presenting results characterizing the PA, sleep, nutrition, and stress of nursing students. Next, the associations of metabolic health and lifestyle in nursing students will be described (RQ 3). For RQ 4, comparisons between nursing students and biology students (comparison group) will be incorporated throughout the results section.

4.2 Participants

A total of 57 undergraduate students participated in this study. By major of study, there were 42 nursing students and 15 biology students that participated. Participant demographics, smoking, and alcohol consumption are presented in Table 1. No differences between age of nursing and biology students were found. Most nursing student participants were female (85.7%) and white (69.0%); all biology student participants were female (100%), and most also identified as white (60%). None of the participants were smokers, however alcoholic drinks consumed per week by nursing students was higher than biology students (1.96±2.32 vs. 0.63±0.77; $Z=-2.266$, $p=0.023$). At an individual level, 21.4% (n=9) of nursing students consumed no alcohol, 47.6%

(n=20) consumed 1 to 2 alcoholic drinks per week, 26.2% (n=11) consumed 3-6 alcoholic drinks per week, and 4.8% (n=2) consumed 7 or more alcoholic drinks per week.

Table 1: Participant demographics for all participants, and by major of study

	All participants N=57		**Nursing students** n=42		**Biology students** n=15	
	n	*%*	*n*	*%*	*n*	*%*
Age (Mean±SD)	21.33±4.52		21.62±4.82		20.53±3.56	
Sex (female)	51	89.5	36	85.7	15	100
Race:						
White	38	66.7	29	69.0	9	60.0
Asian	7	12.3	4	9.5	3	20.0
Black	3	5.3	2	4.8	1	6.7
Latin American	2	3.5	1	2.4	1	6.7
Other/multiracial	7	12.3	6	14.3	1	6.7
Smoker (yes)	0	0	0	0	0	0
Consume alcohol (yes)	40	70.2	33	78.6	7	46.7
Drinks per week (Mean±SD)	1.61±2.11		**1.96±2.32 ***		0.63±0.77	

*: p<0.05 nursing students vs. biology students

SD: Standard deviation

4.3 Metabolic health of nursing students

This section covers characterizing the metabolic health of undergraduate nursing students, as well as in comparison to undergraduate biology students. It will first present the results for individual components of metabolic health, and then address the composite scores for their metabolic health status.

4.3.1 Characteristics of metabolic health in nursing students

Average measured metabolic health characteristics for all participants, and by major of study are presented in Table 2. Fasting blood glucose measurements are missing from 3 participants, and lipid profile measurements are missing from 11 participants either due to a lack of blood collected, participants being unable to fast due to medical conditions, feeling unwell, and/or withdrawing consent for that portion of the study.

On average, nursing students had normal BMI, normal WC, normal WHR, normal BF%, normal resting systolic and diastolic BP, normoglycemia, normal total cholesterol, normal LDL levels, optimal HDL and TG levels, and an ideal ratio of total cholesterol to HDL (Alberti et al., 2009; DeFina et al., 2012; Macek et al., 2020; Millán et al., 2009; NIH, 2002; WHO, 2021; WHO, 2000). Biology students fell into all the same classification ranges as nursing students for metabolic health characteristics, except for their HDL cholesterol levels. Biology student HDL levels were not within the optimal range; they were lower than nursing students, but not yet within the poor HDL level classification (NIH, 2002). There were no differences in BMI, WC, WHR, BF%, systolic BP, MAP, fasting blood glucose, total cholesterol, LDL, TG, and total cholesterol to HDL ratio between nursing and biology students. However, nursing students had higher resting diastolic BP (71.58±7.88 vs. 66.50±6.35; $Z=-2.148$, $p=0.032$) and higher HDL cholesterol levels (1.60±0.41 vs. 1.34±0.33; $Z=-2.151$, $p=0.031$) compared to biology students.

Table 2: Anthropometric and metabolic health characteristics for all participants, and by major of study

	All participants N=57	**Nursing students** n=42	**Biology students** n=15
	Mean±SD	*Mean±SD*	*Mean±SD*
Height (cm)	166.12±71.38	167.10±68.02	163.40±75.86
Weight (kg)	67.51±15.56	67.82±12.96	66.65±21.79
BMI (kg/m²)	24.37±4.80	24.25±4.08	24.69±6.58
WC (cm)	75.42±10.03	75.09±8.32	76.32±14.10
WHR	0.75±0.07	0.75±0.05	0.74±0.09
BF% (%)	27.34±6.63	26.65±6.41	29.41±7.06
Resting systolic BP (mmHg)	112.59±11.51	113.76±11.32	109.30±11.79
Resting diastolic BP (mmHg)	70.25±7.79	**71.58±7.88 ***	66.50±6.35
MAP (mmHg)	84.36±8.43	85.64±8.46	80.77±7.48
	All participants N=54	**Nursing students** n=40	**Biology students** n=14
Fasting blood glucose (mmol/L)	5.17±0.51	5.20±0.47	5.09±0.64
	All participants N=46	**Nursing students** n=35	**Biology students** n=11
Total cholesterol (mmol/L)	4.07±0.92	4.07±0.96	4.09±0.84
HDL (mmol/L)	1.53±0.40	**1.60±0.41 ***	1.34±0.33
LDL (mmol/L)	2.07±0.77	2.00±0.75	2.31±0.85
TG (mmol/L)	1.03±0.59	1.04±0.65	0.99±0.38
Total cholesterol/HDL	2.78±0.91	2.65±0.85	3.19±1.03

*: $p<0.05$ nursing students vs. biology students

BF%: Body fat percentage; BMI: Body mass index; BP: Blood pressure; HDL: High-density lipoprotein; LDL: Low-density lipoprotein; MAP: Mean arterial pressure; SD: Standard deviation; TG: Triglycerides; WC: Waist circumference; WHR: Waist-to-hip ratio

Looking at the BMI of nursing students at an individual level, 2.38% (n=1) were underweight (BMI <18.5kg/m²), 57.1% (n=24) were normal weight (BMI 18.5-24.9kg/m²), 33.3% (n=14) were overweight (BMI 25.0-29.9kg/m²), and 7.14% (n=3) were obese (BMI ≥30.0kg/m^2) (WHO, 2021). For sex-specific WC in nursing students, 95.2% (n=40) had a normal WC (<102cm [males] or <88cm [females]) and 4.8% (n=2) had an elevated WC (Alberti et al., 2009). All nursing students had a normal WHR (<1.0 [males] or <0.85 [females]) and a BF% that was not associated with an increased risk of cardiovascular events (<25.8% [males] or <37.1% [females]) (Macek et al., 2020; WHO, 2000). In terms of BP in nursing students, 81.0% (n=34) had a normal systolic BP, 19.0% (n=8) had an elevated systolic BP (>120mmHg), 85.7% (n=36) had a normal diastolic BP, and 14.3% (n=6) had an elevated diastolic BP (>80mmHg) (WHO, 2021). For fasting blood glucose in nursing students, 75.0% (n=30) were classified as having normoglycemia (3.9-5.5mmol/L), 20% (n=8) as mild hyperglycemia (5.6-6.0mmol/L), and 5.0% (n=2) and intermediate hyperglycemia (6.1-7.0mmol/L) (DeFina et al., 2012). Most nursing students (88.6%, n=31) had a normal total serum cholesterol level (<5.18mmol/L), 8.6% (n=3) had borderline high total cholesterol (5.18-6.18mmol/L), and 2.9% (n=1) had high total cholesterol (>6.18mmol/L) (NIH, 2002). Most nursing students (85.7%, n=30) also had optimal LDL cholesterol levels (<2.6mmol/L), 8.6% (n=3) had near optimal LDL levels (2.6-3.3mmol/L), and 5.7% (n=2) had borderline high LDL levels (3.4-4.1mmol/L) (NIH, 2002). For HDL cholesterol levels in nursing students, 54.3% (n=19) had optimal levels (>1.6mmol/L) and 2.9% (n=1) had poor levels (<1.0mmol/L); the remaining 42.9% (n=15) fell between the optimal and poor HDL level range (NIH, 2002). For TG levels, 85.7% (n=30) of nursing students had optimal levels (<1.7mmol/L), 8.6% (n=3) had borderline high TG levels (1.7-2.2mmol/L), and 5.7% (n=2) had high TG levels (2.3-5.6mmol/L) (NIH, 2002).

4.3.2 Metabolic health composite score in nursing students

When considering the AHA/NHLBI/IDF 2009 definition of metabolic syndrome (Appendix A; Table 10), 50.0% (n=21) met 0 of the criteria, 40.5% (n=17) met 1 of the criteria, 4.8% (n=2) met 2 of the criteria, and 4.8% (n=2) met 3 or more of the criteria. This indicates that 4.8% (n=2) of the nursing student participants met the AHA/NHLBI/IDF guidelines for diagnosing metabolic syndrome (i.e., meeting 3 or more of the criteria).

Using the amended guidelines (Appendix A; Table 12), as outlined in section 3.7, with the nursing student participants, 28.6% (n=12) met 0 of the criteria, 40.5% (n=17) met 1 of the criteria, 23.8% (n=10) met 2 of the criteria, and 7.1% (n=3) met 3 or more of the criteria. This resulted in 69.0% (n=29) of nursing students having low-risk of poor metabolic health, and 31.0% (n=13) being at-risk of poor metabolic health.

In comparison, when using the amended guidelines for identifying low-risk and at-risk individuals (Appendix A; Table 12), 26.7% (n=4) of biology students met 0 of the criteria. 26.7% (n=4) met 1 of the criteria, 40.0% (n=6) met 2 of the criteria, and 6.7% (n=1) met 3 or more of the criteria. Therefore, 53.3% (n=8) of biology students were classified as low-risk of poor metabolic health and 46.7% (n=7) were classified as at-risk of poor metabolic health.

Table 3 summarizes the percentages and number of low-risk and at-risk groups of participants for nursing and biology students. Pearson's chi-squared test indicates that there is no significant association between major of study and risk of poor metabolic health status ($\chi2=1.20$, $p=0.349$).

Table 3: Participants by major of study and risk of poor metabolic health

	Nursing students N=42		**Biology students** n=15	
	n	*%*	*n*	*%*
Low-risk	29	69.0	8	53.3
At-risk	13	31.0	7	46.7

4.4 Lifestyle of nursing students

This section characterizes the lifestyle factors of nursing students. More specifically, it will present results of the PA, sleep, nutrition, and stress levels of nursing students. It will also compare the results to undergraduate biology students.

4.4.1 Physical activity in nursing students

After manual wear time validation, as outlined in section 3.4.5, 48 participants (84.2%) (34 nursing [81.0%] and 14 biology [93.3%] students) wore the accelerometer for at least 4 days and were included in analysis. Accelerometer results for average sedentary time and PA levels per day for all participants, and by major of study are summarized in Table 4, along with average steps per day and MVPA per week.

Table 4: Minutes per day sedentary time and physical activity levels, steps per day, and average moderate-to-vigorous physical activity per week measured by objective accelerometry

	All participants N=48	**Nursing students** n=34	**Biology students** n=14
	Mean±SD	*Mean±SD*	*Mean±SD*
Sedentary time (mins/day)	1020.95±69.51	1013.95±75.22	1037.96±51.63
% of day sedentary (%)	81.18±4.46	**80.29±4.73***	83.33±2.86
Light PA (mins/day)	202.81±55.45	**212.98±57.49***	178.11±42.42
% of day light PA (%)	16.10±4.10	**16.95±4.30***	14.03±2.72
Moderate PA (mins/day)	32.03±13.01	32.33±13.16	31.31±13.07
% of day moderate PA (%)	2.61±1.05	2.62±1.06	2.57±1.08
Vigorous PA (mins/day)	1.36±2.84	1.56±3.22	0.86±1.57
% of day vigorous PA (%)	0.11±0.23	0.13±0.23	0.08±0.14
Steps (steps/day)	6094.2±2045.3	6282.66±2179.00	5636.79±1659.28
MVPA (mins/week)	233.75±96.31	237.28±97.86	225.17±95.43

*: p<0.05 nursing students vs. biology students

MVPA: Moderate-to-vigorous physical activity; PA: Physical activity; SD: Standard deviation

Overall, nursing students engaged in 1013.95±75.22 minutes per day of sedentary time (including sleep; 80.29±4.73% of day), 212.98±57.49 minutes per day of light PA (16.95±4.30% of day), 32.33±13.16 minutes per day of moderate PA (2.62±1.06% of day), and 1.56±3.22 minutes per day of vigorous PA (0.13±0.23% of day). On average, nursing students engaged in 237.28±97.86 minutes of MVPA per week. This does meet the CSEP guidelines of at least 150 minutes of MVPA per week (CSEP, 2020). At an individual level, 82.35% (n=28) of nursing students are meeting the CSEP MVPA guidelines.

In comparison to biology students, nursing students engaged in significantly more light PA, in both minutes per day (212.98±57.49 vs. 178.11±42.42; Z=-2.041, p=0.041) and percentage of time per day (16.95±4.30% vs. 14.03±2.72%; Z=-2.291, p=0.022). Nursing students also had a significantly lower percentage of their day spent sedentary (80.29±4.73% vs. 83.33±2.86%; Z=-2.404, p=0.016), and engaged in less sedentary minutes per day, though this result was not significant. There was no significant difference between the amount of MVPA per week that nursing students and biology students engaged in (237.28±97.86 vs. 225.17±95.43; Z=-0.476, p=0.634).

4.4.2 Sleep quality in nursing students

All 57 participants (42 nursing and 15 biology) completed the PSQI. At an individual level, 61.9% (n=26) of nursing students were classified as having poor sleep quality. The mean nursing student PSQI score was 7.02±3.49, classifying them as having poor sleep quality.

At an individual level, 60.0% (n=9) of biology students were classified as having poor sleep quality. The average biology student PSQI score was 7.07±2.63, classifying them as having poor sleep quality. There was no significant difference between the PSQI scores of nursing and biology students (7.02±3.49 vs. 7.07±2.63; Z=-0.319, p=0.749).

4.4.3 Nutrition in nursing students

A total of 50 participants (39 nursing students and 11 biology students) had their 3-day diet logs included in analysis. The remaining diet logs were excluded since they were either incomplete, not returned, or lacked sufficient information surrounding food type and/or quantities. 3-day diet log results for average daily kcals, kcals per kilogram of body weight, protein, carbohydrate, total and saturated fat content (both in grams consumed per day and percentage of daily kcals), as well as daily cholesterol, dietary fibre, and sodium intake for nursing and biology students is summarized in Table 5. Nursing students consumed an average of 1710.59±486.55 kcals per day; 16.43±4.24% of their daily kcals came from protein, 48.78±9.95% came from carbohydrates, and 34.62±8.90% came from fats. When normalizing kcal intake for body weight, nursing students consumed an average of 26.19±9.01 kcals per day per kilogram of body weight.

Nursing students had increased daily total kcals, kcals per kilogram of body weight, protein, carbohydrate, total fat, cholesterol, and dietary fibre intake, and decreased saturated fat and sodium intake compared to biology students. For nursing student daily kcal intake, 16.43±4.24% came from protein (vs. 15.40±4.38% in biology students), 48.78±9.95% came from carbohydrates (vs. 48.98±7.00% in biology students), and 34.62±8.90% came from fats (vs. 35.88±4.37% in biology students). None of these differences between nursing and biology students were significant ($p>0.05$).

Table 5: Average daily kilocalorie, macronutrient, and sodium intake for all participants, and by major of study

	All participants N=50	**Nursing students** n=39	**Biology students** n=11
	Mean±SD	*Mean±SD*	*Mean±SD*
kcals/day	1688.53±479.18	1710.59±486.55	1610.34±465.77
kcals/day/kg	25.93±8.75	26.19±9.01	25.01±7.86
Protein/day (g)	67.96±22.61	69.80±23.74	61.42±17.43
Carbs/day (g)	207.81±72.62	209.55±74.63	201.65±68.03
Total fat/day (g)	66.59±25.09	67.24±26.56	64.28±19.89
Saturated fat/day (g)	22.03±9.55	21.97±9.97	22.25±8.32
Cholesterol/day (mg)	252.09±188.96	273.35±205.60	176.72±79.57
Dietary fibre/day (g)	16.00±7.30	16.24±7.86	15.13±5.03
Sodium/day (mg)	2694.50±877.04	2627.83±832.71	2930.87±1027.31
% kcals from protein/day (%)	16.20±4.25	16.43±4.24	15.40±4.38
% kcals from carbs/day (%)	48.82±9.31	48.78±9.95	48.98±7.00
% kcals from fat/day (%)	34.89±8.10	34.62±8.90	35.88±4.37

Carbs: Carbohydrates; kcals: Kilocalories; kg: Kilogram; SD: Standard deviation

4.4.4 Stress and psychological health in nursing students

All 57 participants (42 nursing students and 15 biology students) completed the DASS. Nursing students had an average state depression score of 10.32±10.31 corresponding to the mild category, average anxiety score of 11.71±8.00 corresponding to the moderate category, and average stress score of 15.52±8.53 corresponding to the mild category. At an individual level, 61.9% (n=26) of nursing students had normal depression levels, 7.1% (n=3) had mild depression levels, 14.3% (n=6) had moderate depression levels, 9.5% (n=4) had severe depression levels, and 7.1% (n=3) had extremely severe depression levels. For state anxiety levels in nursing students, 50.0%

(n=21) had normal levels, 4.8% (n=2) had mild levels, 21.4% (n=9) had moderate levels, and 16.7% (n=7) had severe levels, and 19.0% (n=8) had extremely severe levels. Finally, for state stress in nursing students, 50.0% (n=21) had normal levels, 14.3% (n=6) had mild levels, 21.4% (n=9) had moderate levels, 11.9% had severe levels (n=5), and 2.4% (n=1) had extremely severe levels.

