VARIATION IN DAILY AND WITHIN DAY INTENTIONS AND BEHAVIOUR

MINDING THE GAP: UNDERSTANDING CHANGES IN MOMENTARY INTENTIONS AND PHYSICAL ACTIVITY BEHAVIOURS DURING LATE ADOLESCENCE USING ECOLOGICAL MOMENTARY ASSESSMENT

By PALLAVI DUTTA, B.Sc.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree Master of eHealth

McMaster University

August 2020

McMaster University MASTER OF SCIENCE (2020) Hamilton, Ontario (eHealth)

TITLE: Minding the Gap: Understanding changes in momentary intentions and physical activity during late adolescence using Ecological Momentary Assessment

AUTHOR: Pallavi Dutta B.Sc.,

SUPERVISOR: Dr. Matthew Kwan

NUMBER OF PAGES: xi, 73

Lay Abstract

Despite the known benefits of physical activity, rates remain low amongst adolescents. Previous research has outlined the importance of intentions as a predictor of physical activity; however, an intention behaviour gap persists. The current study examined this gap by assessing variation in intentions over the course of the week and day, and by examining intentions and physical activity closer together in time through the use of a smartphone app. Significant variation was found in intentions within the day to engage in activity. Descriptively assessing intentions and physical activity by measuring them closer together in time indicated a reduction in the daily intention behaviour gap but no significant differences between intentions and behaviour measured frequently within a day. Findings suggest that the intention to behaviour gap may be reduced by assessing intentions and behaviour more frequently and closer together in time. Further research is required to quantify this reduction.

Abstract

BACKGROUND: The construct of intention continues to be an important correlate and predictor of physical activity; however, a substantial intention behaviour gap continues to exist. Little literature has examined this gap on a micro-temporal scale, and none have addressed the adolescent population. **PURPOSE:** The purpose of this thesis is to 1) examine whether there are variations in daily and within day intentions to be physically active in the adolescent population, and 2) whether the intention - physical activity gap is reduced when assessing intention and behaviour on a micro-temporal scale using Ecological Momentary Assessment (EMA). **METHODS:** This thesis sample included 193 grade 11 students from a large school board in Southern Ontario. Participants responded to 5 EMA prompts for 7 days on their smartphones and wore accelerometers for the duration of the study. Each EMA prompt included a brief questionnaire assessing participant intentions to engage in physical activity. A mixed-effects logistic regression model was used to determine variability in intentions and descriptive analyses were used to examine the intention - behaviour gap. **RESULTS:** A mixed-effects logistic regression did not indicate differences in intentions between days of the week (coef. = -0.07 SE: 0.07, p=.27) but did indicate that likelihood of reporting intentions significantly decreases over the course of the day (coef. = -.479 SE=.05, p<.01). For daily intentions and physical activity, 89% of daily intenders engaged in subsequent physical activity while 46% of within day intenders engaged in subsequent physical activity. **CONCLUSIONS:** Findings suggest that there is some variation in intentions and that a micro-temporal time scale measurement serves to reduce the intention - behaviour gap. This adds to our understanding of the relationship between intentions and physical activity. In better understanding this relationship, we can begin to guide interventions that bridge the gap between intentions and physical activity in the adolescent population.

Acknowledgements

I would like to recognize all the participants who took part in the ADAPT Study. The EMA portion of the study was particularity burdensome and I thank all participants for their time and contributions.

I would like to acknowledge the school administration of the seven Hamilton-Wentworth Catholic District School Board high schools. Conducting this study would not have been possible without the school administration welcoming us and helping us disseminate information to students, collecting participant consents and setting up the data collection in their respective schools. I truly appreciate their involvement.

I would like to express my sincere gratitude towards my supervisor, Dr. Kwan, who continues to support and guide me. Thank-you for your encouragement and your trust in the work that I do. I have gained priceless knowledge under your direction and have had the opportunity to strengthen my critical thinking, writing and presentation skills. Thank-you for providing me with autonomy on the project and allowing me to be a part of all the exciting research that you conduct.

My committee members, Dr. Lokker, Dr. Anderson and Dr. Brown, thank-you for all your insights. You helped to identify the direction of my thesis by asking me questions that helped me to critically think through my analysis and the larger implications of my work.

A hearty thank-you to all members of the INCH lab. Their welcoming nature and continued support allowed me to stay sane while setting up the study and during the data collection process. I would also like to thank them for all their help with data collection and for guiding me through data processing.

Thank-you to the developers at Lumedi for all their help in setting up and executing the ADAPT study. I appreciate your patience with processing the accelerometer data and your continued work on the study.

Thank-you to my marvellous family and friends who continue to support me. You are all superstars. To my mom and dad, thank-you for your unconditional love and for demonstrating resilience in all that you do. To you, I dedicate this thesis.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ADAPT	Application of integrated Approaches to understanding Physical activity during the Transition to emerging adulthood
CSEP	Canadian Society for Exercise Psychology
EMA	Ecological Momentary Assessment
EMI	Ecological Momentary Intervention
MVPA	Moderate to Vigorous Physical Activity
PA	Physical Activity
TRA	Theory of Reasoned Action
TPB	Theory of Planned Behaviour
WHO	World Health Organization

Declaration of Academic Achievement

I declare that I am the sole author of this thesis. I completed all research work under the direction of my supervisor (Dr. Matthew Kwan), who provided continuous guidance and feedback as well as my committee members (Dr. Lokker, Dr. Anderson and Dr. Brown). I understand that my thesis will be electronically available.

Chapter 1: Background and Introduction

1.1 Physical Activity

The World Health Organization (WHO) defines physical activity (PA) as "any bodily movement produced by skeletal muscles that requires energy expenditure" (Norum, 2005). PA is characterized into the four domains of the FITT principle; (1) Frequency (how often the person is active), (2) Intensity (how vigorous the PA is), (3) Time (duration of PA) and (4) Type (aerobic or anaerobic in nature or the domain in which the PA occurs – occupational, leisure, etc.) (Rhodes & Janssen, et al., 2017). Further, exercise, defined to be a subset of PA, is "planned, structured, and repetitive and has a final or an intermediate objective" to improve or maintain "a set of attributes that are health- or skill-related" (Caspersen et al., 1985). There are many physical and mental health benefits associated with PA.

Extensive literature supports the importance of leisure-time and overall PA in reducing premature mortality. In a highly cited systematic review, Warburton and colleagues (2010) identified a dose-response relationship between PA and seven chronic conditions (Warburton et al., 2010). A greater engagement in regular PA was found to be associated with lower risks of cardiovascular disease (<33%), stroke (<31%), hypertension (<32%), colon cancer (<30%), breast cancer (<20%), type II diabetes (<40%) and osteoporosis (<42%) (Warburton et al., 2010). Findings also suggest that there is a 31% risk reduction in premature all-cause mortality with increased PA (Warburton et al., 2010). Beyond its physical health benefits, PA is also important for social, mental, and cognitive health. Meeting PA guidelines is associated with a lower self-reported mental health burden and increased self-esteem (Bray & Born, 2004; Chekroud et al., 2018; Sani et al., 2016) and there is increasing evidence that regular PA can lead to improvements in cognitive functioning (Biddle et al., 2019).

Intuitively, given the numerous benefits associated with PA, one would expect that most people would be actively engaging in PA. This, of course, is not the case as individuals continue to fail meeting recommended PA levels. According to the Canadian Society for Exercise Psychology (CSEP), youth

between 12 – 17 years of age should conduct 60 minutes of moderate to vigorous intensity PA (MVPA) each day while adults aged 18 – 64 years should conduct at least 150 minutes of MVPA per week (Canadian Society for Exercise Physiology, 2019). The most recent Canadian data suggests that only 30% of youth and 16% of adults are meeting these recommended levels of MVPA (ParticiPACTION 2020). This is concerning as physical inactivity predisposes the population to the aforementioned chronic conditions, poorer mental health, and adds to the overall burden on the healthcare system.

It is, therefore, critical to understand the reasons for the lack of sufficient activity in the adolescent population. Indeed, PA is a complex behaviour with a number of individual, social, and environmental factors determining behaviour itself. PA is particularly unique in that a collection of behavioural factors, such as intention formation or perceived behaviour control, result in its benefits or risk reductions and these factors must occur more frequently in comparison to many other health behaviours such as binge drinking or seatbelt use (Dunton, 2017). For instance, if PA significantly falls below recommended levels for just two weeks, cardiovascular benefits begin to taper (Dunton, 2017). Physical inactivity for two to eight months may result in the loss of any health benefits that an individual may have accumulated by having been active earlier on in their lifetime (Shephard, 1994). The broad characterization of PA creates further complexity when studying the decision to perform the behaviour, as it must be repeated on a frequent basis to reap its benefits.

