Analysis of sleep and sleep hygiene in relation to the 2020 24-Hr Canadian Movement Guidelines among adults with intellectual and developmental disabilities: A Pilot Study

by

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BSc., University of Victoria, 2019

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Abstract

Background: A variety of physiological and behavioural factors contribute to adults with Intellectual and Developmental Disabilities (IDD) being at high risk of problems with sleep duration and sleep quality. Sleep problems in this demographic may have been exacerbated by changes and restrictions in place due to the COVID-19 pandemic.
Objective: The objective of this pilot study was to determine if collecting field data using smartwatch technology and sleep and physical activity diaries was feasible in this population. Utilizing these methodologies, the main goal was to monitor the sleep duration and sleep quality of adults with IDD and to compare those findings to the recommendations in the Canadian 24-Hour Movement Guidelines. Additionally, sleep hygiene behaviours and daily activities were recorded to further understand relationships between sleep and these variables.
Methods: Participants (n = 15) were invited to wear a Polar Ignite smartwatch for a 9-day period and instructed how to complete a sleep and physical activity diary. Total sleep, actual sleep, sleep disturbances, and physical activity were recorded quantitatively using actigraphy. Behaviours were assessed using the sleep and physical activity diary.
Results: Participants were able to consistently wear the smartwatch and report information in the sleep and physical activity diary. The majority of participants did not meet sleep duration guidelines based on their weekly average, with 9 out of 15 participants outside the guideline recommendations and only 1 participant meeting the guidelines every night. Participants regularly reported problems with their sleep and smartwatches recorded an average of 35:40 minutes (SD = 10:50) of sleep disturbances each night. Screen time before bed was the most common adverse sleep hygiene behaviour. Screen time was negatively, but not significantly correlated with total sleep (r = -0.34, $p > 0.1$) and actual sleep (r = -0.33, $p > 0.1$). Average moderate-vigorous physical activity (MVPA) was significantly correlated with sleep disturbances. This relationship was negative and moderately strong (r = -0.57, $p < 0.05$).
Conclusions: This pilot study highlights that participants were able to provide seven days of sleep data and adhere to reporting their daily behaviours via a sleep and physical activity diary. Additionally, sleep duration and quality were not adequate in most

participants. It is also likely that before-bed screentime had an adverse effect on sleep duration. Physical activity, on the other hand, had a positive effect on reducing sleep disturbances. These results suggest fruitful lines of enquiry, and future research with larger samples of adults with IDD are recommended to understand these relationships further. Researchers should have an ultimate objective of optimizing sleep, which in turn, would improve the health status of adults with IDD.

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Chapter 1 Introduction

1.1) Rationale

Sleep is a physiological state that is important for daily functioning and long-term survival (Boyle et al., 2010). However, large portions of the general population report problems with their sleep ranging from inadequate duration to poor quality (Janati Idrissi et al., 2020). Consequently, problems with sleep can lead to decreased overall well-being and a lower health-related quality of life (Van de Wouw et al., 2013). Sleep problems are prevalent among individuals with intellectual and developmental disabilities (IDD), with estimates suggesting anywhere from 24% to 86% of adults with IDD experience some sort of problem with their sleep (Shanahan et al., 2019). Sleep hygiene is an area of particular interest, with individuals with IDD reporting poor sleep hygiene behaviours that may be negatively affecting their sleep (Richdale & Baker, 2014). Sleep hygiene is defined as habits and practices that promote healthy sleep based on behavioural and environmental recommendations (Irish et al., 2015). Further, Jahrami et al. (2021) found that the prevalence of sleep problems in the general population was exacerbated during the COVID-19 pandemic. With the appearance of the COVID-19 pandemic and the already high prevalence of sleep problems among the IDD population, further research is necessary to better understand how sleep may have been affected among adults with IDD during the pandemic (Halstead et al., 2021a; Heinze et al., 2021). Given the lack of studies utilizing objective measures to monitor sleep in adults with IDD, this pilot study assesses the feasibility of actigraphy to monitor sleep and physical activity for adults with IDD as well as if they able to provide self-reported information in a sleep and physical

activity diary each day, allowing for the development of better testing methods and protocols in future studies (Lefeaux et al., 2022; van Teijlingen & Hundley, 2002).

1.2) Adults with IDD and Sleep

The term IDD has since been used to describe individuals diagnosed with an intellectual disability, characterized by limitations originating before the age of 18 years, both in intellectual functioning and in adaptive behaviour, which includes conceptual, social, and practical daily living skills (Breuer et al., 2022); and IDD has been defined as a developmental disability, which is a severe chronic disability originating before age 22 that can be cognitive and/or physical (Gilson et al., 2022). IDD is used to define the entire population of individuals with common disabilities and disorders such as autism spectrum disorder, Down syndrome, fetal alcohol syndrome, and Tourette's syndrome (Conrad, 2020). Previously, studies did not often explicitly focus on the population of individuals with IDD, partially due to the term IDD being only relatively recently introduced into the literature as a broader term compared to specific diagnoses such as autism spectrum disorder (Berteli et al., 2016; Cohen et al., 2014; Salvador-Carulla et al., 2011).

Research focussed on adults with an IDD have not always been representative of all types of IDDs, often resulting in minimal research for lesser-known disabilities or disorders (Ervin et al., 2014). To promote broader research, the term IDD is used to account for the possibility of other diagnoses that may not fall under the definition of the narrower term of 'intellectual disability' (McDonald et al., 2016). Individuals with intellectual disabilities often demonstrate multimorbidity, the presence of two or more additional conditions, which means that using an even broader term, like IDD, may better

represent the population and account for a wider variety of characteristics (Cooper et al., 2015; Krahn & Fox, 2014).

Individuals with IDD typically have a variety of physiological body functions and structures that detrimentally affect sleep (Maaskant et al., 2013; Van de Wouw et al., 2013). Common physiological factors include sleep apnea and sleep-disordered breathing, a result of a higher incidence of anatomical abnormalities compared to adults without an IDD (Baker & Richdale, 2015; Van de Broek et al., 2021). With multimorbidity being more common among adults with IDD (Esbensen, 2016; Richdale & Baker, 2014), there is an increased likelihood of fragmented sleep leading to abnormal wake-cycles, lower quality sleep, and more night wakening (Baker & Richdale, 2015; Didden et al., 2002; Lindblom et al., 2001).

Compared to adults without an IDD, a greater proportion of adults with IDD report and demonstrate problems with their sleep quality and duration (Korb et al., 2021; Surtees et al., 2018). Utilizing actigraphy through a wrist-worn accelerometer, Böhmer et al. (2020) found that older adults with IDD demonstrated reduced stability in their sleep-wake rhythms as well as a greater prevalence of sleep problems compared to adults without an IDD. Maaskant et al. (2013) found similar results utilizing actigraphy via a wrist-born accelerometer, with adults with intellectual disabilities having significantly less disrupted sleep-wake rhythms compared to adults without an IDD, leading to poor sleep quality and duration.

The sleep hygiene behaviours of adults with IDD are of particular interest given the prevalence of sleep problems among this demographic (Irish et al., 2015). Poor sleep hygiene is often associated with worse sleep quality and duration and can lead to poorer

long-term physical and mental health outcomes (Korb et al., 2021). Previous research has shown that certain behaviours immediately prior to bedtime, such as screentime or caffeine consumption, have a negative impact on sleep regardless of disability status (Aishworiya et al., 2018; Drake et al., 2013; Drescher et al., 2011). Individuals with IDD are at an even greater risk to be negatively affected by these poor sleep hygiene behaviours, stressing the importance of sleep hygiene in preventing sleep problems (Köse et al., 2017; Sutton et al., 2020).

Sleep dysfunction is common among adults with IDD (Didden et al., 2014). Some of this dysfunction is associated with the neurobiology or craniofacial aspects of specific conditions (Esbensen & Schwichtenberg, 2016) and some is associated with behavioural antecedents such as poor sleep hygiene (Didden et al., 2014). Despite the prevalence of sleep problems among adults with IDD, sleep problems are often treated as secondary to the primary condition (Korb et al., 2021). With the introduction of the 24-hr Movement Guidelines for Canadians in 2020 (Ross et al., 2020), it is timely to examine the sleep component of the guidelines among adults with IDD.

The primary goal of this pilot study was to examine the sleep duration and quality of as well as the sleep hygiene behaviours of adults with IDD. Secondary aims of the study were 1) to compare the sleep durations of study participants to the Canadian 24-Hour Movement Guidelines for Adults aged 18-64 years, and 2) to examine whether total daily physical activity was associated with sleep duration and quality. In addition to the primary questions presented, this pilot study had three aims related to feasibility of the outcome measures: (1) to assess whether it is feasible to monitor sleep and physical activity with smartwatch technology, (2) to investigate whether adults with IDD are able

to consistently wear smartwatches for one week, and (3) to see if adults with IDD are able to provide self-reported information in a sleep and physical activity diary each day, completing entries both in the morning and evening.

1.3) Research Questions

i.) Do adults with IDD meet the recommended guideline for sleep quality and duration (between 7 and 9 hours) as described by Canada's 2020 24-Hour Movement Guidelines?

ii.) Are adults with IDD reporting and demonstrating problems with their sleep quality?

iii.) What are the sleep hygiene behaviours of adults with IDD?

iv.) Are poor sleep hygiene behaviours associated with poor sleep quality and duration?

v.) Is total volume of physical activity associated with better sleep quality and duration?

1.4) Limitations

In this study, those who decided to participate and were eligible were accepted as participants. Due to the volunteer aspect of recruitment, the research had a small sample size that underrepresents individuals with IDD in the greater Victoria region and may lack external validity towards the general population of adults with IDD. Further, participants were only recruited via certain organizations within the region. Individuals who were not working with the organizations we partnered with were unaware of the study and did not have the opportunity to participate. Individuals who took part in this study did not have to report the severity of their disability. Further limitations include

participant selection criteria lacking any form of random selection or a comparison group. Participants may also demonstrate participant bias and may try to report better results. Lastly, the study had a relatively short duration of 9 days to generate 7 full days of data. These data may or may not be representative of participants' typical patterns.

1.5) Delimitations

Delimitations of this study include only observing individuals with IDD. Further, these volunteers were only recruited from the Greater Victoria region. Additionally, this study took place during the COVID-19 pandemic and may lack external validity in contexts outside of the pandemic. Data collection was limited to Polar Ignite smartwatches and a sleep and physical activity diary.

1.6) Operational Definitions

1.6.1) Sleep Hygiene

Before bedtime habits and practices that are essential to sleeping well on a regular basis.

1.6.2) Sleep Quality

An individual's self-satisfaction with all aspects of their sleep experience.

1.6.3) Sleep Duration

The quantity of sleep an individual sleeps over one time period.

1.6.4) Total Sleep

The total duration of sleep between when you fell asleep and when you woke up for the day.

1.6.5) Sleep Interruptions

Periods of time spent awake between when you fell asleep and when you woke up for the day.

1.6.6) Actual Sleep

The time spent asleep between the time you fell asleep and when you woke up. It is the total sleep time minus the interruptions.

1.6.7) Sleep Deprivation
A state caused by inadequate quantity or quality of sleep. Associated with several short-term and long-term health problems.

1.6.7) Intellectual and Developmental Disabilities (IDD)
Disorders that are usually present at birth and that negatively affect the trajectory of an individual's physical, intellectual, and/or emotional development.

1.6.8) Activity
Any specific behaviour which a person does.

1.6.9) Physical Activity
Any bodily movement or activity that is carried out by muscles that require energy.

1.6.10) Sedentary Behaviour
Activities that a person does when sitting, reclining or lying down, typically associated with very little to no exercise.

1.6.11) 24-Hour Movement Guidelines
Guidelines published on what a healthy 24 hours looks like for Canadian adults aged 18-64 and 65 years or older (Ross et al., 2020).

1.6.12) Actigraphy
A non-invasive method of objectively measuring sleep and activity by using a wristwatch-like monitor for prolonged periods of time.

1.6.13) COVID-19 Pandemic
Also known as the coronavirus pandemic, is at the time of writing, an ongoing pandemic of coronavirus disease (SARS-CoV-2) caused by severe acute respiratory syndrome. After attempts to mitigate the virus failed, the novel virus has since spread worldwide, affecting all segments of the population on a global scale.

1.6.14) OMICRON
An extremely transmissible genetic variant of the genetic variant of the SARS-CoV-2 coronavirus first identified in November 2021, quickly becoming the predominant variant of the coronavirus soon after at the time of data collection.

Chapter 2 Literature Review

With the advancements to technology and research, the importance of sleep in our lives has become even more established (Worley et al., 2018; Nichols et al., 2019). Sleep has been associated with a number of short- and long-term health benefits, demonstrating that it is essential for daily functioning (Mukherjee et al., 2015; Ramar et al., 2021). Unfortunately, a large proportion of the population are not achieving sufficient amounts of sleep, creating concern for both current and future negative health outcomes (Chattu et al., 2019). Further, the high prevalence of inactivity in populations has led public health practitioners to design interventions that will find solutions to the ever-increasing rise in adverse health conditions related to everyday behaviours within a 24-hour period such as inactivity and poor sleep (Hamm & Yun, 2019; Nicholas et al., 2019). With the onset of the COVID-19 pandemic, adults with IDD are of particular interest given their increased risk of insufficient sleep and physical inactivity (García-Villamisar & Dattilo, 2010; Korb et al., 2021).

Given the diversity of information collected in this study, the following review of literature will be divided into seven topics: the importance of sleep; sleep in adults with IDD; the relationship between sleep, physical activity, and sedentary behaviour; Canada's 24 hour movement guidelines; smartwatch technology; the impact of COVID-19; and the deficiency of knowledge this study addresses in the context of IDD sleep research with insight into extending the current knowledge base.

2.1) The Physiology and Importance of Sleep

The day-to-day functioning of the human body is based on the circadian rhythm, an approximately 24-hour repeating cycle (Egierska et al., 2021). The circadian rhythm is a natural cycle of changes the body goes through in a 24-hour period (Ma & Morrison, 2019). Almost all processes and functions of the human body are somewhat controlled by the circadian rhythm, leading it to this commonly being referred to as the biological clock (Hastings et al., 2018). This diurnal cycle is regulated by an internal pacemaker known as the suprachiasmatic nucleus (SCN) (Egierska et al., 2021). Located in the anterior part of the hypothalamus, the SCN regulates the circadian rhythm systems of the human body, making it an important aspect of daily functioning (Ma & Morrison, 2019).

One essential aspect of the SCN and its role controlling circadian rhythm is sleep (Hastings et al, 2018). Sleep is an essential biological function and plays an important role in recovery, energy conservation, and survival (Sargent et al., 2021). Sleep is essential for waking cognition which involves the ability to think clearly, be aware of your environment, and remain alert when awake (Worley, 2018). Additionally, sleep plays a significant part in development, in long-term well-being, and in good health throughout all stages of life, with recommendations for sleep duration varying with age and sex (Mukherjee et al., 2015; Ramar et al., 2021).

The SCN initiates a cascade of effects leading to the production of melatonin, a hormone produced by the pineal gland in dark environments (Okechukwu, 2022). Melatonin alters the sleep-wake cycle, shifting it to sleep which is divided into two main phases: rapid eye movement (REM) and non-rapid eye movement (NREM), with NREM divided into three stages, N1-N3 (Patel et al., 2022). As sleep is initiated, NREM begins, starting with stage 1, signifying the transition from wakefulness to sleep, moving through

stage 2 and 3, marking a transition from light to deep sleep, and eventually ending with REM, often associated with dreaming due to increased brain activity (Shirota et al., 2021). The human body cycles through each stage ideally 4-6 times each night, with an average of 90 minutes each cycle (Patel et al., 2022). Each sleep stage has a distinct function for the body, with disruption mid-cycle being detrimental to functioning (Dijk & Landolt, 2019).