Biology students had an average state depression score of 11.53±9.69 corresponding to the mild category, average state anxiety score of 13.07±6.15 corresponding to the moderate category, and average state stress score of 16.87±9.04 corresponding to the mild category. There were no significant differences between nursing and biology students from Mann-Whitney U tests (depression: Z=-0.944, p=0.345; anxiety: Z=-0.853, p=0.394; stress: Z=-0.417, p=0.677).

HRV analysis was successfully completed on 50 participants (37 nursing students and 13 biology students); data was missing from participants if they did not consent to researchers placing the heart rate monitor against the skin around their chest, or if poor quality data was obtained, as indicated by the Kubios HRV software. Obtained HRV measures of LF power (parasympathetic and sympathetic activity), HF power (parasympathetic activity), total power, PNS, and SNS in both the supine and standing positions for nursing and biology students are summarized in Table 6a. Additionally, as HRV measures were not normally distributed, log-transformed HRV measures are presented in Table 6b.

Looking at the observed HRV measures (not log-transformed), nursing students had higher LF power, total power, and SNS in both positions, higher standing HF power and PNS, and lower supine HF power and PNS in comparison to biology students.

However, none of these differences between nursing and biology students were significant for both the observed and log-transformed data, as indicated by Mann-Whitney U tests ($p>0.05$).

Table 6a: Heart rate variability observed measures for all participants, and by major of study

	All participants N=50	**Nursing students** n=37	**Biology students** n=13
	Mean±SD	*Mean±SD*	*Mean±SD*
LF (ms^2)			
Supine	1641.30±1891.30	1877.08±2116.13	970.23±716.12
Standing	1439.37±1761.84	1441.58±1637.80	1433.23±2143.04
HF (ms^2)			
Supine	2163.32±2353.55	2060.49±1902.06	2456.00±3411.67
Standing	686.71±1032.42	746.83±1105.55	520.23±811.11
TP (ms^2)			
Supine	3958.28±3617.70	4119.19±3560.42	3500.31±3886.49
Standing	2392.41±3073.92	2422.11±2874.55	2310.15±3699.38
PNS (HF/TP)			
Supine	0.531±0.184	0.510±0.188	0.591±0.165
Standing	0.248±0.149	0.256±0.164	0.223±0.098
SNS (LF/HF)			
Supine	1.160±1.390	1.301±1.572	0.760±0.497
Standing	4.284±3.824	4.496±4.289	3.698±2.080

HF: High frequency power; LF: Low frequency power; PNS: Parasympathetic nervous system; SD: Standard deviation; SNS: Sympathetic nervous system; TP: Total power

Table 7b: Log-transformed heart rate variability measures for all participants, and by major of study

	All participants N=50	**Nursing students** n=37	**Biology students** n=13
	Mean±SD	*Mean±SD*	*Mean±SD*
LF (ms^2)			
Supine	3.02±0.42	3.04±0.47	2.89±0.30
Standing	2.94±0.42	2.95±0.44	2.94±0.40
HF (ms^2)			
Supine	3.11±0.48	3.10±0.49	3.11±0.49
Standing	2.46±0.59	2.47±0.64	2.43±0.64
TP (ms^2)			
Supine	3.42±0.43	3.43±0.45	3.36±0.40
Standing	3.15±0.43	3.16±0.45	3.12±0.40
PNS (HF/TP)			
Supine	-0.31±0.19	-0.33±0.20	-0.25±0.13
Standing	-0.69±0.28	-0.68±0.31	-0.69±0.19
SNS (LF/HF)			
Supine	-0.09±0.37	-0.06±0.37	-0.22±0.33
Standing	0.48±0.37	0.48±0.41	0.50±0.25

HF: High frequency power; LF: Low frequency power; PNS: Parasympathetic nervous system; SD: Standard deviation; SNS: Sympathetic nervous system; TP: Total power

4.5 Associations between metabolic health and lifestyle in nursing students

This section covers the associations between metabolic health and lifestyle in nursing students. It will first present the Spearman's rank correlation analyses between metabolic health characteristics and lifestyle. Then, it will present the Mann-Whitney U test results comparing lifestyle variables between the low-risk of poor metabolic health and at-risk of poor metabolic health groups of nursing students.

4.5.1 Correlations between metabolic health characteristics and lifestyle factors

Spearman's rank correlation analyses between metabolic health characteristics and lifestyle factors are all found in Appendix C. Correlation coefficients (ρ) and associated p-values for sedentary time, PA levels, steps, weekly MVPA, and metabolic health characteristics in nursing students are shown in Table 13 (Appendix C). No significant differences in sedentary time, PA levels, steps, and weekly MVPA were found across metabolic health characteristics ($p>0.05$).

Spearman's rank correlation analyses for average daily kcal and macronutrient intake, and metabolic health characteristics in nursing students are shown in Table 14 (Appendix C). Significant positive correlations were found between BF% and the percentage of daily kcals from carbohydrates (ρ=0.417, p=0.008), TG and percentage of daily kcals from carbohydrates (ρ=0.423, p=0.016), HDL cholesterol and the percentage of daily kcals from carbohydrates (ρ=0.387, p=0.029), LDL cholesterol and carbohydrates (ρ=0.365, p=0.040), fasting blood glucose and total fat (ρ=0.331, p=0.045), fasting blood glucose and saturated fat (ρ=0.328, p=0.047), and total serum cholesterol and carbohydrates (ρ=0.353, p=0.047). Significant negative correlations were found between TG and dietary cholesterol (ρ=-0.472, p=0.006), BF% and the percentage of daily kcals from fats (ρ=-0.420, p=0.008), TG and percentage of daily kcals from protein (ρ=-0.450, p=0.010), HDL cholesterol and percentage of daily kcals from fats (ρ=-0.393, p=0.026), total serum cholesterol and dietary cholesterol (ρ=-0.375, p=0.034), and TG and percentage of daily kcals from fats (ρ=-0.371, p=0.037). No other significant differences in dietary intake were found across metabolic health characteristics ($p>0.05$).

Spearman's rank correlation analyses for PSQI, DASS, and metabolic health characteristics can be seen in Table 15 (Appendix C). No significant differences in PSQI or DASS scores were found across metabolic health characteristics ($p>0.05$). Spearman's rank correlation analyses for HRV and metabolic health characteristics can be seen in Table 16 (Appendix C). A significant positive correlation was found between WHR and supine SNS ($\rho=0.331$, $p=0.045$). No other significant differences in HRV measures were found across metabolic health characteristics ($p>0.05$).

4.5.2 Associations between metabolic health composite scores and lifestyle

Accelerometer results for PA levels according to metabolic health risk are summarized in Table 7. There were no significant differences in PA participation by risk group ($p>0.05$).

Table 8: Minutes per day sedentary time and physical activity levels, steps per day, and average moderate-to-vigorous physical activity per week measured by objective accelerometry for low-risk and at-risk groups of nursing students

	Low-risk n=24	**At-risk** n=10	**Z**	**p**
	Mean±SD	*Mean±SD*		
Sedentary time (mins/day)	1019.53±80.44	1000.54±62.68	-0.227	0.821
% of day sedentary (%)	80.21±4.77	80.49±4.87	-0.076	0.940
Light PA (mins/day)	215.77±58.20	206.30±58.26	-0.302	0.762
% of day light PA (%)	17.08±4.28	16.66±4.57	-0.227	-1.134
Moderate PA (mins/day)	31.86±14.67	33.47±9.15	-0.964	0.335
% of day moderate PA (%)	2.57±1.18	2.78±0.74	-1.134	0.257
Vigorous PA (mins/day)	1.78±3.69	1.04±1.67	-1.082	0.279
% of day vigorous PA (%)	0.15±0.30	0.09±0.14	-1.044	0.297
Steps (steps/day)	6375.28±2367.23	6060.37±1735.21	-0.038	0.970
MVPA (mins/week)	235.48±108.34	241.61±71.12	-0.643	0.520

MVPA: Moderate-to-vigorous physical activity; PA: Physical activity; SD: Standard deviation

The average PSQI score is 7.17±3.66 for the low-risk group and 6.69±3.43 for the at-risk group; classifying both groups as obtaining poor sleep quality. Mann-Whitney U tests indicate no significant difference in PSQI score between the groups (Z=-0.342, p=0.732).

Average daily total kcals, kcals per kilogram of body weight, protein, carbohydrate, total and saturated fat content (both in grams consumed per day and percentage of daily kcals), as well as daily cholesterol, dietary fibre, and sodium intake for low-risk and at-risk groups is summarized in Table 8. There were no significant differences between the groups for any of the dietary variables (p>0.05).

Table 9: Average daily kilocalorie, macronutrient, and sodium intake for low-risk and at-risk groups of nursing students

	Low-risk n=28	**At-risk** n=11	**Z**	**p**
	Mean±SD	*Mean±SD*		
kcals/day	1678.09±405.22	1712.89±635.59	-0.531	0.596
kcals/day/kg	26.97±8.65	24.21±10.21	-0.749	0.454
Protein/day (g)	69.64±20.50	64.03±27.31	-0.406	0.685
Carbs/day (g)	201.72±59.42	222.02±97.85	-0.780	0.435
Total fat/day (g)	67.21±23.99	65.14±28.32	-0.250	0.803
Saturated fat/day (g)	21.70±9.04	22.81±10.95	-1.061	0.289
Cholesterol/day (mg)	256.10±157.90	242.74±253.56	-0.406	0.685
Dietary fibre/day (g)	15.94±6.90	16.13±8.42	-0.125	0.901
Sodium/day (mg)	2717.20±796.66	2641.54±1070.80	-0.468	0.640
% kcals from protein/day (%)	16.73±4.24	14.97±4.15	-1.452	0.147
% kcals from carbs/day (%)	47.62±9.29	51.62±9.05	-1.248	0.212
% kcals from fat/day (%)	35.45±8.42	33.61±7.42	-0.921	0.357

Carbs: Carbohydrates; kcals: Kilocalories; kg: Kilogram; SD: Standard deviation

The low-risk group of nursing students (n=29) had an average depression score of 10.17±10.96 corresponding to the mild category, average anxiety score of 11.48±7.99 corresponding to the moderate category, and average stress score of 15.31±9.10 corresponding to the mild category. In comparison, the at-risk group (n=13) had an average depression score of 10.38±9.12 corresponding to the mild category, average anxiety score of 12.23±8.33 corresponding to the moderate category, and average stress score of 16.00±7.43 corresponding to the mild category. There were no significant differences between low-risk and at-risk nursing students (depression: Z=-0.396, p=0.692; anxiety: Z=-0.313, p=0.754; stress: Z=-0.477, p=0.634).

Observed and log-transformed HRV measures of LF power, HF power, total power, PNS, and SNS in both the supine and standing positions for low-risk and at-risk nursing students are summarized in Table 9. None of the differences between low-risk and at-risk nursing students were significantly different (p>0.05).

Table 10: Observed and log-transformed heart rate variability measures for low-risk and at-risk groups of nursing students

	Low-risk n=26		**At-risk** n=11		**Z**	**p**
	Mean±SD		*Mean±SD*			
	Observed	*Log*	*Observed*	*Log*		
LF (ms²)						
Supine	1619.31±1540.87	3.06±0.38	2486.36±3099.05	3.01±0.66	-0.266	0.790
Standing	1017.40±712.54	2.89±0.35	2405.64±2587.99	3.09±0.59	-1.168	0.243
HF (ms²)						
Supine	2012.00±1794.56	3.13±0.41	2175.09±2225.44	3.02±0.65	-0.332	0.740
Standing	481.04±560.54	2.40±0.55	1350.91±1716.31	2.63±0.81	-0.738	0.460
TP (ms²)						
Supine	3779.00±2912.17	3.44±0.36	4923.27±4839.59	3.39±0.63	-0.166	0.868
Standing	1659.00±1235.59	3.10±0.34	4156.45±4526.82	3.28±0.63	-0.704	0.481
PNS (HF/TP)						
Supine	0.52±0.17	-0.31±0.16	0.49±0.23	-0.37±0.27	-0.233	0.816
Standing	0.25±0.17	-0.70±0.32	0.26±0.14	-0.65±0.30	-0.670	0.503
SNS (LF/HF)						
Supine	1.08±0.82	-0.08±0.32	1.82±2.61	-0.01±0.48	-0.266	0.790
Standing	4.60±4.12	0.49±0.43	4.27±4.85	0.45±0.40	-0.532	0.595

HF: High frequency power; LF: Low frequency power; PNS: Parasympathetic nervous system; SD: Standard deviation; SNS: Sympathetic nervous system; TP: Total power

5 DISCUSSION

5.1 Introduction

This thesis aimed to address the gap that exists in the literature characterizing the health and lifestyle of nursing students. It is important to address this gap in the literature since nursing students are future nurses that will be caring for an increasing number of patients with poor metabolic health, and their own lifestyle choices can ultimately impact how they counsel their patients (Bakhshi et al., 2015; Marchiondo, 2014). In summary, we found that metabolic health did not differ between nursing and biology students, but that 35.1% of undergraduate student participants (31.0% of nursing and 46.7% of biology students) had an increased risk of poor metabolic health. There were few differences between the lifestyle of nursing and biology students, but in general, nursing and biology students were highly sedentary, had poor sleep quality, increased saturated fat intake, decreased dietary fibre intake, and mild levels of perceived stress.

5.2 Metabolic health of nursing students

Results surrounding the metabolic health of nursing students are outlined in section 4.3.

5.2.1 Body mass index of nursing students

In the current study, we found that Trent University nursing students had an average BMI of 24.37±4.80kg/m^2, classifying them as having a normal BMI, although they were on the higher end of this range (normal BMI=18.5-24.9kg/m²) (WHO, 2021). We initially predicted that nursing students would have a poor BMI, but this does not appear to be the case for nursing students in general. However, at an individual level, 33.3% of nursing students were overweight (BMI 25.0-29.9kg/m²) and 7.1% were obese (BMI ≥30.0kg/m²). We also predicted that nursing students would have a worse BMI than biology students, but there were no differences in BMI between the groups.

Our BMI results fall into the same BMI classification that has been reported for other undergraduate students (Freitas et al., 2013; Gallo et al., 2021; Mbugua, Kimani, & Munyoki, 2017; West et al., 2019), but the mean BMI and prevalence of overweight and obesity is slightly higher in our study. For example, Brazilian university students had an average BMI of 23.27kg/m², with 21.3% being overweight and 5.1% being obese (Freitas et al., 2013). Female Kenyan university students had a mean BMI of 23.3kg/m², and female Australian biomedical undergraduate students had an average BMI of 21.8kg/m², with 9.9% being overweight and 3.5% being obese (Gallo et al., 2021; Mbugua, Kimani, & Munyoki, 2017). Additionally, the mean BMI of nursing students in this study fell in between the range of BMIs seen in the pilot study. The mean BMI of nursing students in this study (24.37±4.80kg/m²) was higher than the mean BMI of first- (20.3±2.3kg/m²) and second-year (23.7±1.9kg/m²) nursing students in the pilot study, but lower than the mean BMI of upper-year (25.4±2.5kg/m²) nursing students in the pilot study (West et al., 2019). We can also compare our findings to the general young adult population (aged 18-24), who are not necessarily attending college or university, to get a better sense of how our nursing students compare to the Canadian population. The Canadian Primary Care Sentinel Surveillance Network, using 2016 data, estimates that 35.9% of Canadian young adults (18-24 years) have an elevated BMI (≥25.0kg/m²), with 24.8% being overweight and 11.1% being obese (Goodarzynejad et al., 2022). In comparison to the general young adult population, a larger proportion of our nursing students had an elevated BMI (40.4%), however, fewer of them were obese (7.1%) (Goodarzynejad et al., 2022).

While the nursing students in this study had a healthy BMI on average, a considerable proportion of them (40.4%) did have an elevated BMI. The nursing students with elevated BMIs could benefit from reducing their BMI, as increased BMI is associated with negative health outcomes such as T2DM, CVD, and certain cancers (Kyrou et al., 2018).