Over the past 30 years, researchers have been attempting to understand how we can get people to be more active. While there is no simple answer to this question, the evidence to date suggests that one's motivation towards being physically active is important. Recent evidence even suggests that a person's intention to be physically active should be considered a necessary condition for a person to engage in PA (Rhodes, 2017). Intention has been considered an important proxy of motivation and is considered one of the most robust and consistent correlates of PA in the literature (Hagger et al., 2002). The

problem, however, is that intentions do not always translate into behaviour. The following section discusses the social cognitive framework to describe the intention-behaviour relationship.

1.2 Social Cognitive Framework

The construct of intentions is derived from early work within exercise psychology that describes factors that impact and determine behaviour while also addressing the mechanisms associated with that behaviour (Buchan et al., 2012). The premise of the framework is that individuals form and successively act upon expectancies of behavioural events and outcomes (Rhodes & McEwan et al., 2019). Expectancies are defined as the capability to perform a behaviour with a specific outcome and are hypothesized to help develop intention that precedes the behaviour (Rhodes, McEwan et al., 2019). The Theory of Reasoned Action (TRA), for example, is an early Social Cognitive theory that still serves as the foundation of many modern theories today (Ajzen et al., 1980). The TRA was among the first to include intention as a predictor to behaviour (Ajzen et al., 1980). Intention is conceptualized as the immediate antecedent to behaviour and is formed based on attitudes and subjective norms (Ajzen, 1991). Attitude refers to the evaluation of the behaviour, where individuals will engage in behaviours that are evaluated positively (Ajzen, 1991). Subjective norm refers to the perceived social pressure to perform the behaviour (Ajzen, 1991). While attitudes and subjective norms are important determinants of intention, the limitation of the TRA is that it does not consider the conditions that enable or impede the performance of a particular behaviour. This led to the development of an extension of the TRA into the Theory of Planned Behaviour (TPB). The schematic representation of the TPB is illustrated in Figure 1.

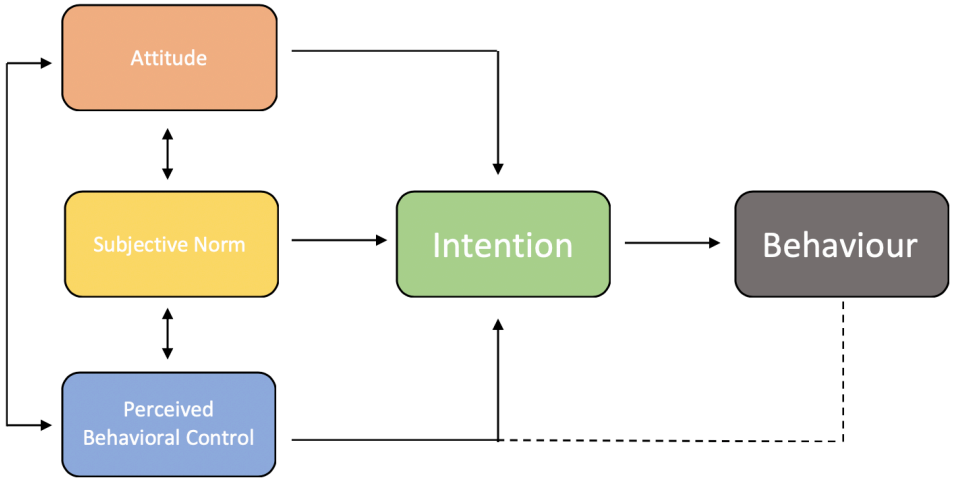

Figure 1: A visual representation of the Theory of Planned Behaviour, whereby intention is the immediate antecedent to behaviour.

The TPB was developed as a direct extension to the TRA to include perceived behavioural control as a factor that contributes to intention. Perceived behavioural control is defined as the perceived ability to perform a behaviour (Ajzen, 1991). It contributes to the formation of intention while also having a direct effect on behaviour. The TPB has been widely applied in the PA literature. Results from a meta-analysis of 72 studies found moderate correlations between attitude-intention (r = 0.48), subjective norm-intention (r = 0.25) and perceived behavioural control-intention (r = 0.44) (Hagger et al., 2002). More importantly, the study found a significant association between intention and PA behaviour (r = 0.42) (Hagger, et al., 2002). Overall, this meta-analysis provided support for the use of the TPB for understanding the factors contributing to intention formation and PA behaviour. In fact, the TPB has become one of the most common theories used by researchers when attempting to understand and explain PA as a behaviour. One constant criticism, however, is that other factors such as past behaviours tends to minimize the explained variance of intentions to behaviours. As a result, researchers have also looked to extend the TPB. For example, a study by Norman and Conner (2005) included the additional measure of planning for PA as a mediator of the relationship between intention and behaviour

(Norman & Conner, 2005). Nevertheless, when taken together, attitudes, social norm and perceived behavioural control contribute to the formation of intention, and a consistent relationship between intention and behaviour continues to be observed.

1.3 The Intention-PA Gap

Another criticism of the TPB has been that intentions do not always translate into behaviours – commonly referred to as the intention-behaviour gap. Although intentions have been found to be related to PA, findings have shown that intentions only explain a moderate amount of the variance in predicting PA and that the intention to be physically active do not automatically translate into behaviour (Plotnikoff, 2011; Conroy et al., 2011; Rhodes & de Bruijin, 2013; Sheeran & Webb, 2016; Maher et al., 2017). Rhodes and de Bruijn (2013), for example, found that nearly 50% of people who report strong intentions to engage in regular PA fail to subsequently engage in activity (Rhodes & de Bruijin, 2013). This gap highlights the possible discordance between intention and PA, which suggests that there may be additional factors that contribute to the translation of intention into PA behaviour. Another reason for this discrepancy is that people tend to overestimate their intentions to enact a particular behaviour, and it requires additional volitional factors to effectively fulfill their positive PA intentions (Rhodes, 2014).

While some mediators of the intention-behaviour gap (self-efficacy, habit, intention stability, etc.) can help to explain the persistence of this gap (Rhodes & Yao, 2015; Rhodes & Dickau, 2013), another contributing factor may be the way in which we measure intentions and subsequent behaviours (Rhodes & Rebar, 2017). That is, how and when the construct of intention is measured, and what time frame these intentions are meant to encompass. Traditionally, intentions have often been measured as a strength-based construct through the use of Likert scales. This is consistent with Ajzen's (2006) guidelines for developing a TPB-based questionnaire (Ajzen, 2006). The issue, however, is that these

scales utilize arbitrary cut-offs when determining if a person intends to or does not intend to engage in PA. This arbitrary assignment may be misrepresenting proportions of intenders and non-intenders, thereby contributing to the gap.

Second, the temporal frame between the measurement of intentions and the execution of behaviour is often long. For example, a study by Faulkner and Biddle (2001) examined the relationship between children's intentions and PA behaviours six months later (Faulkner & Biddle, 2001). This substantial gap between the measurement of intentions to behaviours is consistent across the literature and raises questions about the validity of measuring intentions and behaviour over the span of weeks to months (Conner, 2015). Specifically, it requires that a person think about their evaluations and perceived control over this time, and to make a generalized assessment of their intentions despite understanding that internal and external barriers to their participation in activity may be different from month to month, week to week, or even day to day (Romanzini et al., 2019)

The majority of studies examining intentions to participate in PA also fail to consider the variability in intentions that an individual may experience over a course of a week or even a day. A study conducted by Plotnikoff et al. (2011) measured intentions to engage in PA over the time interval of a month (Plotnikoff et al., 2011). Other studies have used measures that range from weeks to months (de Bruijn et al., 2012; Conroy et al., 2011; Scholz et al., 2009). Asking participants to provide an estimated average of their PA behaviour over large temporal frames fails to account for fluctuations in intentions to engage in PA on a moment-to-moment basis, such as asking about intentions to participate in PA multiple times during the day.

1.4 Intention as a dynamic factor

The determination of whether a person intends to be active changes at different points in time. Therefore, when typical prospective study designs ask participants about their intentions to be physically active over the course of weeks or months, they may be capturing broader motivation towards activity, likely discounting any challenges or barriers within this time. For example, if a high school student is asked about their intentions to be active for the month of March, they may be generally active. However, they may fail to account for any disruption to their organized activities, such as weather or exam season limiting their activity. This failure to perceive barriers likely impacts their behaviours, exemplifying the intention-to-behaviour gap. This appears to be backed by evidence, as intention is a necessary condition for most to be active (i.e., not many people end up being physically active while indicating that they had no or low intentions to be physically active), but nearly half fail to enact on their intentions to be physically active (Rhodes & de Bruijn, 2013).

