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The Prevalence of Ontario Undergraduate University Students Meeting the 24-Hour Movement Guidelines and the Role of Perceived Social Support

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Abstract

The extensive physical and mental health implications of physical activity, sedentary behaviour, and sleep are irrefutable. The COVID-19 pandemic has had drastic consequences on university students and their already poor movement behaviours. Recommendations for a healthful distribution of physical activity, sedentary behaviour, and sleep were presented in the Canadian 24-Hour Movement Guidelines for Adults. The current research sought to report the prevalence of Ontario undergraduate university students meeting the Guidelines approximately two and a half years into the pandemic and assess the association between meeting the Guidelines and perceived social support. A total of 508 undergraduate students registered at 19 universities across Ontario completed the online survey. Only one participant (0.2%) met all recommendations set out in the Guidelines. Biserial correlation revealed a small significant correlation between meeting the sedentary time component of the Guidelines and social support. Meaningful intervention is needed to improve the movement behaviours of university students.

Keywords: physical activity, sedentary behaviour, sleep, university students, movement behaviours, social support

Summary for Lay Audience

Participating in enough physical activity and sleep while also limiting sedentary behaviour has been associated with countless health benefits. Unfortunately, university students have struggled to participate in recommended amounts of these behaviours. The pandemic has negatively impacted university students' already poor movement behaviours. In 2020, the Canadian Society for Exercise Physiology released new guidelines for physical activity, sedentary behaviour, and sleep, entitled *"The Canadian 24-Hour Movement Guidelines for Adults."* In the current study, the research team aimed to assess how many Ontario undergraduate university students were meeting the Guidelines approximately two and a half years into the pandemic. This study also looked at whether perceived social support (i.e., the perception of help received from interpersonal relationships) was associated with university students meeting the Guidelines. A total of 508 undergraduate students registered at 19 universities across Ontario completed the online survey. Only one participant (0.2%) met all recommendations set out in the Guidelines. Students most often met individual recommendations for moderate-to-vigorous intensity physical activity, when walking was included. Students most often did not meet recommendations for recreational screen time. Biserial correlation revealed a small significant correlation between meeting the sedentary time component and social support. The stark lack of students meeting the Guidelines is concerning. Meaningful intervention is needed to improve the movement behaviours of university students. Social support may be beneficial to help students improve their movement behaviours, specifically by helping to reduce their sedentary time.

Co-Authorship Statement

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List of Abbreviations

IPAQ-SF: International Physical Activity Questionnaire – Short Form

MSEQ-SF: Muscle-Strengthening Exercise Questionnaire Short Form

MSPSS: Multidimensional Scale of Perceived Social Support

MVPA: Moderate-to-vigorous physical activity

METs: Metabolic equivalent tasks

Chapter 1: Introduction

It is irrefutable that physical activity, sedentary behaviour, and sleep (i.e., movement behaviours) have serious implications for overall health and well-being (e.g., Biswas et al., 2015; Rollo et al., 2020; Warburton et al., 2006; Yin et al., 2017). Despite the well-established health consequences, researchers have reported that many Canadian adults aged 18 to 79 years do not meet the recommendations for these movement behaviours (ParticipACTION, 2021), which are summarized within the relatively new Canadian 24-Hour Movement Guidelines for Adults (Ross et al., 2020), hereafter referred to as *the Guidelines*. Monitoring compliance to the Guidelines provides researchers with a fulsome understanding of movement behaviours, as time spent in one behaviour has a resultant increase in time spent in another behaviour. Therefore, considering the time spent in each movement behaviour within the context of the other movement behaviours is more meaningful than analyzing each behaviour in isolation, and helps researchers to identify how the behavioural distribution might be best targeted by intervention.

Prior to the COVID-19 pandemic, hereafter referred to as *the pandemic*, university students were identified as a subgroup of adults that regularly did not meet recommendations for the movement behaviours (Ross et al., 2020; Weatherson et al., 2021). Worryingly, researchers around the world have suggested that the pandemic has exacerbated university students' already poor movement behaviours (Bertrand et al., 2021; Suherman et al., 2021; Wright et al., 2020). However, most of this research was conducted during the early months of the pandemic and reflected periods of time when stay-at-home orders and other stringent public health protections were in place. To inform future interventions and improve university students' compliance to the Guidelines since the onset of the pandemic, it is important to first have an updated understanding of the magnitude of the problem (i.e., the prevalence of students meeting and not meeting the

Guidelines). Although the pandemic has impacted all nations around the world, in Canada, public health protections were implemented on a provincial level (Canadian Institute for Health Information, 2022). Therefore, some of the associated movement behaviour challenges are likely to have been experienced differently depending on geographic location, rendering it suitable to assess compliance to the guidelines in each province independently.

In addition to understanding the prevalence of students meeting the Guidelines, it is also important that researchers understand the correlates of movement behaviours. Previously, researchers have explored the multidimensional correlates that influence students' physical activity (Deliens et al., 2015), sedentary behaviour (Castro et al., 2018; Deliens et al., 2015), and sleep (F. Wang & Bíró, 2021), independently. However, as these behaviours are highly related (Chastin et al., 2015; Pedišić, 2014), their correlates may also be connected. One correlate that is known to affect all three movement behaviours is social support, which is defined as the "aid and assistance exchanged through social relationships and interpersonal transactions" (Heaney & Israel, 2008, p. 191). Social support may act to influence a person's ability to make and sustain healthy lifestyle behaviour changes, such as increasing physical activity and sleep and decreasing sedentary behaviour (Williams et al., 2013).

Not surprisingly, in addition to being potentially associated with problematic changes in movement behaviours, the pandemic has also influenced many correlates of those movement behaviours, including social support (Guerrero et al., 2020). For example, university students have experienced reduced opportunities to form on-campus social support networks (Patterson et al., 2021). Consequently, a reduction in social support may have had negative influences on students' physical activity, sedentary behaviour, and sleep (Castro et al., 2018; Krause & Rainville, 2020; Luchene & Delens, 2021). Understanding university students' movement

behaviours, the influence of social support, and the current state of students' social support is vital information to support a generation of students whose movement behaviour patterns may be putting them at an increased risk of physical and mental health concerns.

Rooted in the above content, the two-fold purpose of the current study was to (1) assess the prevalence of full-time Ontario undergraduate university students meeting the Canadian 24-Hour Movement Guidelines approximately two and a half years into the pandemic and (2) assess the association between meeting the Guidelines and perceived social support. It was hypothesized that fewer than 5% of Ontario university undergraduate students would be meeting the Guidelines. This was hypothesized because just prior to the pandemic starting, Weatherson et al. (2021) reported that 9.9% of students were meeting the Guidelines, and since the onset of the pandemic, researchers have reported problematic changes to university students' physical activity, sedentary behaviour, and sleep (Benham, 2021; Huber et al., 2020; Wright et al., 2020). Because social support has been associated with improvement to all three movement behaviours included in the Guidelines, it was hypothesized that perceived social support would be associated with meeting the Guidelines. Specifically, it was expected that a higher level of perceived social support would be associated with an increased likelihood of meeting the Guidelines. To further underscore the rationale for this study's purpose, what follows is a review of the relevant literature to highlight what is currently known about university students' movement behaviours before and during the pandemic, and the association of these behaviours with social support. Next, a description of the methods used is presented followed by the results, a discussion of the results as they apply to the study purpose, and the study conclusion.

Chapter 2: Literature Review

To provide the necessary background to contextualize the purpose of the current study, the following review of the literature begins with an overview of the three movement behaviours: physical activity, sedentary behaviour, and sleep. For each behaviour, the definition and consequences of not meeting recommended levels is presented. Next, the Canadian 24-Hour Movement Guidelines (i.e., the Guidelines), and their rationale, are introduced. Subsequently, the importance of studying university students and their movement behaviours is outlined. Previous research related to students' compliance to the Guidelines and students' participation in each individual component of the Guidelines is then described. Next, the influence of the pandemic on students, and their movement behaviours, is addressed. Thereafter, the correlates of meeting the Guidelines and the individual movement behaviours are discussed, noting particularly the interconnectedness of these correlates. Specifically, social support, and its potential role in compliance to the Guidelines, is highlighted. The theoretical frameworks that underscore the importance of social support are also briefly described. Then, the influence of the pandemic on university students' social support is discussed. Finally, the resultant purpose of this study, inclusive of the hypotheses, is presented.

Movement Behaviours

Over the last decade, researchers have been focussing attention on the entire movement continuum that progresses from sleep to sedentary behaviour to physical activity (Tremblay et al., 2010). As behaviours progress along the movement continuum, greater energy expenditure, measured in metabolic equivalent tasks (METs), is required. Importantly, the three movement behaviours comprise the fixed 24-hour day; and therefore, the time spent in each behaviour is not independent of the time spent in the other movement behaviours (Chastin et al., 2015; Pedišić,

2014). That is, if the total time spent in one behaviour is changed, there is a resultant change in the time spent in one or more of the remaining two behaviours. Each behaviour on the continuum will be discussed in further detail, below.

Physical Activity

Physical activity, as defined by Caspersen et al. (1985), refers to "any bodily movement produced by skeletal muscles that results in energy expenditure" (p. 126). The intensity, and subsequent required energy expenditure, of physical activity can vary from light to vigorous and is defined by the METs needed to perform the activity. Light physical activity refers to movements requiring between 1.6 and 3 METs and includes incidental movements such as standing or light housework (Tremblay et al., 2010). Moderate physical activity refers to movements requiring between 3 and 5.9 METS and may include activities such as brisk walking or dancing (Ainsworth et al., 2012). Finally, vigorous activities are those requiring 6 METS or more, for example jogging or fast cycling (Ainsworth et al., 2012).

The health benefits of all intensities of physical activity are well-known and can be achieved across the lifespan (Warburton et al., 2006). Engagement in physical activity of any intensity has been associated with various physical health benefits such as a decreased risk of numerous chronic diseases including cardiovascular disease, all-cause mortality, all-cancer mortality, type 2 diabetes, hypertension, breast cancer, colon cancer, gestational diabetes, gallstone disease, ischemic heart disease, and ischemic stroke (Warburton & Bredin, 2017). Physical activity of any intensity has also been associated with vast improvements in energy levels, mood, resilience, mental health, and well-being (Fox, 1999; Hegberg & Tone, 2015).

Sedentary Behaviour

Sedentary behaviour is commonly defined as "any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Sedentary Behaviour Research Network, 2012, p. 540). Unfortunately, many physical and psychological health risks have been associated with increased sedentary behaviour (Park et al., 2020). Specifically, a sedentary lifestyle has been associated with increased all-cause mortality, cardiovascular disease mortality, cancer risk, and risks of metabolic and musculoskeletal disorders, depression, and cognitive impairment (Park et al., 2020). Sedentary behaviour has often coincided with recreational screen use (Saunders et al., 2020), which is defined as "all discretionary (e.g., nonemployment or school required) and leisure-time screen time done while sedentary and typically includes television viewing, video-games use and computer use" (Tremblay et al., 2016, p. S324). Recreational screen time has been associated with negative health consequences including reduced mental health (Thomée et al., 2011), sleep impairments (Sampasa-Kanyinga et al., 2018), and musculoskeletal symptoms (S. Lee et al., 2015). Importantly, sedentary behaviour must be distinguished from a lack of physical activity, as sedentary behaviour has unique physiological responses, measurement techniques, and intervention strategies (Tremblay et al., 2010). Furthermore, the two behaviours are not mutually exclusive as those who achieve high levels of physical activity may still participate in high levels of sedentary behaviour, which is associated with independent risks (Tremblay et al., 2010). The physiological adaptations and responses to sedentary behaviour are not merely the opposite of physical activity (Tremblay et al., 2010).

Sleep

Sleep is defined as "a naturally recurring state of body and mind characterized by altered consciousness, relatively inhibited sensory activity, inhibition of nearly all voluntary muscles and reduced interactions with surroundings" (Chaput et al., 2017, p. 8). Sleep duration, timing, and consistency have been found to play an important role in a variety of health outcomes (Chaput, Dutil, Featherstone, Ross, Giangregorio, Saunders, Janssen, Poitras, Kho, Ross-White, & Carrier, 2020; Chaput, Dutil, Featherstone, Ross, Giangregorio, Saunders, Janssen, Poitras, Kho, Ross-White, Zankar, et al., 2020). An excessive or insufficient sleep duration has been associated with increased risk of cardiovascular events and all-cause mortality (Yin et al., 2017), coronary heart disease (D. Wang et al., 2016), type 2 diabetes (Shan et al., 2015), cognitive disorders (L. Wu et al., 2018), falls (L. Wu & Sun, 2017), and reduced cognitive functioning (Lo et al., 2016).

The Need for Cohesive Recommendations

As the three movement behaviours are interrelated, an increase in time spent in one behaviour over a given day reduces time spent in one or more of the other behaviours. There is considerable evidence that variable health outcomes depend on the movement behaviour that is displaced (Chastin et al., 2015; Janssen et al., 2020; McGregor et al., 2018; Rollo et al., 2020). Janssen and colleagues (2020) found that daily movement behaviour composition was related to all-cause mortality, adiposity, and cardiometabolic biomarkers. The most favourable health outcomes were attained by reallocating time from other movement behaviours (e.g., light physical activity or sedentary behaviour) into moderate-to-vigorous physical activity (MVPA; Janssen et al., 2020), which is any physical activity performed at greater than 3 METS (Ainsworth et al., 2012). Additionally, reallocating time from sedentary behaviour into other

movement behaviours (e.g., light physical activity or MVPA) was associated with reduced all-cause mortality (Janssen et al., 2020). Buman and colleagues (2014) found that reallocating sedentary behaviour to light physical activity was also associated with improved health outcomes, such as lower triglyceride and insulin levels. It is therefore more meaningful to consider the 24-hour composition of behaviours, and how these movement behaviours interact, rather than analyzing behaviours in isolation. This knowledge highlighted the need for a cohesive set of population health recommendations considering movement behaviours across the 24-hour day.

The Canadian 24-Hour Movement Guidelines

In 2016, Canada became the first country to release a set of guidelines providing recommendations for all movement behaviours along the movement continuum (Tremblay et al., 2016). Since then, similar guidelines have been released internationally including in Australia (Okely et al., 2022), South Africa (Draper et al., 2020), and the Asia-Pacific region (Loo et al., 2021). The first set of Guidelines provided recommendations for children and youth aged 5 to 17 years (Tremblay et al., 2016). Since 2016, the Canadian Society for Exercise Physiology and partners have released Guidelines for across the lifespan including the earlier years (Tremblay et al., 2017), adults (Ross et al., 2020), and older adults (Ross et al., 2020). The Guidelines are a tool for policy makers, health professionals, and researchers to make evidence-based recommendations and monitor population behaviour (Ross et al., 2020).

According to the recommendations laid out in the Guidelines, adults aged 18 to 64 years should accumulate at least 150 minutes per week of MVPA in addition to performing muscle strengthening activities using major muscle groups at least twice a week (Ross et al., 2020). Adults should also perform several hours of light physical activity every day (e.g., standing).