Given that 4-6 sleep cycles are recommended per night, the Canadian 24-Hour Movement Guidelines recommend that adults obtain 7 to 9 hours of good quality sleep on a regular basis (C. Wang et al., 2022). Good quality sleep is defined as lacking regular interruptions, being asleep for more than 85% of time spent in bed, and lacking symptoms of a sleep disorder such as snoring or gasping for air (Ramar et al., 2021). With newborns requiring the greatest amount of sleep per night (12-18 hrs), the recommended amount of sleep gradually decreases with age as children proceed into adulthood (Matricciani et al., 2013). It has globally been accepted that adults must aim for at least 7-8 hrs per day (Chaput et al., 2020; Watson et al., 2015). Adequate sleep duration and quality has been established as essential for health, with a variety of benefits from achieving the recommended amounts, and with a variety of detriments if not attained (Ramar et al., 2021).

2.1.1) Importance of Sleep through the Lifespan

It is widely accepted that sleep is essential at all ages, especially for children as they develop (Peirano & Algarín, 2007). Sleep is directly linked to development, with infants requiring significant amounts of sleep to ensure healthy development (Matriccinai et al., 2013). Sleep is essential for the neurosensory and motor systems in the brain, a process which is necessary for memory creation and maintenance (Graven & Browne, 2008). In

babies, acquisition of new information occurs during sleep, allowing them to process stimuli and environments they previously encountered while awake (Tarullo et al., 2011). Research in infant sleep has confirmed that interference with sleep at a young age has a variety of implications regarding cognition, learning, and memory, indicating that inadequate sleep is detrimental to brain development (Lokhandwala et al., 2022; Tham et al., 2017). Touchette et al. (2007) confirmed that shortened sleep duration as an infant was associated with lower cognitive performance later in childhood, highlighting the importance and long-term impact of adequate sleep. Parents even demonstrate that their own child's sleep pattern impacts their sleep and daytime function, showing that insufficient sleep among infants negatively affects their families sleep (Mindell et al., 2015).

Sleep is also essential for adolescent development, with adolescence being a significant time for brain development (Schocat et al., 2014). Telzer et al. (2015) found that inadequate sleep was associated with lower white matter integrity among adolescents, a result that can lead to long-term reduced cognitive performance (Bolandzadeh et al., 2012; Kerchner et al., 2012). With approximately 69% of Canadian adolescents meeting sleep recommendations (8-10 hrs), many adults in the future could see long-term negative impacts on their brain function due to earlier periods of insufficient sleep (Gariepy et al., 2020).

Although the age of 25 is often viewed as the approximate endpoint for brain development and maturation post adolescence, the human brain continues to be altered with changes to neuronal plasticity, function, and cognition present throughout the entire lifespan (Arain et al., 2013; Owens et al., 2014). Therefore, sleep continues to support brain

function and cognition throughout the entire lifespan. Due to this, sleep deprivation results in learning and memory impairments regardless of age (Conte & Ficca, 2013). Tai et al. (2022) examined data from 479,420 adults in the United Kingdom and found that for adults, aged 38-73 years, 7 hours per day was associated with the highest cognitive performance. Sleeping 6-8 hours was associated with greater grey matter volume in several different brain regions, demonstrating a positive relationship between optimal sleep duration and brain volume (Tail et al., 2022). Similarly, numerous research studies have confirmed that sleep deprivation reduces brain volume which can result in impairments to brain plasticity and function, potentially leading to future cognitive disorders and psychiatric diseases (Gao et al., 2022; Kreutzmann et al., 2015; Ma et al., 2020; Saksvik-Lehouillier et al., 2020).

With the proportion of older people rapidly increasing, more studies are exploring the connection between sleep and cognitive impairment among an aging world population (Bah et al., 2020). Ma et al. (2020) analyzed data from 20,065 individuals over multiple years to determine the relationship between cognitive decline and sleep duration. They discovered an inverted U-shaped association between cognitive decline and sleep duration, noting that individuals with 4 hours or less and 10 hours or more of sleep per night demonstrated greater cognitive decline than those with between 4 and 10 hours of sleep (Ma et al., 2020). Cognitive impairment can ultimately lead to dementia and Alzheimer's disease, demonstrating that reduced sleep quality and duration can act as a risk factor for these diseases later in life (Li et al., 2018; Lutsey et al., 2018). Interventions for improving sleep may not only contribute to improving short-term outcomes in memory and brain

function but may also modify the risks for the development of future cognitive impairment at all stages of life (Ma et al., 2020; Siddarth et al., 2021).

2.1.2) Emotional Regulation

Sleep has numerous psychological implications given its known effect on regulatory mechanisms and the brain (Barber & Munz, 2010). One mechanism that sleep affects is emotional regulation, referring to a person's ability to manage and respond to emotional experiences (Wilms et al., 2020). The literature suggests that sleep plays an important role in our ability to effectively regulate our emotions, with insufficient sleep directly linked to increased negative emotional responses and risk-taking behaviours (Dahl, 1999; Saksvik-Lehouillier et al., 2020; Watling et al., 2020). For example, Watling et al. (2020) found that impaired sleep had a significant detriment on emotional regulation and cognition, leading to an increased incidence of accidents or close calls while driving. Similarly, Nicholson et al. (2021) found that participants with reduced sleep quality and duration had higher levels of avoidance and impulsivity and lower use of cognitive reappraisal.

Sleep is also often linked to psychiatric disorders including anxiety and mood disorders (Vandekerckhove & Wang, 2018). Depression, being one of the more well-known mood disorders, is closely linked with sleep deprivation (Reynolds et al., 2020). Early work in sleep research often suggested that depression was a risk factor for the onset of sleep problems (Morphy et al., 2007). However, researchers have demonstrated that there is a bidirectional relationship between depression and sleep (Fang et al., 2019). Individuals with insomnia have a higher risk of developing depression and individuals with depression often develop sleep problems (Fang et al., 2019; Furihata et al., 2011). For

example, Buysse et al. (2008) monitored 591 young adults over 20 years and found that between 17% and 50% of individuals without depression, but with insomnia lasting 2 weeks or more developed a major depressive episode. Additionally, a national survey in the UK found that approximately 83% of depressed individuals have some degree of insomnia (Stewart et al., 2006). Sleep deprivation acts as both a risk factor and symptom of depression, highlighting the essential role sleep plays in supporting emotion regulation (Compare et al., 2014; Furihata et al., 2011).

2.1.3) Immune Function and Physical Recovery

Sleep is associated with several regulatory mechanisms, with numerous research findings indicating an interaction between sleep and immune system function (Besedovsky et al., 2012; Garbarino et al., 2021; Irwin, 2019). The immune system alters sleep as necessary, with stimulation of the immune system associated with substantial changes to magnitude and length of sleep, typically increasing sleep duration and intensity to promote host defense (Besedovsky et al., 2019). Sleep also functions as a period of rest, supporting immune system organization and preparation prior to facing immunological challenges that may arise (Irwin, 2022). Sufficient sleep acts as a mediator for a variety of immune parameters, leading to reduced infection risk and improved infection outcome (Besedovsky et al., 2019; Schmitz et al., 2022).

With sleep being so closely tied to immune response, insufficient sleep has a variety of detrimental effects on immune system functioning (Garbarino et al., 2021). Sleep is strongly linked to cytokine response, with cytokines being signaling proteins released as inflammatory agents in response to injury or infection (van Leeuwen et al., 2019). Sleep deprivation results in an inappropriate constant increase in levels of pro-inflammatory

cytokines and inflammation, resulting in a reduction in antiviral immune responses when the host faces a threat (Aldabal & BaHammam, 2011; Irwin, 2019; van Leeuwen et al., 2009). Long-term reductions in sleep are associated with persistent changes in the immune system, increasing the risk of disease development (Kamdar et al., 2012; van Leeuwen et al., 2009).

The importance of sleep in regulating physiological responses extends to physical recovery, with adequate sleep being crucial for optimal physical recovery (Kamdar et al., 2012). Researchers observing high-performance athletes have consistently noted that insufficient sleep is linked to increased incidences of muscle damage (Bonnar et al., 2018; Nédélec et al., 2015; Vitale et al., 2019). Additionally, athletes with insufficient sleep were more likely to experience an injury (Craven et al., 2022; Hamlin et al., 2021). Generalizing these results to the entire population, researchers have suggested that adequate sleep is necessary for physical recovery and injury prevention (Kamdar et al., 2012; Vyazovskiy, 2015).

2.1.4) Cardiometabolic impact

Prior to COVID-19, the leading causes of death in the developed world had shifted away from infectious diseases toward death due to heart disease, cancer, and a variety of other non-infectious diseases (Branchard et al., 2018; Kung et al., 2008). Many of these causes of death have been linked to behavioural and lifestyle choices, suggesting that these health conditions are mediated by other factors. Some of the more common risk factors include hypertension, obesity, and diabetes – with these terms being referred to as cardiometabolic disease (Grandner, 2014). Each of these cardiometabolic disorders demonstrate strong evidence for future development of a variety of more severe conditions

including heart attack, stroke, and atrial fibrillation (Fuchs & Whelton, 2020; Henst et al., 2019).

One area of interest regarding cardiometabolic disorders includes hypertension, with age-related increases in blood pressure being linked to increased cardiovascular consequences usually attributed to aging (Fuchs & Whelton, 2020; Z. Wang et al., 2022). Approximately 54% of strokes and 47% of coronary artery diseases are attributable to hypertension and with the prevalence of hypertension expected to increase over the coming years, prevention and treatment strategies will become increasingly necessary (Lawes et al., 2008; Wu et al., 2015). Inadequate levels of sleep is associated with the development of hypertension, with adequate sleep acting to both reduce and prevent hypertension (Henst et al., 2019; Nagai et al., 2010; Z. Wang et al., 2022). Stock et al. (2020) observed 53 university students located in the USA and found that by achieving the optimal 7-9 hours of nightly sleep, systolic blood pressure could be significantly reduced. Similar results were found in an analysis of 1533 older adults in Japan (aged ≥ 70 years), where Sasaki et al. (2016) found that systolic blood pressure was higher for groups with more than 8 hours or less than 6 hours of sleep. Decreased sleep duration and quality was also linked to hypertension within a sub-study observing 46 Indigenous, Australian adults confirming the importance of both sleep quality and duration in regulating blood pressure (Yiallourou et al., 2021).

Obesity, another common cardiometabolic risk factor, has also been linked to sleep deprivation, with sleep deprivation acting as a risk factor for obesity (Patel & Hu, 2012). With the prevalence of obesity growing to epidemic proportions, researchers are suggesting that recent increases in sleep deprivation among the general population is one contributing

cause (Papatriantafyllou et al., 2022; Sperry et al., 2015). Observational studies have consistently found that insufficient sleep hours are strongly correlated with weight gain (Bonanno et al., 2017; Patel et al., 2006). Additionally, numerous editions of the National Health and Nutrition Examination Survey have shown that higher rates of obesity in adults are observed among individuals with less than 7 hours of sleep per night *(*Gangwisch et al., 2005; Li, 2021*).*

With obesity being strongly correlated with insufficient sleep, numerous interventions have been designed to improve sleep to see if it can decrease weight gain (Miller et al., 2021). Sleep extension has been proposed as one option to improve weight management (Pizinger et al., 2018). Sleep extension interventions, monitored through questionnaires and actigraphy, have successfully demonstrated that better sleep health is associated with greater weight and fat loss (Bonnano et al., 2017; Kline et al., 2021). Tasali et al. (2022) observed 80 participants over 6 years, randomizing half of the participants to a control group and half to a sleep extension group aimed at extending total time in bed to 8.5 hours. Upon conclusion of the study, the sleep extension group demonstrated a significant decrease in energy intake and a weight reduction when compared to the control group. Based on previously mentioned results, improving sleep is an effective way to prevent weight gain and improve weight management (Bonanno et al., 2017; Tasali et al., 2022).

As previously demonstrated by Tasali et al. (2022), individuals with poor sleep quality and duration have higher energy intakes than normal sleepers – this can partially be explained by measured increases in satiety and hunger hormones among short sleepers (Markwald et al., 2013; St-Onge et al., 2016). This apparent difference in hormone release,

provides a possible answer as to why individuals with short sleep duration are more strongly associated with dietary intakes consisting of a high-fat diet, low fruit and vegetable intake, and large amounts of fast food (Gębski et al., 2018; Stamatakis et al., 2008). Given the influence diet has on a variety of conditions, not just obesity, the effect sleep has on diet can be multifaceted (Cena & Calder, 2020).

With the prevalence of obesity ever-increasing and diet being suggested as one potential explanation, diabetes has also unsurprisingly been on the rise, specifically in the form of type 2 diabetes (Hu, 2011). Affecting over 537 million people worldwide, there are numerous reasons for the observed increased prevalence with sleep being of particular interest (IDF Diabetes Atlas, 2022; Koloverou et al., 2014). Given that the presence of diabetes is strongly correlated with significant health complications and increased mortality risk, extensive research into preventing and managing diabetes are being explored with sleep being one important area of concern (Alam et al., 2021; Tomic et al., 2022).

Chao et al. (2011) observed 3,470 obese adults over one year, finding that both short (<6.0 hrs) and long (≥8.5 hrs) sleep durations were independently associated with a new diagnosis of diabetes, finding that both too little and too much sleep is associated with decreased glucose tolerance and increased insulin resistance. Sleep extension interventions have also observed that improving sleep quality and duration is correlated with lower fasting insulin levels and fewer significant increases in blood glucose, improvements that were evident compared to controls (Hartescu et al., 2021). Sleep deprivation has thus been linked to both potential changes an individual may make in their diet as well as alterations to bodily responses to insulin and glucose, causing sleep to significantly influence the onset

of diabetes (Altman et al., 2012; Quist et al., 2016). Based on the previous findings, poor sleep, whether in quality or duration, is linked to a variety of negative cardiometabolic health outcomes, which could lead to more severe consequences in the form of cardiovascular disease (Yiallourou et al., 2021; Z. Wang et al., 2022).

2.2) IDD and Sleep

Individuals with IDD experience problems with sleep at a greater prevalence than the individuals without an IDD (Richdale & Baker, 2014; Shanahan et al., 2019). Reported levels of sleep problems among this demographic range from anywhere between 13% to 86%, largely due to the differences in study design, participant characteristics, and varying definitions of sleep problems (Braam et al., 2009; Korb et al., 2021; Richdale & Baker, 2014; Van de Wouw et al., 2013). Systematic reviews focussed on adults with IDD found that 32% experienced multiple problems with their sleep (Korb et al., 2021; Shanahan et al., 2019; Van de Wouw et al., 2013). Given the variability in these findings and the heterogenous variety of this demographic, optimal assessment and management of sleep problems among adults with IDD has been met with challenges (Al-Farsi et al., 2019; Esbensen & Schichtenberg, 2016; Surtees et al., 2018). Additionally, sleep research on IDD has typically focussed on children, leaving numerous uncertainties regarding the sleep health status of adults with IDD (Korb et al., 2021).

2.2.1) IDD and Sleep Duration

Given the essential aspects of sleep and the increasingly observed limited sleep duration among the general population, recommendations regarding sleep duration have been developed stating that adults typically require 7-9 hours of sleep per night (Chaput et al., 2018). Although there is limited research focussing on adults with IDD, analysis of

sleep duration in adults with and without IDD demonstrates that adults with IDD achieve less sleep than adults without IDD (Korb et al., 2021; Surtees et al., 2018). As demonstrated by a meta-analysis by Surtees et al. (2018), a mean difference of 18 minutes less per night for adults with IDD compared to adults without IDD was observed across 22 studies; however, no differentiation was provided as to whether these studies covered total sleep or actual sleep. Van de Wouw et al. (2013) noted that older adults with IDD who did achieve a sufficient sleep length required longer time in bed compared to adults without IDD, demonstrating that adults with IDD typically have longer sleep onset latency compared to adults without IDD.