The issue of temporal measurement has garnered some recent attention, but at the generalized or macro-temporal levels. The literature generally shows that the relationship between intentions and behaviours is stronger when the temporal frame is shorter (i.e., over the next week vs. over the next 3 months) (Conroy et al., 2011). This may be a result of being able to more accurately project barriers in the short term. It suggests that there is increased accuracy and specificity when examining a smaller window of time. Therefore, some more recent studies have started to examine daily intentions on subsequent day behaviours (i.e., micro-temporal level). In a study by Conroy et al. (2013), participants were asked about intentions to engage in aerobic exercise and vigorous PA for the subsequent day, and PA was self-reported using a modified International Physical Activity Questionnaire (Conroy et al., 2013). The study found that previous day intentions did account for within-person differences in PA for the subsequent day but failed to provide a quantification for the extent to which the intentions predicted

PA (Conroy et al., 2013). Within-person differences are critical when examining the intention-behaviour gap as they can help elucidate situational factors, such as variability in intentions, and its impact on behaviour.

In another recent study by Maher et al. (2017), the authors began examining the intention-behaviour relationship multiple times throughout the day. Specifically, they measured intention eight times per day using ecological momentary assessment (EMA), and PA using accelerometers (Maher et al., 2017). Contrary to their hypotheses, however, the researchers found an even larger intention to PA gap (Maher et al., 2017). Regardless, this study was the first study to highlight the role of context, and that participants more likely intended to be active in the morning and on weekdays in comparison to weekend days. Together, these findings suggest that intentions may vary over the course of the week and even the day. While this study shed light on the importance of measuring intentions and PA closer together in time, it should be noted that they used Likert scales when asking about intentions (Maher et al., 2017). As noted earlier, measuring strength-based intentions (i.e., strongly disagree to strongly agree) may be a limitation as it arbitrarily assigns intentions to those reporting in the middle on the scale (Chyung et al., 2017). The researchers used the mid-point values as arbitrary assignment of intention, dividing the participants as having the intention to engage in PA or not. This may have been one reason that there was greater discordance found between intentions to PA behaviours.

In summary, the literature is suggestive of the temporal frame likely impacting the relationship between intention and behaviour (Rhodes & Rebar, 2017; Maher et al., 2017). Work at the micro-temporal level however remains scant, and most studies are still reliant on self-reported PA assessments that are prone to recall and social desirability biases. Further, there have been no investigations into the role of intentions within the adolescent population. Therefore, more work to understand the micro-temporal relationship between intention to behaviour during adolescence is needed.

1.5 Ecological Momentary Assessment (EMA)

In order to understand the micro-temporal relationship between the measurement of intentions and PA, a methodology with the capability of real-time data collection is required. EMA is one such methodology. EMA is an experience sampling method whereby participants report behaviour, context and other measures relevant to the research question in real-world settings (Stone et al., 2007). The basis of this methodology is that participants are frequently prompted to report an experience or behaviour (Stone et al., 2007).

EMA, as a methodology, is not new as numerous diary-based studies have existed for a long time. However, the proliferation of smartphone technology and smartphone use have created new opportunities to conduct larger EMA studies with more within day responses. According the Canadian 2019 Communication Monitoring Report, 90% of Canadian households have smartphones in use and individual adoption continues to be on the rise (Communications Monitoring Report, 2019). These smartphones provide many different capabilities, such as built-in sensors, the ability to download and use applications, and a companion that people carry around with them everywhere (Harari et al., 2016). This provides unmatched access to people and their lives, which can be leveraged for research by using smartphones as a data collection too for studying behaviour.

Conventionally, behavioural researchers ask participants about the frequency of or a duration of a particular behaviour at one cross-sectional time (Harari et al., 2016). However, this method of data collection is prone to self-serving biases that limit the ecological validity of the findings that may be derived from such studies (Harari et al., 2016). Additionally, asking participants about their behaviours at just one point in time limits any conclusions that can be made about fluctuations in factors leading up to the behaviour (Harari et al., 2016). These limitations can be addressed by using tools and methodologies for data collection that can frequently survey participants to collect records of naturalistic

behaviour in an unobtrusive manner, made possible by the increased uptake of smartphone use (Raento et al., 2009). This enables the use of EMA as a plausible technique for data collection.

There are two primary methods in which an EMA study can sample participants; signal contingent and event contingent (Degroote et al., 2020). Signal contingent sampling prompts participants to respond to surveys at random times throughout the day while event contingent sampling depends on a particular event that may be sensed to prompt participants (Degroote et al., 2020). EMA studies provide an opportunity to assess behaviour on a micro-temporal scale. Further, EMA studies can reduce recall errors as measures are often in reference to real-time, and close in time to the behaviour (Dunton, 2017). The theory supporting the use of EMA for examining PA postulates that this method can provide information regarding synchronicity, sequentiality and instability (Dunton, 2017).

Synchronicity refers to "the extent to which explanatory factors co-occur in time and space with physical activity behaviours" (Dunton, 2017). Sequentiality refers to "the temporal sequence of antecedents to and consequences of physical activity behaviours" (Dunton, 2017). Instability refers to "patterns of fluctuation and change in explanatory factors and physical activity behaviour" (Dunton, 2017). By using EMA to ask participants about intentions multiple times over the course of the day, a better temporal relationship between intention and PA can be developed and insights relating to the intention-behaviour gap can be gathered. Additionally, fluctuations in intentions over the course of the day and week can also be examined and related to PA.

1.6 Rationale for Thesis

Overall, understanding the salient factors associated with PA is important, and can serve to guide intervention efforts to increase PA among the population. The construct of intention has been found to be an important correlate and predictor of PA, yet the substantial intention to behaviour gap suggests

that more work should be done to better understand the role of intentions. Specifically, more work to understand the micro-temporal change in adolescent intentions is required. Given that adolescence is a period associated with significant decline in PA behaviours, a greater understanding of the role of daily and within-day intentions will have significant implications. Using EMA as a data collection method, this thesis aims to answer the following research questions: (1) Are there variations in daily and within-day intentions to be physically active in high school students? and (2) Is there a reduced intention-to-PA behaviour gap when assessing intentions and behaviours on the micro-temporal level; more specifically, on a daily and a within-day basis?

1.7 Hypotheses

It is hypothesized that we will see differences in daily intentions and motivations to engage in PA; it is also hypothesized that intentions will vary over the course of the week and over the course of day.

In the examination of the intention to PA behaviour gap, it is hypothesized that there would be a higher level of concordance between adolescents' intentions and PA behaviours when assessed at a micro-temporal level.

Chapter 2: Methods

2.1 Study Design

This thesis was a part of the current ADAPT Study (Application of integrated Approaches to understanding Physical activity during the Transition to emerging adulthood) and took place in Fall 2019. Specifically, ADAPT is a 4-year prospective cohort study that aims to follow a large group of adolescents as they transition out of high school and to emerging adulthood (Kwan et al., 2020). ADAPT is comprised of two interrelated studies: The first is a broader school-based longitudinal study, using questionnaires to assess the psychosocial factors related to PA, self-reported PA, and mental health and wellbeing (Kwan et al., 2020). At baseline all grade 11 students from across the Hamilton-Wentworth Catholic District School Board (a total of seven secondary schools) were invited to participate (Kwan et al., 2020). Subsequently, using a cluster randomization approach, two to three classes from each school were selected and invited to take part in a more intensive data collection period (Kwan et al., 2020). In addition to completing the baseline questionnaire, participants were asked to wear a wrist-worn accelerometer and to complete EMA prompts sent to their smartphone over a 7-day study period (Kwan et al., 2020). The inclusion criteria for the EMA component of the study are as follows: a) must be a grade 11 student; b) enrolled in the selected English class at time of recruitment; and c) own a smartphone. The data used in the current thesis represent only the baseline data from the EMA component of the ADAPT study.

2.2 Study Recruitment

Prior to data collection at each school, attendance lists of the select English classes were provided to the research team. These lists were used to put together study packages and were only distributed on day of data collection if the participants provided consent to participate. In addition to

this, all grade 11 teachers received a memo providing them with a brief overview of the study and instructions to distribute consent packages to their students. The consent package included an overview of the study in addition to a parental consent form. Students were asked to obtain parental/guardian consent to participate in the study either on the physical copy or online via a link that was shared with them through the package. The consent package is included in Appendix A. In addition to providing students with consent packages, a video reminder of the study was played on the school television system a week before data collection. The video also prompted students to obtain parental/guardian consent, to bring a mobile device to complete survey and the date of data collection.