Sedentary behaviour should be limited to 8 hours or less per day, with frequent breaks, and include no more than 3 hours of recreational screen time per day. Finally, it is recommended that adults get 7 to 9 hours of good-quality sleep on a regular basis, with consistent bed and wake-up times. Good-quality sleep is not specifically defined within the Guidelines, but has been conceptualized to include considerations of sleep latency, number of awake episodes greater than 5 minutes in length, total time awake after sleep onset, and sleep efficiency (Ohayon et al., 2017). To attain optimal health benefits, adults should replace sedentary behaviour with physical activity of any intensity, and replace light physical activity with MVPA, while preserving adequate sleep (Ross et al., 2020). For the purpose of the current study, the targets for the overarching behaviours (i.e., physical activity, sedentary behaviour, and sleep) will be known as *recommendations*, while the targets for the behaviours encompassed in these recommendations (i.e., MVPA, light physical activity, muscle strengthening activity, sedentary time, recreational screen time, break frequency, and sleep) will be referred to as *components*.

The Importance of Focusing on University Students and their Health Behaviours

The years spent in university are known as a period of significant change for many young adults as they transition from adolescence to adulthood while navigating higher education. This time period often involves living away from home for the first time, gaining newfound freedom, and making new friends (Arnett, 2000; Compas et al., 1986). Simultaneously, students must adapt to new expectations and norms to learn in a university environment (Briggs et al., 2012; Gall et al., 2000). Unfortunately, this complex period of change is often accompanied by unhealthy behaviour changes, such as unhealthy eating patterns, excessive alcohol consumption, insufficient physical activity, and risky sexual behaviour (Dodd et al., 2010; Holt & Powell, 2017; Kwan et al., 2012). Concerningly, given the unhealthy behaviour changes, the years spent

in university and, for most, the corresponding transition into adulthood may be a time when many students establish their lifelong health behaviour patterns (Nelson et al., 2008; Von Ah et al., 2004). This behavioural tracking over time emphasizes the importance of studying and improving university students' health behaviours. As students transition into roles as policy makers, managers, and healthcare professionals, their individual experiences and beliefs about health and healthy lifestyles, as shaped through their university years, will play an important role in determining future public health decisions (Leslie et al., 1999; Sparling et al., 2000).

Universities have an especially important role to play in supporting the health of their students, which was emphasized by the Okanagan Charter (International Conference on Health Promoting Universities and Colleges, 2015). The Okanagan Charter called for higher education institutions to embed health into everyday practices, business decisions, and academic mandates, as well as to be leaders in health promotion action and collaboration (International Conference on Health Promoting Universities and Colleges, 2015). Considering over 450,000 undergraduate students are enrolled at universities in Ontario (Ontario Universities, 2022), these provincial universities have the opportunity to engage large numbers of students in behaviour change interventions. Furthermore, as the number of students participating in higher education continues to grow (Statistics Canada, 2021), so too does the importance of addressing their poor health behaviours. In particular, a collection of university students' health behaviours that have been the focus of a substantial amount of research prior to the pandemic is that of their movement behaviours.

University Students' Movement Behaviours

Prior to the pandemic, university students were identified as a subset of the adult population in Canada who participated in insufficient physical activity and sleep, as well as

participating in excessive sedentary behaviour (Ross et al., 2020). Physical activity, sedentary behaviour, and sleep have predominantly been studied independently (e.g., Becker et al., 2018; Castro et al., 2020; Thomas et al., 2019), though, as previously described, it is more meaningful to consider the distribution of these behaviours. In Canada, only one known study has specifically examined all movement behaviours, which was achieved through an evaluation of university students' compliance to the Guidelines (Weatherson et al., 2021). Weatherson and colleagues (2021) used data collected in 2019 and early 2020 (i.e., pre-pandemic) and found that, from a sample of 24,760 students from 20 post-secondary institutions across Canada, only 9.9% of students were meeting the recommendations for physical activity, sedentary behaviour, and sleep, as determined via four measured components of the Guidelines: MVPA, sleep, sedentary time, and recreational screen time. Of the four components, meeting the MVPA component was the most prevalent (61.1%), followed by sleep (59.7%), sedentary time (56.3%) and recreational screen time (36.2%; Weatherson et al., 2021). The poor compliance to the Guidelines reported prior to the pandemic is troubling and suggests additional research is needed among this population. Concerningly, researchers have suggested the pandemic has had a negative impact on university students and their already poor movement behaviours (Benham, 2021; Huber et al., 2020; Wright et al., 2020; Zheng et al., 2020). Given that limited research is available that examines university students' movement behaviours concurrently, what follows is a summary of what is known about each behaviour individually before the pandemic. Next, an overview of how the pandemic has impacted university students in particular will be presented, which is intended to help contextualize the subsequent review of university students' movement behaviours during the pandemic.

University Students and Physical Activity Pre-Pandemic

Regular engagement in physical activity has been documented as gleaning substantial benefits for the health and wellbeing of young adults (e.g., San Román-Mata et al., 2020; Sothern et al., 1999). Additionally, regular physical activity has been associated with greater retention of first-year students and improved graduation rates (Huesman et al., 2009). Of notable importance are the effects of physical activity on mental health. In Canada, many university students deal with poor mental health and high levels of stress (American College Health Association, 2019; Canadian Alliance of Student Associations, 2022; Durand-Bush et al., 2015). Over the last decade, the proportion of students reporting psychological distress, mental illness diagnoses, and help seeking for mental health related challenges has been significantly increasing (Linden et al., 2021). However, regular physical activity participation may help to ameliorate these mental health concerns as physical activity has been associated with a reduction in perceived stress (Nguyen-Michel et al., 2006), lower rates of anxiety and depression (Tyson et al., 2010), and a reduced risk of hopelessness, depression, and suicide (Taliaferro et al., 2009).

Despite the well-established benefits, beginning university has been reported to coincide with a decrease in physical activity participation (Kwan et al., 2012; Larouche et al., 2012). Before the pandemic, on average, university students participated in inadequate levels of physical activity to attain health benefits (Irwin, 2007; Wilson et al., 2021). In 2019, only 13.3% of Canadian students (n = 55,284) reported participating in the recommended 150 minutes of MVPA per week (American College Health Association, 2019). There is both an immediate and long-term concern for the health and well-being of university students as a result of their high level of inactivity (e.g., increased immediate risk of depression and anxiety and long-term risk of chronic disease and premature mortality; I. M. Lee et al., 2012; Uddin et al., 2020). Like other

health behaviours, physical activity habits developed in university are likely to endure throughout the lifespan (Keating et al., 2005; Kjønniksen et al., 2008). In an American study of college alumni (n = 380), researchers reported a significant association between exercise patterns as college seniors and later as alumni (Sparling & Snow, 2002). Specifically, 81.3% of participants who were insufficiently active as college seniors reported maintaining or reducing their physical activity levels for at least ten years after graduation (Sparling & Snow, 2002). The time spent in university may, therefore, be an opportune time to increase physical activity level and cultivate healthy lifestyle habits.

University Students and Sedentary Behaviour Pre-Pandemic

It has been established that university students are at a high risk of excessive and prolonged sedentary behaviour (Castro et al., 2020; Moulin et al., 2021). The physical environments at university campuses have been documented to lack opportunities for movement (von Sommoggy et al., 2020), while university living arrangements (i.e., living in a student residence), university lifestyle (i.e., social norms and peer pressure), and academic pressure (i.e., studying, classes, and exams) have been reported to encourage excessive sedentary behaviour (Deliens et al., 2015). Worryingly, the level of sedentary behaviour of university students has been increasing over the last decade (Castro et al., 2020). Castro and colleagues (2020) found that, on average, university students were accumulating a level of sedentary behaviour that has been associated with an elevated risk for detrimental health outcomes. Moulin and colleagues (2021; 2017) found that university students sat for an average of greater than approximately 11 hours per day, which substantially surpasses the sedentary time recommendations outlined in the Guidelines.

Reducing sedentary behaviour has important health and well-being implications among university students. In a study of American college students (n = 993), the participants predicted standing, instead of sitting, in class would improve their physical health, attention, and restlessness (Benzo et al., 2016). Hosteng and colleagues (2019) supported this contention as they found prolonged bouts of sedentary behaviour were associated with discomfort and sleepiness among university students. Additionally, Felez-Nobrega and colleagues (2018) found that taking breaks from sedentary behaviour every 10 to 20 minutes was associated with improvements in cognitive performance and may increase academic performance. Interestingly, university students with high amounts of daily MVPA have been reported to also participate in high amounts of sedentary time, highlighting the importance of exploring behaviours across the whole day to provide a fulsome understanding of the healthfulness of their behaviours (Peterson et al., 2018).

University Students and Sleep Pre-Pandemic

Unfortunately, university students around the world commonly have not met recommendations for sufficient sleep (Becker et al., 2018; Gaultney, 2010; Lund et al., 2010). Patterns of insufficient sleep, poor sleep quality, and irregular sleep-wake times were reported in high levels among university students (Becker et al., 2018; Gaultney, 2010; Lund et al., 2010). In a 2017 study of Canadian university students, sleeping less than 6.5 hours a night was reported by 30.5% of participants (C. A. Brown et al., 2017). Furthermore, 66.5% of students reported insufficient sleep and 80.6% had not sought help (C. A. Brown et al., 2017). Among this population, poor sleep has been correlated with poor academic performance and physical and mental health difficulties (Orzech et al., 2011; Wong et al., 2013).

The Impact of the Pandemic on University Students and their Movement Behaviours

In Canada, university students have been identified as a group of adults who have been particularly impacted by the pandemic (Statistics Canada, 2020). At the onset of the pandemic, students reported high levels of academic challenges in addition to employment uncertainties and financial difficulties (Statistics Canada, 2020). As a consequence of necessary public health protections to curb the spread of COVID-19, students have faced numerous challenges including transitions to and from online learning, implications of physical distancing measures, learning disruptions, and the cancellation of enriched learning opportunities (e.g., labs, tutorials, field camps; Crawford et al., 2020). Additionally, the pandemic is likely to have affected future educational opportunities, job prospects, and financial stability (Appleby et al., 2022).

The numerous challenges experienced by university students during the pandemic are likely to have affected their health behaviours. Since the onset of the pandemic, university students around the world have been participating in less physical activity (Huber et al., 2020), more sedentary behaviour (Zheng et al., 2020), and more sleep (Benham, 2021; Wright et al., 2020) contrasted by worsened sleep quality (Hyun et al., 2021). However, these findings were from studies conducted early during the pandemic including during stay-at-home orders or initial periods of isolation (Benham, 2021; Huber et al., 2020; Hyun et al., 2021; Wright et al., 2020; Zheng et al., 2020). As the pandemic is a recent, on-going, and evolving public health crisis, it is important that researchers continue to monitor the state of movement behaviours as the pandemic continues.

Although researchers have found the negative influences of the pandemic on university students' sleep, physical activity, and sedentary behaviour, independently (e.g., Benham, 2021; Huber et al., 2020; Hyun et al., 2021; Wright et al., 2020; Zheng et al., 2020), few studies have

examined all movement behaviours simultaneously. Around the world, researchers have reported that the pandemic has been associated with a decrease in MVPA and a concurrent increase in sedentary behaviour among university students (Gestsdottir et al., 2021; Kowalsky et al., 2021; Luciano et al., 2021; Savage et al., 2021). Alongside negative changes to MVPA and sedentary behaviour, researchers reported reduced sleep quality (Gestsdottir et al., 2021), increased sleep duration (Luciano et al., 2021), increased screen time (Kowalsky et al., 2021), and decreased participation in muscle strengthening activities (Kowalsky et al., 2021) among university students since the pandemic's onset. These results suggest a shift towards unhealthful movement behaviour distributions among university students during the early months of the pandemic. Specific to the Guidelines and the Canadian university student context, very little research has been published since the onset of the pandemic. Bertrand and colleagues (2021) found that in April and May of 2020 (i.e., early in the pandemic) only 9.6% of Canadian university students were meeting the MVPA component, while 30% were meeting the sedentary time component of the Guidelines. These students retrospectively reported a significant decrease in meeting both the MVPA and sedentary time components after the onset of the pandemic (Bertrand et al., 2021). It is important to note that no assessment of meeting the Guidelines has been conducted since the initial months of the pandemic when stay-at-home orders and other stringent public health protections were in place. It is important to understand the state of university students' movement behaviours as they are continuing to navigate the pandemic while public health measures are being removed.

Correlates of Meeting the Guidelines

It is imperative that researchers and public health professionals work to understand and support changes to university students' movement behaviours to increase their compliance to the

Guidelines. Before a potential behaviour change intervention can be implemented, it is important to first understand the correlates that impede or encourage students to meet the Guidelines (Graham et al., 2006). Presently, correlates have been widely studied *independently* for each behaviour included in the Guidelines (e.g., Castro et al., 2018; Deliens et al., 2015; F. Wang & Bíró, 2021). These factors are summarized in the content below. Nevertheless, the interconnectedness of these behaviours must not be dismissed. As the Guidelines are a recent addition to the literature, few researchers have explored the interconnected factors that may encourage or restrict an individual's ability to meet the Guidelines.

Thus far, two known studies have explored correlates of meeting the Guidelines. Buchan and colleagues (2020) explored the factors associated with Canadian high school students' compliance to the Guidelines, both cross-sectionally and longitudinally. Buchan et al. (2020) identified that participation in community sport along with parental support of physical activity were associated with an increased likelihood of meeting the Guidelines. Although this study examined an adolescent population, an interesting connection to university students can be noticed. During the transition from high school to university, patterns of parental support and social networks tend to shift and may serve different roles (Nelson et al., 2008). The years spent in university is often inundated with peer-to-peer interactions, such as living, attending classes, studying, and socializing with fellow students (Brooks, 2007). This leads to the contention that the parental support role in determining movement behaviours might be reallocated to peers, as they are a more common support system among young adults (Pugliese & Okun, 2014). Additional research is needed to understand patterns of evolving social influence on health behaviours during university (Nelson et al., 2008).

Specific to university students, Giouridis (2020) completed a qualitative study to examine the perceived barriers and facilitators to meeting the Guidelines among first-year university students in Canada. Giouridis (2020) found that influences operate on multiple levels to impact students' abilities to meet the Guidelines. Specifically, individual factors (i.e., perceptions of the Guidelines, motivation, fluctuating responsibilities), the social environment (i.e., personal relationships with family and peers, cultural influences), and the physical environment (i.e., infrastructure, environmental conditions) were potent influencers on first-year university students' ability to meet the Guidelines (Giouridis, 2020). In terms of social relationships, the author found that support from peers seemed to facilitate healthy physical activity and sedentary behaviours (Giouridis, 2020). However, some students mentioned that peers also deterred them from performing healthy movement behaviours (Giouridis, 2020). More research is needed to clearly outline these relationships. Although little research has examined the correlates specific to meeting the Guidelines, many studies have explored multidimensional factors that contribute to the individual movement behaviours. From reviewing the research, it is clear that there are commonalities in correlates among the movement behaviours, suggesting the importance of examining common correlates to more efficaciously support individuals to meet the Guidelines.