Sleep research observing children has also consistently found differences between individuals with and without IDD, with sleep duration lower among children with IDD compared to children without an IDD (Al-Farsi et al., 2019; Esbensen & Schwichtenberg, 2016). Al-Farsi et al. (2019) observed children in Oman, where 293 children and their caregivers completed questionnaires regarding the child's sleep status. Children with IDD reported lower levels of sleep compared to children without an IDD, with children with autism spectrum disorder having the poorest sleep lengths (Al-Farsi et al., 2019). Esposito and Carotenuto (2013) analyzed 18 children with IDD and 24 children without an IDD, looking to utilize sleep electroencephalogram and overnight polysomnography to determine differences in cortical organization. Their results demonstrated that children with IDD had reduced sleep duration, largely due to increased rates in shifting between sleep stages, as well as increased awakenings during the night. Each sleep stage for children with IDD had a reduction in gamma frequency and an increase in delta frequency, changes

that have been previously associated with sleep deprivation (Li et al., 2008; Posada-Quintero et al., 2019).

2.2.2) IDD and Sleep Quality

In addition to sleep duration, sleep quality measurements among adults with IDD have yielded poorer results compared to adults without IDD (Braam et al., 2009; Maaskant et al., 2013). A meta-analysis by Surtees et al. (2018) analyzed 18 studies that measured sleep quality for people with and without intellectual disabilities, concluding that sleep quality is typically lower among individuals with intellectual disabilities. Maaskant et al. (2013) utilized actigraphy to monitor 551 individuals with IDD and 58 individuals without an IDD, with all participants over the age of 50. Results demonstrated that adults with IDD had less stable sleep-wake rhythms, leading to more disturbed sleep that was of lower quality compared to the general population. Similar work utilizing actigraphy, in this case the validated ActiSleep monitor (Weiss et al., 2010), observed 125 children with disabilities, aged 6-12 years, to monitor sleep over the course of one week (Chen et al., 2015). Their results showed that children with disabilities had more difficulties initiating sleep as well as maintaining sleep. Compared to previous findings observing children without an IDD, children with an IDD demonstrated significant differences with prolonged sleep latency and low sleep efficiency.

Results from questionnaires have also suggested that individuals with IDD have problems with sleep quality (Van de Wouw et al., 2013). Questionnaires distributed to families with a child with Sanfilippo syndrome from USA, UK, and Australia found that 91.5% of children demonstrated sleep disturbances to a greater extent when compared to their siblings (Fraser et al., 2005). Parents reported that their child with Sanfilippo

syndrome had significant difficulties getting to sleep, with 77.5% of parents reporting the use of medications like melatonin and benzodiazepines to manage these sleep difficulties. Cotton and Richdale (2010) monitored children with a variety of IDDs compared to children without an IDD, to identify differences in reported sleep patterns and behaviours over a 14-day period. Observing 82 children with a variety of disorders including Down syndrome, autism, and Prader-Willi syndrome in comparison to a control group of 33 children without an IDD, researchers found that children with IDD had higher levels of daytime sleepiness and an increased incidence of night wakening. Contrastingly, researchers observing adults with IDD have found a lower prevalence of sleep problems. For example, Boyle et al. (2010) found that only 9.2% of participants experienced a significant sleep problem. Utilizing subjective assessments and questionnaires, 1,023 adults reported their sleep problems over a 4-week period. The most noteworthy finding was that individuals taking antiepileptic medication were more likely to report broken sleep, suggesting a relationship between sleep quality and co-morbid health status.

2.2.3) Factors affecting sleep among individuals with IDD

Given that individuals with IDD both demonstrate and self-report problems with sleep duration and quality, medication has often been viewed as one possible intervention to assist with sleep (Boyle et al., 2010; Maaskant et al., 2013). Melatonin, a naturally occurring hormone that helps induce sleep, is often viewed as being one solution to help improve sleep duration and quality, regardless of IDD status (Sajith et al., 2014; Ward et al., 2014). However, melatonin supplementations may be particularly important for individuals with IDD who demonstrate disruptions in melatonin production, such as

individuals with autism spectrum disorder, that in turn, lead to difficulties in sleep onset (Agar et al., 2021; Ballester-Navarro et al., 2021; Schwichtenberg & Malow, 2015).

In addition to variations in chemical messengers, individuals with IDD often have other conditions that may impact sleep (Esbensen & Schwichtenberg, 2016). Chronic pain is an example of this, with individuals with IDD having a higher incidence of chronic pain compared to those without IDD (Havercamp & Scott, 2015; McGuire et al., 2010). An assessment of 187 adults with IDD found that 48% experience pain at a moderate level constantly; with more than 10% of individuals experiencing a high level of constant pain (Weissman-Fogel et al., 2015). Chronic pain disrupts sleep by causing less deep sleep, more awakenings, and increasing sleep latency (Whibley et al., 2019; Zambelli et al., 2021). Breau and Camfield (2011) utilized caregiver assessments of 123 children with IDD to monitor the relationship between pain and sleep. Their results demonstrated that among children with IDD, pain significantly disrupted sleep, leading to significantly shorter sleep durations compared to children without an IDD.

Associated with the wide array of multi-morbidities among individuals with IDD, there are certain physiological characteristics that can hinder sleep quality and duration (Donovan et al., 2015; Shelton & Malow, 2021). One common example of this is obstructive sleep apnea, caused by genetic abnormalities in the upper airways (Reddihough et al., 2021; Senaratna et al., 2017). This genetic defect is common in Down syndrome with 31%-63% of these individuals diagnosed with obstructive sleep apnea syndrome (OSAS) (Pinto et al., 2016; Kang et al., 2019). OSAS is also common in Prader-Willi syndrome as well as other disabilities, with genetic factors leading to physiological abnormalities being the common cause (Maas et al., 2010; Wilckens et al., 2022). Obesity is also a risk factor

for OSAS and with individuals with IDD often at a greater risk and demonstrating a higher level of weight gain, the risk of developing OSAS is magnified (Hsieh et al., 2014; Luijks et al., 2017; Temple et al., 2014; Trois et al., 2009).

2.3) Interactions between Sleep, Physical Activity, and Sedentary Behaviour

While physiological factors can affect sleep, outcomes for both sleep quality and duration can often be predicted based on behavioural choices. Physical activity has long been established as a predictor of healthy sleep (Chang & Lei, 2021; Xiao et al., 2014). Ye et al. (2022) qualitatively assessed 1,006 college students throughout China, seeking to understand the relationship between sleep quality and physical activity. Results demonstrated that physical activity can positively predict sleep, with improvements to mindfulness and positive thinking brought about by physical activity playing a prominent role in improving sleep quality. However, the predictive nature of physical activity is dependent on the level of physical activity (Kline et al, 2013; Rayward et al., 2020). Castiglione-Fontanellaz et al. (2022) utilized actigraphy to objectively measure physical activity among 50 adolescents. Obtaining an average of 119 ± 40 days per participant, Castiglione-Fontanellaz et al. (2022) found a weak association between low to moderate levels of physical activity and sleep. Similar research has demonstrated an optimal level of physical activity for sleep improvement, with regular moderate to vigorous activity resulting in the strongest positive association with sleep enhancements compared to light or vigorous activity (Koohsari et al., 2023; Pesonen et al., 2022; Sloan et al., 2020; Tan et al., 2022).

Sedentary behaviour is also linked to predicting sleep, with a negative association with sleep duration and a positive association with daytime sleepiness (Brunetti et al.,

2016). Foti et al. (2011) examined qualitative data reported by 14,782 high school students in the USA. Findings from their survey demonstrated that engaging in sedentary behaviours like video or computer games for two or more hours per day was associated with insufficient sleep duration. Looking at sleep quality, Kakinami et al. (2017) utilized similar self-reported information from 658 teens in Canada. Responses indicated that spending more time doing sedentary activities was correlated with reduced sleep quality. In contrast to these findings, Saunders et al. (2022) found that not all sedentary behaviours are correlated with sleep duration or quality. Completing a systematic review of 44 papers assessing sedentary behaviours and their effect on sleep in children and youth, they identified screen-based sedentary behaviours as detrimental to sleep while indicating that other non-screen-based sedentary behaviours may not have any significant impact on sleep. These findings correlate with other literature that has found that screen-related sedentary behaviours typically have a greater negative impact on sleep compared to other sedentary behaviours (Dong et al., 2021; Janssen et al., 2020; LeBlanc et al., 2015).

2.3.1) Interactions between Sleep, Physical Activity, and Sedentary Behaviour among Adults with IDD

One area of concern regarding sleep among individuals with IDD is the reported lower levels of physical activity compared to individuals without IDD (Wachob & Lorenzi, 2015). In addition, individuals with IDD are more likely to face barriers that impede participation in activities, often including sport or physical activities (Garcia-Pastor et al., 2019). Decreased physical activity within this demographic can be related to a variety of factors including social, cognitive, and physical limitations exhibited by these individuals (Dairo et al., 2016; Garcia-Pastor et al., 2019).

Individuals with IDD report their own health, accessibility, and costs as being common barriers to physical activity participation (Temple, 2007). These limitations hinder participation and restrict individuals with IDD to only show interest in a small selection of activities related to physical activity (Brown et al., 2020). However, even if the individual demonstrates partial interest, communication issues may make it difficult to participate in group-based physical activity and motor skill issues may prevent these individuals from enjoying the activity they have chosen to engage in. This combination of factors at both the individual and environmental level often result in reduced enjoyment in physical activity, leading to decreased confidence in pursuing physical activity (Brown et al., 2020). To prevent this, physical activity patterns must be easily accessible and introduced into the daily routine of the individual, so it becomes comfortable and familiar. As it is well established that moderate levels of physical activity can promote better sleep quality, a lack of appropriate levels of physical activity is one area of concern for adults with IDD (Dolezal et al., 2017; Wang & Boros, 2021).

Further complications arise when trying to encourage physical activity to improve sleep duration and quality among individuals with IDD because not only do physical activity levels tend to be low, but they often choose to engage in sedentary behaviours (Healy & Garcia, 2018). In addition, the most desirable sedentary behaviour for individuals with IDD is time spent streaming TV shows, watching movies, and playing video games; activities that often fall under the category of ‘screen time’ (Hsieh et al., 2017; Must et al., 2015). Individuals with IDD often view screen-time as one of the most enjoyable activities, preferable to other options such as physical activity. Although not in an adult population, youth with Down syndrome showed significant negative changes in

physical activity, screen-time, and sedentary behaviour from before the COVID-19 pandemic to during the pandemic (Amatori et al., 2022). These particular behaviours have been described as the worst types of sedentary behaviours when compared to others, such as reading or listening to music, given their association with increased risks of all-cause mortality, metabolic disorders, musculoskeletal disorders, and cognitive impairment (LeBlanc et al., 2015; Park et al., 2020; Sousa & Silva, 2017). This mixture of physical inactivity, sedentary time, and screen time often contributes to inconsistent sleep patterns for individuals with IDD (Richdale & Baker, 2014; Wachob & Lorenzi et al., 2015). In some cases, individuals with IDD report time spent sedentary as the reason they actively chose not to sleep (Hamm & Jun, 2019). As technology continues to rapidly develop for home usage, this could exacerbate the issue of sleep problems further among this demographic.

2.4) Canada's 2020 24-Hour Movement Guidelines

Canada's 2020 24-Hour Movement Guidelines for adults aged 18-64 years were developed and are relevant for all individuals within this age category regardless of socio-economic status, cultural background, or gender (Ross et al., 2020). The guidelines are recommendations for a healthy 24-hr period and encourage regular physical activity, consistent sleep, and limiting sedentary time (Chaput et al., 2014). These guidelines are based on current scientific research and were developed to ensure applicability, feasibility, and equity. To quote the CSEP guidelines (pg. 70) as per Ross et al. (2020), a healthy 24-hrs will include:

1. Moderate to vigorous aerobic physical activities such that there is an accumulation of at least 150 minutes per week. Additionally, muscle strengthening activities

using major muscle groups at least twice a week and several hours of light physical activities, including standing.

2. Getting 7 to 9 hours of good quality sleep on a regular basis, with consistent bed and wake-up times.
3. Limiting sedentary time to 8 hours or less, which includes no more than 3 hours of recreational screen time and breaking up long periods of sitting as often as possible.

In general, these recommendations suggest that by reducing sedentary behaviour and incorporating physical activity and sufficient sleep, general health can be improved. Some of the commonly associated health benefits include: a lower risk of mortality, cardiovascular disease, hypertension, type 2 diabetes, several cancers, anxiety, depression, dementia, weight gain, adverse blood lipid profile as well as improved bone health, cognition, quality of life and physical function (Healy et al., 2019; Ross et al., 2020). Research focussed on 24-hr movement guidelines, regardless of the country of implementation or the measures used, consistently find that reaching the minimum requirements is associated with improved health outcomes (Chaput et al., 2014; Healy et al., 2019). Given this information, targeting populations that do not typically meet these guidelines is important for both personal and public health (Kamyuka et al., 2020).

2.5) Smartwatch Technology

With the advancements to technology and research, the importance of improving sleep has become more readily apparent (Mukherjee et al., 2015; Nichols et al., 2019). Although polysomnography is the gold standard for measuring sleep (Esbensen & Schwichtenberg, 2016); recent advances in wearable technology have facilitated the measurement of sleep behaviours in less clinical settings, such as the home. With these

advancements in technology, wearable technology has presented itself as a possible solution to improve physical activity among the general population (Henriksen et al., 2018). Although data utilizing this technology is limited, recent research suggests that technology is steadily improving in both its validity and reliability, allowing for potential widespread usage in medical applications (Reddy et al., 2018). The accuracy of these devices is steadily improving and allowing for a transformation of the way physiology is researched (Wright et al., 2017).

One area of interest among the public is wrist-worn activity monitors, sometimes referred to as smartwatches, which can be used to monitor a variety of variables ranging from step count, heart rate, and energy expenditure (Reddy et al., 2018). In the past, these devices were deemed inferior to other empirical methods of measurement, and it was difficult to produce valid data (Dobbins & Rawassizadeh, 2018). However, advancements to the sensing and recording abilities of these devices have allowed for new techniques for measuring physical activity related variables with a lower cost and less invasive method (Wright et al., 2017). Researchers are suggesting that we are currently entering an era where smartwatches could potentially accurately monitor activity over long periods of time without significant error rates (Henriksen et al., 2018; Reddy et al., 2018).

Given that measurement of physical activity and sleep levels previously required laboratory methods, the use of body-worn sensors provides a user-friendly option to record information in a remote setting (Gilgen-Ammann et al., 2019). However, initial use of these devices reported error rates of approximately 10% to 210% with greater accuracy coming from higher intensity activity compared to low-to-moderate intensity activities. Fortunately, recent advancements to photoplethysmography and GPS applications have

improved the smartwatches enough to provide valid and reliable measurements for metrics such as movement and heart rate (Budig et al., 2021; Lima et al., 2022). Polar Ignite smartwatches have been found to reliably measure a variety of aspects of daily life ranging from heart rate to total sleep time (Al Tunaji et al., 2020). By utilizing these watches, researchers can expect a relatively high degree of accuracy, and results with limited error compared to alternative wearable options (Budig et al., 2021).

The use of actigraphy has dramatically increased in the last decade due the usefulness and accessibility of the technology (Esaki et al., 2021). This methodology provides a less expensive and non-invasive technique for measuring sleep and physical activity levels, providing an alternative method for monitoring individuals with IDD compared to more invasive methods like polysomnography (Giménez et al., 2018). Numerous research has suggested that actigraphy provides an effective mechanism for monitoring adults with IDD, allowing for measurements of physical activity and sleep without removing these individuals from their typical environment (Baker & Richdale, 2015; Hsu et al., 2021). However, Ptomey et al. (2017) suggests that although actigraphy could be a reasonable monitoring option for adults with IDD, long-term data collection may be unsuccessful due to poor compliance with participants wearing the technology. Further research utilizing actigraphy for adults with IDD is, therefore, necessary to see if this population can effectively adhere to using this technology, allowing for an alternative objective measure of sleep and physical activity (Hsu et al., 2021).