5.2.2 Body composition of nursing students

We report that nursing students had an average WC of 75.09±8.32, WHR of 0.75±0.05, and BF% of 26.65±6.41, categorizing each measure as normal (Alberti et al., 2009; Macek et al., 2020; Marchiondo, 2014). Additionally, at an individual level, 95.2% had a normal WC, and all nursing students had a normal WHR and BF%; these results are promising. There were no differences in the mean WC, WHR, or BF% of nursing students in comparison to biology students. Since we initially predicted that nursing students would have a poor WC, WHR, and BF% as well as a worse WC, WHR, and BF% in comparison to biology students, our findings do not support this prediction.

Our findings for WC are similar to what has been reported in female Kenyan (77.4cm) and Australian (74.5cm) university students but appears lower than what was reported for Brazilian university students (94.5cm for all participants, and 90.4cm for females) (Gallo et al., 2021; Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017). There are different WC cut-off recommendations that exist for different ethnicities and countries, so this may account for the variation (Alberti et al., 2009). Our average BF% among nursing students is also similar to what has been reported in female Australian university students (28.1%) (Gallo et al., 2021). The WHR from the current study (0.75) is lower than what was found for both first-year (0.77) and upper-year (0.81) nursing students in the pilot study (West et al., 2019).

Overall, nursing students in the current thesis have a healthy WC, WHR, and BF%. Our findings indicate that the vast majority of nursing students have an ideal body composition, as indicated by a normal WC, WHR, and BF%. As previously mentioned in section 2.3.6, WC, WHR, and BF% may be better predictors of CVD, T2DM, and all-cause mortality risk in comparison to BMI since BMI does not account for fat distribution or muscle mass (Chen et al., 2021; Gómez-Ambrosi et al., 2012; Lee & Giovannucci, 2018; Silveira et al., 2020; WHO, 2008). Due to the suggested benefits of using WC, WHR, and BF% in comparison to BMI, along with the minimal presence of nursing students in the current study with elevated WC, WHR, and/or BF%, these results may somewhat alleviate our concerns surrounding the BMI of nursing students from both the current and pilot studies. While our pilot study indicated that upper-year nursing students had a mean BMI that classified them as overweight and the current study indicates that 40.4% of nursing students had an elevated BMI (overweight/obese), the other indices of body composition suggest that this is an area of minimal concern for this cohort.

5.2.3 Resting blood pressure of nursing students

On average, nursing students had a resting systolic BP of 113.76±11.32mmHg and diastolic BP of 71.58±7.88mmHg. Both the average systolic BP and diastolic BP are within the normal range. Other studies on university students have also reported normal average resting BP; Kenyan female students had a systolic and diastolic BP slightly higher than our findings (116.8mmHg and 74.1mmHg), and Brazilian students had a systolic and diastolic BP that was slightly lower than our findings (109.6mmHg and 71.1mmHg) (Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017).

Nursing students had an average MAP of 85.64mmHg. We were unable to find any studies that reported the mean MAP they found in a young adult and/or undergraduate student population. While we are unable to compare our findings to other studies, the mean MAP of nursing students in our study is within the recommended MAP range of 70 to 100mmHg for all ages (Fei, 2020).

Our findings on the systolic BP, diastolic BP, and MAP of nursing students do not support our initial prediction that nursing students would have a poor BP. We also predicted that nursing students would have worse BP than biology students. There were no differences in the systolic BP or MAP between nursing and biology students, but nursing students had a significantly higher diastolic BP compared to biology students (71.58±7.88 vs. 66.50±6.35; $Z=-2.148$, $p=0.032$). Generally, increased BP is associated with an increased risk for CVD, however, while the diastolic BP of nursing students was higher than biology students it is still within the normal range and is likely of no concern at this point (WHO, 2021).

There do not appear to be any concerns surrounding the systolic BP, diastolic BP, and MAP for the nursing student cohort in general, but some nursing students are at risk at an individual level. Within the nursing student cohort, 19.0% had an elevated systolic BP and 14.3% had an elevated diastolic BP, putting these individuals at an increased risk of CVD (WHO, 2021).

5.2.4 Fasting blood glucose of nursing students

Nursing students had normoglycemia, with an average fasting blood glucose of 5.20±0.47mmol/L. While this is within the normal range (3.9-5.5mmol/L), it is on the higher end of normal and is approaching towards mild hyperglycemia. There was no difference in the fasting blood glucose between nursing and biology students in our study. These results do not support our initial predictions that nursing students would have poor fasting blood glucose and worse fasting blood glucose in comparison to biology students. Other studies also report normoglycemia among university students (4.7mmol/L, 4.9mmol/L, and 5.1mmol/L), but our results are slightly higher than what other studies have found (Gallo et al., 2021; Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017).

While on average the fasting blood glucose of nursing students is not of concern, 25.0% of nursing students had a fasting blood glucose that was above normal (DeFina et al., 2012). These nursing students with an elevated fasting blood glucose may be at an increased risk of insulin resistance, and eventually T2DM (DeFina et al., 2012; Sasaki et al., 2020).

5.2.5 Blood lipid profile of nursing students

We initially predicted that nursing students would have a poor lipid profile based on their total cholesterol, LDL, HDL, and TG levels, as well as their ratio of total cholesterol to HDL, however our results did not support this prediction. Nursing students had a normal total cholesterol (4.07±0.96mmol/L), which is comparable to total cholesterol levels in university students from other studies (4.0mmol/L and 4.4mmol/L) (Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017). Nursing students also had normal LDL levels (2.00±0.75mmol/L), which is similar to what was reported in other studies (1.9mmol/L and 2.0mmol/L) (Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017). Their TG levels were lower (1.04±0.65mmol/L) than what other studies have found in university students (1.31mmol/L and 1.44mmol/L), but all of these TG levels are considered normal (<1.7mmol/L) (Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017). Nursing students also had an ideal ratio of total cholesterol to HDL (2.65±0.85) (NIH, 2002).

We initially predicted that nursing students would have a worse lipid profile than the biology student comparison group, but there were no differences between the total cholesterol, LDL, TG, and ratio of total cholesterol to HDL between the groups. However, nursing students had significantly higher HDL levels (1.60±0.41 vs. 1.34±0.33; $Z=-2.151$, $p=0.031$) compared to biology students. This suggests that nursing students have better HDL cholesterol levels in comparison to biology students, which is the opposite of what we initially predicted. Optimal HDL levels are above 1.5mmol/L and poor HDL levels are below 1.0mmol/L (NIH, 2002). Nursing students were classified as having optimal HDL levels (1.60±0.41mmol/L), whereas biology students fell between optimal and poor HDL categorization (1.34±0.33mmol/L). Other studies on university students report HDL levels that fall between the nursing and biology HDL levels from our study (1.4mmol/L and 1.5mmol/L) (Freitas et al., 2013; Mbugua, Kimani, & Munyoki, 2017). As HDL is thought to have a protective effect against CVD, nursing students are potentially at a decreased risk for CVD in comparison to biology students (NIH, 2002).

Overall, the lipid profile of nursing students does not appear to be an issue, but there may be some concerns at an individual level. Within the nursing student cohort, 11.4% had elevated total serum cholesterol levels, 14.3% had elevated LDL levels, 45.7% were outside of the optimal HDL range (too low), and 14.3% had elevated TG levels. Nursing students with one or more of their serum lipid levels outside of the optimal range may have dyslipidemia and be at an increased risk of CVD and adverse health outcomes (Limbu et al., 2008; NIH, 2002).

5.2.6 Metabolic health of nursing and biology students

When using the AHA/NHLBI/IDF 2009 definition of metabolic syndrome (Appendix A; Table 10), 50.0% of nursing students met 0 of the criteria, 40.5% met 1 of the criteria, 4.8% met 2 of the criteria, and 4.8% met 3 or more of the criteria. This indicates that 4.8% of the nursing student participants met the AHA/NHLBI/IDF guidelines for diagnosing metabolic syndrome (i.e., meeting 3 or more of the criteria). While a small number of nursing students actually met the criteria for the diagnosis of metabolic syndrome, it is concerning that 50.0% of nursing students already had the presence of at least one of the criteria. It is not surprising that so few nursing students met the metabolic syndrome diagnosis criteria as the risk typically increases with age, and the mean age of our nursing student cohort was 21.62±4.82 (Yahia et al., 2017).

The prevalence of metabolic syndrome that we found in our study (4.8%) aligns with previous studies looking at university students, as the prevalence of metabolic syndrome in this cohort has been reported between 0.3% and 20.5%. Some studies on university students from the United States (0.3%, 0.6%, and 3.7%; Fernandes & Lofgren, 2011; Huang et al., 2004; Yahia et al., 2017), Taiwan (4.6%; Yen et al., 2008), Brazil (1.7%; Freitas et al., 2013), and Kenya (1.9% Mbugua, Kimani, & Munyoki, 2017) reported a lower prevalence of metabolic syndrome among students in comparison to our results. Whereas other studies on university students from the United States (7.7%, 10%; Keown, Smith, & Harris, 2004; Morrell et al., 2014), Korea (12%; Cha et al., 2010), and Brazil (20.5%; Barbosa et al., 2016) reported a higher prevalence of metabolic syndrome among students in comparison to our results. The differences may be due racial, ethnic, or cultural differences that exist in different countries or specific racial/ethnic demographic differences that exist between studies (Yahia et al., 2017). A large national study in the United States indicated that the prevalence of metabolic syndrome increases with age and BMI, and varies with race and ethnicity (Ervin, 2009). For example, black males were half as likely to have metabolic syndrome than white males, and black and Mexican-American females were 1.5 times as likely as white females to have metabolic syndrome (Ervin, 2009). Based on this, as our nursing student was predominantly white (69.0%), female (85.7%), with lower rates of obesity (7.1%), this may explain the lower prevalence of metabolic syndrome in comparison to some other studies. Additionally, as previously discussed in section 2.3.2 there still is not a definition of metabolic syndrome that is consistently used in the literature, so slight differences among the criteria used in each study could have impacted the prevalence of metabolic syndrome that was reported (Appendix A; Table 10) (Kyrou et al., 2019). Many of the studies (particularly those published prior to the release of the 2009 AHA/NHLBI/IDF guidelines) used the 2001 NCEP-ATP III (Appendix A; Table 10) guidelines for determining the presence of metabolic syndrome. The NCEP-ATP III guidelines have a cut-off point for fasting blood glucose and BP that is slightly higher than with the AHA/NHLBI/IDF guidelines that we used, so some studies may be underestimating the true prevalence of metabolic syndrome in their samples (Freitas et al., 2013).

Additionally, we can compare our findings of the prevalence of metabolic syndrome in undergraduate nursing students to that of the general Canadian population. Data from the Canadian Health Measures survey, collected between 2007 and 2009 suggests that 17.0% of Canadian young adults/adults (aged 18 to 39) meet the criteria for metabolic syndrome (Riediger & Clara, 2011). This is higher than the 4.8% of nursing students that met the criteria in our study (although it should be noted that the prevalence of metabolic syndrome generally increases with age, and the mean age of our sample was only 21.6 years). This discrepancy in the prevalence of metabolic syndrome between the general population and the undergraduate nursing students in our study helps support Riediger & Clara's (2011) findings which suggest that higher levels of education are associated with a lower prevalence of metabolic syndrome.

For this study we also amended the AHA/NHLBI/IDF guidelines for diagnosing metabolic syndrome to better assess whether a participant was at-risk of developing poor metabolic health in the future. We adjusted the AHA/NHLBI/IDF guidelines, as summarized in Appendix A (Table 12), by 1) changing the increased WC criterion to increased body size (met by having increased BMI, WC, WHR, and/or BF%) and 2) reducing the number of criteria that needed to be met from 3 to 2. Therefore, we were able to separate our participants into “low-risk” (met 0 or 1 criteria) and “at-risk” (met 2 or more criteria) groups for poor metabolic health. We feel that these changes better reflect an individual’s risk of having poor metabolic health in the future as it takes into consideration other aspects related to an individual’s body size (i.e., BMI, WHR, and BF%) that are also associated with the risk of developing T2DM and CVD, rather than just considering WC on its own (Paniagua et al., 2008). Additionally, the reduced number of criteria (from 3 to 2) to be classified in the “at-risk” group gives a better picture to the number of nursing students that are approaching a poor metabolic health status.

Using our amended guidelines, 28.6% of nursing students met 0 criteria, 40.5% met 1 criteria, 23.8% met 2 of the criteria, and 7.1% met 3 or more of the criteria. This resulted in 69.0% having low-risk of poor metabolic health and 31.0% being at-risk of poor metabolic health. Overall, as we initially predicted, there is a concerning proportion of nursing students that have, or are at risk of, poor metabolic health. While the means for many of the individual metabolic health characteristics were within the normal range for nursing students, our results suggest that many nursing students are still individually at risk of poor metabolic health and the consequences associated with it.

We initially predicted that nursing students would have worse metabolic health in comparison to biology students. Biology students actually had a higher prevalence of students who were at-risk of poor metabolic health (46.7%) in comparison to nursing students (31.0%), although this proportional difference was not significant ($\chi2$=1.20, p=0.349). We are unable to compare our results by major of study to other findings, since most studies have students predominantly of one major (particularly nutrition and/or kinesiology majors), or if there is a variety of majors included in the study, the data was not stratified based on major of study (Fernandes & Lofgren, 2011). What we found in the current study is that between one third and one half of students in nursing and biology present with an at-risk profile of poor metabolic health.

The prevalence of metabolic syndrome (with the AHA/NHLBI/IDF guidelines), as well as the prevalence of “at-risk” metabolic health among nursing our population is surprising as young adults, such as university students, generally perceive themselves to be healthy (American College Health Association, 2016). However, our results, along with previous literature, suggests that the metabolic health of nursing students, and more generally university students, is of concern. Earlier prevention and diagnostic interventions should be considered to avoid having these individuals who either already have metabolic syndrome, or who are at-risk of developing it in the future, go undiagnosed until later in life when they are diagnosed with T2DM or CVD (Yahia et al., 2017).

5.3 Lifestyle of nursing students

This section will discuss the findings surrounding the lifestyle of nursing students. It will first discuss their smoking and alcohol consumption, followed by the PA levels, sleep quality, nutrition, and finally, it will discuss their stress levels and psychological health. We will primarily focus on nursing students but will also touch on the potential generalizability of the findings to university students by referring to the results of our biology student comparison group.

5.3.1 Smoking and alcohol consumption in nursing and biology students

None of the participants in this study reported smoking cigarettes. This is a promising finding due to well-established negative impacts that tobacco smoking has on health (e.g., cancer, CVD, and mortality) (Health Canada, 2016). Previous studies on nursing students found tobacco smoking rates of 15.5% and 32.9% among nursing students (Provenzano et al., 2019; Rodríguez-Muñoz, Carmona-Torres, & Rodríguez-Borrego, 2020). It is important to note that the question surrounding smoking that the participants answered on the demographic questionnaire was directed towards tobacco smoking. The use of e-cigarettes (vaping) has been of increasing prevalence, particularly in young adults, in recent years as it is often advertised as a safe alternative to tobacco smoking (Canzan et al., 2019). The long-term effects of vaping are still not fully understood but are likely to also negatively impact respiratory health (Jonas, 2022). As our study only considered tobacco smoking, it is unclear what the prevalence of vaping is in nursing students.

On average, nursing students consumed 1.96±2.32 alcoholic drinks per week. This is slightly higher than the 1.5 alcoholic drinks per week that a study on Canadian university students in health sciences reported (Papaconstantinou et al., 2020). The average alcohol consumption of nursing students in this study was significantly higher than the alcohol consumption of biology students (1.96±2.32 vs. 0.63±0.77; Z=-2.266, p=0.023). While it is interesting that nursing students consumed more alcohol than biology students, the average alcohol consumption of nursing students does not appear to be of concern. The Canadian Centre on Substance Use and Addiction (CCSA) notes that the consumption of 1 to 2 standard drinks per week puts individuals at low risk of alcohol-related consequences, such as breast and colon cancers, CVD, and stroke (CCSA, 2023). Of nursing students, 78.6% consume alcohol to some degree, which is comparable to Spanish and Brazilian nursing students, where 83.7% and 74.9% of nursing students consumed alcohol (Macie & Vargas, 2017; Rodríguez-Muñoz, Carmona-Torres, & Rodríguez-Borrego, 2020). There may be more concern surrounding alcohol consumption in nursing students at an individual level, as 26.2% are at a moderate risk of alcohol-related consequences, and 4.8% are at an increasingly high risk of alcohol-related consequences (CCSA, 2023). These results indicate similar risk levels in nursing students compared to previous studies (Macie & Vargas, 2017). While some nursing students may be consuming alcohol at increased risk levels, as a cohort, it is unlikely that the alcohol consumption of nursing students is putting them at risk of any adverse health effects, but their risk may be greater than that of biology students.