Physical Activity

Among adults in general, Trost et al. (2002) found correlates of physical activity participation fell into six different categories: (1) demographic and biological factors; (2) psychological, cognitive, and emotional factors; (3) behavioral attributes and skills; (4) social and cultural factors; (5) physical environment factors; and (6) physical activity characteristics. Among university students specifically, researchers have also explored many multidimensional correlates (Carballo-Fazanes et al., 2020; Deliens et al., 2015). To date, no known review of

physical activity correlates for university students has been completed; however, Silva and colleagues (2022) completed a systematic review to examine barriers to high school and university students' participation in physical activity. The review from Silva and colleagues (2022) offers an interesting perspective, as the difference in barriers between the two populations may be reflective of factors related to transitioning into university. That is, among high school students, the main barriers to physical activity were categorized into the following dimensions: psychological, emotional, and cognitive (lack of time and motivation); sociocultural (lack of social support); and environmental (lack of accessible places; Silva et al., 2022). However, among undergraduate university students, the main barriers to physical activity were psychological, emotional, and cognitive (lack of time and motivation); environmental (lack of accessible places); and socioeconomic and demographic (lack of financial resources; Silva et al., 2022). Interestingly, the barrier of lack of social support was not present among university students. This suggests there may be a change in social support upon entering university that might play a role in changes in physical activity behaviour. As the transition to university has been associated with decreases in physical activity participation (Bray & Born, 2004), understanding changes in correlates during this time may be especially pertinent to improving physical activity behaviour.

Researchers have underscored the interconnectedness of physical activity correlates with other movement behaviours. For example, Loustalot et al. (2013) found that students who met recommendations for muscle strengthening activities were more likely to also meet the MVPA recommendations. As well, Deliens and colleagues (2015) found students felt that factors that increase physical activity often decrease sedentary behaviour simultaneously. The

interconnectedness of these behaviours suggests their correlates may also be connected and highlights a need for future research on these interconnected correlates.

Sedentary Behaviour

In 2018, Castro and colleagues conducted a systematic review to explore the many multi-level correlates of sedentary behaviour among university students. They found evidence of a range of correlates, including intrapersonal, interpersonal, environmental, and time (Castro et al., 2018). However, significant additional research is needed to draw concrete conclusions about these correlates and their specific influences on sedentary behaviour (Castro et al., 2018). In a qualitative study conducted by Deliens et al. (2015), the authors found that students perceived that their sedentary behaviour was influenced by individual factors (i.e., perceived enjoyment, self-discipline, time, and convenience), social influences (i.e., lack of social support, parental control, modelling), the physical environment (i.e., availability and accessibility, travel time/distance, prices), and the macroenvironment (i.e., media and advertising). Many studies have drawn attention to the influence of the physical campus environment and pervasive university culture, such as lecture hall seating and academic pressure, on university students' sedentary behaviour (Deliens et al., 2015; Moulin & Irwin, 2017; Prapavessis et al., 2015; Smetaniuk et al., 2017). Some of the studies evaluating sedentary behaviour also included considerations of physical activity, further highlighting the interconnectedness of these behaviours and their correlates (Deliens et al., 2015; Smetaniuk et al., 2017).

Sleep

Wang and Bíró (2021) conducted a systematic review and identified many multidimensional correlates of sleep behaviour among university students. The correlates were categorized into lifestyle correlates (e.g., smoking, physical activity), correlates related to mental

health (e.g., depression, stress), social correlates (e.g., social relationships, racial discriminations), and physical factors (e.g., pain, sleep medications; F. Wang & Bíró, 2021). The inclusion of physical activity as a correlate of sleep, further contributed to the importance of considering the interconnectedness of movement behaviours. In terms of social relationships, the existence of healthy social relations has been associated with improved sleep quality (F. Wang & Bíró, 2021).

Interconnected Correlates of Movement Behaviours

In recent years, researchers have begun to focus on multiple health behaviour change, which is defined as "efforts to promote two or more health behaviors" (J. J. Prochaska et al., 2008, p. 3). To have the most efficacious influence on people, health promotion efforts should aim to simultaneously improve multiple health behaviours (J. J. Prochaska et al., 2008). A multiple health behaviour approach focuses on the link among health behaviours (Noar et al., 2008). Findings from researchers in the realm of multiple health behaviour change support the interconnectedness of movement behaviours and their correlates (J. J. Prochaska et al., 2008). Specifically, these findings have important implications in that the understanding of correlates is vital to developing effective behaviour change interventions. Further, Sweet and Fortier (2010) found that successfully changing a behaviour may contribute to increased motivation to change another, thereby increasing the likelihood of sequential behaviour changes. Some researchers caution that participants may view multiple behaviour change as overwhelming (Alageel et al., 2018). However, the interconnectedness of the behaviours in the Guidelines means that a change in one behaviour necessitates a change in one or more of the others. This, coupled with the opportunity to focus on correlates that independently play a role in all three behaviours, suggests an important opportunity for further research and understanding.

Social Support

One correlate that has been found to play an independent role in influencing physical activity, sedentary behaviour, and sleep is social support (e.g., Galambos et al., 2013; Smetaniuk et al., 2017; Wallace et al., 2000). Social support was defined, by Heaney and Israel (2008, p. 191), as "aid and assistance exchanged through social relationships and interpersonal transactions". Broadly, social support has been identified as a factor that influences a person's ability to make and sustain healthy lifestyle behaviour changes (Williams et al., 2013). Importantly, social support is always intended (by the provider of the support) to be helpful, thus differentiating it from other negative social interactions and influences (Burg & Seeman, 1994).

There are a few distinctions that must be made when discussing social support. First, social support implies that support, or perception of support, is readily available when needed (Heaney & Israel, 2008). There is, therefore, a distinction between the support an individual receives, called *received social support*, and their perception of that support, called *perceived social support* (Heaney & Israel, 2008). While many researchers have not distinguished between these two classifications of social support, there is evidence to indicate that perceived social support is more consistently related to positive health outcomes (Uchino, 2009). Second, there are different types and sources of social support (Heaney & Israel, 2008). Types of support can include appraisal support (the provision of information), emotional support (provision of empathy, love, and caring), informational support (the provision of advice, suggestions, and information), and instrumental support (the provision of tangible aid and services; Heaney & Israel, 2008; House, 1981). Sources of social support vary, but have been shown to include primarily family, friends, peers, and significant others (Heaney & Israel, 2008; Tay et al., 2013). Social support is generated by the quantity, structure, and function of these social relationships

(House & Kahn, 1985). As briefly detailed above, social support is independently associated with all three movement behaviours. The relationship between social support and each movement behaviour will be explored in greater detail below, in addition to a brief review of the theoretical support for this relationship. Subsequently, preliminary findings related to the impact of the pandemic on university students' social support will be highlighted.

Physical Activity and Social Support

Wallace and colleagues (2000) found that, among university students, social support was one of the most influential environmental factors predicting exercise and physical activity behaviour. The results of numerous studies have supported this contention (Belanger & Patrick, 2018; Farren et al., 2017; Marmo, 2013; Rovniak et al., 2002). In fact, the effects of social support on physical activity are so pervasive, that research has developed around the topic of social support specific to physical activity (Belanger & Patrick, 2018). It is important to consider that social support for physical activity can come from a variety of sources such as family, friends, and coaches (Belanger & Patrick, 2018). The variety of social support forms include emotional support (e.g., encouragement, praise), informational support (e.g., advice, instruction), instrumental support (e.g., equipment, financial aid), modeling (e.g., demonstration), and co-participation (e.g., performing physical activity together; Duncan et al., 2005; Laird et al., 2016). Even without considering specific sources or forms of social support, the general association of global social support and physical activity has been deemed to be positive (Belanger & Patrick, 2018). Social support has also been associated with various types of physical activity (Farren et al., 2017; VanKim & Nelson, 2013). For example, Farren and colleagues (2017) found that social support was particularly influential for muscle strengthening activities while VanKim and Nelson (2013) found social support was important for vigorous physical activity.

Sedentary Behaviour and Social Support

As previously mentioned, literature on the correlates of sedentary behaviour for university students is still cursory and requires additional research (Castro et al., 2018). Nevertheless, qualitative research has highlighted the beneficial influence of social support on sedentary behaviour (Smetaniuk et al., 2017). Smetaniuk and colleagues (2017) found university students were less sedentary if their peers enjoyed engaging in physical activity. Furthermore, one of the participants stated they were less sedentary and more active as a result of having people with whom to stay active (Smetaniuk et al., 2017).

Sleep and Social Support

Researchers have found that social support is an important correlate of sleep (Galambos et al., 2013; Kent de Grey et al., 2018; Krause & Rainville, 2020; Nieminen et al., 2013). Among adults, those who reported higher levels of social support tended to sleep longer than people with weaker social relationships (Kent de Grey et al., 2018). Krause and Rainville (2020) found that this relationship was more about the perception of social support, rather than simply the amount of support that a person receives. Among university students, Galambos and colleagues (2013) found that students reported significantly longer sleep duration when they reported higher social support. Similarly, Nieminen et al. (2013) found high levels of social support were associated with adequate duration of sleep.

Movement Behaviours and Social Support – Theoretical Support

The above-noted relationships between and among movement behaviours and social support are not surprising, given social support is an important construct contained in several commonly used health-related behavioural theories including, but not limited to: social cognitive theory (Bandura, 1986), theory of planned behaviour (Ajzen, 1991), the health action process

model (Schwarzer, 1992), the transtheoretical model (J. O. Prochaska & DiClemente, 1983), and self-determination theory (Ryan & Deci, 2017). Theories can help researchers understand why certain behaviours are changed and maintained and aid in explaining the link between correlates, such as social support, and health behaviours (Bleijenberg et al., 2018; Uchino, 2009).

Importantly, the aforementioned theories each highlight different aspects of the influence of social support on health behaviours. For example, Bandura (1989) underscored the importance of considering social support through social cognitive theory's self-efficacy promoting constructs such as verbal persuasion and vicarious experiences. In the health action process model, Schwarzer (1992) posited that instrumental, emotional, and informational social support can be particularly influential after an individual has formed a positive intention towards a behaviour. According to self-determination theory, social support may increase the basic psychological need of relatedness, the feeling of social connectivity and acceptance, thereby facilitating motivation for behaviour change (Ryan & Deci, 2017). While each theory has addressed social support in a different way, together, they underscore the value social support has in helping to facilitate behaviour change. The combination of these theoretical underpinnings draws further attention to the vast influences of social support on health behaviours, including the movement behaviours of physical activity, sedentary behaviour, and sleep. In sum, these and other theories underscore the relevance of social support in a wide range of health behaviours including those in the Guidelines.

University Students' Social Support During the Pandemic

Social support is a pertinent and timely variable to study within university student populations, as the pandemic has undoubtedly had an influence (Elmer et al., 2020; Lancaster & Arango, 2021). For example, Lancaster and Arango (2021) found that, for some students,

physical distancing measures may have eliminated entire sources of social support or completely prevented the formation of new social support networks. Elmer and colleagues (2020) similarly found that, among university students in Switzerland, the university closures and physical distancing measures negatively affected the social integration of some individuals, leaving them partly isolated. The pandemic-related reduction in social support was also associated with an increased development of mental health problems (Elmer et al., 2020). Elmer and colleagues (2020) advocated for further research in this area as universities continue to develop hybrid teaching strategies for future academic years, especially for newly enrolled students who have not yet been able to form social ties with their peers.

Few researchers have explored social support and movement behaviours among university students during the pandemic. In a study of 2,688 college students in China, lower levels of internet addiction were associated with higher social support (Jiang et al., 2022). Among 459 college students in China, Tian and Shi (2022) found social support positively predicted exercise adherence during the pandemic. Similarly, among 230 American college students, Dziewior and colleagues (2022) found social support was the top facilitator of physical activity during the first year of the pandemic. Dziewior and colleagues (2022) also found a significant reduction in social support reported by students between May and September of 2020. No known researchers have thus far evaluated the connections between social support, sleep, and sedentary behaviour or multiple movement behaviours among university students during the pandemic.

Importance of Studying University Students' Movement Behaviours, and their Association with Social Support During the Pandemic

Prior to the pandemic, Weatherson and colleagues (2021) found the prevalence of Canadian university students' meeting the Guidelines was concerningly low. Since then, researchers examining movement behaviours and the lives of university students suggest that the pandemic may have greatly influenced university students' compliance to the Guidelines (Bertrand et al., 2021; Kowalsky et al., 2021; Liang et al., 2021; Luciano et al., 2021). However, no researchers have evaluated university students' compliance to all three recommendation, and all seven components, of the Guidelines in Canada since the onset of the pandemic. Understanding the current movement behaviours of university students, in the context of the ongoing pandemic, is needed to inform interventions to support optimal movement behaviours. The initial and ongoing pandemic response in Canada has and continues to vary across provinces, justifying a focus on Ontario students specifically (Detsky & Bogoch, 2020). As many public health protections are being removed, and students are returning to in-person class, it is unclear how the current university environment, as a result of the pandemic, might have changed university students' compliance to the Guidelines.

Perceived social support has been most consistently related to positive health outcomes (Uchino, 2009), and social support is known to independently affect all three movement behaviours captured in the Guidelines (Castro et al., 2018; Deliens et al., 2015; Krause & Rainville, 2020; Luchene & Delens, 2021; Smetaniuk et al., 2017). However, it is unclear whether there is an association between perceived social support and meeting the Guidelines overall. Furthermore, it is evident that university students' social support networks have been disrupted by the pandemic (Elmer et al., 2020; Lancaster & Arango, 2021). However, it is

unclear how the pandemic might have changed university students' perceived social support and thereby compliance to the Guidelines.

Study Purpose

Informed by the literature reviewed above, the first of this cross-sectional observational study's two-fold purpose was to assess the prevalence of full-time Ontario undergraduate university students meeting the Canadian 24-Hour Movement Guidelines approximately two and a half years into the pandemic. It was hypothesized that fewer than 5% of Ontario university undergraduate students would be meeting the Guidelines. This was hypothesized because just prior to the pandemic starting, Weatherson et al. (2021) reported that 9.9% of students were meeting the Guidelines, and since the onset of the pandemic, researchers have reported concerning changes to university students' physical activity, sedentary behaviour, and sleep (Benham, 2021; Huber et al., 2020; Wright et al., 2020). The second purpose of this study was to assess the association between meeting the Guidelines and perceived social support. Because social support has been associated with improvement to all three movement behaviours included in the Guidelines, it was hypothesized that perceived social support would be associated with meeting the Guidelines. Specifically, it was expected that a higher level of perceived social support would be associated with an increased likelihood of meeting the Guidelines.

Chapter 3: Methods

Study Design and Sample Size

The current study was cross-sectional and observational. Sample size was calculated a priori for this study and considered both purposes. Following recommendations from Sharma et al. (2020), sample size was calculated for observational studies with a finite population using the variables of total population (i.e., the number of fulltime undergraduate students enrolled in Ontario universities; N) and margin of error (d) with the formula: sample required (n) = $N/1+N*d^2$. For the study's first purpose, the inclusion of a minimum of 400 participants was deemed sufficient for a population of 465,692 fulltime undergraduate students (Ontario Universities, 2022), with a 5% margin of error ($p < 0.05$). For the second purpose, a sample size of 262 was deemed sufficient for correlational analysis by G*Power Software (version 3.1) to achieve a power of 0.95, with a small effect size of 0.2 and $\alpha = 0.05$. As such, a target sample size of 400 was selected to encompass both purposes.