On the day of data collection, a trained research assistant went into each selected English class during recruitment period and verbally informed the potential participants of this study. Consent forms were collected, and a script was used to recruit participants. This script is included in Appendix B. Participants were instructed that the EMA study will require them to wear an accelerometer in addition to engaging with EMA prompts, which they would receive five times a day for the next seven days.

2.3 Study Procedures

Participants were asked to engage in PA and EMA assessments for a period of seven days. During the recruitment at selected English classes, those students expressing interest in the study were provided with a study package, which included an instruction sheet, their unique EMA code and a wrist-worn accelerometer. The instruction sheet that was provided is included in Appendix C. These packages were prepared a few days prior to data collection from the English class attendance lists that the schools had provided. Setting participants up for EMA had to be done in advance as participants needed to be manually enrolled onto the system in order to produce their unique EMA code.

Once consent was obtained, participants downloaded an EMA app and entered their unique EMA code to register onto the system. In addition to completing the EMA surveys, participants were also asked to wear the accelerometer on their non-dominant wrist for the duration of the study with the exception of removal only for water-based activities. The assessment period started in the morning of the following day. Participants received 5 EMA prompts every day for a total of 7 days on their smartphone. Participants started the study on different days of the week, depending on the recruitment day scheduled for their specific high school.

A signal contingent sampling frame was used, whereby participants received their EMA at a random time within five specified time windows. The first prompt of the day was sent before school (7:30 AM – 8:30 AM) and the remaining prompts were sent after school (3:30 PM – 4:30 PM, 5:00 PM – 6:00 PM, 6:30 PM – 7:30 PM, 8:00 PM – 9:00 PM). Each EMA prompt contained up to 13 items and took approximately 1-to-2 minutes to complete. Each prompt remained open for a total of 30 minutes. In addition to the initial prompt being set at the random time within the sampling window, up to two reminders were also sent every 10 minutes. The EMA was no longer available for response 10 minutes after the second reminder was sent.

2.4 Measures

Sociodemographic factors were measured through a baseline questionnaire administered to all students recruited into the larger cohort study. Participants self-reported their age, gender, ethnicity and parental education. The complete sociodemographic questionnaire can be found in Appendix D.

Daily intention was assessed using a single binary response item (i.e., yes or no). Specifically, it asks, "*It is my intention to be physically active today*". This question was only asked during the first prompt of each day.

Within-day intention was also assessed using a single binary response item (i.e., yes or no). The temporal frame, however, was specified to be over the next 60 minutes, asking "*It is my intention to do at least 10 or more minutes of physical activity sometime over the next hour*". These items along with the complete EMA questionnaire can be found in Appendix E.

Physical Activity was measured using a wrist worn GT9X link accelerometer. Specifically, the ActiGraph GT9X Link was worn on participants' non-dominant wrist for 7 days. This device was set to collect data in 3 axes at a sampling rate of 30Hz. Participants were instructed to wear the device as much as possible while awake and sleeping, removing it only for prolonged water exposure. Wear-time was determined using the Troiano (2007) criteria, with any period ≥ 60-minute of consecutive 0 counts flagged as non-wear (Toriano et al., 2007). Days that the accelerometer was dropped off and picked up were excluded from analyses. PA data was only be analyzed for participants who meet the minimum wear time criteria (≥600 minutes on ≥3 days). Data was processed using ActiGraph's CentrePoint or ActiLife to determine the time spent in MVPA. The specific cut points used for the current study were consistent with a new validation study by Rhudy et al. (2020) based on vector magnitudes. The vector magnitude is the vector of the three axes, "x", "y" and "z", of the accelerometer (the equation used to calculate vector magnitude is included below) (Rhudy et al., 2020). Vector magnitude counts above 5858 over a 60s epoch were classified as MVPA (Rhudy et al., 2020). Daily minutes in MVPA, along with MVPA immediately one hour after each prompt were extracted.

$$Vector\ Magnitude = \sqrt{x^2 + y + z}$$

2.5 Data Processing, Management, and Analysis

A significant component of the current thesis involved data processing and management. Specifically, there were four datasets that had to be merged. First, all potential participants were onboarded into the EMA system, without having previous knowledge of whether they would participate in the study or not. The onboarding information was subsequently linked to the baseline cohort questionnaire, which included the sociodemographic factors. The data for EMA prompts were collected and extracted into a separate data file, which had to be merged with all other data files. This also required having to manually clean the data to ensure that each participant included had 35 data points (including missing values for non-responses). Accelerometer files were pulled from the API using ActiGraph CentrePoint, and the aforementioned cut-points were applied to the vector magnitude and wear-time data, and merged into the EMA file corresponding to each EMA prompt with daily MVPA and hourly MVPA for the after-school prompts. These data were placed in a single master file.

The next step included a secondary processing of the accelerometer data. This was to ensure that participants met the daily wear-time criteria of $\geq$ 600 minutes of wear in the day, and hourly wear-time of $\leq$ 20 minutes of 0 VM count. It was considered to be missing data if these wear-time criteria were not met. Participants who did not respond to any EMA prompts were excluded alongside those who did not have $\geq$ 600 minutes of wear for at least three days of the study were excluded for analyses. Finally, given that participants had different start days (i.e., some schools began data collection on a Wednesday, while others began data collection on Thursday), additional variables were created to reflect day of week and prompt of day to further investigate the role of intentions over time.

Data analyses proceeded sequentially. Inspection of missing data and non-response was first assessed, and as described earlier were identified as missing data (i.e., -999). Second, univariate normality (i.e., range, means, standard deviation) of the data was inspected to ensure the data was

appropriate. Chi-square analyses were conducted to determine if there were differences between participants and non-responders (i.e., participants that signed up, but did not actively engage in the study).

To answer our primary research question, descriptive statistics were first used to describe the means and frequencies of daily and within day intentions. Second, mixed effects logistic regression was used to determine if there were variability of intentions over time. That is, separate models were run to determine if the likelihood of PA intentions changes over time on a daily basis or over time during the afternoon and evening of each day. Lastly, descriptive analyses were used to determine the intention-PA behaviour gap. A 2x2 matrix categorized participants based on their intentions to engage in PA (yes/no) and whether they were considered sufficiently active (active/not active). Participants who reported 'yes' for their intentions towards daily/within day intentions were considered *intenders*, while those that responded no were considered *non-intenders.* Participants that accumulated 60 or more minutes of MVPA over the course of day, and 10 or more minutes of MVPA following the EMA prompt, were considered *active,* while those that failed to meet these thresholds were considered to be *inactive.* Successful intenders were *intenders* that were *active.* Successful non-intenders were *non-intenders* that were *not active.* Unsuccessful intenders were *intenders* that were *not active*, while unsuccessful non-intenders were *non-intenders* that were *active*.

Chapter 3: Results

3.1 Study Sample and Participants

Based on the student class list provided by each school, there were a total of 351 students enrolled into the selected English classes at the time of recruitment. Of these potential participants, 227 (64.7%) expressed initial interest for participating in the study. Subsequently, 219 (96.5%) students provided consent to participate in the study and responded to at least one EMA prompt over the duration of the EMA sampling period; and of these 219 participants, 193 (88.0%) provided sufficient PA data meeting our weekly wear-time criteria of three or more days of 600 or more minutes of wear-time over the sampling period. This was our final sample size for the final thesis analyses. Figure 2 is a consort diagram depicting our final sample size.