5.3.2 Physical activity in nursing and biology students

Results surrounding PA were reported in section 4.4.1. For nursing students, their mean time spent per day engaging in sedentary behaviour was 80.29±4.73%, and they accumulated approximately 19 hours of sedentary time per day on average. We kept sedentary and sleep time together due to the frequently irregular sleep and wake times that university students engage in (Yilmaz, Tanrikulu, & Dikmen, 2017). Additionally, habitual napping is common in this cohort; a study on Australian university students reported that just over half of students (54.6%) napped at least one to two times per week (Lovato, Lack, & Wright, 2014). Students also frequently spend extended periods of time throughout the day sitting while in classes and according to unpublished data from our lab, undergraduate university students spend approximately 8 hours per day on a screen (unpublished data, Holly Bates). These factors make it particularly challenging to discriminate sedentary versus sleep time based on accelerometry in this cohort. Sleep guidelines for young adults and adults is 7-9 hours of sleep per night, but both our results and previous studies suggest that nursing students are getting closer to 7 hours of sleep per night on average (Peltzer & Pengpid, 2016). In our study, 35.7% of nursing students reported getting less than 7 hours of sleep per night, and another study found students got a mean of 7.07 hours of sleep per night, with 39.2% sleeping less than 7 hours per night (Peltzer & Pengpid, 2016). The CSEP 24-hour movement guidelines recommend limiting sedentary time (excluding sleep) to no more than 8 hours per day (CSEP, 2020; ParticipACTION, 2020). Based on this, our results suggest that nursing students are more sedentary than they should be as they are accumulating approximately 19 hours of sedentary time (including sleep) per day. This result is similar to the results of the pilot study, as the mean time spent sedentary was 81.7 ± 4.4% (West et al., 2021).

The CSEP 24-hour movement guidelines suggest that adults should engage in several hours of light PA (standing and light walking) each day, which nursing students appear to be doing, as they spent approximately 3.5 hours engaged in light PA per day (CSEP, 2020). Nursing students spent approximately 30 minutes engaged in moderate and 1.5 minutes engaged in vigorous PA per day. This is a similar break down of PA intensities to another study on nursing students, which found that walking (light PA) was the most common, and vigorous PA was the least common PA intensity that nursing students engaged in (Baj-Korpak et al., 2020). The nursing students in this study engaged in far less vigorous PA compared to the pilot study (1.56±3.22 mins vs. 9.9±8.8 mins/per day) (West et al., 2019). Despite the low amounts of vigorous PA that the nursing students engaged in, they engaged in an average of 237.28±97.86 minutes of MVPA per week, which surpasses the CSEP guidelines of at least 150 minutes of MVPA per week (CSEP, 2020). At an individual level, 82.35% of nursing students are meeting the CSEP MVPA guidelines, which is a promising finding. In comparison, only 61% of Latvian nursing students obtained at least 150 minutes of MVPA per week (Veseta et al., 2022). Overall, nursing students are doing a good job at meeting the CSEP 24-hour movement guidelines in terms of light PA and MVPA, but what is still concerning is the high sedentary levels of nursing students.

While CSEP has not released any specific guidelines for the number of steps individuals should take per day, other organizations worldwide recommended anywhere from 7,000 to 10,000 steps per day for healthy adults (Tudor-Locke et al., 2011). Steps per day has been associated with various physical and psychological health outcomes (Tudor-Locke et al., 2011). For example, women taking at least 7500 steps per day had a 50% lower prevalence of depression than those taking less than 5000 steps per day, women taking 7,500-9,999 steps per day had a significantly lower BMI than those who took 5,000-7,500 steps per day, and individuals taking less than 5000 steps per day had substantially greater cardiometabolic risk factors (Tudor-Locke et al., 2011). While there is no consensus on the number of steps individuals should be taking per day, it is clear that a dose-response relationship exists with steps per day and health (Tudor-Locke et al., 2011). Nursing students in our study took an average of 6282.66±2179.00 steps per day. Based on the various steps per day recommendations that exist, nursing students should aim to increase the number of steps they take per day; doing so would subsequently increase the amount of light and/or moderate intensity PA and reduce the amount of sedentary time they engage in each day.

We initially predicted that nursing students would have poor PA participation, however, based on our results, nursing students appear to be engaging in sufficient weekly MVPA based on accelerometry minutes/day. However, while they are incorporating a few hours of light PA per day, they do appear to be highly sedentary and take less than 10,000 steps per day. This indicates that nursing students should aim to reduce their sedentary time when possible and break up long periods of sitting between their classes to incorporate more PA into their day.

We also predicted that nursing students would have worse PA participation in comparison to biology students, but our results do not support this prediction. Nursing students actually had a significantly lower mean time spent sedentary (80.29±4.73% vs. 83.33±2.86%; $Z=-2.404$, $p=0.016$) and significantly higher mean time spent in light PA (16.95±4.30% vs. 14.03±2.72%; $Z=-2.291$, $p=0.022$) in comparison to biology students. Potential explanations for the increased mean time spent in light PA and decreased mean time spent sedentary in nursing students is the clinical training that nursing students engage in. Clinical placements would involve more standing and light walking than most other courses, and as biology students do not have any clinical placements, it is likely that this is where the discrepancy is coming from (Cilar et al., 2017). However, conversely, there are some biology course labs that involve PA, including walking outdoors. Perhaps the duration of frequency of light PA that nursing students engage in for clinical courses outweighs the light PA that biology students engage in for some of their labs. There were no significant differences in the amount of MVPA that nursing and biology students engaged in (237.28±97.86 vs. 225.17±95.43; Z=-0.476, p=0.634), likely indicating that the amount of purposeful PA that the students engaged in did not differ between the groups.

While biology students engaged in significantly more sedentary time, both groups of students were highly sedentary. That said, while statistically different, both nursing and biology students spent on average 80-85% of their day sedentary; and thus, clinically these are both high amounts. This finding is similar to what was reported in other studies looking at the PA of university students (Castro et al., 2020; Moulin et al., 2021; Papaconstantinou et al., 2020). Other studies using accelerometry found that university students spent a mean time of 9.82 and 10.69 hours sedentary per day (excluding sleep), suggesting that university students have a sedentary lifestyle, are more sedentary the general young adult population, and that this sedentary behaviour among university students may be associated with negative health outcomes (Castro et al., 2020; Moulin et al., 2021). A meta-regression analysis also suggested that sedentary time among university students has increased over the past decade; so, this may be an issue of increasing concern for this cohort (Castro et al., 2020).

Overall, it is important to encourage a reduction of sedentary time among university students and they should attempt to break up long periods of sitting, when possible (CSEP, 2020). The increased sedentary time that we are seeing in nursing and biology students is concerning since it increases the risk of all-cause mortality, hypertension, T2DM, adverse blood lipid profile, adiposity, weight gain, and poor psychological health and sleep (CSEP, 2020; Gerber et al., 2014; Kelley & Kelley, 2017; Kovacevic et al., 2018; Lavretsky & Abbott, 2018; WHO, 2020). Some reasons for reduced PA and increased time spent sedentary that are commonly listed by university students is a lack of time and need to balance other responsibilities, lack of motivation, financial barriers to accessing fitness centers, and time of year (i.e., winter weather) (Cilar et al., 2017). Trying to reduce the barriers to PA among nursing students (and other university students) is important; educating students about the importance of PA and/or the implementation of health programs and policies at universities may aid in reducing sedentary time and increasing PA among students (Castro et al., 2020; Cilar et al., 2017).

5.3.3 Sleep quality in nursing and biology students

Sleep results were reported in section 4.4.2. Overall nursing students have poor sleep quality, with 61.9% of nursing students classified as having poor sleep quality according to the PSQI. This result is what we initially predicted surrounding the sleep quality of nursing students. Our finding of poor sleep quality among nursing students agrees with previous literature that also suggests that nursing students have a low sleep quality (Yilmaz, Tanrikulu, & Dikmen, 2017). Previous studies using the PSQI on nursing students found that 56.7% and 56.1% had poor sleep quality (Karatay et al., 2016; Yilmaz, Tanrikulu, & Dikmen, 2017). It is likely that the poor sleep quality found in nurses can be attributed to the demanding nature of their program in both time and effort and the irregular schedules they often have (Silva et al., 2016; Yilmaz, Tanrikulu, & Dikmen, 2017).

We initially predicted that nursing students would have worse sleep quality than biology students since they typically engage in clinical practice that can involve shiftwork and alter sleep and wake times more than students of other majors (Silva et al., 2016). However, our results suggest that there is no difference in sleep quality between nursing and biology students based on average PSQI score (7.02±3.49 vs. 7.07±2.63; Z=-0.319, p=0.749). This finding differs from previous literature, as other studies found that nursing students had significantly lower sleep quality based on average PSQI scores when compared to non-nursing students (7.3±2.45 vs. 5.9±2.49, p<0.001) (Kim & Yoon, 2013). In our study, at an individual level, 60.0% of biology students had poor sleep quality, compared to the 61.9% in nursing students. In comparison, Kim & Yoon’s (2013) study found that 89.0% of nursing students and 71.6% of non-nursing students had poor sleep quality. The prevalence of poor sleep quality among both nursing and non-nursing students in their study was greater than in this study, however, overall, the data suggests that there is poor sleep quality among both nursing and non-nursing university students.

Our results suggest that poor sleep quality may be a more general concern among all undergraduate university students and may not be dependent upon or worsened by a student’s major of study. This has been supported by other research, which also found poor sleep quality more generally across university students (Orzech, Salafsky, & Hamilton, 2011; Papaconstantinou et al., 2020). University students are in a unique social environment, often involving parties, stress, communal living arrangements, and part-time work in addition to their course work that may be leading to the diminished sleep quality that is being seen in this group (Vail-Smith, Felts, & Becker, 2009). Poor sleep quality among university students is concerning as it has been associated with anxiety, depression, stress, and poorer academic performance in this population (Orzech, Salafsky, & Hamilton, 2011; Vail-Smith, Felts, & Becker, 2009).

5.3.4 Nutrition in nursing and biology students

The dietary intake of nursing and biology students were reported in section 4.4.3. Nursing students consumed an average of 1710.59±486.55 kcals per day (26.19±9.01 kcals per kilogram of body weight per day). The caloric intake in nursing students from our study is lower than the typical suggested range of 1750 to 2350 kcals per day for women and 2200 to 3000 kcals per day for men (McCrory et al., 2016). The unexpectedly low caloric intake that we observed may be due to the nature of self-reported data. While the 3-day diet log is a commonly used dietary assessment tool, there is a possibility that participants may be underestimating the quantities of foods they are consuming or may forget to include all foods that were consumed; this could account for the low caloric intake we found in nursing students (Goulet et al., 2004; Schröder et al., 2001; Yang et al., 2010). However, it is important to note the potential for disordered eating among this cohort. Previous studies have indicated that 84.5% of nursing students were at risk of disordered eating, and 45.3% were at risk of developing orthorexia nervosa (obsession with "healthy" nutrition) (Arslantaş et al., 2017). While it is unknown why this cohort has an increased risk of disordered eating, it may be attributable to increased stress and anxiety, or they may be taking their increased knowledge on the importance of healthy eating to the extreme in their own lives (Arslantaş et al., 2017). It would be of future interest to further examine the attitudes that nursing students have towards food to get a better understanding as to whether our results are underestimating the caloric intake of nursing students, or if there is an increased prevalence of disordered eating among this group. There is also a possibility that the lower than expected caloric intake of our nursing student cohort may be due to students skipping meals. Skipping meals appears to be common practice among university students (Pendergast et al., 2016; Pengpid & Peltzer, 2020). If nursing students are indeed skipping meals, this would be concerning, as skipping meals has been associated with overweight/obesity, T2DM, CVD, poor mental health, and poor academic performance (Pengpid & Peltzer, 2020; Yamamoto et al., 2021).

Nursing students obtained 48.78±9.95% of their daily kcals from carbohydrates, 16.43±4.24% from protein, and 34.62±8.90% from fats. The generally accepted macronutrient distribution ranges for most individuals are 45-65% of kcals from carbohydrates, 10-35% of kcals from protein, and 20-35% of kcals from fats (Health Canada, 2012; Manore, 2005). The average percentage of kcals obtained from carbohydrates, protein, and fats in nursing students falls within these ranges, suggesting that nursing students are consuming the appropriate proportions of the macronutrients.

While nursing students have a macronutrient breakdown that is within the suggested ranges, it should be noted that their percentage of kcals from fats is close the upper end of the range (Manore, 2005). In terms of saturated fat consumption in nursing students, 32.7% of fats consumed are saturated, indicating that 11.32% of total kcals comes from saturated fat. There are no specific dietary reference intakes for saturated fats, however it is ideal to reduce saturated fat consumption wherever possible (Health Canada, 2012). The general adult Canadian population consumes approximately 10% of their daily kcals from saturated fats, therefore the percentage in Canadian nursing students is slightly higher than the general population (Health Canada, 2012). The dietary cholesterol level in nursing students was 273.35±205.60mg per day. There is no set upper limit on dietary cholesterol consumption, but generally individuals should aim to reduce dietary cholesterol, as consuming high levels of cholesterol in the diet may increase blood cholesterol levels in some individuals (Health Canada, 2019b). However, focusing on reducing saturated fat consumption is of greater concern than dietary cholesterol levels when trying to reduce the risk of CVD (Health Canada, 2019b). Nursing students could benefit from reducing saturated fats since increased consumption of saturated fats is associated with increased LDL levels in blood (14.3% of nursing students in our study had elevated LDL levels), which in turn could increase the risk of cardiovascular morbidity and mortality (Heart & Stroke Foundation, 2015).

Additionally, nursing students are not consuming sufficient dietary fibre. Nursing students consumed an average of 16.24±7.86g of dietary fibre per day, which is less than the recommendations of 25g per day for women and 38g per day for men (Health Canada, 2019c). A lack of fibre in the diet is a concern for the whole Canadian population, since most Canadians are only getting half of the recommended daily intake (Health Canada, 2019c). Nursing students should still aim to increase fibre intake as it is beneficial in reducing cardiovascular risk factors, improving measures of glycemic control, and improving gastrointestinal function (Mann & Cummings, 2009).

Nursing students consumed an average of 2627.83±832.71mg of sodium per day; this is above the established goal of no more than 2300mg of sodium per day (Health Canada, 2018). However, the daily sodium intake of nursing students is similar to the average daily sodium intake of the general Canadian population which is 2760mg (Health Canada, 2018). While it is ideal for nursing students to still reduce their sodium intake to below 2300mg per day, it does not appear to be a concern specific to the diet of nursing students. Increased sodium intake is of potential concern as it increases the risk of high BP, and subsequently CVD and stroke (Health Canada, 2018).

Overall, our initial prediction that nursing students would have poor nutrition is not fully supported. In general, nursing students are consuming an appropriate proportion of macronutrients. They are consuming a lower-than-expected quantity of kcals per day, which may be due to inaccuracies in reporting by participants. They would benefit from reducing saturated fat and sodium intake as well as increasing fibre intake, however these are the same recommendations for the Canadian population, and not specific to this cohort.

We initially predicted that nursing students would have poorer nutrition in comparison to biology students, however, there were no differences in daily kcals, protein, carbohydrate, total fat, saturated fat, cholesterol, dietary fibre, and sodium intake between the two groups. This suggests that the concerns surrounding the nutrition of nursing students may be more generalizable to university students of all majors. In general, university students should aim to replace saturated fats in their diet with unsaturated fats (Health Canada, 2019a). To reduce saturated fat consumption, students should limit consumption of highly processed foods like processed meats, chips, French fries, cookies, and candies (Heart & Stroke Foundation, 2015). University students can reduce their sodium intake by being more conscious of, and reducing, their consumption of certain foods including bakery products, mixed dishes, processed meats, cheeses, soups, sauces, and condiments, which are all major contributors to sodium intake in Canadians (Health Canada, 2018). Students can increase their fibre intake by consuming more fruits, vegetables, whole grains, legumes, nuts, and seeds (Health Canada, 2019c).

Of additional interest, nursing students take mandatory courses that touch on the principles of human nutrition, whereas human nutrition courses are elective for biology students at the institution our participants attended. Therefore, nursing students would likely be better educated on the recommended nutritional guidelines as well as the impact that diet has on their health in comparison to biology students. However, based on our results, there are no differences in the nutrition intake of nursing and biology students, so it appears that nursing students are not incorporating their knowledge on nutrition into their daily lives.