Eligibility Criteria and Associated Rationale

Participants were eligible to participate if they were: (1) registered as a full-time undergraduate student at an Ontario university; and (2) able to read and write in English. Participants were excluded from the study if they were: (1) a part-time student; (2) registered at a university outside of Ontario; (3) registered at a college; (4) registered in a professional or graduate program; and (5) unable to read and write in English. In Canada, the public health measures that were implemented in response to the pandemic were largely provincially mandated and varied between and among provinces across the country (Canadian Institute for Health Information, 2022). Therefore, the geographic limitation of Ontario-only students was selected. As universities and colleges in Ontario offer different learning experiences and program lengths,

undergraduate university students were the sole focus. Part-time students were excluded to limit associated factors (e.g., full-time employment) that may have affected their movement behaviours. Finally, undergraduate students were selected as researchers have previously advocated for the importance of the early years of tertiary education in forming life-long movement habits (Nelson et al., 2008; Von Ah et al., 2004).

Recruitment

Upon receiving approval by the host institution's Health Science Research Ethics Board (#121144; Appendix A), data collection began, spanning September 19th to December 8th, 2022. Fulltime undergraduate students from Ontario universities were recruited by convenience sampling. Recruitment graphics (see Appendix B) were circulated on university-affiliated social media pages including through Facebook, Instagram, LinkedIn, Twitter, and Reddit. A total of 2,824 student groups from all public universities in Ontario were contacted through their public email addresses to request they share the recruitment graphic with their members (see Appendix C). At the host institution, participants were also recruited by mass email (see Appendix C) and professor announcements (see Appendix D). A total of 3 mass emails (i.e., one approximately every 4 weeks of recruitment) were sent to all full-time undergraduate students at the host institution. To facilitate professor course-based announcements, the members of the research team compiled a list of all professors from the host institution teaching any undergraduate courses for the Fall 2022 semester. A total of 740 professors were contacted via email and asked to share the recruitment graphic with their undergraduate class(es). The email requests both to student groups and professors did not ask for a response; therefore, it is unknown how many complied with the request. The recruitment graphic and mass email included a link to the letter of information (see Appendix E), consent, and contact information for the researchers. All

participants confirmed their eligibility and provided informed consent prior to completing the survey.

Data Collection

The start of data collection occurred two weeks after classes began for the fall term, to limit any influence related to the start of school and return from summer holiday. The end of data collection coincided with the end of classes, in an effort to reduce influence related to changes in student behaviour during final exams and the end of term period. Upon consenting, participants were asked to complete an online survey using Qualtrics^{XM} (Qualtrics, Provo, UT).

Data Collection Tools

At the time of this study, to the best of the research team's awareness, no tool existed to assess compliance with the Guidelines. Instead, a collection of previously validated scales was administered to assess whether participants were meeting each component of the Guidelines, in addition to demographic questions.

Demographic Information. Participants were asked to complete a demographic questionnaire that included measures of age, gender, ethnicity, year of study, residence status (i.e., on- vs. off-campus), number of roommates (including family members), mode of course delivery (i.e., in-person, hybrid, or online), number of course hours, university of registration, and field of study (e.g., engineering, health sciences). The demographic questions, and specific wording, were informed by best practices recommended by the University of British Columbia's Equity & Inclusion Office (2020).

Physical Activity Recommendation. A combination of tools was used to assess the MVPA, light physical activity, and muscle strengthening activity components of the physical activity recommendation.

MVPA Component. The International Physical Activity Questionnaire – Short Form (IPAQ-SF; Craig et al., 2003; see Appendix F) was used to assess if participants were meeting the MVPA component of the Guidelines. Among adults aged 18 to 65, the IPAQ-SF produced repeatable data (Spearman's ρ between 0.66 and 0.88). Craig and colleagues (2003) found between 93% and 100% agreement on a test-retest evaluation for the measure of greater than 150 minutes per week of at least moderate intensity physical activity, which was the applicable measure for this study. Compared to accelerometry, the IPAQ-SF had a median criterion validity of about 0.30, which was comparable to the criterion validity of other self-report physical activity questionnaires (Craig et al., 2003). The IPAQ-SF has been specifically validated for use with university student populations (spearman ρ = 0.28; Murphy et al., 2017). The IPAQ-SF includes seven items, six of which assess physical activity at varying intensities, and one of which assesses sitting time. Participants are asked to submit the number of days per week that they participate in each intensity of physical activity, as well as the time in minutes and hours. Craig and colleagues (2003) provided recommendations for data cleaning and truncation.

Light Physical Activity Component. Two study-specific questions were created by the research team to assess light physical activity. The questions were modelled after the IPAQ-SF and read "During the last 7 days, on how many days did you do light physical activities like walking at a slow pace, standing work or light housework such as washing dishes?" and "How much time did you usually spend doing light physical activities on one of those days?". Examples of light physical activity were taken from the Guidelines.

Muscle Strengthening Activities Component. Meeting the muscle strengthening activities component of the Guidelines was assessed via the Muscle-Strengthening Exercise Questionnaire Short Form (MSEQ-SF; Shakespear-Druery et al., 2022a; see Appendix G).

Among a sample of adults, the MSEQ-SF showed high Spearman's rank correlations (ρ range 0.76–0.91; Shakespear-Druery et al., 2022a). Compared with a 7-day log, the MSEQ-SF showed high Spearman's rank correlation for concurrent validity (ρ range 0.58–0.77). As this was a relatively new measure, it had not yet been validated with university students, specifically. The MSEQ-SF includes six items that measure frequency, type, duration, intensity, and targeted muscle groups for muscle strengthening activities. The MSEQ-SF does not include a total summary score.

Sedentary Behaviour Recommendation. Questions from a combination of tools were used to assess the three components of the sedentary behaviour recommendation of the Guidelines.

Sedentary Time Component. The IPAQ-SF includes one question to measure average daily time engaged in sedentary behaviour. This question asks, "During the last 7 days, how much time did you spend sitting on a week day?" (Craig et al., 2003; see Appendix F). Participants were asked to submit their response in minutes and hours. Adequate reliability and validity have been demonstrated for this sitting question (mean Spearman's $\rho = 0.33$;. Craig et al., 2003).

Recreational Screen Time Component. To reduce participant burden, rather than including an additional scale, a study-specific question was added to assess meeting the screen time component of the sedentary behaviour recommendation. The question about recreational screen time was taken from the International Sedentary Assessment Tool (Prince et al., 2017) and was phrased "On a typical day in the past week, how much time did you spend sitting, reclining, or lying down and watching TV or using a computer, tablet, or smartphone during your free time?". Participants were asked to provide their response in minutes and hours. At the time

of the current study, reliability and validity measures were not available for this question, likely due to the difficulty of objectively delineating one type of sedentary behaviour from another (Prince et al., 2017). In their review of sedentary behaviour measurement tools for population health surveys, Prince et al. (2017) underscored that even in the absence of psychometric properties, many self-report sedentary behaviour surveys remain useful given their correlation with health behaviour risk.

Break Frequency Component. To reduce participant burden, rather than including an additional scale, a study-specific question was added to assess the break frequency component of the sedentary behaviour recommendation. The question about break frequency was taken from the South Australian Physical Activity Survey (Dollman et al., 2016) and was phrased, "How often do you take regular breaks (every 15–20 minutes) when sitting for long periods?" with response options: Always; Sometimes; Rarely; Never". To score the question, responses are to be coded 1 to 4 with lower scores indicating more frequent breaks (Dollman et al., 2016). At the time of current study, no psychometric properties were available for this question.

Sleep Component and Recommendation. To assess whether participants were meeting the sleep recommendation, sleep duration from the Pittsburgh Sleep Quality Index (PSQI) was used (Buysse et al., 1989). The question was phrased, "During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed"; Buysse et al., 1989, p. 209). The PSQI is a widely-used, 19-item questionnaire that measures 7 domains: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction (Buysse et al., 1989). The PSQI has well-established psychometric properties (Chronbach's alpha = 0.83; Buyesse et al., 1989). Among university students, the PSQI sleep duration component showed

moderate convergent validity with a sleep diary (r = 0.51; Dietch et al., 2016). Researchers have previously followed the practice of using a single question from the PSQI to assess sleep duration among university students (e.g., Benham, 2021; Quick et al., 2016).

Perceived Social Support. To assess perceived social support, the Multidimensional Scale of Perceived Social Support (MSPSS) scale was used (Zimet et al., 1988; see Appendix H). The MSPSS is a 12-item scale that measures perceived social support from three sources: family, friends, and significant others (Zimet et al., 1988). Each item is presented on a seven-point Likert scale ranging from 'very strongly disagree' (1) to 'very strongly agree' (7; Zimet et al., 1989). The MSPSS has good psychometric properties among adults (Cronbach's alpha = 0.88; Zimet et al., 1989) and adequate psychometric properties among university students in the United States (Cronbach's alpha = 0.91; Ermis-Demirtas et al., 2018) and Turkey (Cronbach's alpha = 0.93; Başol, 2008). Examples of items include: 'There is a special person who is around when I am in need', 'My family really tries to help me', and 'I can count on my friends when things go wrong' (Zimet et al., 1988). To score the MSPSS, Zimet and colleagues (1988) advised calculating an average score across all 12 items to yield a score between one and seven with higher scores indicating greater perceived social support.

Data Analysis

Statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS; Version 28) and Excel using the Real Statistics Resource Pack (Release 7.6). All statistical analyses and presentation decisions were made collaboratively with consultants from Western Data Science Solutions. The dataset was examined for missing data and Little's Missing Completely at Random Test was used to explore mechanism of missingness (Little, 1988). There were minimal missing data (0.2%), and it was found that data was missing completely at random

(p = .106). As such, and considering the large sample size, listwise deletion was employed and only participants providing complete data were utilized for analyses (per Kang, 2013).

To report the prevalence of the sample of full-time Ontario undergraduate university students' meeting the Guidelines, descriptive statistics were used. Because the Guidelines are comprised of three recommendations (i.e., physical activity, sedentary behaviour, and sleep) which are made up of seven components (i.e., MVPA, muscle strengthening activities, light physical activity, sedentary time, recreational screen time, break frequency, and sleep), the number of students who were meeting each individual component was first calculated.

Physical Activity Recommendation

MVPA Component. As the IPAQ-SF is not intended to assess the Guidelines specifically, deviation from the published scoring protocol was required. To calculate the amount of MVPA each participant reported per week, the time in each intensity of physical activity (i.e., vigorous, moderate, and walking) was summed. Given that Craig et al. (2003) recommended any physical activity reported in the walking domain be calculated at 3.3 METs, it posed a challenge as to whether or not walking time should be included in MVPA. That is, by definition, moderate physical activities include movements requiring between 3 and 5.9 METS (Ainsworth et al., 2012), which would indicate walking should be classified as MVPA. However, according to the compendium of physical activities (Ainsworth et al., 2012), walking activities require between 2.0 and 10.0 METs, suggesting that walking may also occur at a light intensity. As the distinction between walking at a light or moderate intensity was not made in the current study, whether students were meeting the MVPA component was calculated both including and excluding walking. As such, the number of participants meeting the physical activity recommendation, and the overall Guidelines, was calculated both including and excluding walking. To assess if

students were meeting the MVPA component of the physical activity recommendation, weekly minutes of each intensity of physical activity were calculated by converting all time to minutes, applying truncation and data cleaning rules per Craig et al. (2003), and multiplying average minutes per day by the number of days reported for each intensity of physical activity in the last week. Total weekly MVPA (excluding walking) was calculated by summing weekly minutes of vigorous and moderate activities. Total weekly MVPA (including walking) was calculated by summing weekly minutes of vigorous, moderate, and walking activities. Per the Guidelines, participants who reported engaging in at least 150 minutes of MVPA per week were classified as having met the MVPA component. Following the calculation of total MVPA per week, a dummy variable was created to score whether participants were meeting the MVPA component (1 = met component, 0 = did not meet component).

Muscle Strengthening Activities. To assess compliance to the muscle strengthening activities component of the physical activity recommendation, the number of days per week of participating in muscle strengthening activities, scored from zero to seven, was assessed. Per the Guidelines, students were classified as meeting the muscle strengthening activities component if they reported participating in at least 2 days of muscle strengthening activities per week. A dummy variable was created to score whether participants were meeting the muscle strengthening activities component (1 = met component, 0 = did not meet component).

Light Physical Activity. To assess if students were meeting the light physical activity component of the physical activity recommendation, the number of weekly minutes of light physical activity was calculated by converting all time to hours and multiplying the hours per day by the number of days of light physical activity in the last week. Then, daily average light physical activity time (i.e., weekly time divided by seven) was calculated to facilitate comparison

to the Guidelines. The goal of "several hours of light physical activity" from the Guidelines (Ross et al., 2020, p. S70) was operationalized as an average of 3 hours per day, similar to practices from Bailey and colleagues (2022). Therefore, students were classified as meeting the light physical activity component if they reported participating in an average of at least 3 hours per day of light physical activities. A dummy variable was created to score whether or not participants were meeting the light physical activity component (1 = met component, 0 = did not meet component).

If students met the MVPA, muscle strengthening activities, and light physical activity components, they were classified as meeting the physical activity recommendation.

Sedentary Behaviour Recommendation

Sedentary Time Component. To assess if the participants were meeting the sedentary time component, daily sedentary behaviour was determined by converting time submitted in minutes and hours to hours. Data was cleaned to exclude any outliers (i.e., participants who reported more than 16 hours per day of sedentary time per Craig et al. 2003). Per the Guidelines, participants were classified as meeting the sedentary time component if they reported less than 8 hours of sedentary behaviour per day. A dummy variable was created to score whether participants were meeting the sedentary time component (1 = met component, 0 = did not meet component).

Recreational Screen Time Component. To assess if the participants were meeting the recreational screen time component, daily recreational screen time was determined by converting time submitted in minutes and hours to hours. As no data cleaning or truncation guidance was available for the recreational screen time question (Prince et al., 2017), data was cleaned to exclude any outliers following practices recommended by the IPAQ-SF creators (i.e.,

participants who reported more than 16 hours per day of recreational screen time were excluded; Craig et al., 2003). Per the Guidelines, participants were classified as meeting the recreational screen time component if they reported less than 3 hours of recreational screen time per day. A dummy variable was created to score whether participants were meeting the recreational screen time component (1 = met component, 0 = did not meet component).

Break Frequency. To assess compliance to the break frequency component of the Guidelines, it was interpreted that the 'always' or 'sometimes' response options suggested a positive indication that participants were taking regular breaks, while the 'rarely' or 'never' options indicated participants were not taking regular breaks were scored as not meeting the Guidelines. As the Guidelines suggest "breaking up long periods of sitting as often as possible" (Ross et al., 2020, p. S70), participants were classified as meeting the break frequency component if they reported 'always' or 'sometimes' taking regular breaks. A dummy variable was created to score whether participants were meeting the break frequency component (1 = met component, 0 = not meeting component).