Although the rapid advancements in wearable technologies have created what appears to be an alternative option to more invasive measurement technologies, consideration should be given to the accuracy of these devices in contrast to established

methods (Shei et al., 2022). Fuller et al. (2020) conducted a systematic review focussed on 158 studies examining smartwatch technology. After examining the literature, they concluded that accuracy of movement and heart rate demonstrate a large degree of variability across devices, suggesting that more research is necessary to establish if these devices can consistently provide valid and reliable data. A review of the literature by Rentz et al. (2022) indicates that these devices often lack third-party validation, recommending that more research is necessary to establish the accuracy of these devices in their ability to measure sleep as often marketed. Due to this, it is necessary to exercise caution when approaching the use of these technologies, acknowledging that the validity and reliability of these devices may vary significantly across devices and manufacturers (Shei et al., 2022).

Fortunately, actigraphy allows for more research among individuals with IDD to be considered, largely due to this form of measurement acting as an alternative to self-reported measures (Shogren et al., 2021). There is a common belief that self-reported data among individuals with IDD is prone to error, with the possibility of problems with understanding and communication limiting the accuracy of obtained data (Emerson et al., 2013). The validity of self-reported data among individuals with IDD is often questioned, but with the use of actigraphy in combination with self-reported data, comparisons can effectively be made (Giménez et al., 2018; Johnson et al., 2014). Due to the benefits of a mixed-methods approach, combinations of self-reported data and actigraphy is becoming more common in research, allowing for improved accuracy in measuring a variety of metrics including sleep and physical activity (Doroudgar et al., 2021; Wei & Boger, 2020).

2.6) The Impact of COVID-19

Individuals with IDD are more likely to face barriers to attaining adequate sleep and physical activity and the onset of the COVID-19 pandemic has only worsened these pre-existing inequalities (Kamyuka et al., 2020). Upon the rapid spread of the virus across the globe and the declaration of a worldwide pandemic, restrictions were put in place to stop the spread (Theis et al., 2021). By early April 2020, international travel had almost ceased entirely, and individuals were encouraged to stay home. Upon the implementation of restrictions, many individuals became socially isolated as they no longer had access to many of their opportunities for social interaction (Bailey et al., 2021). Many individuals reported worsening mental health, with vulnerable populations such as older adults and individuals with IDD reporting some of the worst results (Bailey et al., 2021; Theis et al., 2021).

Researchers have suggested that due to the presence of COVID-19 and lockdown restrictions, that there has been a detrimental impact on sleep and physical activity while an increase in sedentary activity among populations (Amatori et al., 2022; Sojka et al., 2022). A decrease in sleep and physical activity has been observed among all ages, making the impact of COVID-19 age independent (Hoffman et al., 2022; Rowlands et al., 2021). Individuals who previously reported lower levels of sleep prior to the onset of the pandemic reported even lower levels throughout the pandemic, with a reduction in quality and an increase in the level of disturbances (Reynaud et al., 2022). The negative impact of the pandemic was similar for physical activity, with individuals who reported low levels prior to the pandemic reporting even lower levels during the pandemic with an increase in time spent sedentary (Rowland et al., 2021).

The risks and concerns associated with insufficient sleep, physical inactivity, and sedentary behaviour amongst the IDD demographic has only worsened upon the onset of the COVID-19 pandemic and the various restrictions associated with it (Ameis et al., 2020). Given the variety of changes brought about by the COVID-19, one of the most drastic changes includes the increased exacerbation of existing inequalities, including but not limited to, marginalized groups reporting increased levels of wealth insecurity, declining health status, and poor mental health (Ameis et al., 2020; Gauthier et al., 2020; Kamyuka et al., 2020). In addition to the negative impact on mental health, a large proportion of individuals within IDD reported alterations to their regular routines due to lockdown restrictions (Kamyuka et al., 2020). Individuals with IDD have found themselves and their families significantly impacted given the changes to resources available to them and the restrictions in place preventing them from their regular routines (Ameis et al., 2020).

With lockdown restrictions associated with COVID-19 affecting sleep, physical activity, and sedentary behaviours for individuals with IDD to a greater extent than individuals without an IDD, the impact to daily routine has been largely to blame (Theis et al., 2021). Many individuals with IDD rely upon services within their community, with these services providing essential opportunities for connection, activity, and support (Ameis et al., 2020). Upon losing access to specialist facilities and equipment, certain group led activities in the regular routine of individuals with IDD such as sport were lost (Temple, 2022). Some individuals may have found it difficult to incorporate similar activities back into their routine on their own without support (Temple, 2022; Theis et al., 2021). Given that individuals with IDD already demonstrated problems with their physical

and mental health prior to COVID-19, further damage should be mitigated (Healy et al., 2019). Due to the disruptions in the lifestyle among individuals with IDD, it is expected that some of these individuals are unable to adequately follow the Canadian 24-Hour Movement Guidelines (Healy et al., 2019; Heinze et al., 2021).

2.7) Current Study in Relation to Existing Knowledge Base

Individuals with IDD make up 0.5-1% of the adult population in Canada and are often underrepresented in research, public health efforts, and intervention programs (Durbin et al., 2019; McKenzie et al., 2016). The importance of sleep and physical activity is well-established among individuals without an IDD, but there is still a lack of research focussed on this specifically for adults with IDD (Dairo et al., 2016; Ferreira et al., 2022). With less knowledge available to the individual and their families, health care needs go unidentified and unmet compared to adults without an IDD (Mayo et al., 2021).

There is a scarce amount of research focussed on monitoring adults with IDD in the context of sleep duration and quality (Richdale & Baker, 2014). A large majority of the sleep research that does exist for this demographic has focussed on autism spectrum disorder and Down Syndrome, leading to a lack of sleep research focussed on individuals with other IDDs (Esbensen et al., 2016). Research that has included individuals with a variety of IDD, often includes children, making it difficult to relate results to adults with IDD (Van de Wouw et al., 2013). In addition, existing research focussed on adults with IDD has predominantly relied on qualitative measures, leading to speculation about the validity of any reported data (Kooijmans et al., 2022; Rothschild et al., 2019; Van de Wouw et al., 2013). Research utilizing objective measures using methods like actigraphy to monitor sleep among adults with IDD is essential (Shanahan et al., 2019). Given that

the estimated prevalence of sleep disorders in adults with IDD ranges from 8.5% to 34.1%, more research is necessary to better understand sleep in this demographic (Korb et al., 2021).

Research monitoring sleep among adults with IDD during the COVID-19 pandemic has been minimal (Courtenay & Perera, 2020). Due to the nature of the pandemic, any existing research monitoring adults with IDD has relied on qualitative measures, lacking an objective component (Heinze et al., 2021). Given this population was underrepresented prior to the pandemic, it is necessary to assess this demographic to ensure policy measures are implemented to adequately provide support and understand the negative impacts the pandemic may have had (Majnemer et al., 2021). Additionally, there is currently a lack of research regarding the 24-Hr Movement Guidelines and whether adults with IDD are meeting those recommendations (Healy et al., 2019). Most research has focussed on the lack of resources available to individuals with IDD during COVID-19, but little to no research has looked at sleep for adults with IDD in the context of the Canadian 24-Hr Movement Guidelines (Ross et al., 2020). This pilot study is multifaceted and will provide information on the feasibility that adults with IDD in wearing a smartwatch and keeping an activity/sleep journal over the course of a week in addition to collecting data on the sleep and sleep hygiene behaviours of adults with IDD in the context of the COVID-19 pandemic.

Chapter 3 Method

3.1) Design

A descriptive cross-sectional design was used to examine the 24-hour movement behaviour of adults with IDD in Victoria, BC. The specific focus of this study was the sleep portion of the 24-hour movement guidelines (Ross et al., 2020).

3.2) Research Team

The research team consisted of two supervisors, two graduate students, and two undergraduate students. Each member had completed their TCPS 2: CORE training on research ethics and had received ethical approval to be involved in the study, see Appendix A. Both supervisors were not in direct contact with participants but were in contact with organizational heads at the start of study and acted in an advisory capacity throughout the course of the study. Initial contact with participants was primarily done by the graduate students, with the undergraduate students helping the graduate students with baseline visits, follow-ups, and exit appointments.

3.3) Sampling Frame and Final Sample

Participants were recruited from four organizations providing services and educational programs for individuals with intellectual disabilities in Victoria, BC. Participant eligibility as an individual with intellectual disability was not ascertained directly, but through the eligibility criteria of each organization, specifically:

- Both The Society of Vincent de Paul of Vancouver Island's Frederic Ozanam Centre and the Garth Homer Society provide services to adults (19 years or older) with developmental disabilities. Clients are referred to these organizations by Community Living British Columbia (CLBC) which is the provincial crown corporation that

funds supports and services to adults with developmental disabilities, autism spectrum disorder, and fetal alcohol syndrome (Community Living BC, 2023). CLBC defines development disability as significant impaired intellectual functioning and adaptive functioning with impairments starting before the age of 18.

- The Greater Victoria Down Syndrome Society works with individuals with Down syndrome as well as their families, friends, associates, seeking to create a community of support and a better understanding of diversity.
- Special Olympics BC determines eligibility for their services based on an IQ of 70 or below, deficits in mental abilities which limit and restrict participation and performance in aspects of daily life, and onset of the disability during the developmental period (before the age of 18 years).

Consistent with Canada's 2020 24-hr Movement Guidelines for adults (18-64 years of age) (Ross et al., 2020), individuals were only included within this age range. Participants were excluded if they had major mobility restrictions that prevented them from performing MVPA or were unable to wear the watch for nine consecutive days.

Recruitment took place throughout December 2021-April 2022, throughout the Omicron wave of the COVID-19 pandemic. Recruitment was primarily conducted through the Garth Homer Society in Victoria and was later expanded to include the Greater Victoria Down Syndrome Society, Society for Saint Vincent de Paul, and Special Olympics British Columbia. Posters (Appendix D) were displayed on location and emails were sent to potential participants and their caregivers to inform them about the study. Site specific posters were also developed for certain sites, providing clarity that the organization distributing the poster was directly involved with the study. Individuals

interested in participating could reach out independently to the research team, or with the help of their support workers, caregivers, or families. After expressing an interest in participating, consent and assent forms were given to the participants, caregivers, or staff to look at prior to agreeing to participate in the study (Appendix E). Information regarding the study in the form of informative posters and informed consent forms were distributed either online via email or through paper copies distributed by staff in-person.

If the potential participant met the eligibility criteria, a meeting was setup by the research team with the participant either at the organization they were affiliated with or at the location of their choosing. The Garth Homer Society was the first organization the research team worked with. Initially, participants were met in designated break rooms at Garth Homer locations throughout the Greater Victoria region. However, due to the spread of COVID-19 Omicron variant, by January 2022, at the request of each organizations' staff, participants were met off-site at a location of their choosing such as their home or community sites to reduce interactions and the risk of transmission of COVID-19. At the meeting, participants and their caregivers were provided with additional information regarding the study and given an opportunity to ask any final questions. The informed consent was reviewed and explained in layman's terms to ensure the study was fully understood. If participants and their caregivers understood the study and were still willing to participate, the informed consent form was signed. Upon signing the informed consent, participants received the relevant equipment which included the smartwatch, charger, and diary. Any personal information including names and contact information was kept locked in a secure location within the Movement Skills Analysis Lab in the McKinnon Building at the University of Victoria.

3.4) Measures

Polar Ignite smartwatches were used to collect physical activity and sleep data. Created by Polar Electro Oy, typically referred to as Polar, the Polar Ignite is a wrist sports watch manufactured in Kempele, Finland and was first announced on June 26, 2019. These smartwatches record movement duration, intensity of physical activity (ranging from rest to vigorous activity), sedentary time, as well as duration and quality of sleep. These variables were recorded using the watch's 3D accelerometer and heart rate analysis based on photoplethysmography (Budig et al., 2022). Photoplethysmography utilizes contact and green LED reflective light with a battery life of ≤ 5 days (Klier & Wagner, 2022). These features allow for measurement of heart rate, heart rate variability, and real-time location tracking, allowing for an accurate analysis of sleep duration and quality as well as insight into physical activity (Klier & Wagner, 2022).

Research by Klier and Wagner (2022) analyzed the Polar Ignite to a standardized sleep diary for, making comparisons based on time in bed, total sleep time, sleep efficiency, sleep stages, and sleep interruptions. Thirty participants wore three devices simultaneously for a period of four consecutive days. Bland-Altman plots were utilized to assess reliability, Shapiro-Wilk tests were utilized to assess normality, and the Breusch-Pagan test assessed homoscedasticity. Klier and Wagner's results demonstrated a substantial agreement between the Polar Ignite and the diary. Of three devices compared, the Polar Ignite was the most accurate, with the authors indicating that the devices should be considered reliable, especially for the measure of time in bed and total sleep time.

Research by Budig et al. (2022) aimed to validate the Polar Ignite's heart rate and distance measurements. Comparing the smartwatches data to a Polar H10 chest strap, 36 adults completed a number of measured distance tests consisting of a baseline rest period,

walking and running 3km, a 1.6km run (in a 400m outdoor stadium), a 3km outdoor run in a forest, a 500m and 1000m swim, and a 4.3 and 31.5 cycling test. For HR values, there were high correlation values between the chest strap and the wristwatch, apart from the swimming tests and the 1.6km run. The results demonstrate that measurements of heart rate can be considered good, allowing for an effective method of measuring physical activity.

Physical activity and sleep diaries (Appendix C) were utilized to qualitatively record the client's physical activity and sleep hygiene behaviours. Questions within the diary were based on commonly asked questions found in the existing literature, drawing inspiration from resources already used in previous studies (Carney et al., 2012; Mallinson et al., 2019; Mazza et al., 2020). Formatting was based on existing works as well, ensuring clarity and a simple layout that would not overwhelm participants (Mazza et al., 2020). The 8-page diaries had 4 sections included to assess physical activity behaviours, sleep hygiene, and sleep quality.

- Section 1 focused on daily physical activity behaviours and was completed at the end of the day. Sports, exercise, and household activities throughout the day were recorded through a mixture of dichotomous "Yes" or "No" responses and fill-in the blank sections, see Appendix C, pp. 3-4. Three items were sport (if they played a sport, what sport they played, and if the sport was part of Special Olympics), three items were physical activities and exercise other than sport (participation in physical activity or exercise, what the activity was, and who they completed the activity with), and four items assessed household activities (if they completed housework or yard work as well as what the household activity was).

- Section 2 assessed seven sleep hygiene behaviours using dichotomous “Yes” or “No” responses such as “Did you use technology within 30 minutes of going to bed? (like TV, phone, computer, iPad)”. This sleep hygiene section was completed right before going to bed each evening, see Appendix C, p. 5. Three items were negative sleep hygiene behaviours (technology use, caffeine intake, exercising close to bedtime), two items were positive behaviours (calming activities and regular bedtime routine, and two items recorded medications and devices to facilitate sleep.
- Section 3 assessed sleep quality and duration and was completed when waking up. Participants could report events that occurred at night and record when they believe they went to bed and woke up, see Appendix C, p. 6. Sleep quality was assessed using dichotomous “Yes” or “No” responses and had four items (trouble falling asleep, waking up during the night, waking up earlier than planned, and too hot or cold during the night). Sleep duration was assessed by participants reporting the time they believe they fell asleep and when they woke up.
- Section 4 asked individuals to describe their usual sleep routine and allowed for feedback to be passed along to the research team. Participants report any significant details about their sleep that the diary had not assessed, see Appendix C, p. 7.