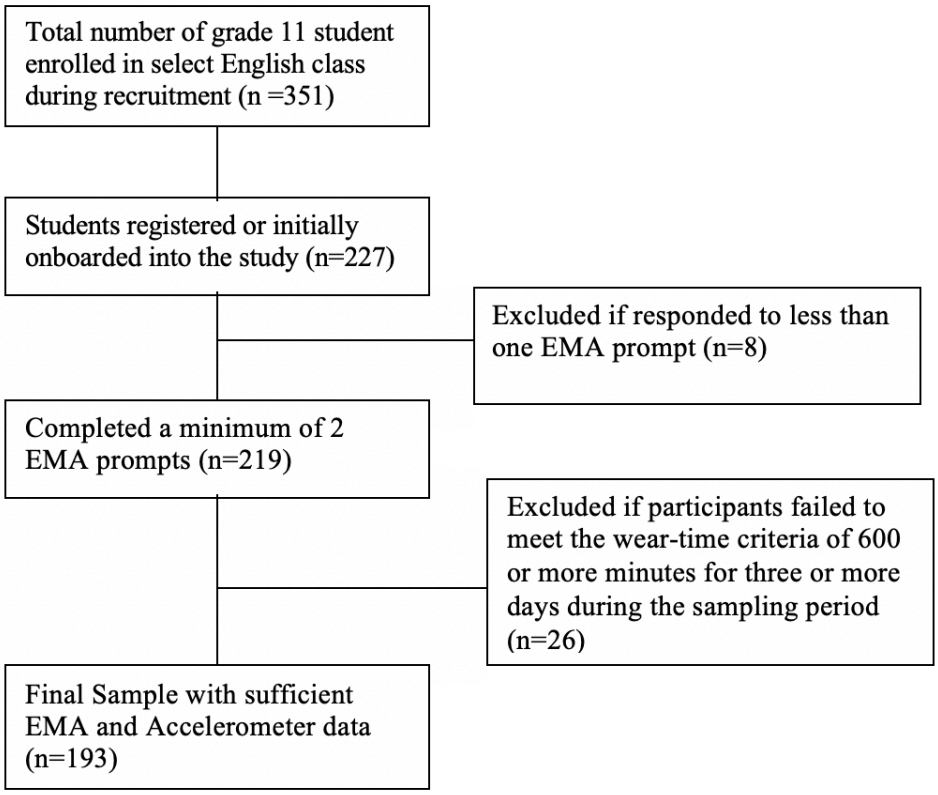

Figure 2. Consort diagram of participant recruitment and final sample.

Sample Characteristics

Table 1 shows the complete demographic information for our sample, comparing participants that were included in the final analysis and those who were excluded as they did not meet the minimum EMA or accelerometer wear-time compliance requirement. These groups did not differ significantly in age, gender, parental education and smartphone use (p-value > 0.05). There was a significant difference for ethnicity, and the proportion of ethnic groups that were compliant with the study (p-value = 0.002). The differences in these proportions, however, look relatively small. It should also be noted that there were some participants included into the final sample size that did not complete the baseline questionnaire, and thus did not report socio-demographic information.

As described in Table 1, within our included sample, the mean age was 15.74 years and was comprised of roughly an equal proportion of males (50.31%) and females (47.83%). Three additional participants preferred not to answer (1.89%). The majority of the participants reported being of Caucasian decent (63.19%). As a proxy for socio-economic status, data on parental education was collected. The majority of the participants (69.99%) indicated that at least one parent had either completed college or university, while approximately one in five (19.14%) students reported a parent having completed some secondary school or having entirely completed secondary school education. Given that the inclusion criteria indicated that participants required a smartphone, the vast majority were owners of a smartphone, though one participant completed their EMAs through an iPod.

Table 1. Descriptive Statistics for participants and non-responders of the study.

	Participants (n=193)		**Non-Responders** (n=26)		**p-value**
	n	**%**	**n**	**%**	
Age					0.350
14	1	0.62	0	0.00	
15	41	25.47	1	5.26	
16	118	73.29	18	94.74	
17	1	0.62	0	0.00	
Gender					0.601
Male	81	50.31	10	52.63	
Female	77	47.83	8	42.11	
Prefer not to answer	3	1.86	1	5.26	
Ethnicity					**0.002**
Aboriginal People of Canada	4	2.45	0	0.00	
Indigenous (outside of Canada)	1	0.61	0	0.00	
Arab	9	5.52	1	5.26	
Black	5	3.07	1	5.26	
Chinese	0	0.00	2	10.53	
Filipino	7	4.29	0	0.00	
Japanese	0	0.00	1	5.26	
Korean	1	0.61	0	0.00	
Latin, Central/South American	4	2.45	2	10.53	
South Asian	4	2.45	0	0.00	
Southeast Asian	1	0.61	0	0.00	
Taiwanese	0	0.00	0	0.00	
West Asian	1	0.61	0	0.00	
White	103	63.19	9	47.37	
None of the above	23	14.11	3	15.79	
Parental Education					0.125
Some Secondary	19	11.73	6	31.58	
Completed Secondary	12	7.41	1	5.26	
Some College	7	4.32	0	0.00	
Completed College	52	32.10	3	15.79	
Some University	9	5.56	0	0.00	
Completed University	63	38.89	9	47.37	
Smartphone Ownership					0.731
Own a smartphone	161	99.38	10	100.00	

Note: Demographic information for participants who were included in the final sample and those who were not due to missing accelerometer or EMA data. Demographic information is missing for 30 participants.

3.2 Compliance to EMA

Compliance to EMA statistics for the sample are described in Table 2. Overall, on average, participants responded to 47.9% of the prompts that were sent to them. Compliance differed significantly by day of week (χ^2 = 49.542, p = 0.00), with higher compliance being associated with weekdays (50.2%) in comparison to weekend days (42.4%). Compliance to EMA also differed by time of prompt, with morning/before school prompts (40.1%) having lower compliance in comparison to afternoon/after school prompts (49.9%) (χ^2 = 173.233, p = 0.000). This difference was more pronounced on weekend days with compliance to morning prompts being much lower (13.51%) in comparison to weekdays (50.83%). Figure 3 illustrates the difference in compliance between morning and afternoon prompts on weekdays and weekend days. No significant differences in compliance was observed in response of afternoon prompts. A complete breakdown of compliance by day of week and time of day is included in Table 2.

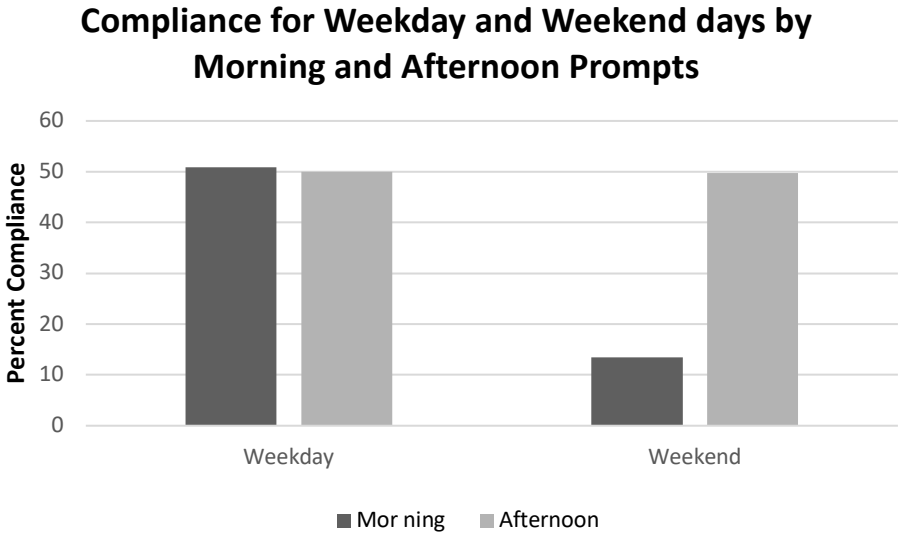

Figure 3. Compliance for Weekday and Weekend days by Morning and Afternoon Prompts.

Table 2. Statistics for compliance to EMA prompts

Total number of EMA prompts (n=6720)			
		Yes	**No**
Overall		**47.90%**	**52.10%**
Day of Week	Monday	49.60%	50.40%
	Tuesday	46.50%	53.50%
	Wednesday	47.70%	52.30%
	Thursday	53.00%	47.00%
	Friday	54.10%	45.90%
	Saturday	42.80%	57.20%
	Sunday	42.10%	57.90%
Prompt of Day	Prompt 1	40.10%	59.90%
	Prompt 2	54.80%	45.20%
	Prompt 3	47.70%	52.30%
	Prompt 4	49.10%	50.90%
	Prompt 5	52.00%	48.00%
Weekdays by morning vs. afternoon prompts	Morning Prompt	50.83%	49.17%
	Afternoon Prompts	50.13%	49.87%
Weekend by morning vs. afternoon prompts	Morning Prompt	13.51%	86.49%
	Afternoon Prompts	49.71%	50.29%

3.3 Variations in Intentions

The first objective of the current thesis was to investigate if there were variations in intentions when assessed using a micro-temporal scale through the use of the EMA methodology. This was examined in two ways; first through the examination of daily intentions, as assessed by the first prompt of the day asking participants of their intentions to be active for that day (i.e., $\geq$ 60 minutes of MVPA that day); and second through the examination of within-day intentions, as assessed through four prompts during the afternoon and evening times asking participants of their intentions to be active for $\geq$ 10 minutes of MVPA over the next hour. First, descriptive analyses describe reported intentions each day and at each within-day prompt. Second, mixed effects logistic models were run to examine if the likelihood of reported intentions changes over time.