If students met the sedentary time, break frequency, and recreational screen time components, they were classified as meeting the sedentary behaviour recommendation.

Sleep Recommendation

To assess if the participants were meeting the sleep recommendation, data was first cleaned to exclude any outliers (i.e., submitted more than 24 hours of sleep per night). Per the Guidelines, participants were classified as meeting the sleep duration component, and therefore sleep recommendation, if they reported between 7 and 9 hours of sleep per day. A dummy variable was created to score whether participants were meeting the sleep duration component (1 = met component, 0 = not meeting component).

The Guidelines

Students who met the physical activity, sedentary behaviour, and sleep recommendations were classified as meeting the Guidelines. For each participant, the number of individual components and recommendations they were meeting was determined by summing the dummy variables for each. Each participant was also classified according to how many, and what combination of recommendations they were meeting and placed into one of the following categories: no recommendations, sleep only, sedentary behaviour only, physical activity only, sleep + sedentary behaviour, sleep + physical activity, sedentary behaviour + physical activity, or sleep + sedentary behaviour + physical activity.

Social Support

To measure the association between perceived social support and meeting the Guidelines, a series of biserial correlations were conducted. Correlation coefficients were calculated between social support and meeting each of the individual components and recommendations. Preliminary analysis identified that the summary social support variable was not normally distributed. Therefore, a reflection and natural log transformation was completed. After transformation, analysis showed (a) no outliers, as assessed by boxplot; (b) perceived social support score was normally distributed, as assessed by Q-Q plots; and (c) there was homogeneity of variances, as assessed by Levene's test for equality of variances. Therefore, all biserial correlations were conducted using transformed data to better match assumptions of normality. To assess the association between the number of components and recommendations met and perceived social support, Kendall's tau-b correlation coefficient was calculated. As Kendall’s tau-b is a non-parametric measure, the untransformed data were used. A biserial correlation was

planned between meeting the Guidelines and social support but was not possible as detailed in the results sections below.

Chapter 4: Results

Demographics

A total of 508 undergraduate students registered across 19 universities in Ontario completed the online survey. Participants predominantly identified as a woman (68.8%, *n* = 346), with a majority reporting white/European ethnicity (67.3%, *n* = 342), and a mean age of around 20 years. Participants were distributed across years of study, with the majority being in first (30.8%, *n* = 155) or second year (25.6%, *n* = 129). The majority of participants indicated registration at Western University (62.4%, *n* = 317). There was also a wide distribution in field of study, with the highest proportions studying health sciences (28.94%, *n* = 147), social sciences (23.23%, *n* = 118), and biological sciences (21.06%, *n* = 107). More than half of the participants were attending only in-person classes (56.6%, *n* = 286), with an average of 16.7 hours of class per week. Participants were primarily living with friends or roommates in off-campus accommodations (*n* = 216; 42.9%), with an average of 2.7 roommates. Full demographic details can be found in Table 1.

Table 1.

Demographic Characteristics of Participants (n = 508)

Characteristic	Number and proportion of sample (%) or SD
Gender	
Woman	346 (68.8%)
Man	129 (25.6%)
Non-Binary	16 (3.2%)
Gender Fluid	7 (1.4%)
Other	3 (0.6%)
I prefer not to answer	2 (0.4%)
Mean Age in Years	20.1 (SD: 3.0)
Self-Identified Race/Ethnicity	
White/European	342 (67.3%)
Southeast Asian (e.g., Chinese, Japanese, Korean)	69 (13.6%)

South Asian (e.g., East Indian, Sri Lankan)	49 (9.6%)
Caribbean	19 (3.7%)
Latin, Central, and South American	16 (3.1%)
Arab (e.g., Saudi Arabian, Palestinian, Iraqi)	14 (2.8%)
African	13 (2.6%)
Indigenous (First Nations, Metis, or Inuit)	8 (1.6%)
West Asian (e.g., Iranian, Afghani)	4 (0.8%)
Other (e.g., Egyptian, Jewish, Biracial)	4 (0.8%)
I prefer not to answer	1 (0.2%)
Current Year of Study	
First	155 (30.8%)
Second	129 (25.6%)
Third	99 (19.7%)
Fourth	90 (17.9%)
Fifth	20 (4.0%)
Six +	6 (1.2%)
I prefer not to answer	4 (0.8%)
Living Arrangement	
Off-campus (with roommates/friends)	216 (42.9%)
On-campus (with roommates/friends)	118 (23.4%)
Off-campus (with family)	106 (21.0%)
Off-campus (with significant other)	24 (4.8%)
Off-campus (alone)	21 (4.2%)
On-campus (alone)	19 (3.8%)
Number of Roommates	2.7 (SD: 1.6)
Mode of Course Delivery	
In-person	286 (56.6%)
Hybrid (mix of in-person and online)	217 (42.7%)
Online	2 (0.4%)
Hours of Classes per Week	16.7 (SD: 7.5)
University	
Western University	317 (62.40%)
University of Ottawa	43 (8.46%)
Nipissing University	24 (4.72%)
University of Guelph	23 (4.53%)
Carleton University	18 (3.54%)
Brock University	16 (3.15%)
University of Toronto	12 (2.36%)
Trent University	11 (2.17%)
Other	44 (8.66%)
Field of Study	
Health Sciences	147 (28.94%)
Social Sciences	118 (23.23%)
Biological Sciences	107 (21.06%)
Engineering	49 (9.65%)
Business Studies	41 (8.07%)

Physical Sciences	40 (7.87%)
Computer Science	21 (4.13%)
Languages, Linguistics, Literatures, Cultures & Societies	20 (3.94%)
Education Studies	14 (2.76%)
Historical, Philosophical & Religious Studies	13 (2.56%)
Mathematics	13 (2.56%)
Creative Arts & Design	11 (2.17%)
Media and Communication Studies	10 (1.97%)
Other	19 (3.74%)
I prefer not to answer	2 (0.39%)

Note. Not all categories summed to equal 508 due to missing data. The values and proportions may exceed 508 or 100% respectively as participants were able to select multiple options for self-identified race/ethnicity and field of study.

Meeting the Guidelines

As described in the data analysis section, participants were removed as outliers if they reported engaging in a physical activity or sedentary behaviour time-based variable for over 16 hours in one day, or the sleep variable for over 24 hours in one day (per recommendations from Buysse et al., 1989; Craig et al., 2003). The fewest number of outliers were removed in the sleep duration component (n = 4, 0.7%), while the largest number of outliers were removed in the sedentary time component (n = 68, 13.4%). After the removal of outliers, 422 participants had complete data for all components and were included in the analysis of level of compliance to the Guidelines (i.e., number of met components or recommendations). The percentage of the sample who met each of the components and recommendations can be found in Table 2. Only one participant (0.2%) was meeting the overall Guidelines (i.e., all of the components). Of the recommendations (i.e., physical activity, sedentary behaviour, and sleep), the sleep recommendation was most commonly met (n = 294, 58.3%). Comparatively, 74 participants (17.6%) were meeting the sedentary behaviour recommendation, 42 participants (8.4%) were meeting the physical activity recommendation when walking was included, and 32 participants

(6.4%) were meeting the physical activity recommendation when walking was excluded. When considering the individual components, the MVPA (walking included) component was met most often (n = 478, 94.7%). Conversely, the component that was met least often was light physical activity (n=128, 25.5%).

The majority of participants were meeting only one of the three recommendations (n=219, 51.9%, including walking; n=221, 52.4%, excluding walking). Of those who met only one recommendation, it was most often the sleep recommendation (n=186, 44.1%, including walking; n=189, 44.8%, excluding walking – when walking was included three participants newly met the physical activity recommendation, meaning they no longer were categorized as meeting sleep only). When walking was included as MVPA, 65 participants (15.4%) were meeting two of the recommendations, while 137 participants (32.5%) were not meeting any of the recommendations. When walking was not included as MVPA, 61 participants (14.5%) were meeting two of the recommendations, while 139 participants (32.9%) were not meeting any of the recommendations. Of those meeting two of the recommendations, the most common combination was to meet both the sleep and sedentary behaviour recommendations (n=46, 10.9%). The breakdown of number of recommendations met, and the respective combinations, can be found in Table 3. When considering the components within each behavioural recommendation, it was most common for participants to be meeting four components out of the possible seven components (n=116, 27.5%, with walking; n=103, 24.4%, without walking). The breakdown of number of components met can be found in Table 4.

Table 2.

Movement behaviours of participants, and the number and percent of participants meeting the components, recommendations, and Guidelines (n = 508)

Behaviour	*M* (SD)	Meeting # (%)	Not meeting # (%)
Physical Activity Recommendation (including walking)	-	42 (8.4%)	456 (91.6%)
Physical Activity Recommendation (excluding walking)	-	32 (6.4%)	467 (93.6%)
MVPA Component (including walking; mins/week)	854.6 (600.1)	478 (94.7%)	27 (5.3%)
MVPA Component (excluding walking; mins/week)	318.5 (364.6)	288 (56.9%)	218 (43.1%)
Muscle Strengthening Activities Component (days/week)	1.64 (2.0)	215 (42.4%)	292 (57.6%)
Light Physical Activity Component (mean hours/day)	2.0 (2.1)	128 (25.5%)	373 (74.5%)
Sedentary Behaviour Recommendation	-	74 (17.6%)	346 (82.4%)
Sedentary Time Component (hours/day)	7.9 (3.2)	263 (60.0%)	175 (40.0%)
Recreational Screen time Component (hours/day)	4.8 (3.2)	187 (38.1%)	304 (61.9%)
Break Frequency Component	-	271 (53.5%)	236 (46.5%)
Sleep Recommendation (hours/night)	6.8 (1.2)	294 (58.3%)	210 (41.7%)
Guidelines (including walking)	-	1 (0.2%)	421 (99.8%)
Guidelines (excluding walking)	-	1 (0.2%)	421 (99.8%)

Note. Not all categories sum to equal 508 due to missing data and data removed as outliers.

Table 3.

Number and which of the recommendations are met by participants (n=422)

Number of Recommendations Met	Number (%), walking included	Number (%), walking excluded
No Recommendations	137 (32.5%)	139 (32.9%)
One Recommendations	219 (51.9%)	221 (52.4%)
Only Physical Activity	12 (2.8%)	10 (2.4%)
Only Sedentary Behaviour	21 (5.0%)	22 (5.2%)
Only Sleep	186 (44.1%)	189 (44.8%)
Two Recommendations	65 (15.4%)	61 (14.5%)
Physical Activity + Sleep	15 (3.6%)	12 (2.8%)
Physical Activity + Sedentary Behaviour	4 (0.9%)	3 (0.7%)
Sleep + Sedentary Behaviour	46 (10.9%)	46 (10.9%)
All Recommendations	1 (0.2%)	1 (0.2%)

Note. Participants could report meeting between zero and three recommendations.

Table 4.

Number of participants meeting the components of the Guidelines (n=422)

Number of Components	Number (%), walking included	Number (%), walking excluded
No Components	2 (0.5%)	14 (3.3%)
One Components	24 (5.7%)	46 (10.9%)
Two Components	67 (15.9%)	73 (17.3%)
Three Components	87 (20.6%)	87 (20.6%)
Four Components	116 (27.5%)	103 (24.4%)
Five Components	76 (18%)	57 (13.5%)
Six Components	49 (11.6%)	41 (9.7%)
Seven Components	1 (0.2%)	1 (0.2%)

Note. Participants could report meeting between zero and seven components.

Associations with Social Support

A biserial correlation coefficient was calculated between social support and independently meeting each of the components and recommendations. As only one participant was meeting the Guidelines, no correlation was calculated between meeting the overall Guidelines and social support. As a transformation was performed to meet the assumption of normality, the direction of the correlation is reflected. There was a small statistically significant correlation between meeting the physical activity recommendation (including walking) and social support (r_b = -.18, p = .002). This result should be interpreted with caution, as the dichotomy is lopsided (P_0 = 0.91) which may limit its accuracy (Guilford, 1942). There was a small statistically significant correlation between meeting the sedentary time component and social support (r_b = -.13, p = .03). There were no statistically significant correlations between social support and meeting any other recommendations or components of the Guidelines. The correlation coefficients and p-values can be found in Table 5.

Table 5.

Biserial correlation coefficient (r_b) of social support and meeting the components and recommendations of the Guidelines

Recommendation or Component	**r_b**	**p-value**
Physical Activity Recommendation (including walking)	-0.18	0.002*
Physical Activity Recommendation (excluding walking)	-0.08	0.14
MVPA Component (including walking)	-0.03	0.54
MVPA Component (excluding walking)	-0.04	0.47
Muscle Strengthening Activities Component	-0.06	0.29
Light Physical Activity Component	-0.06	0.25
Sedentary Behaviour Recommendation	0.09	0.15
Sedentary Time Component	-0.13	0.03*
Recreational Screen Time Component	-0.01	0.8
Break Frequency Component	-0.01	0.85
Sleep Recommendation	0.01	0.92

Note. An asterisk (*) indicates statistical significance (p = < 0.05).

A Kendall's tau-b correlation coefficient was calculated to determine the association between social support and the number of recommendations and components met. For all cases, there was a weak, positive association between meeting the recommendations or components of the Guidelines, that was not statistically significant. The correlation coefficients and p-values can be found in Table 6.

Table 6.

Correlation coefficient (Kendall's τ_b) of social support and meeting the components and recommendations of the Guidelines

Measure of Meeting the Guidelines	τ_b	**p-value**
Number of Recommendations (including walking)	.028	.475
Number of Recommendations (excluding walking)	.014	.722
Number of Components (including walking)	.057	.113
Number of Components (excluding walking)	.063	.079

Chapter 5: Discussion

To the best of the research team's knowledge, this was the first study to examine university students' compliance to the Canadian 24-Hour Movement Guidelines (i.e., the Guidelines) since the onset of the pandemic in March 2020. Furthermore, the current study provides novel insight into the movement behaviours of university students as it was the first known study to include all components of the Guidelines. Moreover, it was the first study to consider the association between compliance to the Guidelines and perceived social support. As university students' were identified as having poor movement behaviours before the pandemic (Ross et al., 2020), and the early months of pandemic coincided with concerning changes to the movement behaviours included in the Guidelines (Benham, 2021; Huber et al., 2020; Hyun et al., 2021; Wright et al., 2020; Zheng et al., 2020), understanding the distribution of students' movement behaviours as the pandemic continues and evolves by assessing compliance to the Guidelines is paramount.