3.5) Procedures

Data collected via the Polar Ignite was synced to Polar’s companion application, Polar FlowSync, to observe heart rate zones, physical activity, and sleep data. Utilizing Samsung Galaxy tablets (Seoul, South Korea) containing the downloaded Polar FlowSync application, data was collected every 2-3 days by syncing the watches with the

respective Polar Ignite watch. A Polar account was made for each participant that was connected to the Polar FlowSync application through use of the Samsung tablet.

Participants were instructed how to wear their watch for nine days to collect seven days worth of data. Details on how to wear the watch and charge it after use were also provided both in-person and through paper instructions. Participants were instructed to always wear the watches and that they should only be taken off for a required one-hour charging time every two to three days. The watches were started with the "other indoor" activity, which tracked their physical activity and sleep data.

Diaries were provided to participants at the same time as watches and participants were encouraged to complete the diaries each day. Parents/Guardians/Caregivers were asked to do their best to verify that data was correctly recorded or record it for the participant. Quantitative data from these diaries were recorded in Microsoft Excel and completed diaries were stored in a secure location within a lab in the McKinnon lab at the University of Victoria.

Participant information was recorded and included age, gender, weight, and height. Measurements were collected at baseline, either at the organization they were affiliated or a location of their choosing, if participants had consented to inclusion in the research study. Age and gender were recorded based on participant responses and were confirmed by a parent/guardian/caregiver if the participant was uncertain or unable to report that information. Height was collected using a STANLEY PowerLock Tape Measure (30-Foot), with participants standing with their backs against a wall and their shoes off to generate an accurate result. Participants were instructed to hold their head straight while a clipboard was placed on top, allowing for a measurement at the highest

point on their head. From there, the tape measure was utilized to record the distance from the ground to the clipboard, allowing for an assessment of the subject's height. Weight was collected using a PHILIPS Body Analysis Scale, with participants standing with their shoes off on the scale until a recording was determined.

Two days after receiving the watch, participants were contacted either in-person or by phone to check the battery level of the watch and assess the status of the diary. For in-person visits, battery level on the watch was checked and if it was not over 80%, watches were temporarily removed from the participant and recharged until 100% (~no longer than 30 minutes for a full charge). Diary status was assessed by reviewing the diary and ensuring that participants had completed each section. If a question had not been answered, participants and their caregivers were asked if they could provide an accurate response. If they could not recall an accurate answer, that part of the diary was left blank. For remote check-ins, participants would be asked to ensure the watch had been charged recently and if not, were requested to do so when able. Diary status was assessed by asking participants and their caregivers to review the last two days and ensure a question was not missed. If they mentioned a question was incomplete, they were asked to answer it if they could accurately do so. If they were uncertain or could not recall, that part of the diary was left blank. Check-ins continued throughout the course of the nine days every two days to ensure compliance with wearing the watch and

completing the diary. An illustrated timeline of the typical 9-day procedure is presented in Figure 3.1.

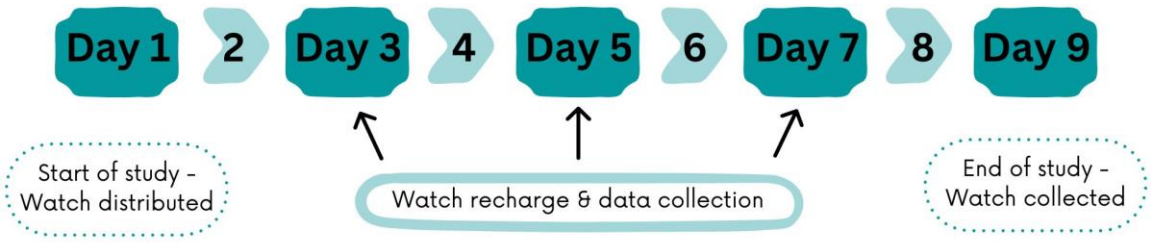

Figure 3.1. Illustrated timeline of the typical 9-day procedure.

At the end of the study protocol of nine days, the research team met with the participant to collect the rest of the data as well as the watch and the diary. Participants received a $5 Tim Hortons gift card as a thank you for completing the study and returning the equipment. If a participant consistently wore the watch throughout the 9-day duration, the study was complete. For participants who had been unable to regularly wear the watch, they were invited to continue to wear the watch until a full 9 days of data were collected.

3.5) Data treatment and Analysis

Upon completion of the study, the data from the watches were synced via the Polar FlowSync app on Android tablets and made available on the Polar FlowSync server. Data on the Polar FlowSync server was then accessed from a secure laptop or desktop connected to the UVIC server. Each participant's Polar account contained activity and sleep logs, displaying their average heartrate, duration of activity, total sleep duration, actual sleep duration, sleep disturbances, and sleep rating. Data treatment for the quantitative data involved transferring sleep and physical activity recordings stored in

the Polar FlowSync application into Microsoft Excel for further data analysis. Once data was copied from the Polar FlowSync server to Excel by a member of the research team, it was reviewed to ensure that data between the Polar FlowSync server and Microsoft Excel matched. To prevent transcription errors, a second individual reviewed collected data and ensured accurate comparisons between data found on Polar FlowSync and Microsoft Excel.

For qualitative responses in sleep and activity diaries, data was manually entered into Microsoft Excel based on participant response. For non-numeric responses, "Yes" responses were assigned a 1 and "No" responses were assigned a 0. As only seven days of data was analyzed, there was a maximum score of 7 and a minimum score of 0. Data analysis was completed by looking at seven of the nine days of recorded data. The first day spent wearing the watch was not analyzed as most participants only received the watch part of the way through the day. The last day was not analyzed as most participants removed the watch part of the way through the day. This allowed for a full 7-day analysis, with 168 hours analyzed (except for the time spent to charge the watch), for sleep, physical activity, and sedentary time. Participant qualitative responses were only considered relevant if they corresponded to a time period where the watch was being worn within that 168-hour window. As only seven days of data was analyzed, there was a maximum score of 7 and a minimum score of 0 for non-numeric "Yes" or "No" responses.

To assess the first and second research question, assessing sleep quality and duration, participant responses the following morning after sleep was recorded. Sleep duration and quality were also determined by reviewing quantitative recordings from the

Polar Ignite watch, looking at total sleep time, actual sleep time, and sleep disturbances. To analyze sleep duration, average total sleep and average actual sleep were tabulated for further data analysis. Group averages were calculated, allowing for comparisons between minimum total sleep and maximum total sleep as well as differences between total sleep and actual sleep. To analyze sleep quality, diary responses were tabulated and compared based on participant. “Yes” and “No” responses were documented, allowing for comparisons between each response. Average sleep disturbances were also tabulated.

To answer the third question, responses to different activities before bed each night were tabulated and compared. “Yes” and “No” responses were documented, allowing for comparisons between participants and assessment of which responses were most and least common.

To assess the fourth question, responses regarding behaviours before bed were correlated to quantitative measures of total sleep time, actual sleep time, and sleep disturbances. Participants’ responses in the diary were correlated to their sleep measurements from the smartwatch and compared to the other group responses. This led to the generation of correlation coefficients, which allowed an analysis of relationships between variables.

To answer the fifth question, quantitative recordings of physical activity and total sleep time, actual sleep time, and sleep disturbances were correlated together to examine the relationship between these variables. Physical activity data was collected based on heart rate analysis from the smartwatch, allowing for an interpretation of weekly averages of MVPA. The weekly MVPA was then correlated against sleep metrics, leading to the

generation of correlation of correlation coefficients which allowed for an analysis of relationships between variables.

No personal information for participants was kept except age at the time of participation, height, and weight. Participants were de-identified by assigning a number to them based on order of participation. No other personal information was utilized for this study, ensuring the participant's and their caregiver's confidentiality. The only personal information that was retained was each participant's consent form, which also contained the necessary contact details for future contact. Only the research team were aware of each participant's assigned number.

3.6) Feasibility Study

To assess the feasibility of the study design, two participants who had previously enrolled in research studies within the Greater Victoria region and were directly contacted to determine if they were interested and informed consent was obtained. The measures and procedures were largely as described in this Method section, except that feedback was requested from the participants and their caregiver to see what aspects of the study could be improved upon. The suggestions provided helped in the administration of the diary and COVID-19 precautions.

One suggestion was to allow for participants to complete their 2-day visit remotely. To allow for this, participants would have to have the charger left at their own residence and be informed as to how to charge the watch as well as resume the data recording upon charge completion. This option was also beneficial as it allowed for a more COVID-19 friendly approach. Another suggestion was to alter the diaries to allow for an option to write the specific day of the week. Since we had assumed each

participant would start the study at a different day based on preference, the original diary design did not include days of the week nor a space to write this in (Appendix B). The diary was then altered to allow for this, with blank spaces being included above each day for writing each day in (Appendix C). The final change was to include a more thorough consent process regarding the use of the watches. Participant 2 was not overly keen on wearing the watch but nonetheless had agreed to participate. As a result, little to no data was available from their time wearing the watch. To improve compliance with wearing the watch, more extensive information was provided to other participants later in the study about the importance of the watch at the time of consent and should they feel uncomfortable about the idea of wearing the watch, they were not enrolled. Future participants were only recruited if they did not express hesitancy to wearing the watches.

As mentioned, no significant changes were made to the protocol based on the recommendations of the pilot participants and their caregiver. Therefore, one participant's data was included in this study, however, as the other participant did not wear the watch for a sufficient period of time, their data was not included.

3.7) Pilot Study

The term pilot study is commonly used to describe a smaller version of a full-scale study, acting as a test for a particular research methodology (van Teijlingen & Hundley, 2002). The argument for a pilot study is that by evaluating the efficacy of the research tools being utilized, future studies will be better informed of the feasibility of using the research tools previously tested (Malmqvist et al., 2019). Our methodologies are based on previous research utilizing actigraphy; however, this technology has not typically been utilized for observing sleep in adults with IDD (Budig et al., 2022).

Smartwatch monitoring is still a new area being studied and further investigation is necessary to understand the applications of this technology in sleep research (De Zambotti et al., 2019; Gaiduk et al., 2022). Given that previous researchers have suggested that objectively monitoring sleep and physical activity among adults with IDD is challenging due to issues with compliance, this pilot study assesses smartwatches as an effective tool of measurement for this population (Harris et al., 2018; Phillips & Holland, 2011). This study also utilized sleep and physical activity diaries, relying on self-reported information from participants and their caregivers. Self-reported information from adults with IDD has often been viewed as questionable due to speculation regarding the reliability and validity of the information collected (Fellinger et al., 2021; Vlot-Van Anrooij et al., 2018). However, by regularly checking in with participants and their caregivers, the accuracy of the information reported can be monitored and updated as needed. So, in addition to the aim and research questions presented in Chapter 1, this pilot study had three aims related to feasibility of the outcome measures: (1) to assess whether it is feasible to monitor sleep and physical activity with smartwatch technology, (2) to investigate whether adults with IDD are able to consistently wear smartwatches for one week, and (3) to see if adults with IDD are able to provide self-reported information in a sleep and physical activity diary each day, completing entries both in the morning and evening.

Chapter 4 Results

4.1) Sample Population Characteristics

The recruitment goal of this study was upwards of 20 individuals. Due to the emergence of the COVID-19 pandemic, recruitment was difficult and ultimately sixteen adults with IDD in the Greater Victoria area participated in this study. One participant, Participant 2, was not included in the data analysis, as after providing consent and wearing the watch for one day, they decided they were uninterested in wearing a watch for one week and they also struggled to consistently complete their diary. Selected characteristics of the participants in this study are displayed in Table 4.1.

Table 4.1. *Demographic Characteristics of Adults with IDD (n = 15) participating in the study within the Greater Victoria Region.*

	N	Mean	SD	Range
Age (years)	15	35.9	13.1	20-64
Age distribution by Sex (years)				
Male	6	38.0	14.46	21-58
Female	9	34.4	13.58	20-64
Weight status, % (BMI)				
Underweight (BMI <18.5)	0	-	-	-
Healthy Weight (BMI = 18.5-24.9)	6	22.31	1.05	20.54-23.81
Overweight (BMI = 25.0-29.9)	5	28.70	1.12	26.93-29.41
Obese (BMI ≥ 30.0)	4	36.02	4.17	33.01-42.19

Note. BMI classification for all four categories is taken directly from WHO guidelines (Chernenko et al., 2019).

The remainder of this chapter is organized around the research questions.

4.2) Do adults with IDD meet the recommended guidelines for sleep quality and of duration as described by Canada's 2020 24-Hour Movement Guidelines?

Table 4.2 displays the average total sleep duration for each participant throughout their participation in the study over one week. The group average for total sleep was 7:25 (hr:mm) ± 1:12 (*SD*); however, these times ranged from a low of 5:07 ± 0:41 for Participant 13 to a high of 9:29 ± 0:39 for Participant 8.

Table 4.2 also depicts average actual sleep which was calculated from the total sleep minus the disturbances and interruptions. Actual sleep of participant 9 could only be calculated for Friday-Saturday due to insufficient sleep-cycle duration and total sleep was used for all other data points. Actual sleep from Monday-Tuesday from participant 14 could not be calculated due to insufficient sleep-cycle duration and total sleep was used for this data point. The shortest average actual sleep time was 4:43 ± 0:36 for Participant 13 and the longest average actual sleep time was 9:02 ± 0:29 for Participant 8. The overall average actual sleep time for all participants was 6:55 ± 1:04. Based on actual sleep, Table 4.2 also depicts the number of days that each participant met the CSEP guideline of 7 – 9 hours (Ross et al., 2020). Only 1 participant out of the 15 met the guidelines on all seven nights.

Table 4.2. *Average total sleep, actual sleep, sleep disturbances, and MVPA for each participant over one week.*

Participant	Total Sleep (hr:mm)	SD	Range	Actual Sleep (hr:mm)	SD	Range	Sleep Disturbances (hr:mm:ss)	SD	Range	MVPA (min)	Days Met Sleep Guideline*
1	7:56	0:57	6:14-9:12	7:26	0:54	5:49-8:36	0:29:30	0:04:51	0:23-0:36	1282.92	5
3	7:14	2:00	4:11-9:19	6:45	1:59	3:48-8:50	0:29:09	0:03:32	0:24-0:33	111.42	2
4	6:56	1:14	5:11-8:33	6:14	1:04	4:53-7:46	0:42:17	0:15:38	0:18-1:00	899.94	4
5	8:07	1:33	5:38-10:23	7:42	1:18	5:28-9:28	0:25:51	0:18:33	0:08-0:56	1085.94	4
6	5:58	1:10	4:07-6:59	5:41	1:05	3:58-6:43	0:17:10	0:07:08	0:09-0:27	1508.64	0
7	6:45	1:29	8:41-10:18	6:13	1:18	4:45-7:53	0:32:00	0:15:01	0:21-1:01	165.02	3
8	9:29	0:39	8:41-10:18	9:02	0:29	8:21-9:34	0:30:00	0:10:23	0:19-0:44	144.36	3
9	5:04	1:19	5:00-10:11	4:51	0:59	3:37-5:48	1:31:00	-	-	25.84	0
10	8:02	1:58	3:37-7:19	7:26	1:45	4:38-9:32	0:35:26	0:24:40	0:20-1:30	166.4	4
11	8:40	1:02	7:51-10:21	8:24	0:58	7:37-9:59	0:16:00	0:05:19	0:08-0:22	1178.64	5
12	8:38	0:22	8:06-9:15	8:10	0:26	7:36-8:54	0:28:43	0:05:51	0:21-0:38	529.03	7
13	5:07	0:41	4:04-6:07	4:43	0:36	3:50-5:23	0:25:34	0:10:10	0:14-0:44	904.5	0
14	6:58	1:19	4:20-8:15	6:30	1:08	4:20-7:40	0:33:40	0:05:45	0:24-0:40	556.45	4
15	8:35	1:24	6:19-10:47	7:44	1:10	5:52-9:32	0:50:09	0:15:19	0:27-1:15	144.69	4
16	7:48	0:54	6:23-9:08	6:59	0:49	5:53-8:10	0:48:34	0:09:33	0:30-0:58	361.94	3
Averages	**7:25**	**1:12**	**-**	**6:55**	**1:04**	**-**	**0:35:40**	**0:10:50**	**-**	**604.38**	**3.2**

Note. * Frequency of days out of 7 when the participant met the sleep duration guideline of 7-9 hours (Ross et al., 2020).