Daily Intentions

Daily intentions were assessed during the first prompt of each day, and it should be noted that the first prompt resulted in the lowest level of overall EMA compliance. Nonetheless, nearly 70% of participants, on average, reported having the intentions to be physically active for the day in question. As illustrated in Figure 3, daily intentions did vary from day to day. Intentions ranged from 61.54% on Sunday to 81.00% on Monday. The likelihood of having intentions to engage in PA were significantly different (χ^2 =14.919, p =0.021) between these days. Figure 3 illustrates daily intentions to engage in PA by day of week.

Though weekday intentions were somewhat higher than weekend day intentions, the likelihood of intentions to engage in PA between weeday and weekend days were not statistically significant (χ^2 =0.965, p = 0.326). Similarly, results from the mixed-effects logistic regression did not find that the likelihood of reporting PA intentions changed over the duration of the study (coef.=-0.07 SE: 0.07, p=.27). Complete results of the final model with covariates are shown in Table 3.

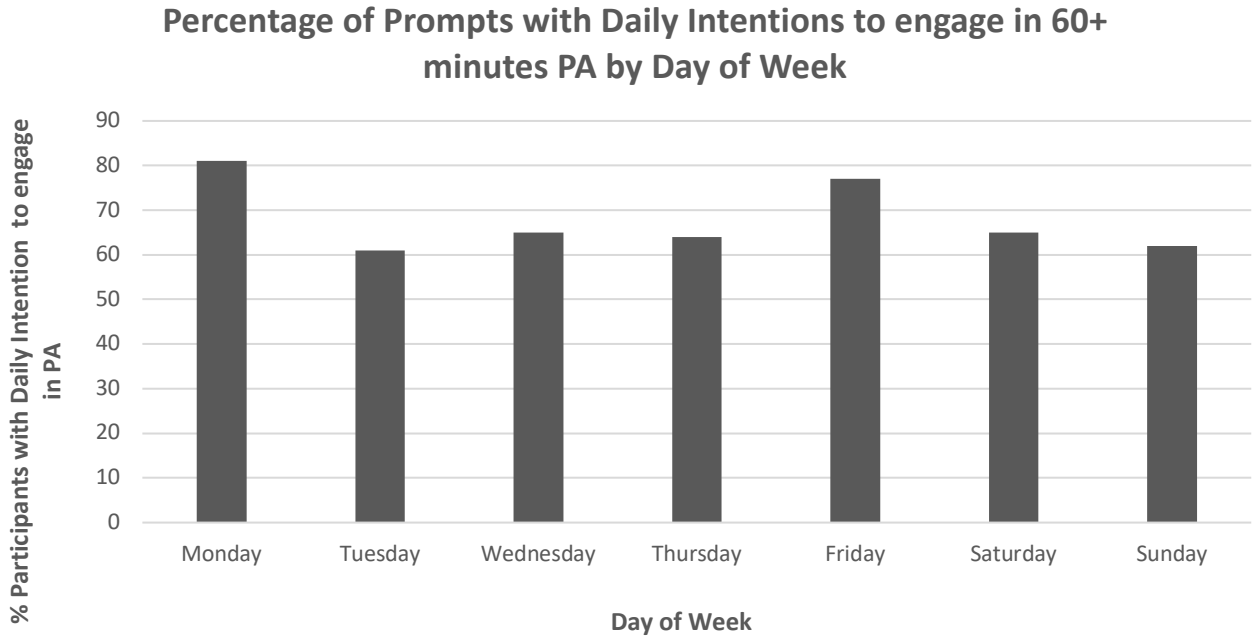

Figure 3. Percent of participants reporting daily intentions to engage in 60 or more minutes of PA by day of week.

Table 3. Results of the mixed effects logistic model predicting the likelihood of reporting daily intentions to be active over the study days.

	Coef	SE	z-score	p-value
Daily Intentions				
(intercept)	10.34406	10.05588	1.029	0.304
Time (daily prompt)	-0.07450	0.06793	-1.097	0.273
Weekday	0.15539	0.53564	0.290	0.772
Gender	-0.67267	0.57606	-1.168	0.243
Age	-0.50411	0.63209	-0.798	0.425
Var(cons)	7.78	2.79		

Note: Coef: coefficient; SE: standard error. Model only includes the 163 participants who provided demographic information. The reference point for Gender was set to be males.

Within-Day Intentions

Within day intentions were assessed using four afternoon/evening prompts. On average, within-day intentions were lower than daily intentions, with participants reporting lower intentions to be active for 10 or more minutes of MVPA in the next hour. Participants, on average, reported having intentions to be active for 10+ minutes over the next hour 29.30% of the time. Figure 4 illustrates participant reported within-day intentions for each day of the week and by prompt of each day. There were variations in reported intentions, with average intentions ranging nearly 40% in the first afternoon prompt to only 17.86% for the final prompt of the day. Results from the chi-square analysis found these differences in proportions to be to be statistically significant, $\chi^2 = 80.68$, $p < 0.001$. Results from the mixed-effects logistic modeling indicates that the likelihood of reporting intentions significantly decreases over the course of the day (coef.=-.479 SE=.05, p<.01). Complete results of the final model with covariates are shown in Table 4.

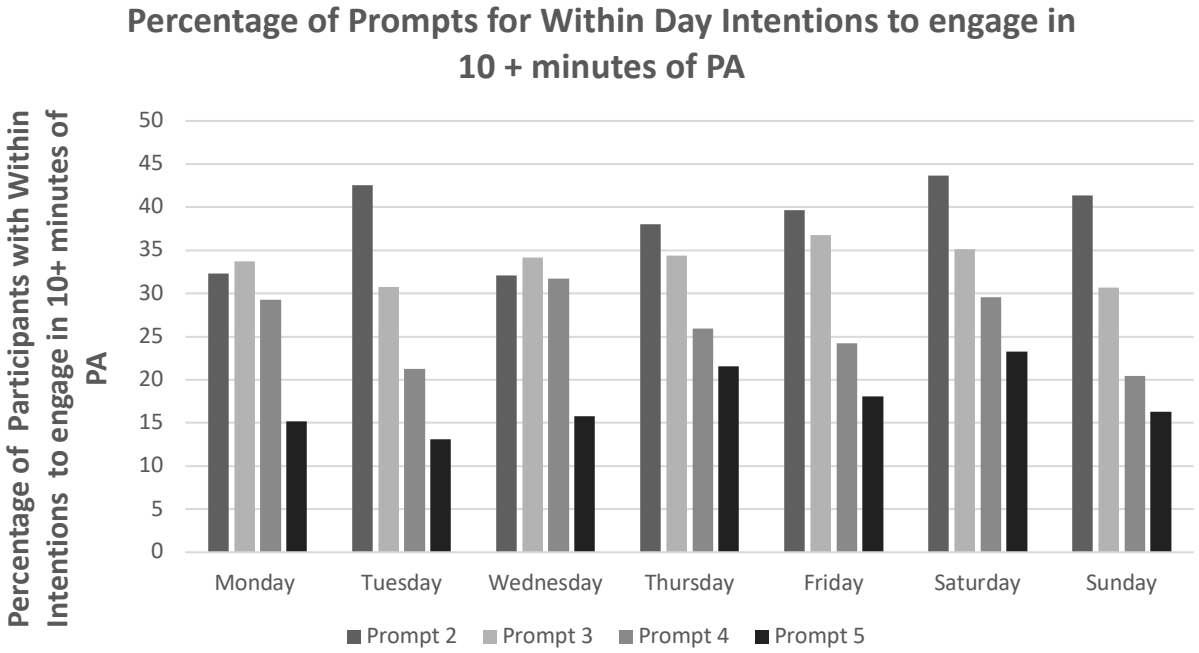

Figure 4. Percentage of prompts for within day intentions to engage in 10+ minutes of PA.

Table 4. Results of the mixed effects logistic model predicting the likelihood of reporting within day intentions to be active over the study days.

	Coef	SE	z-score	p-value
Daily Intentions				
(intercept)	4.61462	4.72331	0.977	0.329
Prompt of day	-0.47903	0.05166	-9.273	<0.001
Weekday	-0.08656	0.12487	-0.693	0.488
Gender	-0.43243	0.26492	-1.632	0.103
Age	-0.24842	0.29882	-0.831	0.406
Var(cons)	2.45	1.58		

Note: Coef: coefficient; SE: standard error. Model only includes the 163 participants who provided demographic information. The reference point for Gender was set to be males.

3.4 Intentions to PA Behaviour Gap

The second purpose of this study was to investigate the intention-PA behaviour gap when using micro-temporal scaling. It was hypothesized that this gap would be reduced when measuring intentions and PA closer together in time using EMA as a methodology. Intentions and behaviour were assessed daily and within each day of the study. The first prompt of the day was in reference to intentions towards being physically active for the day (i.e., $\geq$ 60 minutes of MVPA), while the afternoon and evening prompts were in reference to being physically active (i.e., $\geq$ 10 minutes of MVPA) over the next hour.