The most salient finding from the current study is the lack of students who were meeting the overall Guidelines, with only one student (0.2%) meeting all components of the Guidelines. As the Guidelines are still quite new, few studies have examined university students' compliance to the overall Guidelines. Our findings are similar, though more concerning, to those of Weatherson and colleagues (2021) who, in their study of 20,090 university students in Canada before the pandemic, found only 9.9% of students were meeting the Guidelines. Similarly, in a study of 403 American college students before the pandemic, Bailey and colleagues (2022) assessed compliance to the Canadian Guidelines and found 8.44% of students were meeting the Guidelines. It is important to note that both Bailey et al. (2022) and Weatherson et al. (2021) did not examine all components of the Guidelines. Weatherson and colleagues (2021) examined the

MVPA, sedentary time, recreational screen time, and sleep components of the Guidelines. However, they did not include considerations for the muscle strengthening activities, light physical activity, or break frequency components of the Guidelines. Similarly, Bailey and colleagues (2022) only examined compliance to the light physical activity, MVPA, sedentary time, and sleep components of the Guidelines. Since the current study included a more fulsome representation of compliance to the Guidelines, it is not surprising that the level of compliance was even lower than previously documented.

The current study may reflect poorer compliance to the Guidelines than has previously been reported as it was conducted during the pandemic. It has been well-documented that problematic changes to all movement behaviours encompassed in the Guidelines were observed during the early months of the pandemic (Benham, 2021; Huber et al., 2020; Hyun et al., 2021; Wright et al., 2020; Zheng et al., 2020). As the current study was cross-sectional, it is impossible to know if students were engaging in poorer movement behaviours as a result of or simply coincident with the pandemic. However, one must consider that at the time of the current study, participants had experienced over two years of challenges and disruption related to the pandemic. In the current study, over three quarters of the sample were in their first three years of university, suggesting they began university during the pandemic. Aside from the pandemic, the transition to university is a challenging and vulnerable time of life (Baik et al., 2015). These challenges have been compounded by uncertainties and difficulties related to the pandemic (Busonera et al., 2023; McKay et al., 2021). Researchers regularly highlight the importance of targeting university students' movement behaviours (e.g., Castro et al., 2020; Frederick et al., 2023; Visser & Hirsch, 2014), as the university years are known to be a time when students develop life-long habits (Nelson et al., 2008; Von Ah et al., 2004). Given the extremely poor compliance to the

Guidelines reported in the current study, compounded by the challenges of the pandemic, the population of current university students is clearly an important group to target in future intervention.

It is imperative that something be done to address the poor movement behaviours of university students in Ontario. Previous researchers have found numerous associations between meeting the Guidelines and mental health outcomes, including lower anxiety (Bu et al., 2021), lower depressive symptoms (Frederick et al., 2023), reduced suicidal ideation (D. M. Y. Brown, Hill, et al., 2022), and improved mental health (D. M. Y. Brown, Faulkner, et al., 2022; Frederick et al., 2023; Liang et al., 2021). Significant declines in the mental health of university students have been documented in recent years (American College Health Association, 2019) and improving compliance to the Guidelines may prove to be an avenue to help improve this poor mental well-being. Furthermore, there is a paucity of research examining the association of physical health indicators and the Guidelines among university students. Bailey and colleagues (2022) found that meeting the MVPA and sleep components of the Guidelines were associated with lower body mass index. Among adults, a systematic review from Janssen and colleagues (2020) found composition of daily movement behaviours was associated with reductions in all-cause mortality, adiposity, and cardiometabolic biomarkers. As university students are building behavioural habits for the future (Nelson et al., 2008; Von Ah et al., 2004), attention to improving movement behaviours during this time of life may provide lasting physical health benefits later in life. Furthermore, addressing the Guidelines presents a unique opportunity to foster healthy behaviours from multiple avenues, as altering the time spent in one behaviour directly results in a change to the time spent in another behaviour. To highlight areas of concern, findings from the current study for each component of the Guidelines will be discussed below

and opportunities will be highlighted to alter the distribution of behaviours to positively influence university students.

The participants in the current study reported poor compliance to the physical activity recommendation with fewer than one tenth of participants meeting all three components of the physical activity recommendation regardless of whether walking was included or not included in the analyses. To our knowledge, no researchers have previously considered compliance to all three components of the physical activity recommendations (i.e., MVPA, light physical activity, and muscle strengthening activity). However, researchers have previously examined compliance to both MVPA and muscle strengthening activity components. For instance, in a study of 7,088 Irish college students, Shannon and colleagues (2022) reported that 41% of participants met both the MVPA and muscle strengthening activity components. Similarly, Wilson and colleagues (2019) found, among their sample of 606 American college students prior to the pandemic, 40.3% met both the MVPA and muscle strengthening activity components. Although not explicitly analyzed together, the results of the current study appear to be similar as almost all participants met the MVPA component when walking was included and just under half of the participants were meeting the muscle strengthening activities component, similar to findings from Wilson et al. (2019) and Shannon et al. (2022). However, when considering light physical activity as well the results of the current study depict much lower compliance to the overall physical activity recommendations. As such, light physical activity might be an important target in future interventions intending to help increase students' compliance to the overall physical activity recommendations.

The MVPA component of the Guidelines (i.e., the measurement of aerobic activity) is most commonly cited in the literature when referencing university students' insufficient physical

activity participation (e.g., Clemente et al., 2016; Fagaras et al., 2015; Peterson et al., 2018). The results of the current study are contradictory in that when walking was included almost all participants met the MVPA component. However, when walking was excluded, just over half of the participants were meeting the MVPA component of the Guidelines, which is similar to levels reported by other researchers before the pandemic. For example, Weatherson and colleagues (2021) found, among a sample of 20,090 university students in Canada, that 61.1% were meeting the MVPA component before the pandemic. Weatherson et al. (2021) measured MVPA using a modified version of the IPAQ-SF which included walking at a self-reported moderate or vigorous intensity in the calculation of MVPA time. Wilson and colleagues (2019) reported, among a sample of 606 college students in the United States before the pandemic, 71.0% met recommendations for 150 minutes per week of MVPA. However, Wilson et al. (2019) assessed MVPA using the Global Physical Activity Questionnaire (Bull et al., 2009), which does not separate walking from other types of physical activity and therefore includes any walking at a moderate to vigorous intensity. Weatherson et al. (2021) and Wilson et al. (2019)'s inclusion of walking at a moderate or vigorous intensity as an MVPA behaviour might help to explain why these authors' findings for compliance to the MVPA component fell between the current study's findings of MVPA when walking at any intensity was or was not included. Conversely, Bertrand and colleagues (2021) found that, among their sample of 125 university students in Saskatchewan, 16% of the participants were meeting the MVPA component before the pandemic and only 9.6% met the component during the pandemic. However, Bertrand and colleagues (2021) utilized the Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1985), which measures exercise during free time, including walking, at a mild, moderate, and vigorous intensity. Therefore, Bertrand and colleagues (2021) may not have captured other types of

physical activity such as during work or transportation, which may explain their reporting of lower level of compliance to the Guidelines.

It is well documented that the pandemic has had negative effects on the physical activity, and the MVPA specifically, of university students (Dziewior et al., 2022; López-Valenciano et al., 2021). However, in a review of studies from the early months of the pandemic, López-Valenciano and colleagues (2021) found, despite overall reductions in physical activity duration, students who met minimum physical activity recommendations (i.e., 150 minutes per week) before the pandemic generally met the recommendations during the pandemic. This may explain the similarities between our findings and that of Weatherson et al. (2021) and Wilson et al. (2019), in that participants may have experienced decreased level of activity during the pandemic but not to the point of changing whether or not they were meeting the MVPA component of the Guideline. Furthermore, the majority of published studies investigating university students' physical activity since the onset of the pandemic have been conducted cross-sectionally and during the early months of the pandemic when the most stringent public health protections were in place (Canadian Institute for Health Information, 2022). As such, at this time it is difficult to know whether students have been able to increase their physical activity from the level of decline observed at the beginning of the pandemic.

In Canada, the average post secondary student takes around 4.5 years to complete their education (Statistics Canada, 2023). As such, many students have graduated since the onset of the pandemic and a new cohort of students has completed high school and entered university during this time. Considering poor physical activity was observed in Canadian youth (Colley & Watt, 2022; Watt & Colley, 2021) during the early months of the pandemic, it stands to reason that populations of incoming university students continue to be at increased risk for the

deleterious effects of poor movement behaviours. It is also likely that changes in the education system, such as online or hybrid learning, that have been spurred by the pandemic and might impact students' movement behaviours will remain prevalent (Xie et al., 2020). In a study of 238 university students in the United States, Rice and colleagues (2019) found total MET minutes per week were significantly higher among students attending classes in-person, compared to online. In the current study, despite the option for in-person learning, almost half of the participants in the current study were participating in some amount of online learning. As such, it is important that future interventions and studies consider the implications of these educational delivery changes on students' movement behaviours and aim to support students' healthy movement patterns, regardless of pandemic status or learning modality.

Interestingly, when walking was included in MVPA, almost all participants in the current study were meeting the MVPA component of the Guidelines, but when walking is excluded, that figure dropped to just over half meeting the component. The difference between compliance level when including or excluding walking points to the importance of clearly articulating the targets in the Guidelines and utilizing appropriate methods of data collection. In previous studies, researchers have conceptualized walking documented by self-report as both MVPA (e.g., Bennie et al., 2019) and light physical activity (e.g., López-Valenciano et al., 2021), often without consideration for walking intensity. When utilizing the IPAQ-SF, participants are instructed not to count any walking time in their reporting of vigorous and moderate activities (Craig et al., 2003). However, if walking is entirely excluded from calculations of MVPA time, it is likely time spent in MVPA will be missed as many speeds/types of walking would fall into the category of moderate, or even vigorous, activity (Ainsworth et al., 2012). This was reflected in an IPAQ-SF validation study conducted by Murphy and colleagues (2017) who did not include

walking time in their calculation of MVPA for comparison with accelerometery. Murphy and colleagues (2017) found the IPAQ-SF underestimated MVPA compared to accelerometry. Murphy and colleagues (2017) suggested this may have been because participants did not consider their active transport and occupational movements as physical activity, in turn causing the self-report measures to underestimate MVPA when compared to accelerometry. Both active transportation and occupational movements could reasonably include walking behaviours, which leads one to posit that excluding walking from the calculation of MVPA may also have been partially responsible for the underestimation of MVPA by the IPAQ-SF in Murphy et al.'s (2017) study. These results lend to the notion that future iterations of the Guidelines should clearly articulate what is considered MVPA. Furthermore, researchers should specify how MVPA was reported and calculated to allow consistent comparison. The development of a tool specifically intended to measure compliance to the Guidelines would also be a beneficial addition to rectify discrepancies in the literature. Scheers and colleagues (2013) supported this notion with their finding that the prevalence of participants achieving sufficient physical activity differed greatly depending on the definition of physical activity and the data collection method used.

In reality, it is likely that students engage in walking behaviours at both a light and greater intensity. However, the dramatic difference in achieving sufficient MVPA when walking was included or excluded suggests walking is a common behaviour among university students. This is unsurprising, as previous researchers have noted that university students in Canada are likely to utilize active transportation (e.g., walking or cycling for transportation; Nash & Mitra, 2019). In fact, a study of 2,873 French university students found active transportation to be the most common type of physical activity in students' daily lives. The popularity of active

commuting is highly beneficial for student populations as it provides a simple, inexpensive, and easy opportunity for increased physical activity (Palma-Leal et al., 2021). Walking is associated with numerous physical and mental health benefits, regardless of age or sex (Kelly et al., 2017). Future studies should aim to examine the amount of university students' walking time that is classified as MVPA.

Since walking appears to be an amenable type of physical activity for university students, walking-related interventions may prove to be beneficial among this population. Previous researchers have corroborated this assumption, in walking-related interventions during both leisure-time and commuting time. For example, a campus forest-walking program improved physical and psychological health among 60 university students in Seoul, South Korea (Bang et al., 2017). In the United States, students (n = 563) engaged in a higher average percentage of active trips after a campaign using a smartphone application and social media promotion (Bopp et al., 2018). Interventions have also been successful at improving walking behaviour, not specific to leisure or commuting time. Caso and colleagues (2021) found a messaging intervention was effective at improving psychological variables and walking behaviour among a sample of 156 Italian university students. The findings of the above studies confirm that walking may be a viable modality of physical activity to target in intervention with university students and could be applied more broadly.

When compared to MVPA, muscle strengthening activities are often overlooked as a public health opportunity for chronic disease prevention (Bennie et al., 2020). The results of the current study suggest that less than half of the participants were meeting the muscle strengthening activities component of the Guidelines. This finding represents an important contribution to the literature, as many studies that assess compliance to physical activity

recommendations fail to consider the muscle strengthening activity component (Wilson et al., 2021). Although no known research has been published that reports on compliance to the muscle strengthening activities component of the Guidelines among university students in Canada, our findings are similar to those of researchers in the United States who examined compliance to the same recommendation (i.e., to engage in at least 2 days per week of muscle strengthening activities) from the 2018 Physical Activity Guidelines Advisory Committee (2018). In a study of 606 college students in the United States, Wilson and colleagues (2019) found 44.4% of students were meeting muscle-strengthening recommendations. Furthermore, a scoping review (n = 8 studies from the United States) that measured compliance to the muscle strengthening activity component found the median number of students meeting recommendations was 47.8% (Wilson et al., 2021). These findings suggest interventions are needed to help increase the number of university students regularly engaged in muscle strengthening activities.

General reductions in physical activity, including MVPA and muscle-strengthening activities, among university students during the pandemic have been posited as being influenced by public health protections that mandated the closures of gyms and other recreation facilities as well as due to reduced active transportation to campuses (Bertrand et al., 2021). Importantly, this study was conducted at a time where many public health protections were no longer in place and the majority of students in the current study were attending at least some of their classes in person, and more than half were attending only in-person classes. Therefore, with university students continuing to report concerning levels of compliance to the Guidelines, it is possible that poor movement behaviour habits developed during the early months of the pandemic may now be ingrained in this population. When addressing movement behaviours moving forward, it is important to recognize disparities that have been observed in physical activity participation

among university students. For example, Wilson and colleagues (2019) documented a decreased likelihood to meet MVPA and muscle strengthening activity components among university students who identified as racial/ethnic minorities and women. In the current study, the sample predominantly identified as women, which may have contributed to the poor level of compliance to the physical activity components. Wilson and colleagues (2021) advocate for the continued importance of examining and targeting sociodemographic factors in future research and intervention.

Although few studies have reported levels of light physical activity among university student populations, light physical activity has important implications in reducing all-cause mortality (Chastin et al., 2019; Ekelund et al., 2019). The current study identified light physical activity as an area of concern for university students, with only a quarter of participants reporting an average of at least 3 hours per day. Of all seven components of the Guidelines, light physical activity was least often met by students in the current sample. The poor compliance to the light physical activity component observed in the current study contrasts results observed by Bailey and colleagues (2022), who found 70.47% of students were engaging in 3 or more hours of light physical activity per day. However, Bailey and colleagues (2022) objectively measured light physical activity using accelerometers. Researchers have demonstrated that self-report is not always accurate when measuring light physical activity (Haskell, 2012). In the future, researchers may explore employing objective measurements of physical activity, including light physical activity, to ensure accuracy of findings. However, one must also acknowledge the difficulty of employing objective measurement on such a large population and during a pandemic. In an effort to reduce participant burden, the current study employed an additional question rather than an extra scale to assess light physical activity. Recognizing the

impracticality of objective measurement while also considering the importance of accurate results, future researchers may consider the use of a full tool that has been validated specifically for the purpose of assessing light physical activity (e.g., Barwais et al., 2014). The recording of walking behaviour may also have played a role in the low level of light physical activity reported in the current study. Depending on type and speed, walking may be classified as light physical activity (Ainsworth et al., 2012). As students had already reported their walking time in the IPAQ-SF, they may have not considered this behaviour when answering the additional question related to light physical activity. In the current study, it was not possible to decern the level of intensity of the reported walking behaviour and therefore it was not included as light physical activity. Furthermore, the light physical activity question specified that slow walking should be included and therefore including walking measured in the IPAQ-SF may have resulted in counting the same behaviour twice. As previously highlighted, it is important that future studies attempt to delineate the intensity of walking behaviours to accurately reflect compliance to the Guidelines.