4.3) Are adults with IDD reporting and demonstrating problems with their sleep quality?

Table 4.3 below displays the frequency of "Yes" responses from seven days of recorded data based on qualitative responses in the sleep and physical activity diary related to sleep quality. Being too hot or cold during the night had the fewest yes responses, with only 3 individuals answering "Yes" for at least one night throughout their participation in the study. Waking up during the night had the most "Yes" responses, with 10 individuals answering "Yes" for at least one night throughout their participation in the study.

Table 4.3. *Number of days (out of seven) where participants reported "Yes" responses regarding sleep quality in one week.*

Participant	Trouble Falling Asleep	Woke up during the night	Woke up earlier than planned	Too hot or cold during the night
1	2	2	0	0
3	0	0	0	0
4	0	3	2	0
5	6	6	3	1
6	0	0	0	0
7	4	0	2	0
8	0	3	0	0
9	3	2	3	0
10	0	0	1	2
11	0	7	1	7
12	0	4	1	0
13	0	1	0	0
14	0	7	7	0
15	0	7	1	0
16	0	0	0	0
Total	**15**	**42**	**21**	**10**

Table 4.2. also depicts the length of disturbances measured on the Polar Ignite smartwatch for each participant over the course of one week. On average, the group experienced 35 minutes of sleep disturbance each night. As can be seen in the table, there was considerable variability, ranging from a low of 16 minutes (Participant 11) to 1 hour and 31 minutes (Participant 9). However, sleep disturbance for Participant 9 could only be calculated on Friday-Saturday due to insufficient sleep-cycle duration on other nights. Excluding Participant 9, who only had one analyzable disturbance, the greatest amount of sleep disturbance was 50 minutes (Participant 15).

4.4) What are the sleep hygiene behaviours of adults with IDD?

Table 4.4 displays the ratio of "Yes" responses from seven days of recorded data based on qualitative responses in the sleep and physical activity diary related to sleep hygiene. Exercising or playing sports within 3 hours of going to bed had the fewest "Yes" responses, with only 5 individuals answering "Yes" for at least one night throughout the study. Of the possible 103 responses (night x number of participants, excluding incomplete responses), participants indicated they exercised before bed 13 times, or 13% of the nights. Completing their usual sleep routine before going to bed had the most "Yes" responses, with all 15 participants answering "Yes" for at least one night throughout the study. Of the possible 103 responses, participants indicated they kept their usual routine 99 times, or 96% of the nights.

Table 4.4. *Number of days (out of seven) where participants reported "Yes" responses regarding sleep hygiene behaviours in one week.*

Participant	Technology Use Before Bed	Caffeine Consumption Before Bed	Exercise Before Bed	Calming Activities Before Bed	Usual Sleep Routine	Medication to Help You Sleep	Using a Sleep Device
1	3	4	1	5	4	0	7
3	7	1	0	7	7	7	6
4	6	3	1	5	7	0	0
5	0	3	0	0	5	3	0
6	7	2	0	0	7	7	0
7	7	7	0	7	6	0	0
8	1	3	0	7	7	0	0
9	7	2	0	3	7	0	0
10	7	6	3	0	7	0	0
11	7	4	0	0	7	0	7
12	4	0	7	6	7	0	7
13	7	5	1	0	7	0	7
14	7	0	0	6	7	0	0
15	3	0	0	6	7	0	0
16	7	0	0	0	7	0	0
Total	**80**	**40**	**13**	**52**	**99**	**17**	**34**
Valid Responses	**105**	**103**	**104**	**103**	**103**	**105**	**105**
%*	**76%**	**39%**	**13%**	**50%**	**96%**	**16%**	**32%**

Note. * % is the proportion of responses divided by total valid responses

4.5) Are poor sleep hygiene behaviours associated with poor sleep quality and duration?

The relationship between sleep hygiene behaviours and sleep quality and duration was also examined. Table 4.5 shows that sleep hygiene behaviours were correlated with total sleep, actual sleep, and disturbances; however, none of those relationships were significant. The strongest correlations observed in these data were for technology use and total sleep, technology use and actual sleep, medication use and disturbances, and sleep device use and disturbances.

Table 4.5. *Correlation matrix between all values of total sleep, actual sleep, and disturbances correlated with sleep hygiene behaviours.*

	Total Sleep	*Actual Sleep*	*Disturbances*
Technology	-0.34	-0.33	0.00
Caffeine	-0.04	-0.10	-0.16
Exercise	0.13	0.11	-0.07
Calming	0.07	0.12	0.08
Usual Routine	0.04	0.06	0.07
Medication	-0.10	-0.13	-0.23
Sleep Device	0.01	-0.03	-0.30

4.6) Does total volume of physical activity predict better sleep quality and duration?

Table 4.2 also shows the 1-Week Average of MVPA for each participant throughout their participation in the study. The 1-Week group average for MVPA was 604.38 minutes. The lowest 1-Week Average MVPA was 25.84 minutes (Participant 9) and the highest 1-Week Average MVPA was 1508.64 minutes (Participant 6). MVPA data from Table 4.2 were correlated with 1-Week Averages of Total Sleep, Actual Sleep, and Sleep Disturbances. There was a moderately strong statistically significant relationship between weekly averages minutes of MVPA and minutes of Sleep Disturbance ($r = -0.57$, $p < 0.05$). There were no significant relationships between MVPA and Total Sleep ($r = -0.10$, $p > 0.1$) or MVPA and Actual Sleep ($r = -0.05$, $p > 0.1$).

Chapter 5 Discussion

5.1) Do adults with IDD meet the recommended guidelines for sleep quality and of duration as described by Canada's 2020 24-Hour Movement Guidelines?

Canada's 2020 24-Hour Movement Guidelines suggest that adults aged 18-64 years should achieve 7 to 9 hours of good-quality sleep on a regular basis while having consistent bed and wake-up times (Ross et al., 2020). Although the average for total sleep of participants fell within the recommended range, the average for actual sleep fell below the recommended minimum. Meaning that disruptions to sleep pushed the group averages below the level recommended for critical health outcomes. As Ross et al. (2020, p.S79) commented, "time in bed" is not actual sleep. At the individual level, 6 out of 15 participants had an average actual sleep within the recommended duration of 7 to 9 hours, while 8 were below the guideline and one participant's actual sleep average was above the recommended 9 hours. Looking at the suggested sleep duration guidelines over a period of 7 days, 7 participants met the guideline on 0-3 nights, 7 on 4-6 nights, and 1 met the guideline on all 7 nights.

Participant 8 was the only participant to have an average actual sleep duration above the recommended guidelines of a maximum of 9 hours each night. Results from participant 8 potentially skewed the average upwards given that the second highest actual sleep average recorded was 8 hours and 24 minutes, which was 38 minutes lower than sleep duration results for participant 8. Excluding participant 8, the group average for actual sleep was 6 hours 46 minutes. Additionally, participant 9 was not sleeping enough for accurate analysis of their average sleep and actual sleep was only recorded on one

night. Due to this, total sleep had to be used for all other nights to calculate their actual sleep, suggesting that this participant was sleeping longer than they actually were.

The modal score for participants meeting the recommendation for sleep duration nightly was 4 out of 7 nights; with only 1 participant meeting the recommended guideline every night. Expressed another way, of the total number of nights observed for all participants (7 nights x 15 participants = 105), participants met the guideline on 48 nights or 45.7% of observations. This is in contrast with results from a recent survey of 9,248 Canadian adults aged 18-64 (C.Wang et al., 2022). Wang and colleagues found that 77% of adults met sleep duration recommendations. However, these results are somewhat consistent with Surtees et al.'s (2018) meta-analysis comparing sleep time and quality among adults with intellectual disabilities of heterogeneous origin (446 adults from 15 studies) and adults without an IDD. Surtees and colleagues found significantly lower sleep time (18 minutes less) among adults with IDD. Research by Lampinen et al. (2022) had similar results when observing 304 young adults (aged 18-35 years old), where 86.01% had problems with their sleep, including a short total sleep time. However, Lampinen et al. (2022) focussed solely on adults with autism spectrum disorder compared to this study which focussed on adults with IDD, providing a potential explanation for the difference in results (Baker & Richdale, 2015).

The findings of this study show that all but one participant did not meet the sleep duration recommendation across the week, with 11/15 participants getting insufficient sleep on 3 or more nights per week. Numerous research studies have demonstrated that catch-up sleep, typically utilized in the form of sleeping for a longer time on a weekend to make up for lost sleep on a previous weekday under the assumption that sleep is a debt

that can be “paid off” at a later point, is not effective in recovering lost sleep and leads to alterations in the metabolic, neurological, and hormonal balance of the body (Leger et al., 2020; Lv et al., 2020; S. Park et al., 2022; Putilov, 2021). Sleep loss is associated with reduced amounts of slow wave sleep and rapid eye movement sleep, leading to insomnia and poorer quality sleep on following nights (Spiegel et al., 1999, Takano et al., 2022). Leger et al. (2020) conducted a survey on 12,367 adults throughout France, hoping to understand if napping and weekend catchup sleep could compensate for short weekday sleep. Their findings indicated that napping and weekend catch-up sleep only compensated for severe sleep debt in 25% of participants, suggesting that catch-up sleep does not adequately restore lost sleep.

In addition to sleep debt affecting future sleep, it is associated with short- and long-term health problems. Lv et al. (2020) observed data for 4,699 children in China, aiming to assess the relationship between weekend catch-up sleep and executive functioning. Their results indicated that weekend catch-up sleep did not adequately restore executive functioning in the week following a short weekday sleep. S. Park et al. (2022) observed 17,665 participants across South Korea, focussing on the effect of weekend catch-up sleep on high-sensitivity C-reactive protein (hs-CRP), an important epidemiological marker. Their results suggested that individuals who demonstrate inconsistent bedtimes are unlikely to have a protective effect from weekend catch-up sleep, leaving hs-CRP levels elevated which can contribute to reduced immune function and insomnia (Ho et al., 2019). Long-term elevated hs-CRP levels are associated with higher frequency of all-cause death, specifically cancer mortality and cardiovascular mortality rates, indicating that efforts should be made to keep levels of hs-CRP reduced

(Fukase et al., 2021). The findings of the present study demonstrate that almost all the participants were not getting enough sleep each night. It will be important to replicate this study with a larger sample to establish whether individuals with IDD at a population level meet the duration guideline on every day of the week. If that they are not meeting the guideline each night, then intervention is needed to avoid short- and long-term health issues because "catching up" is not a viable solution.

The Canadian 24-hour movement guidelines also mention the importance of maintaining a consistent sleep routine. Specifically, suggesting that individuals should aim to meet the recommended duration with a consistent sleep/wake time (Ross et al., 2020). In this study, total sleep times varied considerably. Within the span of one week, the difference between average minimum and maximum sleep times was more than 3 hours. With the average minimum total sleep times and average maximum total sleep times representing a statistically significant difference at $p < 0.01$ level, participants in this sample were not adequately maintaining a consistent sleep length within a one-week timespan.

Although the diary data pointed to consistent bedtime routines, the smartwatch data demonstrated inconsistent sleep times. Given that consistent bedtimes and wake-up times are associated with better sleep and improved short- and long-term health outcomes, researchers have suggested there is room for improvement in this population (Chaput et al., 2020; McMahon et al., 2020). This current study data supports this and recommends that monitoring sleep hygiene behaviours include both bedtime routine and the timing of those routines.

Both the sleep routine itself and the scheduling are important. Ganaie et al.'s (2015) systematic review of sleep pattern and disturbances and problem behaviour revealed that there is significant variation in the sleep routines of individuals with IDD. In general, consistent sleep schedule and routines are important predictors of sleep quality (McMahon et al., 2020; Siddiqui et al., 2016). An intervention study by Hylkema and Vlaskamp (2009) supports this observation. Working with 48 adults with IDD, these authors found that participants spent on average 11 hours and 19 minutes lying in bed each day while only sleeping an average of 8 hours and 3 minutes. When they helped individuals establish a sleep routine and consistent sleep schedule, participants spent an average of 10 hours and 41 minutes lying in bed each day but slept an average of 8 hours and 40 minutes. Hylkema and Vlaskamp's findings showed that sleep routines can improve sleep efficiency and sleep latency while also minimizing sleep disruptions.

There is a little research showing the length of disturbances for adults with IDD (Shanahan et al., 2019). The paucity of research is likely a result of the challenges of obtaining these data before the advent of wearable technologies (Van de Wouw et al., 2013). Results from this study demonstrated that the group average for sleep disturbances was 35 minutes. A systematic review by Shanahan et al. (2019) that reviewed the prevalence of sleep difficulties amongst adults with IDD found that 32% experienced sleep disruptions, however, no exact number in minutes per evening was reported. As mentioned earlier, the modal score for participants in this study meeting the recommended guideline for sleep duration across 7 nights was 4. This result mainly came from sleeping less than recommended. The inconsistent sleep/wake times very likely

contributed to this inadequate level of sleep and warrants further investigation and intervention.

5.2) Are adults with IDD reporting and demonstrating problems with their sleep quality?

Results presented in Table 4.3 show that participants in this study did have problems with sleep disturbances. Specifically, problems with waking up during the night was the most common issue. This is consistent with research showing that adults with IDD have more fragmented sleep than adults without an IDD due to more disturbed sleep-wake rhythms (Maaskant et al., 2013) as well as a high frequency of night awakenings (Halstead et al., 2021b; Korb et al., 2021; Smith et al., 1998). At least part of the explanation for these sleep disturbances is the severity and prevalence of associated co-morbid conditions common among adults with IDD, such as obesity, depression, chronic pain, cerebral palsy, and OSAS (Dutt et al., 2015; Esbensen, 2015; Lindblom et al., 2001). Similarly, large population surveys have shown that middle-of-the-night awakening are strongly correlated with co-morbid disorders (Moline et al., 2014; Ohayon, 2008). Co-morbid conditions were not documented in this study. Future research investigations into sleep disturbances would benefit from including a measure of associated and secondary health conditions of participants.

Waking up earlier than planned was somewhat common, with 9 out of 15 participants reporting this at least once in the week. Waking up too early is considered a risk factor for long-term ill-health, affecting individuals across their entire lifespan (Bennet et al., 2018). Vallat et al. (2022) found that how a person wakes up is directly related to both the quality of sleep and the activities completed the prior day. Waking up too hot or cold during the night was not common within this sample. Irregularities in

temperature are strongly correlated with sleep disturbances (Newman et al., 1997; Porkka-Heiskanen et al, 2013). Given that temperature is based on environmental factors, individuals struggling with temperature should seek to make necessary changes to prevent awakenings or poor-quality sleep (Okamoto-Mizuno & Mizuno, 2012). However, some individuals with IDD may not be in circumstances where they can change their environment independently. In such cases, caregivers should encourage adults with IDD to talk about feeling too hot or too cold and collaborate to ensure a comfortable sleeping temperature (Vicente et al., 2017). Few participants reported having any trouble falling asleep even though insomnia and problems with sleep onset are common among adults with IDD. However, no exact statistics exist to adequately report how common this sleep disturbance is among this demographic (Korb et al., 2021).

5.3) What are the sleep hygiene behaviours of adults with IDD?