5.3.5 Stress and psychological health in nursing and biology students

Results surrounding stress and psychological health were presented in section 4.4.4. From the results of the DASS, nursing students had mild levels of state depression (mean=10.32±10.31), moderate levels of state anxiety (mean=11.71±8.00), and mild levels of state stress (mean=15.52±8.53). It is important to note that the DASS measures state depression, anxiety, and stress, and is not necessarily designed to be a clinical tool used to diagnose trait anxiety or depression (Lovibond & Lovibond, 1995; Marijanović et al., 2021). Similar DASS results have been seen in previous studies on nursing students (Gangadharan & Madani, 2018; Teo et al., 2019). A study on nursing and midwifery students from Brunei found mild levels of depression (score=12.3 $\pm$ 3.40), moderate levels of anxiety (13.3 $\pm$ 3.45), and mild levels of stress (score=14.8 $\pm$ 4.18); these are the same classifications that were found in this study (Teo et al., 2019). At an individual level, 38.1%, 50.0%, and 50.0% of nursing students had levels of depression, anxiety, and stress that were above the normal classification. This prevalence of negative emotional states is comparable to previous research on nursing students that found the prevalence of depression, anxiety, and stress to be 34.4%, 54.6%, and 35.8% respectively (Gangadharan & Madani, 2018). This suggests that many nursing students are experiencing negative emotional states, particularly those of anxiety and stress, and would benefit from some kind of stress and/or anxiety reducing intervention.

In terms of HRV results in nursing students, the average measurements in the supine position were a LF power (parasympathetic and sympathetic activity) of 1877.08±2116.13ms^2, HF power (parasympathetic activity) of 2060.49±1902.06ms^2, total power of 4119.19±3560.42ms^2, PNS (HF/total power ratio; related to relief from stress) of 0.510±0.188, and SNS (LF/HF ratio; related to increased stress) of 1.301±1.572. These values in nursing students are higher than the 5-minute supine standard measures for LF power (standard=1170±416ms^2), HF power (standard=975±203ms^2), and total power (standard=3566±1018ms^2), but lower than the standard measure for SNS (LF/HF; standard=1.5-2.0) (Task Force of the ESC & the NASPE, 1996). More recently, reference values have been created for healthy adults based on past studies using short-term HRV in the supine position (Nunan, Sandercock, & Brodie, 2010). As with the HRV standard values, the measures of LF power and HF power in nursing students are higher than these reference values (reference LF=519±291ms²; reference HF=657±777ms²), and the LF to HF ratio is lower than the reference value (reference=2.8±2.6) (Nunan, Sandercock, & Brodie, 2010). There are no standard measurements that exist in the literature for short-term (5-minute) HRV recording in the standing position, however, that data is presented in Table 6a to allow for comparability between studies. There is also no standard measure for PNS (HF/total power ratio), however, when comparing the ratio in our study (0.51) to the ratio you would obtain using the standard measurements (0.27), the HF to total power ratio in nursing students may be higher than what is ideal (Task Force of the ESC & the NASPE, 1996).

As the ratio of LF power to HF power is an indicator of SNS activity (Brenner et al., 2020), nursing students appear to have a slightly lower SNS activity than both the standard and reference values for healthy adults (Nakayama et al., 2018; Nunan, Sandercock, & Brodie, 2010; Task Force of the ESC & the NASPE, 1996). Additionally, as HF power and the ratio of HF to total power are indicators of parasympathetic/PNS activity, nursing students appear to have higher parasympathetic/PNS activity than the standard and reference values for healthy adults (Akselrod et al., 1981; Brenner et al., 2020; Nakayama et al., 2018; Nunan, Sandercock, & Brodie, 2010; Task Force of the ESC & the NASPE, 1996). Increased SNS activity ("fight or flight") and decreased PNS activity ("rest and digest") would be indicative of increased stress, as the SNS system typically activates or intensifies in response to a stressor (supressing the PNS) and the PNS system activates or intensifies with the removal of stressors (Weissman & Mendes, 2021; Won & Kim, 2016; Yoo et al., 2021). Our HRV results display decreased SNS and increased PNS activity in nursing students, which suggests that they may have similar to or decreased stress levels in comparison to healthy adults.

We initially predicted that nursing students would have high stress levels due to the demanding nature of their academic program (Yazdani, Rezaie, & Pahlavanzadeh, 2010). The results from both the DASS and HRV provide mixed support for this prediction, although they are measuring different types of stress (i.e., psychological/perceived stress with the DASS and physiological stress with HRV). The DASS results suggest mild to moderate prevalence of depression, anxiety, and stress in nursing students. In comparison, the HRV results suggest that nursing students are experiencing less stress than the healthy adult population. However, it should be noted that this conclusion is based solely off of the comparison between the HRV values in nursing students to the reference/standard values, and the differences between the nursing students and reference/standard values may not be significant. It is likely more accurate to state that nursing students do not have any increased stress in comparison to the healthy adult population based on the HRV results. While HRV is an effective objective tool for measuring ANS activity, and many studies have found a relationship between HRV, stress, and mental health, it is important to acknowledge that HRV results can be influenced by modifiable (e.g., PA, smoking, drinking, obesity) and non-modifiable (e.g., age, sex, genetics) factors, and therefore should not be used for psychological diagnostic purposes on their own (Kim et al., 2018). It is equally as important to consider self-reported information in addition to objective physiological information when evaluating stress and psychological health (Kim et al., 2018). For this reason, even though the HRV results do not indicate any areas of concern surrounding the stress levels of nursing students, it is important to take the DASS results into account as well. Since the DASS is a self-reported questionnaire, it is still important to acknowledge that nursing students are perceiving themselves to be experiencing negative emotional states of depression, anxiety, and stress.

We also predicted that nursing students would have higher stress and poorer psychological health than biology students. This was predicted since nursing students have an additional burden of completing clinical training along with their other courses (Lim & Kim, 2014). Clinical training can be stressful for nursing students as they are in a new clinical environment, need to establish relationships with clinical instructors and nursing staff, and often lack some of the professional skills and knowledge needed for taking care of patients (Lim & Kim, 2014). These are additional stressors that students of most other undergraduate majors do not have to face. However, our study found no differences in the scores or categorizations for the levels of depression, anxiety, and stress among nursing students (depression: $Z=-0.944$, $p=0.345$; anxiety: $Z=-0.853$, $p=0.394$; stress: $Z=-0.417$, $p=0.677$). There were also no differences in observed or log-transformed measures of HF power, LF power, total power, PNS, or SNS between nursing and biology students ($p>0.05$).

These results, particularly those obtained from the DASS, suggest that both nursing and biology students (and perhaps all university students) could benefit from reducing depression, anxiety, and stress. For university students, having negative emotional states is concerning as it could negatively impact academic performance, concentration, problem solving, and decision making, but it is particularly of concern for nursing students as they have known additional stressors that come with clinical training, and negative emotional states can negatively impact their professional development (Gangadhara & Madani, 2018; Kim & Lim, 2014; Yazdani, Rezaie, & Pahlavanzadeh, 2010). Early recognition of negative emotional states is key in preventing negative outcomes, since prolonged stress is associated with hypertension, CVD, decreased immunity, exacerbations of auto-immune diseases, along with depression and adverse effects on mental health (Gangadhara & Madani, 2018; Schneiderman, Ironson, & Siegel, 2005). It is important for universities to improve awareness and/or access to existing stress management and counselling services available to students, as well as improving training or education surrounding coping mechanisms for stress (Gangadharan & Madani, 2018). Relaxation training, such as progressive muscle relaxation and autogenic training, have been shown to be particularly effective in nursing student cohorts (Gangadharan & Madani, 2018; Kim & Lim, 2014; Yazdani, Rezaie, & Pahlavanzadeh, 2010). Using these, or similar, relaxation training tools may be effective ways to manage and reduce stress, anxiety, and depression in nursing students, and could aid with their ability to cope with events occurring in their lives (Gangadharan & Madani, 2018; Kim & Lim, 2014; Yazdani, Rezaie, & Pahlavanzadeh, 2010).

5.4 Associations between metabolic health and lifestyle in nursing students

Results surrounding the associations of metabolic health and lifestyle in nursing students are reported in section 4.5. This section will discuss our findings on the relationship of metabolic health characteristics and risk status with PA, sleep quality, nutrition, and psychological health. Additionally, it will compare our findings to the general consensus that exists in the literature on the relationships of metabolic health and lifestyle.

5.4.1 Associations between metabolic health and physical activity in nursing students

We initially predicted that poor PA participation would be associated with worse metabolic health outcomes in our nursing student cohort. We found no significant correlations in sedentary time, PA levels, steps, and weekly MVPA across metabolic health characteristics, and there were no differences in PA variables by metabolic health risk group. These results are surprising as the IDF recommends increasing PA as a primary intervention against metabolic syndrome (IDF, 2006).

Our results do not align with findings from previous research in both university students and the general population (Pan & Pratt, 2008; Smith & Essop, 2009; Yahia et al., 2017). Other studies on university students have reported that PA is associated with lower metabolic health risk factors (Smith & Essop, 2009; Yahia et al., 2017). There is the potential that we did not see any associations between PA and metabolic health in our cohort as most of the students (82.35%) were meeting the recommended MVPA guidelines. Despite our findings, increased PA has well established dose-response relationship with all-cause mortality, CVD mortality, hypertension, T2DM, certain cancers (including breast and colon cancers), adverse blood lipid profile, adiposity, and weight gain, along with improved mental and cognitive health, sleep, and physical function (CSEP, 2020; Gerber et al., 2014; Kelley & Kelley, 2017; Kovacevic et al., 2018; Lavretsky & Abbott, 2018; WHO, 2020). For these reasons, nursing students should be encouraged to participate in regular PA for the benefits that it has on both physical and psychological health.

5.4.2 Associations between metabolic health and sleep quality in nursing students

We initially predicted that poor sleep quality would be associated with worse metabolic health outcomes in our nursing student cohort. However, there was no support for this prediction from our findings, as there were no significant correlations between PSQI scores across metabolic health characteristics or by metabolic health risk group. These results do not agree with the findings from other studies on university students (W. Liu et al., 2021; Papaconstantinou et al., 2020). For example, W. Liu et al. (2021) found that BMI was negatively associated with aspects of sleep (e.g., sleep efficiency and sleep quantity) in their cohort of college students. Similarly, Papaconstantinou et al., (2020) reported that in their cohort of Canadian university students, those who were not meeting the recommended sleep quality or sleep quantity had a significantly higher BMI than those who were. However, another study looking at adults (18 years of age and older) only found that difficulty falling asleep was associated with metabolic syndrome and high blood pressure (Mesas et al., 2014).

The lack of association between metabolic health and sleep quality in our study could be from the use of the PSQI. Since the PSQI is a self-reported questionnaire, individuals may not be accurately remembering their sleep habits, and the PSQI only considers a single time point (i.e., the past 7 days), so that period may not have been a period that accurately reflects their typical sleep habits. Additionally, Mesas and colleagues (2014) only found associations between a specific aspect of sleep quality and metabolic health, which could explain why we did not see any associations between sleep quality and metabolic health in our study since we only looked at the cumulative PSQI score which encompasses various aspects of sleep quality.

While our results did not find any associations between sleep quality and metabolic health, good sleep hygiene (e.g., consistent sleep-wake times) should be recommended for nursing students due to the established relationships that exist between circadian rhythm disturbance and both physical and psychological health (CSEP, 2020; Jehan et al., 2017; Nelson, Davis, & Corbett, 2022). Numerous studies have indicated that circadian rhythm disturbance from poor sleep quality or quantity is associated with an increased risk of all-cause mortality, obesity, T2DM, metabolic syndrome, breast cancer, anxiety, depression, and mood disorders (Gozal, Dumin, & Koren, 2016; Jehan et al., 2017; Nelson, Davis, & Corbett, 2022).

5.4.3 Associations between metabolic health and nutrition in nursing students

We initially predicted that poor nutrition would be associated with worse metabolic health outcomes in our nursing student cohort. While there were no associations of nutrition variables by metabolic health risk status, there were some associations between individual metabolic health components and nutrition variables.

In relation to BF%, an increased BF% was associated with an increased percentage of daily kcals from carbohydrates and a decreased percentage of daily kcals from fats. This is similar to another study that found that metabolic syndrome was associated with a diet that contained more carbohydrates and less dietary fat, although the study was conducted on patients with non-alcoholic fatty liver disease and may not be representative of the relationships of macronutrients with metabolic health in the general population (Kang et al., 2006). Other studies have found no relationship between the proportion of carbohydrate intake and body composition (Kim & Song, 2019). In terms of dietary fat and BF%, some studies found the opposite direction of association than we did, suggesting that increased dietary fat is associated with increased body fat (Tucker & Kano, 1992), however other studies more closely agree with our findings as they state that diets high in fat do not appear to be the primary cause of high BF% (Willett & Leibel, 2002). The relationship of dietary fat and BF% is likely influenced by the types of fats (i.e., saturated vs unsaturated) consumed. Conversely, in animal studies, high-fat and/or high-sucrose diets are commonly used to successfully induce obesity, hyperinsulinemia, hyperglycemia, and hypertension (Liang et al., 2021; Sato et al., 2010; Speakman et al., 2007; Wang & Liao, 2012). For example, in one study, mice on a high-fat diet for 16 to 20 weeks exhibited a 20 to 30% increase in body weight compared to mice on a chow diet (Speakman et al., 2007). Another study found that mice fed a diet high in fat had significantly more body fat than mice fed a normal diet (Liang et al., 2021). While studies using animal models may not fully translate into human models, since obesity and metabolic syndrome are complex chronic diseases that develop over long periods of time, taking into consideration the findings of these animal studies is beneficial (Wang & Liao, 2012).

In our nursing student cohort, increased fasting blood glucose was associated with increased fat and saturated fat consumption. Generally, carbohydrate consumption has the largest direct impact on blood glucose levels, as they are directly digested and absorbed as sugars, with minimal impact from protein (Franz, 1997). Fat intake has limited direct impact on blood glucose levels, but high fat intake may contribute to insulin resistance (Franz, 1997). A large meta-analysis of randomized control trials has shown that reducing saturated fat intake can help reduce blood glucose levels and improve insulin resistance and secretion (Mayor, 2016). Insulin resistance could impact fasting blood glucose levels and could therefore explain the association we found between fasting blood glucose and saturated fat consumption. Similar findings are also seen in animal models, since high-fat diets are commonly used to induce hyperglycemia and insulin resistance in mice (Reilly et al., 2022; Sato et al., 2010; Wang & Liao, 2012).

In nursing students, an increased total serum cholesterol was associated with a decreased dietary cholesterol intake. Historically, dietary recommendations were to reduce dietary cholesterol in order to reduce total serum cholesterol levels, however there are no longer specific recommendations on dietary cholesterol intake due to mixed evidence on its relationship with blood cholesterol levels (Carson et al., 2019). An animal study on rats found that cholesterol-fed rats had higher total serum cholesterol levels, as well as a lower HDL cholesterol and higher non-HDL cholesterol levels (Wang et al., 2010). While the mechanism is not fully understood, these results indicate that elevated dietary cholesterol led to dyslipidemia and hyperlipidemia in the rats, although the pathophysiology behind these findings in mice may not translate to humans (Wang et al., 2010). Another paper discussing the evidence for preventing atherosclerosis and CVD in rodents by reducing dietary cholesterol indicates that effectiveness varies based on the capacity to modulate circulating plasma LDL cholesterol levels (Vinué, Herrero-Cervera, & González-Navarro, 2018). In our study, total serum cholesterol was also associated with increased carbohydrate intake. Other studies have reported the opposite association, with increased carbohydrate intake being associated with a lower total serum cholesterol (Ma et al., 2006). A large-scale cohort study (n=5873), the Rotterdam study, found no consistent associations between the intake of macronutrients and total cholesterol levels (Voortman et al., 2021). It is unclear why our results suggest a negative association between total serum cholesterol and dietary cholesterol intake.

In relation to TG levels in nursing students, an increased TG level was associated with an increased percentage of daily kcals from carbohydrates and a decreased percentage of daily kcals from protein and fats. The Rotterdam study found no consistent associations between the intake of macronutrients and TG levels (Voortman et al., 2021). Increased TG levels were also associated with decreased intake of dietary cholesterol in this study, but as previously mentioned, there is mixed evidence on the relationship of dietary cholesterol with aspects of blood lipid levels in humans (Carson et al., 2019). However, an animal study on rats found the same relationship between dietary cholesterol and TGs as we did, since they found that cholesterol-fed rats had significantly lower TG levels than the control rats (Wang et al., 2010).

In nursing students, an increased LDL level was associated with an increased consumption of carbohydrates. Another study found the opposite association, with increased LDL being associated with a decreased consumption of carbohydrates (Ma et al., 2006). However, the Rotterdam study found no consistent associations between the intake of macronutrients and LDL levels (Voortman et al., 2021). Our results also suggest that decreased HDL is associated with an increased percentage of daily kcals from fats and a decreased percentage of daily kcals from carbohydrates. Conversely, Ma et al. (2006) reported that increased percentage of daily kcals from carbohydrates was associated with decreased HDL levels. As with other measures of blood lipids, the Rotterdam study, found no consistent associations between the intake of macronutrients and HDL levels (Voortman et al., 2021). In comparison, an animal study on mice found that those fed a high-fat high-cholesterol diet had significantly higher total cholesterol, HDL, and LDL cholesterol levels than mice fed a normal diet, although mice fed a diet that was only high in fat (not in cholesterol) did not have any differences in the lipid profile in comparison to mice fed a normal det (Liang et al., 2021). Another animal study on mice fed high-fat high-fructose diets found similar results to us (Zhuhua et al., 2015). In Zhuhua and colleagues' (2015) paper, they reported that mice fed high-fat high-fructose diets had higher total cholesterol, TG, and LDL levels, along with lower HDL levels in comparison to chow-fed mice.