Daily Intention-Behaviour gap

Table 5 describes the proportion of participants that intended to be active on any of the first prompts of the day, and their subsequent PA, as assessed through the wrist-worn accelerometers that participants wore for the duration of the study. This 2x2 matrix displays the proportion of intenders (i.e., those who intended to engage in PA) by column, and the proportion meeting daily PA guidelines (i.e., those engaging in 60 or more minutes of MVPA). The majority of intenders (89.51%) engaged in 60 or more minutes of PA, while 10.49% did not. The majority of non-intenders (84.49%) also engaged in 60 or more minutes of PA. The difference between daily intenders and non-intenders engaging in PA was not statistically different ($\chi^2 = 1.936$, p = 0.164).

Table 5. Matrix with the proportions of intenders and non-intenders of daily PA engaging or not engaging in 60 or more minutes of PA.

		Intenders		
		Yes	**No**	**Total**
Physically Active	**Yes**	273 (89.51%)	118 (84.89%)	391
	No	32 (10.49%)	21 (15.12%)	53
	Total	305	139	444

Within-day intention-behaviour gap

Similar to daily intentions, within day intentions are presented in a matrix, displaying the proportions of intenders and non-intenders who engaged in PA for 10 or more minutes in the hour after the prompt. Table 6 displays a 2x2 matrix with proportions of intenders and non-intenders of within day PA and their subsequent action of engaging in or not engaging in 10 or more minutes of PA. Less than half (45.97%) of the intenders engaged in 10 or more minutes of activity while 54.03% did not. For non-intenders, 30.56% engaged in 10 or more minutes of PA and 69.44% did not. The differences between intenders and non-intenders engaging in PA is significantly different ($\chi^2 = 47.151$, $p = 0.001$).

Table 6. Matrix with the proportions of intenders and non-intenders of within day PA engaging or not engaging in 10 or more minutes of PA in the hour after responding to the EMA prompt.

		Intenders		
		Yes	**No**	**Total**
Physically Active	**Yes**	291 (45.97%)	481 (30.56%)	772
	No	342 (54.03%)	1093 (69.44%)	1435
	Total	633	1597	2207

Chapter 4: Discussion

4.0 Discussion

The purpose of this current thesis was to take a closer look at adolescents' intentions towards physical activity on a micro-temporal scale and to examine the consistency or variations in daily and within-day intentions to be physically active. Additionally, the thesis sought to determine if the intention-behaviour gap would be improved by measuring intentions at a micro-temporal level, assessed using the EMA methodology. Specifically, it was hypothesized that the adolescent sample would report different intentions to be physically active from day to day, and that there would be specific times within each day that intentions to be active would be greater; and it was expected that there would be less of an intention-behaviour gap when examining daily and within-day intentions to subsequent PA behaviours closer together in time.

Overall, the current thesis significantly adds to our knowledge of the role of intentions as it relates to PA behaviours during adolescence. This is the first study that indicates that there are fluctuations in intentions when using a micro-temporal timescale for high school students; though interestingly, the results of the current thesis both support and contradict our hypotheses. First, although the likelihood of reporting intentions to be active significantly changes within the day, the results suggest that the variations in intentions to be active between days were not statistically significant. In the examination of the intention-behaviour gap among adolescents, the findings of the current thesis found a greater concordance between those that report having intentions to be active that day to their subsequent PA; however, contrary to the hypothesis, a significant number of non-intenders were also physically active that day. In the examination of within day intentions, a greater intention-behaviour gap was found. Together, these findings suggest that intentions to engage in PA do change over the course of the day, but that it may be relatively stable between days. More research, however, is needed to fully understand the relationships between reported intentions to their subsequent behaviours.

4.1 Daily and Within Day Intentions

Although intentions have been considered to be an important and robust correlate of PA behaviour, it is also evident that intentions towards being physically active do not automatically translate into the behaviour of being physically active (Rhodes & Dickau, 2012). This intention-behaviour gap has been identified and has been a focus for a number of investigations over the past 10 years, but few research studies have considered the dynamic nature of ones' motivation towards being physically active – and none have focused on the adolescent population (Rhodes, 2017; Maher et al., 2016; Rebar et al. 2019). To date, studies have examined longer-term intentions, which is an important facet to understanding general motivation towards physical activity (Scholz et al., 2009; Plotnikoff et al., 2011; Conroy et al., 2011). However, this approach falls short of accounting for the day-to-day complexities of being able to translate intentions into behaviour. It is, therefore, noteworthy to examine intentions on a smaller timescale, such as daily or even within-day intentions towards PA.

To date, little research has examined how intentions varies from day-to-day, and even fewer studies have examined how intention varies within a day. The data collected through the ADAPT study enables us to take a closer examination of daily intentions and within-day intentions during the afterschool or afternoon/evening times. From a descriptive perspective, we observed that participants' intentions tend to differ based on the day of the week. These findings also indicated that daily intentions to be active tend to be slightly higher on Mondays (81.00%) and Fridays (76.85%). Together, daily intentions tend to be higher on weekday days (70.06%) compared to weekend days (63.46%); but this difference was not found to be statistically significant. Results from the mixed-effects logistic regression also confirmed that the likelihood of daily intentions did not significantly change between days of the week, as expressed by the variable of study days. Current findings are in contrast to a study by Conroy and colleagues (2013), which found differences in daily intentions and PA between weekday and

weekend days to be significantly different. This study included a sample of college students and examined only daily intentions and measured daily intentions and behaviours on each evening (i.e., young adults' intentions to be physically active for the next day) (Conroy et al., 2013). This may be one reason for the discrepant finding in addition to the study team asking about intentions in two separate questions (one for moderate activity and one for vigorous activity) and subsequently averaging the results to produce a single intention score for each day. Given that current findings suggest that intentions may vary within the day, further investigation for the optimal time during which daily intentions are measured would be important to understand. Another study by Maher et al. (2016) also examined daily intentions and found intentions to be active are higher on weekend days in comparison to weekdays (Maher et al., 2016). This study, however, examined intentions only across a four-day period and were focused on middle aged adults. This contradiction in the literature may be due to the details of the different methodologies as the study by Conroy et al. asked about intentions in two different questions over the course of the week while the study conducted by Maher et al. looks at daily intentions using a single-item Likert scale question (Conroy et al., 2013; Maher et al., 2016). Nonetheless, the broader literature has found that youth participation in PA varies between weekdays and weekends (Comte et al., 2013), and more research is required to better understand the impact that day of week may have on the intention-behaviour relationship.

From a descriptive standpoint, it was interesting that daily intentions were moderately higher on Mondays and Fridays. This has not previously been reported in the literature. Participants may intend to be more active on Mondays to start their week off on good terms by engaging in PA. Participants may also be highly motivated after a restful weekend to be physically active. On Fridays, participants may have more time afterschool due to the approaching weekend and they may have more time to engage in PA. While current findings suggest that these daily intentions did not significantly change over time,

differences between weekdays may be an area for future research to explore. As part of the ADAPT study, contextual information on participants was collected and analysis of these additional variables could shed light on why there may be some days that high school students report greater intentions.

In the examination of within-day intentions, it was clear from a descriptive standpoint that a pattern of intentions emerged. Consistently, intentions were reported to be higher earlier in the afternoon, and intentions diminished over the evening hours. This pattern that emerged over the course of the day was evident for all days of the week. Results from the mixed-effects logistic regression confirms that the likelihood of daily intentions changed significantly over the afternoon and evening prompts. This observation makes practical sense as intentions to engage in PA later in the day may decrease due to participants already having engaged in PA earlier in the day. Further, this finding illustrates that people may think ahead about being physically active not only because it is generally considered a healthy behaviour, but also because they understand that they would be less willing to be active later in the day. A decrease in intentions over the course of the day emphasizes this point. Average within day intentions to engage in PA were lowest on Monday (28.23%) and were highest on Saturday (49.81%). This is an interesting observation as daily intentions were highest of Mondays. This may be suggestive of individuals overestimating their intentions even on a daily basis, highlighting the importance of examining intentions on smaller time scales. That is, it is possible that the youth may be waking up on Mondays with an optimistic view and report good intentions to be active; but in reality, may underestimate the challenges or competing priorities that may end up interfering with their ability to be active. Overall, it does appear that intentions would be the strongest in the afternoon, immediately following the end of school-time, and thus suggest that this may be the ideal time to be intervening on PA with youth.