Sleep hygiene behaviours have been suggested as one of the reasons for the high prevalence of sleep problems among adults with IDD (Richdale & Baker, 2014). Overall, there were 133 “Yes” responses to negative sleep hygiene behaviours from a total of 312 valid responses, or 43% of the valid responses (Questions 1-3, Appendix C, p. 5). There were 202 “Yes” responses to positive sleep hygiene behaviours from a total of 416 valid responses, or 49% of the valid responses (Questions 4-7, Appendix C, p. 5). As shown in Table 4.4, most participants reported completing their usual sleep routine each night. Looking within the literature, greater sleep variability is associated with adverse health outcomes, stemming from insufficient sleep duration with poor quality (Chaput et al., 2020). Maintaining and adhering to a structured sleep-wake schedule is associated with better sleep outcomes (McMahon et al., 2020). Consistent

sleep schedules are associated with cognitive function, with inconsistent sleep associated with a reduction in short- and long-term cognitive function (Finley & Cowley, 2005; Lo et al., 2020; Okano et al., 2019). Given the positive benefits of adhering to a consistent sleep routine, it is positive to note that many participants were completing their usual sleep routine each night. However, as indicated earlier, there was a discrepancy between the diary and the smartwatch data in terms of sleep times. As Ross and colleagues (2020) mentioned in the development of the 24-hour movement guidelines, people tend to report when they go to bed and get up as "sleep time". It seems that may have occurred within this study too. Although participants reported having a usual sleep routine, which was a good thing, the actual sleep-wake schedule was highly variable. For adequate sleep duration and quality, both the bedtime routine and the latency between going to bed and going to sleep need to be optimized.

Exercising within 3 hours of going to bed was infrequent among this sample However, participants were fairly active, so most exercise must have been limited to times at least 3 hours prior to bedtime. Previous research has suggested that exercise too close to bedtime could negatively impact both sleep quality and duration, leading it to be considered a negative sleep hygiene behaviour when pursued too close to bedtime (Albakri et al., 2021; Dolezal et al., 2017). However, other research has contested these findings, suggested that there is little to no negative impact from exercising prior to bedtime (Kahn et al., 2021). Stutz et al. (2019) found that evening exercise improved sleep-onset latency and total sleep time, refuting the hypothesis that evening exercise negatively affects sleep. Nonetheless, this sample suggests that a relationship between

evening exercise and sleep is not particularly relevant given that these participants were not regularly exercising prior to bedtime.

Using technology within 30 minutes before bed was very common in this sample. Most participants reported this at least 3 out of 7 days, with only one participant reporting it for just one day and another participant reporting having never engaged in this behaviour. This aligns with literature that suggests that individuals with IDD regularly pursue screen time throughout the day, including right before bed (Aishwroiya et al., 2018; Heitplatz et al., 2022). Given that bedtime screen usage is associated with insufficient sleep duration, reduced sleep quality, and daytime sleepiness, it may be necessary to consider interventions to reduce screen time before bed (Hale et al., 2018; Pham et al., 2021). He et al. (2020) conducted an intervention to this effect, seeking to reduce screen time 30 minutes before bedtime. Randomizing 38 university students, 19 acted as a control and 19 followed the intervention. Their results indicated that reducing screen usage 30 minutes prior to bedtime both reduced sleep latency and increased sleep duration, providing evidence that interventions to reduce screen time could be beneficial in the context of adults with IDD.

Caffeine consumption was somewhat recurrent, but the frequency of this behaviour was substantially lower than screen usage prior to bedtime. Drake et al. (2013) demonstrated that caffeine taken 0, 3, or even 6 hours prior to bedtime leads to significant disruptions in both sleep quality and duration. With caffeine consumption linked to a reduction in total sleep time, efforts may be necessary to prevent consumption prior to bed.

Reports of calming activities were not frequently observed in this sample. Sleep hygiene recommendations have empirically demonstrated that pursuing calming activities prior to sleep is optimal for sufficient sleep of a high quality (Irish et al., 2015; J. Park et al., 2022). Given the low frequency of responses, interventions aimed at promoting calming activities may be beneficial for this demographic. Research has suggested that calming activities are not always accessible for individuals, due to either their lifestyle or home environment (Hale et al., 2018; Hedin et al., 2020; Kitsaras et al., 2021). Nonetheless, it may be useful to investigate how to increase this positive sleep hygiene behaviour among adults with IDD. An effective way to increase health-promoting lifestyle behaviours is to focus on building health-promotion capacity in these settings (Vlot-van Anrooij et al., 2020). This capacity will include a social network aware of sleep hygiene behaviours and tools that fit adults with IDD and their support network.

Medication to help with sleep was not typical in this sample. In addition, only three participants utilized medication, with two of them using it every night and one participant using it for three of the seven nights. Using a sleep device was infrequent, consistently used each night be the participants who used one. Only five participants utilized a sleep device, with four of the five using it every night and one individual forgetting to use it for one night as per documented notes in the journal. Given that both medication and sleep devices promote sleep (Ballester et al., 2019; van de Broek et al., 2021), these approaches could be considered in collaboration with health care providers. As the use of wearable technology increases, it is likely more individuals with IDD will be identified as having sleep problems. From a health-promotion perspective, primary

prevention of poor sleep through education is a good first step to empower individuals to take care of their own health and prevent secondary health conditions. However, secondary prevention such as medication and sleep devices may also be needed to prevent conditions associated with poor sleep (Government of Canada, 2013).

5.4) Are poor sleep hygiene behaviours associated with poor sleep quality and duration?

The correlation coefficients in Table 4.5 were not statistically significant. Given that this study utilized a small sample, further exploration is needed with a larger group to see if there are meaningful relationships. Given the high rate of technology use before bedtime in this study and that screen usage before bed is associated with delayed bedtime and longer sleep onset latency (Hale et al., 2018; Mei et al., 2018) it is an area that need follow-up. However, screen usage in this study may have been higher due to environmental factors outside of their control (Vézina-Im et al., 2022). The onset of the COVID-19 pandemic brought about several related lifestyle changes, one of which includes increased screen time usage among the general population (Drumheller & Fan, 2022). Although adults with IDD are known to engage in high levels of screen time, occurrences of this behaviour in the context of this study may have been increased compared to prior to the pandemic due to possible lifestyle changes brought about by the pandemic (Hsieh et al., 2017; Must et al., 2015).

5.5) Is total volume of physical activity associated with better sleep quality and duration?

Physical activity results suggested that only some participants were meeting the guidelines of 150 minutes per week of MVPA (Ross et al., 2020). With the group average of 604.38 minutes of MVPA per week, 9 of the 15 participants with analyzable data were

above 150 minutes per week. This finding contrasted with other results that have typically found adults with IDD rarely meet weekly MVPA recommendations (Oviedo et al., 2017; Stancliffe & Anderson, 2017). Similarly, a systematic review by Dairo et al. (2016) found among the participants observed, only 9% of adults with intellectual disabilities were meeting the 150 minutes of MVPA goal. Work by Chow et al. (2018) in Hong Kong observed 67 adults with intellectual disabilities and found that these adults only achieved 2% of their daily time (~10 minutes per day) in MVPA. One consideration is that participants in this study sample may have been more independent as they had to be part of a community program to participate in this study, potentially giving them more opportunities for physical activity. Given the complexity of the possible reasonings for this increase in physical activity in this sample. Please note, the majority of the physical activity data collected as part of the broader study have been reported in another study.

Correlating MVPA to total sleep, actual sleep, and sleep disturbances yielded a significant negative correlation between average MVPA and sleep disturbances. The relationship was moderately strong (Akoglu, 2018) and potentially this finding can be used with families and caregivers to further promote physical activity for adults with IDD. This finding is like other well-established findings over the years that have demonstrated that regular physical activity is associated with an improvement in sleep quality (Esnaasharieh et al., 2022; Wang & Boros, 2021; Xie et al., 2021). A systematic review by Dolezal et al. (2017) found that after review of 34 studies examining the relationship between exercise and sleep, there was conclusive evidence from 29 of the 34 studies that exercise improved sleep quality and/or duration. There is a lack of research directly observing the relationship between exercise and sleep among adults with IDD but

based on results from individuals without IDD, results from this study align with the current literature.

Correlation coefficients for total sleep and actual sleep with MVPA did not yield any statistically significant results. Looking at comparisons with population level data, one explanation could be that physical activity has a greater influence on sleep quality than sleep duration (Takács & Török, 2019). A systematic review by Wang and Boros (2021) found that sleep quality was strongly correlated with moderate physical activity. In addition, research has demonstrated that physical activity may play a larger role in improving sleep quality than sleep duration (Seol et al., 2022; Wendt et al., 2022). Behaviours prior to bed may play a larger role on sleep duration, than activities completed earlier in the day, such as physical activity (Banks & Dinges et al., 2007; Magalhães et al., 2020). In the context of adults with IDD, these individuals often follow consistent and individualized routines (Burns et al., 2022). Although their routines are largely positive, often improving independence and self-efficacy, negative sleep hygiene behaviours may be adopted if deemed desirable, leading to regularly delayed sleep bedtimes and unchanged scheduled wake times (Burns et al., 2022; Mesibov et al., 2002; Sutton et al., 2020). Given the results of this study, increasing MVPA is likely to improve the quality of sleep among adults with IDD.

5.6) Pilot Study

The three goals of this pilot study were met. First, the results demonstrated that sleep and physical activity could feasibly be monitored with smartwatch technology, with data successfully recorded for 15 participants for one week. Secondly, adults with IDD in this study demonstrated that they were able to adhere to wearing a smartwatch for one

week, allowing for sleep and physical activity data to be collected. Lastly, adults with IDD, with regular check-ins and encouragement from the research team as well as, in some circumstances, support from their caregiver, were able to provide self-reported information in the form of a sleep and physical activity diary each day throughout their involvement in the study.

5.7) Limitations

Future studies should look to observe larger populations of adults with IDD. Given the small sample size observed here, it is not possible to generalize to the population of adults with IDD. Both recruiting more individuals and stratifying the sample by relevant characteristics such as age and gender is needed. This would give the study more power and facilitate a better understanding of the problems and challenges experienced by adults with IDD, allowing for more targeted primary and secondary health-promotion efforts.

Given the short timeframe of the study, it is difficult to view the results as being fully representative of what a typical week looks like for each participant in this study. Only observing 7 days of an individual's activities leaves room for biases and does not adequately consider the variability an individual may have in their behaviour from week to week. Other psychological phenomena like the Hawthorne effect may have also played a part, which stipulates that when participants know they are being observed, they may go out of their way to alter their behaviours or activities which could have undermined the integrity of the study (McCambridge et al., 2014). By increasing the length of the study, biases are likely to dissipate, and participants are more likely to stick with their regular routine, allowing for more accurate data.

5.8) Conclusion

The current study investigated sleep duration and quality among adults with IDD. Average actual sleep in this sample was below recommended guidelines, with 9 out of 15 participants not meeting the recommended sleep duration guidelines across one week (Ross et al., 2020). However, average sleep across a timespan of a week somewhat underrepresented the sleep difficulties in this sample. Only one participant met the sleep guideline every night. Given the complications associated with sleep debt, these findings suggest that most participants' sleep patterns were not optimal. The significant negative relationship between sleep quality and MVPA demonstrated that disruptions were lower among those with higher levels of MVPA. This result can be added to the reasons to support efforts to increase physical activity among adults with IDD. The use of screens within 30 minutes of going to bed was high and calming activities typical of better sleep hygiene routines was low. Efforts should be made to optimize sleep hygiene behaviours and to examine the relationships between these behaviours and sleep duration and quality in a population-based sample.

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Appendix A

University of Victoria
Office of Research Services | Human Research Ethics Board
Michael Williams Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Approval

PRINCIPAL INVESTIGATOR	**Lynneth Stuart-Hill** (Supervisor)	**ETHICS PROTOCOL NUMBER** Expedited review - delegated	**20-0601**
PRINCIPAL APPLICANT	**Cooper Coats** **Master's student**	ORIGINAL APPROVAL DATE	01-Oct-2021
		APPROVED ON	01-Oct-2021
UVIC DEPARTMENT	**Exercise Science, Physical and Health Education EPHE**	APPROVAL EXPIRY DATE	30-Sep-2022

PROJECT TITLE **The success of Adults with Intellectual Disability or on the Autism spectrum in meeting the new Canada's 24 hour movement guidelines**

RESEARCH TEAM MEMBERS
Cara Butler - Research Assistant, UVic
Stefanie Sajko - Research Assistant, UVic
Matthew Coxon - Principal Applicant, UVic
Viviene Temple - Principal Investigator, UVic

DECLARED PROJECT FUNDING
Canadian Institutes of Health Research (CIHR), Canadian Institutes of Health Research (CIHR)

DOCUMENTS INCLUDED IN THIS APPROVAL
tcps2_core_certificate.pdf - 14-Jun-2021
Research Ethics_TCPS 2_Core.pdf - 18-Jun-2021
Email-Recruitment-Script.docx - 20-Jul-2021
Sleep-Hygiene-and-Physical-Activity-Diary.pdf - 20-Jul-2021
UVic ethics letter from Garth Homer.pdf - 23-Sep-2021
Garth Homer Society Visitor Protocol.PNG - 23-Sep-2021
Recruitment Poster.docx - 23-Sep-2021
Consent and Assent - C24hMG.docx - 23-Sep-2021

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

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Certificate of Approval - Amendments

PRINCIPAL INVESTIGATOR:	**Lynneth Stuart-Hill** (Supervisor)	**ETHICS PROTOCOL NUMBER** Expedited review - delegated	**20-0601**
PRINCIPAL APPLICANT:	**Cooper Coats** **Master's student**	ORIGINAL APPROVAL DATE:	01-Oct-2021
		APPROVED ON:	04-Mar-2022
UVIC DEPARTMENT:	**Exercise Science, Physical and Health Education EPHE**	APPROVAL EXPIRY DATE:	30-Sep-2022

PROJECT TITLE: **The success of Adults with Intellectual Disability or on the Autism spectrum in meeting the new Canada's 24 hour movement guidelines**

RESEARCH TEAM MEMBERS:
Viviene Temple - Principal Investigator, UVic
Cara Butler - Research Assistant, UVic
Stefanie Sajko - Research Assistant, UVic
Matthew Coxon - Principal Applicant, UVic

DECLARED PROJECT FUNDING:
Canadian Institutes of Health Research (CIHR), Canadian Institutes of Health Research (CIHR)

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Consent and Assent Form Version 2.docx - 28-Feb-2022
UVICStudyLetter.pdf - 28-Feb-2022

Conditions of approval

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Amendments
To make changes to the approved research procedure in your study, please submit "Amendments" or "Annual renewal with amendments" form. You must receive research ethics approval before proceeding with your amended protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

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Certificate of Approval - Amendments

PRINCIPAL INVESTIGATOR:	**Lynneth Stuart-Hill** (Supervisor)	**ETHICS PROTOCOL NUMBER** Expedited review - delegated	**20-0601**
PRINCIPAL APPLICANT:	**Cooper Coats** **Master's student**	ORIGINAL APPROVAL DATE:	01-Oct-2021
		APPROVED ON:	01-Apr-2022
UVIC DEPARTMENT:	**Exercise Science, Physical and Health Education EPHE**	APPROVAL EXPIRY DATE:	30-Sep-2022

PROJECT TITLE: **The success of Adults with Intellectual Disability or on the Autism spectrum in meeting the new Canada's 24 hour movement guidelines**

RESEARCH TEAM MEMBERS:
Cara Butler - Research Assistant, UVic
Stefanie Sajko - Research Assistant, UVic
Matthew Coxon - Principal Applicant, UVic
Viviene Temple - Principal Investigator, UVic

DECLARED PROJECT FUNDING:
Canadian Institutes of Health Research (CIHR), Canadian Institutes of Health Research (CIHR)

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2022-03-29 UVic Research Project Approval Letter.pdf - 29-Mar-2022
Recruitment Poster (General Use).docx - 29-Mar-2022
SOBC_Victoria_March2022.pdf - 30-Mar-2022

Conditions of approval

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Amendments
To make changes to the approved research procedure in your study, please submit "Amendments" or "Annual renewal with amendments" form. You must receive research ethics approval before proceeding with your amended protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
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Certificate of Approval - Annual Renewal

PRINCIPAL INVESTIGATOR:	**Lynneth Stuart-Hill** (Supervisor)	**ETHICS PROTOCOL NUMBER** Expedited review - delegated	**20-0601**
PRINCIPAL APPLICANT:	**Cooper Coats** **Master's student**	ORIGINAL APPROVAL DATE:	01-Oct-2021
		APPROVED ON:	21-Sep-2022
UVIC DEPARTMENT:	**Exercise Science, Physical and Health Education EPHE**	APPROVAL EXPIRY DATE:	30-Sep-2023

PROJECT TITLE: **The success of Adults with Intellectual Disability or on the Autism spectrum in meeting the new Canada's 24 hour movement guidelines**

RESEARCH TEAM MEMBERS:
Matthew Coxon - Principal Applicant, UVic
Viviene Temple - Principal Investigator, UVic
Cara Butler - Research Assistant, UVic
Stefanie Sajko - Research Assistant, UVic

DECLARED PROJECT FUNDING:
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Appendix B

Physical Activity and Sleep Hygiene Diary

Please complete this diary each day
and show it to Matthew or Cooper
each time your watch is charged

Name: _____

PHYSICAL ACTIVITY

1. Complete Before Going to Bed Each Day

Answer the questions by circling YES or NO, then tell us what those activities were

	Day of the week							
SPORT								
Did you play a **sport** today? Like soccer, golf, 5-pin or 10-pin bowling, gymnastics	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what sport did you play?								
Was this sport part of Special Olympics?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
PHYSICAL ACTIVITIES AND EXERCISE (NOT SPORT)								
Did you do **physical activities or exercise** today? Like walking, yoga, club fit, riding a bicycle, or lifting weights	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what physical activities or exercises did you do?								
Who did you do the activities or exercise with? Like Garth Homer Society (GHS), family, recreation centre program, physiotherapist								

HOUSEHOLD ACTIVITIES								
Did you do **housework** today? Like washing dishes, sweeping floors, cooking, or vacuuming	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what housework did you do?								
Did you do **yard work** or **gardening** today? Like mowing the lawn, raking leaves, planting flowers, or weeding	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what yard work did you do?								