For the most part the associations between aspects of metabolic health and nutrition that we found in this study did not agree with the associations reported by other studies on humans in the literature. However, there appears to be a lack of agreement between the association of various nutrition and metabolic health characteristics by other studies, making interpretation difficult. It is likely that there are many complex relationships that exist between nutrition and metabolic health (Ma et al., 2006). It should also be noted that there could be some limitations surrounding the 3-day diet logs that were used to collect our nutrition variables (further discussed in section 5.6), so that should be considered when interpreting our results. Many of our findings are similar to what has been reported in animal models, where more variables can be controlled for and limitations can be avoided, however, we acknowledge that findings from animal studies do not necessarily translate to humans.

A dietary recommendation that is clear from both our results and previous literature is the potential benefits of reducing saturated fat intake. Until more clear recommendations can be defined surrounding other aspects of nutrition, nursing students should focus on following Health Canada's dietary guidelines (Health Canada, 2019a). Health Canada recommends regular consumption of fruits, vegetables, and whole grains, and replacing saturated fat with unsaturated fat (when possible) to reduce the risk of developing chronic diseases, such as CVD, T2DM, and colorectal cancer, which are impacted by diet (Health Canada, 2019a).

5.4.4 Associations between metabolic health and psychological health in nursing students

We initially predicted that worse state stress levels would be associated with worse metabolic health outcomes in our cohort of nursing students. However, there were no significant associations in DASS scores across metabolic health characteristics, or by metabolic health risk. There were also no associations in HRV measures across metabolic health characteristics or by metabolic health risk, other than a positive correlation between WHR and supine SNS. As increased SNS activity ("fight or flight") is indicative of psychological stress, a positive correlation between WHR and SNS would suggest a potential relationship between poor metabolic health and increased stress levels in our nursing student cohort (Weissman & Mendes, 2021; Won & Kim, 2016; Yoo et al., 2021).

Other studies have reported some relationships between poor metabolic health and increased stress and/or poor psychological health (Gowey et al., 2019; Radin et al., 2020; S.J. Rhee et al., 2014; Pan et al., 2012). For example, one study on non-diabetic North American adults (≥ 45 years) found that elevated depressive symptoms and/or perceived stress was associated with increased WC and decreased HDL levels (Gowey et al., 2019). Additionally, a study on Korean adolescents and adults found that the presence and severity of depressive symptoms were associated with the presence of metabolic syndrome in females, depressive symptoms were also associated with HDL levels in females (S.J. Rhee et al., 2014). While not measured in our study, there is a relationship between cortisol and aspects of metabolic health, particularly blood glucose levels (Marik & Bellomo, 2013; Vedantam et al., 2022). Cortisol is one of the body's primary stress hormones, and elevated cortisol levels can also cause elevated blood glucose levels (Thau, Gandhi, & Sharma, 2022). While this mechanism is typically adaptive/protective for individuals, chronic stress leading to chronic hyperglycemia (from raised cortisol levels) is detrimental to one's health (Marik & Bellomo, 2013; Vedantam et al., 2022).

While our findings did not suggest that metabolic health was associated with state stress, chronic stress is also known to have other negative health impacts, such as an increased risk of hypertension, CVD, decreased immunity, chronic depression, and adverse effects on mental health (Schneiderman, Ironson, & Siegel, 2005). For these reasons, nursing students should aim to reduce stress or engage in stress management/coping mechanisms (e.g., progressive muscle relaxation, biofeedback, mindfulness, and meditation) (Varvogli & Darviri, 2011).

5.5 Importance of health and lifestyle of nursing students in their future profession

5.5.1 University as a critical point in determining lifestyle habits

For most students, university is a period where they gain independence in decision making surrounding their lifestyle choices that may have previously been more limited (Yahia et al., 2017; Yahia et al., 2016). The lifestyle habits that individuals adopt throughout university surrounding diet, PA, and sleep may persist into adulthood and impact their future health (Wengreen & Moncur, 2009; Yahia et al., 2017). Therefore, university can be considered a critical time for individuals to adopt healthy eating habits, reduce sedentary time and regularly exercise, and get sufficient sleep quality and quantity, as these factors are generally associated with a reduction in the risk of developing metabolic syndrome and associated chronic diseases (Health Canada, 2019a; Nelson, Davis, & Corbett, 2022; Tremblay et al., 2011; Yahia et al., 2017). Adherence to lifestyle changes including a healthy diet and regular PA can lead to an 82% reduction in chronic diseases (Stampfer et al., 2000). Additionally, learning how to better manage and cope with stress is beneficial due to the relationship of stress with many chronic diseases and psychological wellbeing (Varvogli & Darviri, 2011).

Although our mean outcomes of metabolic health and lifestyle of nursing students were normal, there were still a concerning number of nursing students who are already at-risk of poor metabolic health in the future (31.0%). As well, many students did not exhibit optimal lifestyle choices surrounding PA, sleep, nutrition, and stress. Many university students are not aware of what metabolic syndrome is, consider themselves to be in good health, and are unaware of their risks of developing metabolic syndrome (American College Health Association, 2016; Becker, Bromme, & Jucks, 2008; Munoz et al., 2010; Yahia et al., 2017). Identifying poor metabolic health risk factors early and managing them is key in reducing the progression of metabolic syndrome and/or delaying its onset (Yahia et al., 2017). Therefore, for these at-risk students, it may be especially important to adjust their lifestyle habits while they are still in university, as lifestyle habits set during this period often persist into adulthood (Wengreen & Moncur, 2009; Yahia et al., 2017).

Lifestyle interventions relating to PA, nutrition, sleep, and stress have been shown to be effective in a university student cohort, and implementation among nursing students should be considered. Many studies have reported significant improvements to various PA outcomes when using intervention techniques in university students, including web-based interventions and PA labs/lectures (Grim, Hortz, & Petosa, 2011; Hager et al., 2012; Plotnikoff et al., 2015). Various sleep intervention techniques have had beneficial impacts on both the sleep quality and quantity of university students (Friedrich & Schlarb, 2018). For example, implementation of a sleep media campaign in university students significantly improved their sleep quality (Orzech, Salafsky, & Hamilton, 2011), and an online sleep education module improved sleep behaviour, sleep quality, and mood (Hershner & O'Brien, 2018). Studies have also reported significant improvements to various nutrition outcomes (including decreasing saturated fat intake and increasing fruit and vegetable intake) through online education/demonstration videos and in-person training programs (Abu-Moghli, Khalaf, & Barghoti, 2010; Brown et al., 2011; Plotnikoff et al., 2015). Additionally, stress management techniques including cognitive-behavioural therapy, social support interventions, coping skills, relaxation training, and mindfulness have been found to reduce stress and anxiety levels in university students (Amanvermez et al., 2020; Hintz, Frazier, & Meredith, 2015; Yusufov et al., 2019). Overall, evidence suggests that lifestyle interventions are effective in the university student cohort, and since we know lifestyle habits adopted during university often persist through adulthood, the necessity of implementing lifestyle interventions in this cohort may be even more critical.

5.5.2 Influence the lifestyle choices of nursing students can have on their future patients

It is well established that RNs play an important role in managing and preventing obesity, poor metabolic health, and associated secondary diseases in their patients by acting as educators, advocates, and role-models (Almajwal, 2015; Bucher Della Torre et al., 2018; Groenewold et al., 2020; Reed et al., 2018; Rowen, 2009; WHO, 2016). However, the increased knowledge that RNs have about the importance of healthy lifestyle behaviours on health does not necessarily translate to their own behaviours (Kyle et al., 2017). Additionally, we know that a RN’s personal lifestyle choices can influence their behaviour in counselling their patients, and RNs who engage in a healthy lifestyle are more likely to be positive role-models and educate their patients on healthy behaviours (Bakhshi et al., 2015; Esposito & Fitzpatrick, 2011; Marchiondo, 2014). For example, nurses who engage in healthy eating and regular PA are more likely to promote those behaviours to their patients (Bakhshi et al., 2015; Marchiondo, 2014). This could limit the effectiveness of their role as an educator, advocate, and/or role-model to their patients, and could impact the health outcomes of their patients (Bakhshi et al., 2015; Esposito & Fitzpatrick, 2011; Marchiondo, 2014).

In the present study we were interested in nursing students, since they are future RNs that are still actively engaged in education, providing an opportunity to better inform them of the importance of lifestyle choices in relationship to their own health, and the health of their future patients (Bakhshi et al., 2015; Camden, 2009; Marchiondo, 2014). While our results did not support our specific predictions, our findings still do suggest that most nursing students have poor sleep quality (61.9%), consume insufficient fibre (89.7%), have elevated perceived depression (38.1%), anxiety (50.0%), and stress (50.0%), and on average spend the majority of their time sedentary. This suggests than some of the lifestyle behaviours that we are seeing in RNs may be beginning during the nursing education (or earlier). Another study indicated that the body composition, diet, and attitudes towards role-modelling in nursing students have a positive association with their attitudes toward, and confidence in, health promotion (Blake et al., 2021). This emphasizes the importance of training nursing students about the relationships of health and lifestyle throughout the nursing degree (Silva et al., 2016). Additionally, the experiences that nursing students have with health promotion during their clinical practice can either positively or negatively impact their attitudes towards health promotion (Blake et al., 2021). Therefore, nursing department faculty and instructors can actively promote healthy lifestyles to their students and include more opportunities for health promotion practice during clinical placements (Blake et al., 2021).

Many university students assume they are healthy and are unaware of any risks they have of poor metabolic health (American College Health Association, 2016). As RNs have known lifestyle risks associated with their profession, nursing students may be at a greater risk of poor metabolic health in the future (Chappel et al., 2017; d'Ettorre et al., 2020; Reed et al., 2018; van Amelsvoort, Schouten, & Kok, 1999). Nursing students should be informed of the potential risks they have of poor metabolic health in the future, along with how the typical behaviours of RNs can impact metabolic health status. Making nursing students aware of these risks early on, before entry to the workforce, may make them more proactive and motivated to make necessary changes to their lifestyle habits sooner (Cilar et al., 2017).

It should be noted that many of the average values for metabolic health and lifestyle variables in the nursing student cohort were normal, so the degree of poor metabolic health and lifestyle that is seen in RNs may be occurring or worsening after entry to the workforce. While it is important for nursing students to be educated on the relationships of metabolic health and lifestyle during their nursing education, these messages should also regularly be reinforced and interventions should be implemented in working RNs (Miller, Alpert, & Cross, 2008; Reed et al., 2018). There is an apparent lack of awareness and/or knowledge in RNs surrounding obesity, so there is a general recommendation for educating RNs (and other health care workers) on obesity related topics (Bucher Della Torre et al., 2018; Miller, Alpert, & Cross, 2008).

5.6 Recommendations for future research

In the future, we recommend that additional research is done to address some of this study's limitations. This includes increasing the sample size of both the nursing and comparison groups to reduce the risk of type II errors and self-selection bias.

Additionally, future research should consider choosing a comparison group that differs more significantly from the nursing student cohort, either by including all non-nursing majors, or including multiple comparison groups of various majors to better identify if the results we are seeing in nursing students and biology students are generalizable to all undergraduate university students, or more specific to those in science-based degrees. Nursing and biology students may have a greater awareness surrounding the relationships of health and lifestyle in comparison to other majors, however this does not mean that they put this knowledge to practice in their own lives. For example, one study found that undergraduate students majoring in the arts engaged in more PA than students in science, social science, and health science disciplines (Chow & Choi, 2019). This could be impacted by the time-commitment and demandingness of associated with different majors (e.g., most science programs have labs in addition to lectures), which could impact perceived stress levels, the amount of leisure time that individuals have, and the amount of sleep they obtain each night (Chow & Choi, 2019). Therefore, it is difficult to conclude whether the results of the current study can be generalized to a wider range of undergraduate students, and further research incorporating a wider range of majors would be necessary.

Furthermore, future research should be considered surrounding the implementation and effectiveness of lifestyle interventions in the nursing student cohort.

Based on successful intervention techniques in other university student cohorts, a lifestyle intervention that may be beneficial in our nursing student cohort includes online and/or in-person PA, sleep, and nutrition education modules (Brown et al., 2011; Hershner & O'Brien, 2018; Plontikoff et al., 2015), sleep media campaigns around campus (Orzech, Salafsky, & Hamilton, 2011), and teaching stress management techniques (e.g., mindfulness, relaxation, and coping skill training) (Amanvermez et al., 2020; Hintz, Frazier, & Meredith, 2015; Yusufov et al., 2019). Also, increasing awareness and encouraging the use of current services/facilities available to nursing students from their enrollment fees, such as access to the on-campus athletic centre, counselling services, academic advisors, and peer support may be helpful. These interventions would ideally target the areas of concern that were identified in the current study by reducing sedentary time, improving sleep quality, improving nutrition (particularly surrounding saturated fat, sodium, and dietary fibre intake), and reducing negative emotional states in our nursing student cohort. While many students in the collaborative (4-year) nursing program are directly entering university from high school, students in the compressed (accelerated 28-month) nursing program have previous postsecondary experience. Since there were similar results in the metabolic health and lifestyle of nursing and biology students, along with the potential for biology students to transfer to the compressed nursing program in the future, it may also be of interest or benefit to implement similar lifestyle interventions in the biology student cohort as well.

5.7 Limitations

There are certain limitations that must be considered when interpreting the results of this study. First, the smaller sample size of this study in both the nursing students (n=42) and biology student (n=15) cohorts may have had an impact on the results. While there were some significant differences between the nursing student and biology student groups, our results may be prone to type II errors. A larger sample size may help determine if some of the insignificant differences that were seen between nursing and biology students are actually significant and/or differ between metabolic health risk group. Additionally, the small sample size, particularly with the biology student cohort, may make our results more prone to self-selection bias. As our participants all volunteered for the study, they may be more motivated and interested in learning about their health and lifestyle, and there is a chance that some aspects of their lifestyle choices are not representative of the entire nursing student population.

Another limitation in our study is that the data was not separated by males and females. While males and females were classified appropriately for metabolic health characteristics based on their sex in our metabolic measures, the averages for the metabolic health and lifestyle variables are presented with males and females combined. These sex-specific differences exist for WC, WHR, and BF% (Alberti et al., 2009; WHO, 2021). Our sample was predominantly female, with all biology student participants and 85.7% (n=36) of nursing student participants being female. This limits comparability with other studies that have stratified their results by sex, or that have closer to a 50/50 ratio of male and female participants. However, for our nursing student cohort, the ratio of females to males that we had in our study does mimic the ratio of females to males in the nursing profession (approximately 91% female) (Canadian Nurses Association, 2021). Furthermore, 2020 data for the university our nursing student participants attended indicates that 86.6% of full-time undergraduate nursing students at the institution are female (Council of Ontario Universities, 2023a; Council of Ontario Universities, 2023b). For these reasons, it is likely that our averages combining female and male nursing students are reflective of the nursing student demographic.

A strength of our research study was that our assessment of metabolic health did not rely on any self-reported data. The main potential limitations surround the accuracy of the WC, HC, and skinfold measurements, which may be subject to measurement error. Researchers followed the methods in obtaining WC, HC, and skinfold measurements as outlined in section 2.3.6 to keep consistency in the measurements. Additionally, while skinfold measurements are a frequently used method to estimate BF%, it is not as accurate in determining BF% in comparison to some other methods (like dual-energy x-ray absorptiometry) (Silveira et al., 2020). Also, while the CardioChek PA Analyzer used in this study to measure total cholesterol, HDL, LDL, and TGs is a validated device (Bastianelli, Ledin, & Chen, 2017; Gao et al., 2016), a study on Kenyan individuals found that the device was inaccurate in assessing blood lipid levels compared to laboratory testing methods (Park et al., 2016). The study found that measures of total cholesterol, HDL, and LDL fell outside of the National Cholesterol Education Program's (NCEP) acceptable percent bias range for each measure (Park et al., 2016). For example, Park and colleagues (2016) found that using the CardioChek PA Analyzer had a –15.9% bias for total cholesterol, –25.9% bias for LDL, and –8.2% bias for HDL cholesterol levels (NCEP's acceptable range= ≤±5%, ≤±3%, and ≤±5%, respectively). Based on this, our study may be underestimating the percentage of nursing and biology students who have elevated total cholesterol, HDL, and/or LDL cholesterol levels. Furthermore, as two of the five criteria in our modified guidelines for metabolic health risk (Appendix A) rely on measurements obtained from the CardioChek PA Analyzer, there may be more nursing and biology students that fall into the at-risk of poor metabolic classification than our results indicate.