Surprisingly, although most participants in the current study did not meet the overall sedentary behaviour recommendations, a lower than expected proportion (40.0%) reported more than 8 hours of sedentary time per day. This is a very unusual finding, as previous researchers have reported much higher levels of sedentary behaviour among university students (Moulin et al., 2021), especially during the pandemic (Romero-Blanco et al., 2020). Bailey et al. (2022) found only 15.38% of students were meeting the sedentary time component before the pandemic. Similarly, Weatherson and colleagues found 22.1% of students were meeting the sedentary time component of the Guidelines, before the pandemic. That said, on average, students in the current study were engaging in 7.9 hours of sedentary behaviour per day, which is very close to the

upper limit of the recommended amount. It is possible the unusually high compliance to the sedentary time recommendation in the current study was partially due to the exclusion of a large number of outliers for the sedentary time component, as over one tenth of participants were excluded for reporting more than 16 hours of sedentary time each day. It is possible that some accurate data were incorrectly removed as outliers. Additionally, the measure used in the current study asked participants to report the time spent sitting in a day, which means the results do not reflect sedentary time spent reclining or lying down. As such, the results of the current study should be interpreted with caution and future research should be conducted to examine university students' sedentary time beyond the initial months of the pandemic.

The results of the current study suggest many students were not taking frequent breaks when engaging in long periods of sedentary behaviour. Few researchers have previously reported the frequency and duration of university students taking breaks in sedentary behaviour (Castro et al., 2020). To our knowledge, no studies have specifically conceptualized and measured compliance to the break frequency component of the Guidelines, making it unclear how findings from the current study compare to others. Low levels of light physical activity, in conjunction with high levels of sedentary time and recreational screen time and infrequent engagement in sedentary behaviour breaks, presents an important opportunity for the transfer of time spent in each behaviour. In a study of 21 university students, frequent light physical activity breaks had a positive impact on cognitive performance compared to idle sitting (Y. Wu et al., 2023). Similarly, Felez-Nobrega and colleagues (2018) determined that breaking up sedentary behaviour every 10 to 20 minutes was associated with higher academic achievement. Achieving sufficient light physical activity is also of particular importance, as simply meeting the MVPA or muscle strengthening components is not sufficient to protect against the negative health effects

of excessive sedentary behaviour (Thorp et al., 2011). As such, future interventions should aim to transfer sedentary time to light physical activity among university students by encouraging more frequent and lightly active breaks. For example, classroom movement breaks have been shown to be a feasible and effective strategy to increase physical activity and reduce sedentary behaviour among university students (Lynch et al., 2022).

Sedentary behaviour among university students often extends to outside the classroom, with time spent engaging in recreational screen time presenting a large concern (Deyo et al., 2023; Lavados-Romo et al., 2021). In the current study, less than half of the participants were meeting the recreational screen time component. This finding mirrors that of Weatherson and colleagues (2021), who found that only 36.2% were engaging in less than 3 hours per day of recreational screen time, as recommended by the Guidelines. These findings are concerning because in addition to contributing to sedentary time, recreational screen time has been associated with unique health risks among university students, including higher anxiety, depression, stress (Deyo et al., 2023) and lower quality of life, specifically in the domains of psychological and social health (Lavados-Romo et al., 2021). Moving forward, interventions would be sensitive to consider that time spent engaged in recreational screen time would be better spent engaged in any intensity of physical activity.

With more than half of participants in the current study achieving the recommended 7 to 9 hours of sleep per night, sleep was the most commonly met recommendation. This is not surprising, as it is also the simplest recommendation being comprised of only one component. The findings of the current study are similar to that of Bailey and colleagues (2022) found 58.56% of students were achieving the recommended 7 to 9 hours of sleep per night. The results also mirror those from Weatherson and colleagues (2021) who found that 59.7% of students

were meeting the sleep recommendation. The results of the current study may also reflect changes in sleep patterns that were observed at the beginning of the pandemic. A systematic review from Valenzuela and colleagues (2023; n = 72 studies from 22 countries) reported increased sleep duration among university students during the pandemic, while simultaneously reported decreased sleep quality. As the current study did not include a measure of sleep quality, it is impossible to know whether students in the sample were experiencing good or poor sleep quality. Future studies should aim to include a measure of sleep quality, as the Guidelines do include the recommendation of achieving "good-quality sleep" (Ross et al., 2020, p. S70). Interestingly, the average number of hours of sleep per night reported by participants in the current study (i.e., 6.8 hours) is still outside the recommended 7 to 9 hours per night. As such, there may be a subset of students who are engaging in significantly below the recommended amount of sleep and would be a valuable target for future sleep-related intervention. Importantly, the authors of the Guidelines recognize that improvements to the physical activity recommendation should not compromise sleep (Ross et al., 2020).

The level of compliance to the Guidelines highlighted throughout the current study is extremely concerning. Such a low level of compliance leads to the possibility that the Guidelines might not be aligned with realistic and attainable targets for movement behaviours of university students. Moving forward, it is important that appropriate steps are taken to disseminate the recommendations laid out in the Guidelines and encourage attainable changes to movement behaviours among university students. Holllman and colleagues (2022) suggested the importance of balancing the evidence base for health behaviour guidelines with pragmatic implementation, so the Guidelines are not perceived as a barrier or ignored. Researchers have also highlighted the need for a comprehensive messaging plan to disseminate the Guidelines (Faught et al., 2020). At

the time of the current study, the Guidelines were still relatively new, but a knowledge translation plan had been conceptualized (Tomasone et al., 2020), and implementation interventions among university students were in the works (Flood et al., 2023). Knowledge translation may be an effective strategy to improve university students' movement behaviours, as a study of 44 university students from the University of British Columbia suggested low awareness of the Guidelines (Barghouthi et al., 2022). The students in the study perceived that improving awareness would encourage behaviour change (Barghouthi et al., 2022), although future research is needed to confirm this assertation.

In addition to educating students about the Guidelines, it is important to recognize and address the factors inherent in university student life that increase the difficulty to achieve a healthful distribution of movement behaviours. Universities themselves may have an important role to play in disseminating and facilitating healthier movement behaviours amongst their students. This role is recognized by the Okanagan Charter (International Conference on Health Promoting Universities and Colleges, 2015), which calls upon "higher education institutions to incorporate health promotion values and principles into their mission, vision and strategic plans, and model and test approaches for the wider community and society" (p. 5). As such, universities should take an active role in supporting students to strive towards meeting the Guidelines. Holt and colleagues (2015) suggested universities may influence and support students through a number of factors including their policies, facilities and services, environment, curriculum, and research. These avenues of influence have often been highlighted in the research as targets for interventions. For example, researchers have called for universities to support movement behaviours through changes to physical environments such as offering sit-stand desks, improving recreation facilities, and offering bicycle parking (Abdullah & Mohamad, 2016; von Sommoggy

et al., 2020). Universities may also embed support in learning through curriculum or class-based strategies, such as offering movement breaks in classes or embedding lifestyle interventions within courses (Peiris et al., 2021; Plotnikoff et al., 2015). Moving forward, universities should identify an overarching strategy with tangible action items, articulate on-going targets, and set achievable and specific goals towards increasing students' compliance to the Guidelines (Squires & London, 2021).

The findings of the current study demonstrate association between perceived social support and compliance to two subsections of the Guidelines. Specifically, in the current study perceived social support was associated with meeting the physical activity recommendation (walking included) and sedentary time component. A small statistically significant positive association was observed between the physical activity recommendation when walking was included suggesting those with higher perceived social support were more likely to meet this recommendation. However, this result must be interpreted with caution as the number of participants who were meeting the recommendation was much smaller than the number of participants who were not. This result was anticipated, as increased social support is regularly associated with increased physical activity (Belanger & Patrick, 2018; Farren et al., 2017; Marmo, 2013; Rovniak et al., 2002). For example, in a study of 230 American college students, social support was reported as the top facilitator to physical activity during the pandemic (Dziewior et al., 2022). Interestingly, social support was not associated with meeting the physical activity recommendation when walking was excluded. It is, therefore, possible that social support had a unique influence on walking-related physical activity, which may lend to types of interventions that may be effective to increase walking MVPA or light physical activity. For instance, walking groups have been shown to be an effective way to increase physical activity

and social support (Kassavou et al., 2013). Alternatively, forming clubs or organizations related to active transportation may increase both MVPA and social support (Bopp et al., 2011). Further research is needed to corroborate these findings, and further examine social support as a correlate of meeting the MVPA component of the Guidelines.

As participants' self-reported perceived social support increased, so too did their likelihood of meeting the sedentary time component of the Guidelines. This is an interesting finding, as previous research into the associations between social support and sedentary time is limited (Smetaniuk et al., 2017). Previous qualitative research has suggested that university students were less sedentary if their peers enjoyed engaging in physical activity and as a result of having people with whom to stay active (Smetaniuk et al., 2017). This suggests the relationship between sedentary time and social support might be mediated by physical activity. As the Guidelines have the unique benefit of addressing the composition of time spent in each behaviour, and the results of the current study advocate for the transfer of time spent being sedentary to time being more physically active, future research should more closely examine these associations. Elevated and increasing sedentary behaviour has been highlighted by researchers as a concern among university student populations (Castro et al., 2020). The results of the current study suggest increasing perceived social support may provide a benefit toward students' engagement in less sedentary time per day.

Prior to the pandemic, social support was independently associated with the movement behaviours included in the Guidelines (e.g., Galambos et al., 2013; Smetaniuk et al., 2017; Wallace et al., 2000). However, in the present study perceived social support was not associated with meeting more components or recommendations of the Guidelines. It is possible that although increased social support may be associated with improved movement behaviours (i.e.,

increased physical activity and sleep, and reduced sedentary behaviour), the association may not be related to the cut-points set out in the Guidelines. Although beyond the scope of the current paper, future studies may benefit from employing compositional data analysis to model the associations between movement behaviours and their correlates (see Chastin et al., 2015 for an example). Compositional data analysis techniques are intended for use with compositional variables, such as the fixed 24-hour time spent in various movement behaviours (Chastin et al., 2015). As well, future research should examine other types of social support and social influences as researchers have shown friends and social norms do play a role in whether or not students are meeting the Guidelines (Anderson et al., 2022; Bu et al., 2021).

Limitations

The present study provided novel insights into all components of the Guidelines, which had previously not been examined among university students during the pandemic. Although this study provides valuable insight into the breath of university students' movement behaviours outlined in the Guidelines, it is not without limitations. Firstly, the tools used to assess each movement behaviour were not intended to be used with the cut-points identified in the Guidelines and therefore were not validated for this study's specific purposes. Moving forward, continued monitoring of compliance to the Guidelines is critical. To facilitate the ease of this monitoring, it would be beneficial if a tool was specifically designed and validated to measure all components of the Guidelines. The design of a concise but effective tool would greatly improve the ability to monitor and advocate for behaviour change. The homogeneity of the demographics of sample (e.g., most participants identified as female and attended the host institution) in the current study may limit the generalizability of the study findings. Caution should be used when applying the findings to university students more broadly. The current study was cross-sectional

in nature and therefore does not reflect or account for factors that influence students' movement behaviour throughout the course of a semester (e.g., midterms, exams, weather). As well, the cross-sectional nature means no causal inferences can be drawn for any associations between social support and meeting the components of the Guidelines. Finally, the current study was conducted using self-report data, which is known to be susceptible to social desirability bias and may over- or underestimate compliance to the Guidelines.

Conclusions

The results of the current study suggest undergraduate university students in Ontario were largely not meeting the Canadian 24-Hour Movement Guidelines two and half years into the COVID-19 pandemic. Specifically, only one participant met all recommendations set out in the Guidelines. Meeting the sedentary time component of the Guidelines was associated with social support. Although additional research is needed using a Guideline-specific measurement tool to more accurately assess the prevalence of university students' meeting the Guidelines, the current study points to the need for meaningful intervention to improve the movement behaviours of university students. Social support may be beneficial to help students improve their movement behaviours, specifically by helping to reduce their sedentary time.

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Appendices

Appendix A – Ethics Approval Notice

Western Research

Date: 5 July 2022

To: Dr. Jennifer Irwin

Project ID: 121144

Review Reference: 2022-121144-68205

Study Title: The Prevalence of Ontario Undergraduate University Students Meeting the 24-Hour Movement Guidelines and the Role of Social Support

Application Type: HSREB Initial Application

Review Type: Delegated

Meeting Date / Full Board Reporting Date: 26/Jul/2022

Date Approval Issued: 05/Jul/2022 13:56

REB Approval Expiry Date: 05/Jul/2023

Dear Dr. Jennifer Irwin

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above mentioned study as described in the WREM application form, as of the HSREB Initial Approval Date noted above. This research study is to be conducted by the investigator noted above. **All other required institutional approvals and mandated training must also be obtained prior to the conduct of the study**.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
uMOVE24 - Study Protocol (June 2022)	Protocol	08/Jun/2022	1
uMOVE24 - Recruitment Graphic	Recruitment Materials	08/Jun/2022	1
uMOVE24 - Tiktok	Recruitment Materials	08/Jun/2022	1
uMOVE24 - Social Media & Professor Annoucement Recruitment Messaging - 2022-06-27	Recruitment Materials	27/Jun/2022	2
uMOVE24 - Mass Email Recruitment	Email Script	27/Jun/2022	2
uMOVE24 - Qualtrics Survey - 2022-06-29	Online Survey	29/Jun/2022	2
uMOVE24 - Letter of Information - 2022-06-27	Written Consent/Assent	27/Jun/2022	2

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
uMOVE24 - Rationale References	References	08/Jun/2022	1

No deviations from, or changes to, the protocol or WREM application should be initiated without prior written approval of an appropriate amendment from Western HSREB , except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University HSREB operates in compliance with, and is constituted in accordance with, the requirements of the TriCouncil Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is registered with the U.S. Department of Health &

Human Services under the IRB registration number IRB 00000940.

Please do not hesitate to contact us if you have any questions.