Is there anything else you want to tell us about your physical activity?

2. Complete Before Going to Bed

Answer the questions by circling YES or NO

	Day of the week							
Activity								
Did you use technology within 30 minutes of going to bed? (like TV, phone, computer, iPad)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you eat or drink any caffeine within 4 hours of going to bed? (like coffee, tea, chocolate or cola)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you exercise or play sports within 3 hours of going to bed?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you do calming activities before going to bed (like listening to music or meditating)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you do you usual sleep routine before going to bed?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you take medication to help you sleep?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Are you using a sleep device tonight? (like a CPAP)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

3. Complete When You Wake Up

Answer the questions by circling YES or NO

	Day of the week							
Activity								
Did you have trouble falling asleep?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you wake up during the night?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you wake up earlier than planned?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Were you too hot or too cold during the night?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

3. What time did you go to bed last night and get up today? (Write the hour and minutes e.g. 9.35 pm)

	Day of the week							
Activity								
What time did you go to bed at night?								
What time did you get up in the morning?								

4. Sleep routine

Please describe your usual sleep routine? Including:

What time do you usually go to bed and wake up? Are the times different on different days? What do you do before going to bed? (like, clean my teeth and put on pajamas, do some yoga and deep breathing, put on my CPAP).

Is there anything else you want to tell us about your sleep?

Please provide the following information:

Did someone help you fill in this diary? If so, can you provide their name and contact information

Name: _____

How best to contact?

Email:

Phone number:

If you have any questions or concerns, contact Matthew Coxon at mwcoxon@uvic.ca or Cooper Coats jcoopercoats@uvic.ca

Appendix C

Physical Activity and Sleep Hygiene Diary

Please complete this diary each day and show it to Matthew or Cooper each time your watch is charged

Name: _____

2

1. **Complete Before Going to Bed Each Day**

Answer the questions by circling YES or NO, then tell us what those activities were

	Day of the week							
SPORT								
Did you play a sport today? Like soccer, golf, 5-pin or 10-pin bowling, gymnastics	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what sport did you play?								
Was this sport part of Special Olympics?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
PHYSICAL ACTIVITIES AND EXERCISE (NOT SPORT)								
Did you do physical activities or exercise today? Like walking, yoga, club fit, riding a bicycle, or lifting weights	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what physical activities or exercises did you do?								
Who did you do the activities or exercise with? Like Garth Homer Society (GHS), family, recreation centre program, physiotherapist								

HOUSEHOLD ACTIVITIES								
Did you do **housework** today? Like washing dishes, sweeping floors, cooking, or vacuuming	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what housework did you do?								
Did you do **yard work** or **gardening** today? Like mowing the lawn, raking leaves, planting flowers, or weeding	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, what yard work did you do?								

Is there anything else you want to tell us about your physical activity?

2. Complete Before Going to Bed

Answer the questions by circling YES or NO

	Day of the week							
Activity								
Did you use technology within 30 minutes of going to bed? (like TV, phone, computer, iPad)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you eat or drink any caffeine within 4 hours of going to bed? (like coffee, tea, chocolate or cola)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you exercise or play sports within 3 hours of going to bed?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you do calming activities before going to bed (like listening to music or meditating)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you do you usual sleep routine before going to bed?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you take medication to help you sleep?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Are you using a sleep device tonight? (like a CPAP)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

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3. Complete When You Wake Up

Answer the questions by circling YES or NO

	Day of the week							
Activity								
Did you have trouble falling asleep?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you wake up during the night?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Did you wake up earlier than planned?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Were you too hot or too cold during the night?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

3. What time did you go to bed last night and get up today? (Write the hour and minutes e.g. 9.35 pm)

	Day of the week							
Activity								
What time did you go to bed at night?								
What time did you get up in the morning?								

4. Sleep routine

Please describe your usual sleep routine? Including:

What time do you usually go to bed and wake up? Are the times different on different days? What do you do before going to bed? (like, clean my teeth and put on pajamas, do some yoga and deep breathing, put on my CPAP).

Is there anything else you want to tell us about your sleep?

Please provide the following information:

Did someone help you fill in this diary? If so, can you provide their name and contact information

Name: _____

How best to contact?

Email:

Phone number:

If you have any questions or concerns, contact Matthew Coxon at mwcoxon@uvic.ca or Cooper Coats jcoopercoats@uvic.ca

Appendix D

University of Victoria

Are you getting enough exercise? Are you spending too much time on the couch? Are you getting enough sleep?

If you are 18 years or older, this study may be for you.

Study for adults with intellectual disabilities within the Greater Victoria region through the School of Exercise Science, Physical Health & Education, University of Victoria. We are looking for adults 18 years and older with an existing intellectual disability to examine their current physical activity levels, time spent sedentary, and sleep duration.

Many individuals with intellectual disabilities have been unable to regularly participate in physical activity due to the impact of the COVID-19 pandemic. This research seeks to observe physical activity levels and examine the existing relationship with sedentary time and sleep duration by using smartwatch technology.

Participants will be asked to participate in:

- 1 preliminary visit from the team to receive equipment
- 3 separate remote follow-ups to recharge watch
- 9 days of wearing the smartwatch both day and night
- 1 final visit from the team to return equipment

Participants will receive:

- $5 Tim Hortons Gift Card
- The oppurtunity to wear a smartwatch for one week

Location

- Equipment will be dropped off at the participant's home and follow-up appointments will take place remotely
- Data recording will take place wherever you go through the wearable smartwatch

Are you eligible?

- 18 years or older
- No existing physical condition that prevents movement
- Existing intellectual disability

If you are unsure if you meet the requirements, call or email a member of the study team:

- mwcoxon@uvic.ca or 778-887-7862
- jcoopercoats@uvic.ca or 902-237-5568

Appendix E

Levels of Physical Activity, Sedentary Activity, and Sleep in Adults with Intellectual Disability during COVID-19: A Pilot Study on the 2020 Canadian 24-Hour Movement Guidelines

Adults with an intellectual disability (ID), aged 18 to 50 years, are invited to participate in a study entitled *"Levels of physical activity, sedentary activity, and sleep in adults with intellectual disability in Victoria, BC during COVID-19: A pilot study on the 2020 Canadian 24-hour movement guidelines"* that is being conducted by Mr. Cooper Coats and Mr. Matthew Coxon who are graduate students at the University of Victoria, and Dr. Viviene Temple and Dr. Lynneth Stuart-Hill, who are professors at the University of Victoria.

If you have further questions, you may contact any of the following contacts:

Cooper Coats	902-237-5568	jcoopercoats@uvic.ca
Matthew Coxon	778-887-7862	mwcoxon@uvic.ca
Dr. Viviene Temple	250-721-7846	vtemple@uvic.ca
Dr. Lynneth Stuart-Hill	250-721-7884	lstuhill@uvic.ca

Purpose and Objectives

The aim of this study is to see, on average, how much time you're spending sedentary or doing physical activity during the day. Furthermore, we also want to know how much sleep you're getting each night.

Importance of this Research

Achieving regular physical activity has many short- and long-term benefits, such as a decrease in blood pressure, a lowered risk of cardiovascular disease and dementia, as well as improvements to overall bone health and quality of life.[1] Sleep is also a crucial factor in maintaining health life, as regular sleep has been shown to reduce the risk of heart disease and type II diabetes, as well as improving immune function, mood, and learning.[1] Understanding the current level of physical activity, sedentary activity, and sleep for adults with an intellectual disability, will provide policymakers and community outreach programs within Victoria, BC with salient information for public health provisions.

What is Involved?

If you agree to be in this project, you will be asked to do these things:

1. You wear a Polar Ignite smartwatch for 9 consecutive days as shown in the picture below.

2. <u>On the first day</u>, your body height and weight will be measured in person by one of our researchers and information like age, sex, medication use, and medical diagnosis will be collected.

3. <u>Every two days after that,</u> a researcher from our team will come to you and borrow the watch for an hour in order to charge it and download the data. After this, the watch will be returned to you.

Inconvenience

Participation in this study may cause some inconvenience to you because you will be asked to wear a wristwatch for 9 consecutive days during the day and at night. There will be a total of 5 visits of an hour each from the researchers during those 9 days which may also cause some inconvenience.

Risks

Given the current circumstances with the COVID-19 global pandemic, the risk is potentially getting the virus. However, researchers coming meet with you to complete the data collection will be wearing masks, maintaining social distancing when possible, sanitizing hands before and after each visit, and wearing disposable gloves at all times.

Benefits to You

- You will learn on average how much physical activity you're getting
- You will learn on average how much time you spend sedentary during the day
- You will learn on average how much sleep you're getting
- The societies involved with the study will know the overall results of the study, which will help the staff with programming
- You will receive a $5 Tim Hortons gift card

Benefits to Community

- The societies involved with the study will know how much, on average, their members are moving, staying sedentary, and sleeping
- Novel experimental design will provide a valuable framework for future studies with vulnerable populations, limiting contact time through the use of wearable technologies

Voluntary Participation

It is important that you understand that you don't have to participate in this project if you don't want to and you can stop at any time. You can tell any one of the researchers, staff at the organization you are affiliated with, or care-providers that you want to quit, and you can. If you decide to leave the study at any time, you must return the watch to the researchers, care-providers, or staff at the organization you are affiliated with, and it will be collected by someone from the research team.

If you decide to stop being in the project, you can decide if the information we have already collected can be used in our research, or you want it destroyed. If you decide we can use the information, we will write you a letter asking to use the information and the letter will be mailed to you. You can sign the letter and mail it back to us if you are comfortable with us using the information. If we do not receive a signed letter in return, we will throw away the information.

Anonymity and Confidentiality

The research team will not tell anyone you are in the study. However, other persons may know that you are a part of a study given you will be wearing a smartwatch. All the information we collect from you (e.g. your age, height, weight, activity levels) will be put into a password-protected computer and Polar Flow online software it will not have your name on it. Your information will be kept safe in a locked cabinet and on a password protected computer and password-protected online software for a long time in case the researchers want to look at it again. In five years, the information will be destroyed.

Dissemination of Results

After we have collected the information from many different participants, we will share what we learned about physical activity, sedentary behaviour, and sleep length. We will talk about it at meetings so other people learn about our project. We will write about it a professional magazine. However, your name will not be used, so no one will know you were in the study. The researchers can also provide to you the results from our study including your average level of physical activity, time spent sedentary and sleep.

In addition, you may check the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

COVID-19 Contract Tracing

Participants will be advised if they have or may have come into contact with an individual who has tested positive for COVID-19. Contact information for participants will be stored in a separate file from research data in the event that follow up is needed.

Your signature below shows that you understand and agree with what is written in this form, and that you have had the opportunity to have your questions answered by the researchers.

Resources

[1] U.S. Department of Health and Human Services. (2018). *Physical Activity Guidelines 2nd Edition*. 118.

Name of Participant	*Participant Signature*	*Date*

Name of Parent/Guardian/Caregiver	*Parent/Guardian/Caregiver Signature*	*Date*

Levels of Physical Activity, Sedentary Activity, and Sleep in Adults with Intellectual Disability during COVID-19: A Pilot Study on the 2020 Canadian 24-Hour Movement Guidelines

I agree to work with Cooper, Matthew, Viviene, and Lynneth who work at the University of Victoria on a project about the 2020 Canadian 24-hour movement guidelines and whether these guidelines are being adhered to in Victoria, BC by adults with intellectual disability during the COVID-19 pandemic. The project will collect data for physical activity, sedentary activity, and sleep hygiene. I will participate in the following for the project:

1. I will be weighed and measured for my height.
2. I will answer some questions about what kind of support I need every day, my age, and the sports I play.
3. I will wear the Polar Ignite wristwatch for nine consecutive days, including during the day and at night.
4. I will return the Polar Ignite wristwatch to the researcher for data collection and charging every two days during the nine-day data collection period.
5. I will return the Polar Ignite wristwatch to the researcher at the end of the data collection period.

I understand that none of the things I will be asked to do will hurt me, but it may be inconvenient to wear a wristwatch for nine days.

I understand that I don't have to participate in this project if I don't want to, and I can stop at any time. I can tell any one of the researchers, care-providers, or staff at the organization I am affiliated with, that I want to quit, and I can. I will still keep the Tim Hortons gift card for my participation regardless of the time at which I quit. I will return the watch to the researchers, care-providers or staff at the organization I am affiliated with once I quit.

If I decide to quit, the researchers will ask me if they can use my data. If I tell them that they can, they will send my caregiver/parent a letter asking if they can use the data that they got from the time that I was participating. If I am okay with them using my data, my caregiver/parent and I will sign the letter and send it back to the researchers. If I am not okay with my data being used, I do not have to mail the letter back, and my results will be thrown away.

All of my data, numbers, and other information collected from me will not be shared with anyone except for the researchers. After five years, all my data, numbers, and other information will be destroyed.

The researchers will share what they learned about the levels of physical activity, sedentary activity, and sleep at meetings and in professional journals, but my name will not be used, so no one will know I was in the study. The researchers will also share the information with me. I can also ask Cooper, Matthew, Lynneth, or Viviene to share with me how much physical activity, sedentary activity, and sleep I achieved during the nine days of data collection.

I may be advised if I have come or may have come into contact with a person who has tested positive for COVID-19. My contact information will be stored in a separate file from the research data in the event that a follow up is needed.

If I have any questions, my parent/guardian/service provider or I can call Viviene at 250-721-7846 or email her at vtemple@uvic.ca.
Your signature below shows that you understand and agree with what is written in this form, and that you have had the opportunity to have your questions answered by the researchers.

Name of Parent/Guardian/Caregiver	*Parent/Guardian/Caregiver Signature*	*Date*
Name of Participant	*Participant Signature*	*Date*