There are some potential limitations with the lifestyle variables that were collected. Sleep quality was assessed using the PSQI, and while it is a validated questionnaire used to assess sleep quality, it requires participants to retrospectively answer questions on their sleep which may lead to over- or underestimation in their answers (Dietch et al., 2016). More objective measures of sleep quality include polysomnography and actigraphy, however there are some disadvantages with these methods (Fabbri et al., 2021). Polysomnography is costly and time-consuming, and actigraphy is only a proxy measure of sleep, as it measures inactivity rather than sleep itself (Fabbri et al., 2021). There may also be some inaccuracies surrounding the 3-day diet log, as individuals often under-report their true food intake or change their diet during the collection period (Cook, Pryer, & Shetty, 2000). We observed a low average kcal intake based on what participants reported on the food logs, so frequent under-reporting with 3-day diet logs may explain this finding (Cook, Pryer, & Shetty, 2000). Caution should be taken in interpreting our diet log results as individuals who under-report their daily kcal intake often over-report their protein and starch intakes and under-reported their fat and sugar intakes; this could impact our results (Cook, Pryer, & Shetty, 2000). Commonly used alternatives to the 3-day diet log are 24-hour recall and food frequency questionnaires (Bailey, 2021). While these alternatives would avoid individuals altering their dietary behaviours during the collection period, they have their own disadvantages, including relying on recall and limited quantifiability (Bailey, 2021).

Another potential limitation of our study is our comparison group (discussed in more detail in section 5.6). With our biology student comparison group there were few significant differences that were found between them and nursing students. Based on this, our results suggest that our findings could be more generalizable to all undergraduate university students. However, students within the biology department may be majoring specifically in biomedical science or have a health science specialization. The biology students that participated in our study may be similar to our nursing student participants in that they likely have more knowledge or awareness of the relationships of health and lifestyle than an undergraduate student in the arts, humanities, or even other areas of science (e.g., chemistry and physics). If our comparison group was more general to include all non-nursing majors, or if it was a non-science major, our results may have been different.

6 CONCLUSION

The goal of this thesis was to address the gap that exists in the literature surrounding the characterization of the metabolic health and lifestyle of nursing students. It is necessary to address this gap in the literature since, in the future, nursing students will be caring for an increasing number of patients with poor metabolic health, and their own lifestyle choices can impact how they care for and counsel their patients (Bakhshi et al., 2015; Marchiondo, 2014). A total of 57 undergraduate students attending a Canadian university participated in the study, 42 of them were nursing students, and the other 15 were biology students acting as our comparison group. Mean scores for metabolic health characteristics (BMI, WC, WHR, BF%, BP, fasting blood glucose, and lipid profile) were all normal/optimal in our nursing student cohort, however there were concerns surrounding metabolic health characteristics at an individual level. Poor metabolic health characteristics that were most common in nursing students were HDL levels outside of the optimal range (45.7%), elevated BMI (40.4%), elevated fasting blood glucose (25.0%), elevated systolic BP (19.0%), elevated diastolic BP (14.3%), elevated LDL (14.3%), elevated TG (14.3%), and elevated total serum cholesterol (11.4%). Therefore, at an individual level some nursing students may be at greater risk of CVD, T2DM, and certain cancers in comparison to students with normal measures of these metabolic health characteristics (DeFina et al., 2012; Kyrou et al., 2018; NIH, 2002; WHO, 2021).

Using the AHA/NHLBI/IDF 2009 definition of metabolic syndrome, 50.0% of nursing students met at least one criterion, and 4.8% met the diagnostic criteria for metabolic syndrome. Using our amended guidelines for determining the risk of poor metabolic health, 31.0% of nursing students were considered at-risk of poor metabolic health. Our biology student comparison group had a higher prevalence of students who were at-risk of poor metabolic health (46.7%), but the association between major of study and risk of poor metabolic health was not significant (p=0.349). The prevalence of metabolic syndrome and poor metabolic health in both nursing and biology students is concerning, especially because university students generally perceive themselves to be healthy (American College Health Association, 2016). Early prevention and diagnostic interventions should be considered for both nursing and biology undergraduate students, to avoid having students with metabolic syndrome, or an increased risk of metabolic syndrome, go undiagnosed until later in life when more serious health consequences arise (Yahia et al., 2017).

In our assessment of lifestyle habits, we found that most nursing students (82.4%) were meeting the recommended guidelines of 150 minutes of MVPA per week, however 80.3% of their time (including sleep), or approximately 19 hours per day, was spent sedentary, indicating that nursing students are still highly sedentary. Our biology student comparison group engaged in a significantly higher proportion of sedentary time (83.3% vs. 80.3%, p=0.016) and lower proportion of light PA (14.0% vs. 17.0%, p=0.022) in comparison to nursing students. However, there were no differences in the amount of MVPA between the two groups, likely indicating that there were no differences in the amount of purposeful exercise the students engaged in. Overall, nursing and biology students are more sedentary than the general young adult population and should aim to reduce sedentary time and break up long periods of sitting when possible (CSEP, 2020). The sedentary behaviour of nursing and biology students in this study increases their risk of all-cause mortality, hypertension, T2DM, and poor psychological health and sleep

(CSEP, 2020; Gerber et al., 2014; Kelley & Kelley, 2017; Kovacevic et al., 2018; Lavretsky & Abbott, 2018; WHO, 2020).

As well, most nursing students (61.9%) and biology students (60.0%) had poor sleep quality. University students are in a unique social environment, often involving parties, stress, communal living arrangements, and part-time work in addition to their course work that may explain the poor sleep quality in our participants (Vail-Smith, Felts, & Becker, 2009). Poor sleep quality among university students is concerning as it has been associated with anxiety, depression, stress, and poorer academic performance (Orzech, Salafsky, & Hamilton, 2011; Vail-Smith, Felts, & Becker, 2009).

There were no differences in nutrition variables between our nursing and biology student cohorts. In general, our nursing student cohort was consuming an appropriate proportion of macronutrients but would benefit from reducing their saturated fat and sodium intake as well as increasing their fibre intake, however these recommendations are applicable for all university students, as well as the Canadian population in general. University students should follow Health Canada's recommendations of regularly consuming of fruits, vegetables, and whole grains, and replacing saturated fat with unsaturated fat to help reduce their risk of developing diet impacted chronic diseases, such as CVD, T2DM, and colorectal cancer (Health Canada, 2019a).

Nursing students had mild levels of self-reported state depression and stress, and a moderate level of self-reported anxiety. At an individual level, 38,1%, 50.0%, and 50.0% of nursing students had levels of depression, anxiety, and stress that were above the normal classification level. Objectively measured stress indicated that nursing students do not have increased stress compared to the healthy adult population. There were no differences in objectively measured stress, or subjectively reported negative emotional states between nursing and biology student cohorts. While nursing students do not appear to have increased levels of stress using objective measurement tools, they are still perceiving themselves to be experiencing negative emotional states. For this reason, nursing students should aim to reduce negative emotional states as it could negatively impact academic performance and decision making, and prolonged stress is associated with hypertension, CVD, and decreased immunity (Gangadhara & Madani, 2018; Kim & Lim, 2014; Schneiderman, Ironson, & Siegel, 2005).

To our knowledge, this study is the first to comprehensively characterize the metabolic health status and multiple lifestyle factors (PA, sleep, stress, and nutrition) in undergraduate nursing students attending a Canadian university. Additionally, our inclusion of a biology student comparison group allowed us to better understand whether our findings were unique to nursing students, or perhaps more generalizable to other university students at our institution. Our findings suggest that some of the poor lifestyle choices and poor metabolic health that is seen in RNs may be beginning during the nursing education, or even earlier. We know that a RN's personal lifestyle choices can influence how they counsel their patients, since RNs who engage in a healthy lifestyle are more likely to promote a healthy lifestyle to their patients (Bakhshi et al., 2015; Esposito & Fitzpatrick, 2011; Marchiondo, 2014). Consequently, not only do poor lifestyle choices negatively impact the health of RNs, but it could also impact the health outcomes of their patients (Bakhshi et al., 2015). The lifestyle habits that individuals adopt throughout university surrounding diet, PA, and sleep may persist on during adulthood and could potentially impact their future health (Wengreen & Moncur, 2009; Yahia et al., 2017).

Therefore, the lifestyle choices of nursing students in this study may persist throughout their career as an RN and could impact their own health and how they care for their future patients. For this reason, our findings suggest a need for the implementation of lifestyle interventions that target reducing sedentary behaviour, improving sleep quality, reducing saturated fat intake, increasing fibre intake, and improving stress management in nursing students. Previous studies have found that lifestyle interventions are effective in university students, and lifestyle interventions in nursing students have positively impacted their metabolic health status (Pawloski & Davidson, 2003). Therefore, universities and nursing departments should consider implementing lifestyle interventions for their students and improving the education surrounding the relationships of health and lifestyle throughout the nursing degree.

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APPENDICES

Appendix A: Metabolic health classification methods

Table 11: Comparison of prominent definitions of metabolic syndrome. Adapted from Alberti et al., 2009 and Kyrou et al., 2019.

IDF (2005)	*NCEP-ATP III (2001)*	*AHA/NHLBI/IDF (2009)*
Central obesity (based on WC criteria specific to sex and ethnicity) and at least **two** of the following:	At least **three** of the following:	At least **three** of the following:
A. ↑ TG levels: ≥ 1.7 mmol/L B. ↓ HDL levels: ≤ 1.03 mmol/L (males), ≤ 1.29 mmol/L (females) C. ↑ BP: systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg D. ↑ FBG: ≥ 5.6 mmol/L	A. ↑ WC: > 102 cm (males), > 88 cm (females) B. ↑ TG levels: ≥ 1.7mmol/L C. ↓ HDL levels: ≤ 1.03 mmol/L (males), ≤ 1.29 mmol/L (females) D. ↑ BP: ≥ 135/85 mmHg E. ↑ FBG: ≥ 6.1 mmol/L	A. ↑ WC: population- and country-specific definitions (Table 11) B. ↑ TG levels: ≥ 1.7 mmol/L C. ↓ HDL levels: ≤ 1.03 mmol/L (males), ≤ 1.29 mmol/L (females) D. ↑ BP: systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg E. ↑ FBG: ≥ 5.6 mmol/L

AHA: American Heart Association; BP: Blood pressure; FBG: Fasting blood glucose; HDL: High-density lipoprotein; IDF: International Diabetes Federation; NCEP-ATP III: National Cholesterol Education Program-Adult Treatment Panel III; NHLBI: National Heart, Lung, and Blood Institute; TG: Triglycerides; WC: Waist circumference

Table 12: Recommended waist circumference cut-offs for abdominal obesity by ethnicity and country. Adapted from Alberti et al., 2009.

Population	*WC in males*	*WC in females*	*Organization (Reference)*
Europid	≥ 94 cm	≥ 80 cm	IDF
Caucasian	≥ 94 cm (increased risk) ≥ 102 cm (higher risk)	≥ 80 cm (increased risk) ≥ 88 cm (higher risk)	WHO
United States	≥ 102 cm	≥ 88 cm	AHA/NHLBI
Canada	≥ 102 cm	≥ 88 cm	Health Canada
European	≥ 102 cm	≥ 88 cm	European CV Societies
Asian	≥ 90 cm	≥ 80 cm	IDF
Asian	≥ 90 cm	≥ 80 cm	WHO
Japanese	≥ 85 cm	≥ 90 cm	Japanese Obesity Society
China	≥ 85 cm	≥ 80 cm	Cooperative Task Force
Middle East, Mediterranean	≥ 94 cm	≥ 80 cm	IDF
Sub-Saharan African	≥ 94 cm	≥ 80 cm	IDF
Ethnic Central & South American	≥ 90 cm	≥ 80 cm	IDF

AHA: American Heart Association; CV: Cardiovascular disease; IDF: International Diabetes Federation; NHLBI: National Heart, Lung, Blood Institute; WHO: World Health Organization

Table 13: Amended AHA/NHLBI/IDF (2009) criteria for determining individuals at risk of poor metabolic health. Adapted from Alberti et al., 2009.

At least **two** of the following:
1. ↑ Body size; indicated by one of more of the following: A. ↑ WC: ≥ 102cm (males) or ≥ 88cm (females) B. ↑ BMI: ≥ 25.0kg/m² C. ↑ WHR: ≥ 1.0 (males) or ≥ 0.85 (females) D. ↑ BF%: ≥ 25.8% (males) or ≥ 37.1% (females)
2. ↑ TG levels: ≥ 1.7mmol/L
3. ↓ HDL levels: ≤ 1.03 mmol/L (males) or ≤ 1.29 mmol/L (females)
4. ↑ BP: systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg
5. ↑ FBG: ≥ 5.6 mmol/L

AHA: American Heart Association; BF%: Body fat percentage; BMI: Body mass index; BP: Blood pressure; FBG: Fasting blood glucose; HDL: High-density lipoprotein; IDF: International Diabetes Federation; NHLBI: National Heart, Lung, and Blood Institute; TG: Triglycerides; WC: Waist circumference; WHR: Waist-to-hip ratio

Appendix B: Consent form

Discriminating Metabolic Health Status in a Cohort of Nursing Students

I. SPONSOR: Trent/Fleming School of Nursing (TFSON) Research Grant Program, 2020.

II. INVESTIGATORS:

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III. PURPOSE AND BACKGROUND

We are conducting a study to determine whether certain lifestyle factors influence the health of full-time undergraduate nursing students. Research shows that registered nurses may have poor metabolic health compared to the general population. However, there isn't a lot of information about metabolic health and lifestyle factors in nursing students. This study will be the first to examine metabolic health and lifestyle factors in nursing students at a Canadian university.

IV. PROCEDURES

As a full-time undergraduate nursing student who is currently studying at the Trent/Fleming School of Nursing, or as a full-time undergraduate biology student (serving as a member of the comparison group), and is over the age of 17, you are being asked to participate in this study to determine which lifestyle factors including physical activity, nutrition, sleep, and stress levels influence the health of nursing students.

If you agree to be a participant in this study, you will be asked to complete the following tests, one time:

Questionnaires:

1) Demographic questionnaire
2) Modifiable Activity Questionnaire (MAQ)
3) International Physical Activity Questionnaire (IPAQ)
4) Pittsburgh Sleep Quality Index (PSQI)
5) Depression Anxiety Stress Scale (DASS)

Demographic/Metabolic tests:

6) Height and weight measured
7) Waist and hip circumference measured
8) Body fat percentage determined using a skinfold calliper (this is a device that slightly pinches your skin to aid in determining body fat percentage).
9) Blood pressure measured using a blood pressure monitor placed on the upper portion of your arm
10) Lay down for 10 minutes and stand for 10 minutes while having your heart rate monitored with a heart rate monitor
11) After fasting (i.e., not consuming food or beverages, with the exception of water) for 12 hours prior to your study visit at the laboratory, have your blood glucose and lipid levels measured which will involve a prick of your finger to obtain a small blood sample
12) Wear an accelerometer (small pager like device) on your non-dominant hip for 7 consecutive days (including while asleep, but not while showering)
13) Maintain a log of the food you have consumed for 3 days during your 7 day accelerometer assessment

V. BENEFITS OF PARTICIPATION

Tracking sleep, diet, and activity has the potential to help participants understand their strengths and weaknesses associated with these lifestyle factors and may motivate participants to pay more attention to their health.

VI. COMPENSATION

Upon return of 3 day food log and accelerometer to the lab, all research participants will receive a $10 gift card to a food venue on Trent University’s Peterborough campus. In the event that a participant chooses to discontinue participation before the completion of the study, they will still receive the compensation once lab equipment is returned.

VII. USAGE OF STUDY DATA

Data obtained from this study will be included undergraduate and graduate theses. In addition, results may be published in an academic journal and/or presented at an academic conference.

VIII. CONFLICTS OF INTEREST

The investigators have no conflict of interest.

IX. VOLUNTARY PARTICIPATION

Your participation in this study is completely voluntary. You are not obligated to answer any questions or participate in any tests or measurements you do not wish to. You may remove your consent and discontinue participation in the study at any time, without any consequences.

X. CONFIDENTIALITY

The participants will be identified by study number without initials, protecting their confidentiality. All hard copy study material will be stored in a locked cabinet, in the locked West Kin Lab, which is only accessible by members of the research team. All digital data will be stored on Trent University's secure network. Data will be stored for 5 years following the completion of the study, after which it will be destroyed. The data will be under the ownership of Dr. Sarah West who will take responsibility for the removal of the data after 5 years.

XI. RISKS OF PARTICIPATING IN THIS STUDY

The risks of study participation are minimal. When you are fasting before your laboratory visit, there is a risk that hypoglycemia (i.e., low blood sugar levels. However, this risk is minimal, in individuals without a pre-existing glycemic disorder (e.g., diabetes). Therefore, individuals with any pre-existing medical conditions in which fasting would be discouraged will be excluded from the blood analysis portion of the study.