Electronically signed by:

Patricia Sargeant, Ethics Officer [redacted] on behalf of Dr. Roberta Berard, HSREB Vice-Chair, 05/Jul/2022 13:56

Reason: I am approving this document

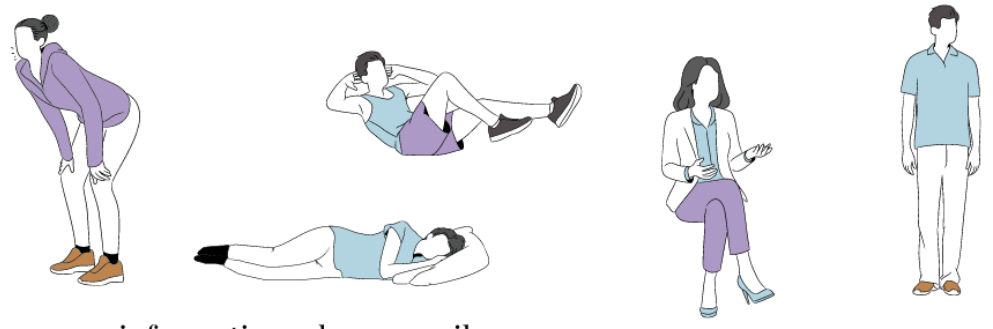
Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations, See Electronic System Compliance Review)

Appendix B – Recruitment Graphic

Are you a full-time student at an Ontario university?

Researchers at Western University invite you to participate in a short survey exploring your movement behaviours and their relationship with social support.

Scan this QR code to be taken to the survey!



For more information, please email:
Nia Contini at [redacted] or Dr. Jennifer Irwin at [redacted]

Western

Appendix C – Mass Email Recruitment Script

Dear Undergraduate Student,

Researchers from the Faculty of Health Sciences at Western University are conducting a study to to investigate full-time Ontario undergraduate university students' movement behaviours and their relationship with social support. To examine this, researchers will be conducting a cross-sectional, observational study and asking Ontario undergraduate students to fill out a short (10-15 minute) survey.

Interested participants who are currently enrolled as a full-time, undergraduate student at an Ontario university and are able to read and write in English are asked to follow the link below for a detailed letter of information about the study.

Link to LOI: https://uwo.eu.qualtrics.com/jfe/form/SV_ekxdJGQNF2c1nn0

Thank you for your time, if you have any questions, please feel free to reach out to either:

Ms. Nia Contini, Co-Investigator
Health and Rehabilitation Sciences, Western University
[redacted]

Dr. Jennifer Irwin, Principal Investigator
School of Health Studies, Faculty of Health Sciences, Western University
[redacted]

Appendix D – Invitation Email to Course Instructors and Student Groups

Dear [insert professor name/group/organization here],

I hope this message finds you well. My name is [name] and I am a [master's student/research assistant] in Dr. Jennifer Irwin's lab in the Faculty of Health Sciences at Western University. I am a [co-investigator/research assistant] on the uMOVE24 study, which we are conducting to investigate full-time Ontario undergraduate university students' movement behaviours and their relationships with social support. To examine this, researchers will be conducting a cross-sectional, observational study and asking participants to fill out a short (10-15 minute) survey.

We are currently recruiting full-time, undergraduate students at any Ontario university. We are hoping that you might be willing to share our recruitment details with your [organization/group/followers]. Should you be willing to assist us with recruitment, I have attached our promotional graphic and accompanying text, inclusive of the link to our study survey found here: https://uwo.eu.qualtrics.com/jfe/form/SV_ekxdJGQNF2c1nn0

Thank you for considering our request, and please do not hesitate to reach out if you have any questions.

Warm regards,
[name, co-investigator/research assistant, the uMOVE24 study]

Sample caption to post along with graphic (Facebook/Instagram/Reddit/LinkedIn/OWL announcement):

> Are you a full-time undergraduate student at an Ontario university? Researchers from Western University in the Faculty of Health Sciences are investigating Ontario undergraduate university students' movement behaviours and their relationship with social support. To participate in a quick, 10–15 minute survey regarding the study, please [click the following link/visit the link in our bio]
> : https://uwo.eu.qualtrics.com/jfe/form/SV_ekxdJGQNF2c1nn0

Tweet/TikTok Messaging

> Are you a full-time undergraduate student at an Ontario University? We invite you to participate in our study exploring movement behaviours and their relationship with social support. To participate, please click the following link click the following link/visit the link in our bio]: https://uwo.eu.qualtrics.com/jfe/form/SV_ekxdJGQNF2c1nn0

Appendix E – Letter of Information

Welcome to the uMOVE24 Study

Study Title: **uMOVE24**: The Prevalence of Ontario Undergraduate **U**niversity Students Meeting the **24**-Hour **Move**ment Guidelines and the Role of Social Support
Principal Investigator: Dr. Jennifer Irwin ([redacted])
Co-Investigator: Ms. Nia Contini ([redacted])

Thank you for your interest in participating in the uMOVE24 Study. Before you decide whether to participate, the researchers would like you to read some important information about the study. If you choose to participate, you will be able to continue to survey to confirm your eligibility and provide consent for the study.

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

Background/Study Rationale

Physical activity, sedentary behaviour, and sleep have serious implications on health and well-being. There is considerable evidence that health outcomes depend on the time spent in each of these three movement behaviours. Nevertheless, many Canadian adults aged 18 to 79 years are not meeting the recommendations for these movement behaviours. The 24-Hour Movement Guidelines are a relatively new set of guidelines that provide recommendations for Canadian adults' physical activity, sedentary behaviour, and sleep. University students are one specific subgroup of the adult population that have found it challenging to participate in sufficient physical activity or sleep, while simultaneously participating in excessive sedentary behaviour. Considering the large influence that the COVID-19 pandemic has had, and continues to have, on students and their movement, it is vital that researchers continue to understand students' movement behaviours at this time.

One determinant that is known to affect all three movement behaviours is social support, which is defined as "aid and assistance exchanged through social relationships and interpersonal transactions". Although social support has been found to play an independent role in influencing physical activity, sedentary behaviour, and sleep behaviour, it has not yet been explored as a determinant of meeting the overall 24-Hour Movement Guidelines. Not surprisingly, the pandemic has influenced many determinants of movement behaviours, including social support. Understanding university students' movement behaviours, the influence of social support, and the current state of students' social support is vital to support students' movement behaviour patterns in the short- and longer-term.

Purpose of this Study

The proposed study is a cross-sectional, observational design. The first of this study's two-fold purpose is to assess the prevalence of full-time Ontario undergraduate university students meeting the Canadian 24-Hour Movement Guidelines approximately two and a half years after

March 2020, when the COVID-19 pandemic began. The second purpose of this study is to assess the association between meeting the Canadian 24-Hour Movement Guidelines and perceived social support.

Eligibility Criteria
Participants will be eligible to participate if they are: (1) registered as a full-time undergraduate student at an Ontario university; and (2) are able to read and write in English.

Study Procedures
Your participation in this study will involve the completion of one online survey that will take approximately 10-15 minutes. The survey will include the brief demographics questionnaire followed by three validated scales (International Physical Activity Questionnaire, Muscle-Strengthening Exercise Questionnaire, Pittsburgh Sleep Quality Index) and four additional questions to assess whether participants are currently meeting the 24-Hour Movement Guidelines. The survey will finish with a validated scale (Multidimensional Scale of Perceived Social Support) to assess students' current level of perceived social support. A maximum of 3000 participants will be enrolled in this study.

Risks & Benefits
For those who choose to participate in the study, there is a risk that some questions, such as those pertaining to perceived social support, might cause some distress and anxiety in some participants. Resources have been included at the end of the survey to provide participants with an opportunity to discuss these emotions. While there are no direct benefits to the study, a reflection on one's own movement behaviours may be beneficial.

Cost & Compensation
There is no cost or compensation for participation in this study.

Voluntary Participation
Participation in this study is voluntary. You do not waive any legal right by participating in this study. The majority of the questions are voluntary; however, there are some screening questions or required fields that are mandatory in order to participate. If you do not want to respond to the mandatory questions, please close the browser before the survey is submitted. You may refuse to participate at any time. Once your responses are submitted, they cannot be withdrawn as they are not identifiable.

Confidentiality
Your survey responses will be collected through a secure online survey platform called Qualtrics. Qualtrics uses encryption technology and restricted access authorizations to protect all data collected. The data will then be exported from Qualtrics and securely stored on a Western University server behind institutional firewalls. The data will be accessed remotely (via Western's OneDrive) by the research team. Study data will not contain any identifiable

information. All data collected will remain confidential and accessible only to the investigators of this study. While we do our best to protect your information, there is no guarantee that we will be able to do so. We are collecting some sensitive information. For example, demographic information (e.g., age, gender, ethnicity, year of study, university of registration). These identifiers will be collected for the purposes of descriptive statistics and understanding the population/cohort that is being studied. After a minimum of 7 years, all data will be destroyed. By participating in this research, you agree that the results may be used for scientific purposes, including publication in scientific journals. No individual information will be reported. Only group-level and aggregated data will be reported.

Contacts for Further Information

If you require further information regarding this research project or your participation in the study, your first points of contact are Ms. Nia Contini ([redacted]) or Dr. Jennifer Irwin ([redacted])/[redacted]. If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics ([redacted]). For non-local participants you may contact: [redacted], email: [redacted].

Eligibility and Consent

Prior to participating in this study, you will be asked to give consent and confirm your eligibility. If you do not provide consent, you will not be able to participate. If you are interested in participating, you will be able to click a link at the end of this survey that will redirect you to confirm your eligibility and provide consent for the study.

If you would like to participate in the uMOVE24 study, please click the next button and it will ask you to confirm your eligibility and provide consent for the study.

If you are not interested in participating, please close your web browser.

Thank you for your time!

Appendix F – International Physical Activity Questionnaire – Short Form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Appendix G – Muscle-Strengthening Exercise Questionnaire Short Form

Supplemental Digital Content 2

Muscle-strengthening Exercise Questionnaire Short Form (MSEQ-Short)

Your participation in muscle-strengthening exercise

The next set of questions are about your participation in **muscle-strengthening exercise,** sometimes called weight or resistance training.

When thinking about muscle-strengthening exercise, we are only interested in exercises that you do during your leisure or free time, and NOT done as part of your work/job, or as a part of household activities (chores).

The types of muscle-strengthening exercise we are interested in include:

- **Using weight machines** - typically in a gym or fitness centre
- **Bodyweight exercises** - including push-ups or sit-ups
- **Resistance exercises** – using free weights like dumbbells or using resistance bands
- **Holistic exercises** - including Yoga, Tai-Chi or Pilates

1. Do you **do muscle-strengthening exercise** in a **usual week?**

   ☐ **Yes**

   ☐ **No** ⟶ **Skip to next module**

2. How **many days,** in a **usual week,** do you do muscle-strengthening exercise?

   _____ **days per week**

3. **On the day(s)** that you **do muscle-strengthening exercise**, please indicate **how long** you spend doing this activity?

   _____ **minutes per day**

4. On a scale from 0 to 10**,** how **hard do you feel** you are **working when doing muscle-strengthening exercise** with '0' being 'extremely easy' and '10' being 'extremely hard'

   _____ **intensity of session**

5. What **types of muscle-strengthening exercise do you usually do**?

Weight machines (Lat pulldown, bench press, leg press)	Yes or No _____
Resistance exercises (resistance bands/dumbbells)	Yes or No _____
Bodyweight exercises (push-ups, sit-ups)	Yes or No _____
Holistic exercises (Yoga, Tai-Chi and Pilates)	Yes or No_____

6. When you do muscle-strengthening exercise, **do you usually do exercise that target or use the** following **muscle groups or parts of your body?**

Legs (e.g. squats, lunge, leg press)	Yes or No _____
Hips (e.g. bridges, lateral banded walk)	Yes or No _____
Back (e.g. lat pulldown, dumbbell row)	Yes or No _____
Abdomen (e.g. sit-ups, planking)	Yes or No _____
Chest (e.g. bench press, push-ups)	Yes or No _____
Shoulders (e.g. shoulder/overhead press)	Yes or No _____
Arms (e.g. bicep curl, tricep dips)	Yes or No _____

This is the end of the survey, thank you for participating.

Appendix H – Multidimensional Scale of Perceived Social Support

Multidimensional Scale of Perceived Social Support

Instructions: We are interested in how you feel about the following statements. Read each statement carefully. Indicate how you feel about each statement.

Circle the "1" if you **Very Strongly Disagree**
Circle the "2" if you **Strongly Disagree**
Circle the "3" if you **Mildly Disagree**
Circle the "4" if you are **Neutral**
Circle the "5" if you **Mildly Agree**
Circle the "6" if you **Strongly Agree**
Circle the "7" if you **Very Strongly Agree**

		Very Strongly Disagree	Strongly Disagree	Mildly Disagree	Neutral	Mildly Agree	Strongly Agree	Very Strongly Agree
1.	There is a special person who is around when I am in need.	1	2	3	4	5	6	7
2.	There is a special person with whom I can share joys and sorrows.	1	2	3	4	5	6	7
3.	My family really tries to help me.	1	2	3	4	5	6	7
4.	I get the emotional help & support I need from my family.	1	2	3	4	5	6	7
5.	I have a special person who is a real source of comfort to me.	1	2	3	4	5	6	7
6.	My friends really try to help me.	1	2	3	4	5	6	7
7.	I can count on my friends when things go wrong.	1	2	3	4	5	6	7
8.	I can talk about my problems with my family.	1	2	3	4	5	6	7
9.	I have friends with whom I can share my joys and sorrows.	1	2	3	4	5	6	7
10.	There is a special person in my life who cares about my feelings.	1	2	3	4	5	6	7
11.	My family is willing to help me make decisions.	1	2	3	4	5	6	7
12.	I can talk about my problems with my friends.	1	2	3	4	5	6	7

Curriculum Vitae

Name:	Nia Contini
Post-secondary Education and Degrees:	University of Ottawa Ottawa, Ontario, Canada 2017-2021 B.Sc Western University London, Ontario, Canada 2021-Present, M.Sc
Honours and Awards:	Ontario Graduate Scholarship April 2022 Canada Graduate Scholarship Social Science and Humanities Research Council (SSHRC) April 2022 Dean's Honour List University of Ottawa April 2019 – April 2021 Dean's Award of Excellence University of Ottawa, Faculty of Health Science December 2019
Related Work Experience	Graduate Teaching Assistant Western University HS 2700: Health Issues in Childhood and Adolescence (Fall 2021) HS 1001: Personal Determinants of Health (Summer 2022) HS 2250: Introduction to Health Promotion (Fall 2022) Research Assistant Lakehead University July 2022 – Present Research Assistant University of Ottawa October 2019 – August 2022 Research Assistant Thunder Bay District Health Unit March 2022

Publications:

Contini, N., Shillington, K. J., Vanderloo, L. M., Burke, S. M., Ng, V., Tucker, T., & Irwin, J. D. (Manuscript Submitted for Publication, March 2022). Ontario adults' health behaviours during the COVID-19 pandemic. Applied Physiology, Nutrition, and Metabolism.

Contini, N., Giles, A. R., Giesbrecht, G., & Raddi, T. (2021). The adaptation of the beyond cold water bootcamp course for Inuvialuit communities in Northwest Territories, Canada. *International Journal of Circumpolar Health*, *80*(1), Article 1969744. https://doi.org/10.1080/22423982.2021.1969744