There is a risk of minor physical discomfort during the collection of certain study data. For instance, while using the skinfold calliper to determine body fat percentage which can pinch the skin a bit, or using a blood pressure monitor which can squeeze the arm. Your finger will be pricked to collect a small blood sample to measure blood glucose and blood lipid levels. The amount of blood sampled is small, however there is a risk that participants may feel lightheaded.

If you experience any emotional distress or discomfort from participating in this study, please do not hesitate to contact Dr. Sarah West (sarahwest@trentu.ca) or Shanna Lowes (shannalowes@trentu.ca). As well, below are some resources you may also consider:

Trent Counselling Services
Blackburn Hall, Suite 113, Trent University
Phone: 705-748-1137
Email: counselling@trentu.ca

I.M. Well

For crisis, contact: 1-877-554-6935
Counselling Intake Form: http://machform.studentvip.ca/view.php?id=47138

XII. QUESTIONS

Please contact graduate student Shanna Lowes (shannalowes@trentu.ca), or PI Dr. Sarah West (sarahwest@trentu.ca) with any questions you may have regarding this study.

XIII. CONSENT

By signing this document, you;

- Agree that you have been informed of the research study and freely give consent to participate in the research.
- Have received a copy of the consent form for my own records.
- Understand that the project has been approved by the Trent Research Ethics Board.

Name: ______________________ Signature: _________________________

Date: ______________________ Phone Number (optional): ___________________

Witness Name: ________________ Witness Signature: ___________________

Date: ______________________ Phone Number (optional): ___________________

Appendix C: Correlations between metabolic health and lifestyle

Table 14: Spearman's rank correlation coefficients (ρ) and p-values with metabolic health characteristics and physical activity levels for nursing students

ρ (p-value)	**Sed. time** (mins per day)	**% of day sed.** (%)	**Light PA** (mins per day)	**% of day light PA** (%)	**Mod. PA** (mins per day)	**% of day mod. PA** (%)	**Vigorous PA** (mins per day)	**% of day vigorous PA** (%)	**Steps per day**	**MVPA** (mins per week)
BMI (kg/m²)	0.084 (0.64)	0.125 (0.48)	-0.004 (0.98)	-0.099 (0.58)	0.021 (0.91)	-0.038 (0.83)	-0.074 (0.68)	-0.051 (0.773)	-0.044 (0.81)	-0.034 (0.849)
WC (cm)	0.043 (0.81)	0.132 (0.46)	-0.022 (0.90)	-0.115 (0.52)	-0.065 (0.71)	-0.118 (0.51)	0.068 (0.70)	0.098 (0.58)	-0.067 (0.71)	-0.067 (0.71)
WHR	0.046 (0.80)	0.030 (0.87)	0.031 (0.86)	-0.027 (0.88)	0.027 (0.88)	-0.025 (0.89)	0.292 (0.09)	0.296 (0.09)	0.055 (0.76)	0.074 (0.68)
BF% (%)	0.121 (0.50)	0.101 (0.57)	0.007 (0.97)	-0.057 (0.75)	-0.167 (0.34)	-0.205 (0.246)	-0.119 (0.50)	-0.107 (0.55)	-0.035 (0.85)	-0.147 (0.41)
Resting systolic BP (mmHg)	-0.164 (0.35)	-0.228 (0.20)	0.221 (0.21)	0.213 (0.23)	0.213 (0.23)	0.174 (0.32)	-0.066 (0.71)	-0.063 (0.72)	0.179 (0.31)	0.168 (0.34)
Resting diastolic BP (mmHg)	0.057 (0.75)	0.011 (0.95)	-0.039 (0.83)	-0.58 (0.75)	0.093 (0.60)	0.079 (0.69)	-0.234 (0.18)	-0.230 (0.19)	-0.039 (0.83)	-0.005 (0.98)
Fasting blood glucose (mmol/L)	-0.237 (0.19)	-0.187 (0.31)	0.176 (0.34)	0.152 (0.41)	0.109 (0.55)	0.100 (0.59)	0.010 (0.96)	0.030 (0.87)	0.120 (0.51)	0.127 (0.49)
Total chol. (mmol/L)	0.005 (0.98)	0.124 (0.53)	-0.119 (0.55)	-0.101 (0.61)	0.031 (0.87)	0.069 (0.73)	-0.048 (0.81)	-0.077 (0.70)	-0.138 (0.48)	-0.049 (0.80)
HDL (mmol/L)	-0.256 (0.19)	-0.070 (0.72)	0.124 (0.53)	0.151 (0.44)	-0.084 (0.67)	-0.125 (0.53)	-0.058 (0.77)	-0.090 (0.65)	0.155 (0.43)	-0.008 (0.97)
LDL (mmol/L)	-0.064 (0.75)	0.085 (0.67)	-0.103 (0.60)	-0.068 (0.73)	0.047 (0.81)	0.100 (0.61)	-0.050 (0.80)	-0.050 (0.80)	-0.184 (0.35)	-0.066 (0.74)
TG (mmol/L)	0.288 (0.14)	0.241 (0.22)	-0.274 (0.16)	-0.278 (0.15)	0.108 (0.58)	0.164 (0.40)	-0.274 (0.16)	-0.317 (0.10)	-0.150 (0.45)	0.025 (0.90)
Total chol./HDL	0.314 (0.10)	0.165 (0.40)	-0.180 (0.36)	-0.198 (0.31)	0.142 (0.47)	0.161 (0.41)	-0.63 (0.75)	-0.078 (0.69)	-0.164 (0.41)	0.008 (0.97)

BF%: Body fat percentage; BMI: Body mass index; BP: Blood pressure; Chol.: cholesterol; HDL: High-density lipoprotein; LDL: Low-density lipoprotein; Mod.: Moderate; MVPA: Moderate-to-vigorous physical activity; PA: Physical activity; Sed.: Sedentary; TG: Triglycerides; WC: Waist circumference; WHR: Waist-to-hip ratio

Table 15: Spearman's rank correlation coefficients (ρ) and p-values with metabolic health characteristics and dietary intake for nursing students

ρ (p-val)	**kcals**	**Prot.** (g)	**Carb.** (g)	**Total fat** (g)	**Sat. fat** (g)	**Chol.** (mg)	**Fibre** (g)	**Sod.** (mg)	**% kcals from prot.**	**% kcals from carb.**	**%kcals from fats**
BMI (kg/m²)	-0.133 (0.42)	-0.084 (0.61)	0.16 (0.93)	-0.193 (0.24)	-0.075 (0.65)	-0.302 (0.06)	0.003 (0.99)	0.017 (0.92)	0.015 (0.93)	0.026 (0.88)	-0.055 (0.74)
WC (cm)	-0.025 (0.88)	0.039 (0.82)	0.176 (0.28)	-0.188 (0.25)	-0.129 (0.43)	-0.254 (0.12)	0.180 (0.27)	0.133 (0.42)	-0.074 (0.65)	0.171 (0.30)	-0.118 (0.48)
WHR	0.005 (0.98)	0.029 (0.86)	0.293 (0.07)	-0.291 (0.07)	-0.245 (0.13)	-0.303 (0.06)	0.068 (0.68)	0.088 (0.60)	-0.080 (0.63)	0.241 (0.14)	-0.219 (0.18)
BF% (%)	-0.233 (0.15)	-0.289 (0.07)	-0.101 (0.54)	-0.166 (0.31)	-0.114 (0.49)	-0.256 (0.12)	-0.044 (0.79)	0.042 (0.80)	-0.098 (0.55)	**0.417** (0.008)**	**-0.420** (0.008)**
Sys. BP (mmHg)	0.156 (0.34)	0.175 (0.29)	0.116 (0.48)	0.075 (0.65)	0.090 (0.59)	0.047 (0.78)	0.199 (0.23)	-0.061 (0.71)	-0.151 (0.36)	0.089 (0.59)	-0.024 (0.89)
Dia. BP (mmHg)	0.252 (0.12)	0.147 (0.37)	0.156 (0.34)	0.171 (0.30)	0.186 (0.26)	0.035 (0.83)	0.278 (0.09)	0.109 (0.51)	0.065 (0.70)	0.000 (0.99)	-0.014 (0.93)
FBG (mmol/L)	0.264 (0.11)	0.242 (0.15)	0.259 (0.12)	**0.331* (0.045)**	**0.328* (0.047)**	0.157 (0.35)	0.261 (0.12)	0.182 (0.28)	-0.080 (0.63)	-0.10 (0.95)	0.010 (0.95)
Total chol. (mmol/L)	0.136 (0.46)	-0.101 (0.58)	**0.353* (0.047)**	-0.085 (0.644)	-0.063 (0.73)	**-0.375* (0.034)**	0.105 (0.57)	0.025 (0.89)	-0.058 (0.73)	-0.129 (0.45)	0.211 (0.21)
HDL (mmol/L)	0.095 (0.60)	-0.013 (0.94)	0.187 (0.31)	0.122 (0.51)	0.006 (0.98)	-0.060 (0.74)	0.183 (0.32)	0.008 (0.97)	-0.289 (0.11)	**0.387* (0.029)**	**-0.393* (0.026)**
LDL (mmol/L)	0.181 (0.32)	0.021 (0.91)	**0.365* (0.040)**	-0.034 (0.86)	0.072 (0.70)	-0.283 (0.12)	0.102 (0.58)	0.107 (0.56)	-0.093 (0.61)	0.053 (0.77)	0.031 (0.87)
TG (mmol/L)	0.106 (0.57)	-0.256 (0.16)	0.262 (0.15)	-0.158 (0.39)	-0.051 (0.78)	**-0.472** (0.006)**	0.049 (0.79)	-0.186 (0.31)	**-0.450** (0.010)**	**0.423* (0.016)**	**-0.371* (0.037)**
Total chol./ HDL	0.127 (0.49)	-0.022 (0.91)	0.260 (0.15)	-0.108 (0.56)	0.083 (0.65)	-0.301 (0.09)	0.042 (0.82)	0.074 (0.69)	-0.245 (0.18)	0.288 (0.11)	-0.337 (0.06)

**: correlation is significant at the $p<0.001$ level (two-tailed)

*: correlation is significant at the $p<0.05$ level (two-tailed)

BF%: Body fat percentage; BMI: Body mass index; BP: Blood pressure; Dia.: Resting diastolic; Carb.: Carbohydrates; Chol.: Cholesterol; FBG: Fasting blood glucose; HDL: High-density lipoprotein; kcals: Kilocalories; LDL: Low-density lipoprotein; Prot.: Protein; Sat. fat: Saturated fat; Sod.; Sodium; Sys.: Resting systolic; TG: Triglycerides; WC: Waist circumference; WHR: Waist-to-hip ratio

Table 16: Spearman's rank correlation coefficients (ρ) and p-values with metabolic health characteristics and PSQI and DASS scores for nursing students

ρ (p-value)	PSQI score	Depression score	Anxiety score	Stress score
BMI (kg/m²)	0.255 (0.10)	0.231 (0.142)	0.097 (0.54)	0.227 (0.15)
WC (cm)	0.159 (0.31)	0.299 (0.054)	0.072 (0.65)	0.262 (0.09)
WHR	0.209 (0.18)	0.256 (0.10)	0.046 (0.77)	0.243 (0.12)
BF% (%)	0.189 (0.23)	0.206 (0.19)	0.162 (0.31)	0.245 (0.12)
Resting systolic BP (mmHg)	-0.041 (0.80)	-0.091 (0.57)	-0.079 (0.62)	-0.018 (0.91)
Resting diastolic BP (mmHg)	-0.171 (0.28)	-0.241 (0.12)	-0.112 (0.48)	-0.141 (0.38)
Fasting blood glucose (mmol/L)	0.277 (0.08)	0.004 (0.98)	0.041 (0.80)	-0.001 (0.99)
Total cholesterol (mmol/L)	-0.052 (0.77)	0.021 (0.91)	0.007 (0.97)	0.176 (0.31)
HDL (mmol/L)	0.142 (0.42)	-0.270 (0.12)	-0.185 (0.29)	0.027 (0.88)
LDL (mmol/L)	0.036 (0.84)	0.053 (0.76)	-0.023 (0.89)	0.076 (0.67)
TG (mmol/L)	-0.198 (0.25)	0.107 (0.54)	-0.018 (0.92)	0.058 (0.74)
Total cholesterol/HDL	-0.146 (0.40)	0.265 (0.13)	0.114 (0.51)	0.050 (0.78)

BF%: Body fat percentage; BMI: Body mass index; BP: Blood pressure; DASS: Depression Anxiety Stress Scale; HDL: High-density lipoprotein: Low-density lipoprotein; PSQI: Pittsburgh Sleep Quality Index; TG: Triglycerides; WC: Waist circumference; WHR: Waist-to-hip ratio

Table 17: Spearman's rank correlation coefficients (ρ) and p-values with metabolic health characteristics and heart rate variability for biology students

ρ (p-value)	**LF supine**	**HF supine**	**TP supine**	**PNS supine**	**SNS supine**	**LF stand**	**HF stand**	**TP stand**	**PNS stand**	**SNS stand**
BMI (kg/m²)	-0.173 (0.31)	-0.156 (0.36)	-0.122 (0.47)	-0.005 (0.98)	0.005 (0.98)	0.120 (0.49)	0.021 (0.90)	0.031 (0.86)	-0.006 (0.97)	0.050 (0.77)
WC (cm)	-0.034 (0.84_	-0.200 (0.24)	-0.080 (0.64)	-0.265 (0.11)	0.272 (0.10)	0.078 (0.65)	0.003 (0.99)	0.002 (0.99)	-0.007 (0.97)	0.042 (0.81)
WHR	0.047 (0.78)	-0.208 (0.22)	-0.127 (0.45)	-0.321 (0.052)	**0.331* (0.045)**	-0.063 (0.72)	-0.048 (0.78)	-0.044 (0.80)	0.001 (0.99)	0.005 (0.98)
BF% (%)	-0.070 (0.68)	0.136 (0.42)	0.010 (0.95)	0.208 (0.22)	-0.200 (0.23)	-0.152 (0.38)	-0.079 (0.65)	-0.129 (0.45)	0.036 (0.84)	-0.023 (0.89)
Resting systolic BP (mmHg)	-0.065 (0.70)	-0.178 (0.29)	-0.067 (0.69)	-0.173 (0.31)	0.180 (0.29)	0.221 (0.20)	0.156 (0.36)	0.165 (0.34)	0.131 (0.45)	-0.106 (0.54)
Resting diastolic BP (mmHg)	-0.061 (0.72)	-0.055 (0.75)	-0.028 (0.87)	-0.115 (0.50)	0.088 (0.60)	0.016 (0.93)	-0.030 (0.86)	-0.013 (0.94)	-0.007 (0.97)	0.027 (0.88)
Fasting blood glucose (mmol/L)	-0.251 (0.15)	-0.107 (0.54)	-0.211 (0.23)	0.076 (0.67)	-0.063 (0.72)	-0.176 (0.32)	-0.237 (0.18)	-0.252 (0.15)	-0.178 (0.31)	0.199 (0.26)
Total chol. (mmol/L)	-0.107 (0.57)	-0.045 (0.82)	-0.035 (0.86)	0.021 (0.91)	-0.036 (0.85)	-0.070 (0.72)	-0.136 (0.48)	-0.058 (0.77)	-0.190 (0.32)	0.175 (0.36)
HDL (mmol/L)	0.056 (0.77)	-0.101 (0.60)	-0.010 (0.96)	-0.168 (0.38)	0.184 (0.33)	-0.102 (0.60)	-0.008 (0.97)	-0.046 (0.81)	0.052 (0.79)	-0.71 (0.71)
LDL (mmol/L)	**-0.393* (0.032)**	-0.108 (0.57)	-0.245 (0.19)	0.309 (0.10)	-0.322 (0.08)	-0.291 (0.13)	-0.314 (0.10)	-0.314 (0.10)	-0.174 (0.37)	0.174 (0.37)
TG (mmol/L)	-0.028 (0.88)	-0.078 (0.68)	-0.041 (0.83)	-0.120 (0.53)	0.103 (0.59)	0.048 (0.80)	0.004 (0.98)	0.044 (0.82)	-0.107 (0.58)	0.100 (0.61)
Total chol./ HDL	-0.174 (0.36)	0.036 (0.85)	-0.074 (0.70)	0.231 (0.22)	-0.257 (0.17)	-0.127 (0.51)	-0.292 (0.13)	-0.190 (0.32)	-0.335 (0.08)	0.349 (0.06)

*: correlation is significant at the $p<0.05$ level (two-tailed)

BF%: Body fat percentage; BMI: Body mass index; BP: Blood pressure; Chol.: Cholesterol; HDL: High-density lipoprotein; HF: High frequency power (ms²); LDL: Low-density lipoprotein; LF: Low frequency power (ms²); PNS: Parasympathetic nervous system (HF/TP); SNS: Sympathetic nervous system (LF/HF);TG: Triglycerides; TP: Total power (ms²); WC: Waist circumference; WHR: Waist-to-hip ratio