4.2 Intention-Behaviour Gap at a Micro-time Scale

Given how little research attention has been paid to the dynamic nature of intentions, very little work investigating the intention-behaviour gap has assessed it on a micro-temporal scale. The current thesis describes the relationship between measuring intentions and PA closer together in time; on a daily basis and a within day (hourly) basis. In general, intentions to engage in PA have consistently fallen short of being followed through with PA (Rhodes, 2017). This gap has been the subject of discussion amongst PA researchers for years. While much of the attention has been given to identifying additional factors that may be influencing PA behaviour, such as habits and perceived behaviour control (de Brujin et al., 2012; Rebar et al., 2014; Rhodes & Yao, 2015), understanding the limitations of how intentions and PA behaviours have been assessed is also important – and something that very few researchers have explored to date. EMA as a methodology has enabled researchers to make more repeated assessments of intentions. In the current study, we used the first prompt of the day to ask participants about their daily intentions to engage in 60 or more minutes of PA and also hourly intentions during the afternoon/evening times to engage in 10 or more minutes of PA.

Overall, participants had an average daily intention to engage in PA about 70% of the time. This group is defined as intenders. Importantly, these intenders followed through with PA 89.5% of the time (i.e., successful intenders), only failing to engage in 60 minutes of MVPA 10.5% of the time (i.e., unsuccessful intenders). This proportion of successful intenders is much higher than 42% reported in a meta-analysis conducted by Rhodes & de Bruijn (2013). In isolation, these findings are consistent with our hypothesis, demonstrating that the intention-behaviour gap diminishes when assessed closer together in time as the studies included in the meta-analysis asked about intentions over the span of weeks and months. This provides a comparison to a longer-term measurement of intentions to behaviour.

Intuitively our findings make sense, as people should have a more realistic view of their abilities or potential hinderances to their participation in PA when intentions are in reference to the day ahead.

Contrary to expectations, however, our findings also indicated that there were a significant number of unsuccessful non-intenders. That is, about 85% of participants reporting no intentions to be physically active were still engaging in more than 60 minutes of MVPA. This is markedly higher than findings from the Rhodes & de Bruijn meta-analysis (2013), which found only 2% being unsuccessful non-intenders. This finding was particularly surprising and may be attributed to a number of reasons. First, it should be noted that a high proportion of participants in our sample were physically active. This was the case even with a more conservative cut-point being applied in our classification of MVPA. Therefore, there may be some issues with PA measurement based on the thresholds we used. Second, it is possible that youth may be underestimating their intentions to be active within a day. While MVPA is usually accumulated through more intentional leisure-time activities, it is possible that youth may be underestimating some of their other forms of activity (e.g., active transportation, skateboarding at the park, organized physical activity at school, etc.) which in part may be inflating the proportion of unsuccessful non-intenders.

An additional potential reason for our discrepant findings may be participant reactivity to EMA-type data collection (Ram et al., 2017). Some studies have outlined that EMA prompts may lead to reflection that may alter the behaviour of participants towards a particular behaviour (Ram et al., 2017). This may compromise the ecological validity of the EMA approach as the reality of a participant's behaviour is altered. Nonetheless, the ecological validity provided by the EMA methodology still supersedes traditional, one-time surveys while also minimizing instances of recall bias.

In the examination of within day intentions and subsequent 60 minutes of PA, the intention-behaviour gap increased from our examination of daily intention to PA behaviours. Overall, participants indicated on about one-third of the EMA prompts that they intended to be active for 10 or more minutes over the next hour. Of these intenders, only 46% of intenders followed through with activity, and successfully accumulated 10 or more minutes of MVPA. These findings were more in line with findings from Rhodes & deBriun (2013) meta-analysis. Interestingly, the proportion of non-successful intenders also decreased, however, about 30% of non-intenders were still accumulating 10 or more minutes of MVPA for that hour. In the only other EMA study that has examined the within-day intention to behaviour gap, Maher et al. (2017), found the concordance between intention and PA to be only 16%. Together, it may suggest that intentions being assessed at such a micro-temporal scale may have limited utility.

Overall, the current thesis found some discrepant findings; some that were in support of our initial hypotheses, and others that were contrary to expectations. Given that we asked participants to think about their intentions towards PA over the course of the day, or over the course of a particular hour within the afternoon/evening, it was expected that they would have a more reasonable or accurate sense of their overall control that would enable them to formulate more accurate reported intentions. On one hand, the intention to behaviour gap was diminished or were similar to previous research but, on the other hand, it is unexpected to see such large proportions of the sample being physically active despite not having the intentions to be active. Intention is often considered to be a necessary condition to be active (Rhodes, 2014; Rhodes, 2017), as very few individuals would enact on a behaviour such as physical activity without having the motivation to do so. Future research may be needed to try and better capture different temporal-scales (e.g., behaviours within mornings, afternoons or evenings) while

operationalizing PA in different ways (e.g., leisure-time activities, sports, unorganized activities) using both self-reported and device-assessed PA measurement tools.

4.3 Challenges with EMA Research

Data collection for the ADAPT Study was based on community-based sampling. Recruitment for the broader cohort study, and subsequently this sub-study, occurred at individual high schools. Particularly for the EMA study, using this sampling approach, participants from the study had little time to decide whether or not they wanted to participate. Further, participants did not realize or anticipate the actual burdens associated with the study as the level of commitment was initially perceived to be low. In the end, it was easier for participants to agree to participate in the EMA study than it was to continue participation due to the inherent burdensome nature of EMA studies (Ram et al., 2017). This may be a big reason for why compliance to our EMA prompts were around 50%. This is lower than what has been reported in the literature for EMA studies of this scope, which report an average compliance of 78.3% (Wen et al., 2017). In a meta-analysis by Wen et al. (2017), the researchers looked at compliance to EMA in youth and children. They found differences in compliance based on the number of prompts that were sent to participants in a day, with highest compliance being reported in studies that prompted participants 2 – 3 times a day (92%) in comparison to prompts being sent 4 -5 times a day (74%) (Wen at al., 2017). Lower compliance to increasing prompts during the day may be suggestive of participant fatigue. Further, in our sample, participants were teenagers, who can be particularly difficult to engage. Future EMA studies need to keep in mind the response to prompt relationship and ensure that the timing of prompts caters to the population being studied. We attempted to do this by ensuring that participants

did not receive any prompts during school, however, did not make changes to account for students likely sleeping in on weekend days, leading to lower compliance on weekend days.

While smartphone technology has enabled new opportunities for EMA studies, as smartphones become ubiquitous with our everyday lives (including in the youth population), it does not diminish the voluntary act of completing a diary or survey as a part of EMA. Indeed, it may be easier than carrying a book around to log and answer questions at pre-determined times, but EMAs may still overwhelm participants with multiple surveys throughout the day. This could also diminish willingness to participate over time. Lower compliance might mean there is not adequate coverage of the natural environment of a participant, thereby questioning the ecological validity of the approach (Ram et al., 2017). Although compliance with our study was lower than what is observed in the literature, we did collect more data points than what a traditional one-time questionnaire would enable. In total, our study gathered 3,222 data points for 193 participants. This is a substantial amount of data, which can be used to help understand factors associated with PA on a daily basis.

While overall compliance was lower than what is observed in the literature, we also noted variance in compliance by day of week and time of day. These variances are most notable between the first prompt of the day on weekdays and weekend days, with compliance being 49.71% and 13.51%, respectively for the first prompts. This may be due to there not being school on weekend days, so our participants may not have been awake during the 7:30 – 8:30 AM prompt. This highlights a potential pitfall of the EMA approach, where it may be prone to day of week and time of day effects. The literature reports potential reasons for lower compliance including device malfunction, participants forgetting, other devices competing for engagement and not hearing the notification (Dunton et al., 2017; Wen et al., 2017). Nonetheless, future research should consider the day of week impacts on compliance, and a post-study questionnaire or focus groups that ascertain the reasons for which

participants responded to some prompts and not others. Insights from such investigations could help better the EMA methodology.

4.4 Limitations

There are a number of important limitations associated with the current study. The first limitation to consider for this study is related to the measurement of PA. While using device-assessed PA (i.e., accelerometers) reduces recall error and limits social desirability biases, they are largely dependent on questionable cut-points for which raw accelerometry data is characterized. There are multiple ways to process data, including some which is completed behind the scene with companies such as ActiGraph, and multiple cut points being used can make it difficult to compare results to other studies. There is no established consensus for MVPA cut-offs when using an accelerometer, especially for wrist-worn devices. Several studies have found that the established cut-off points for what is considered MVPA can contribute to the findings of the study (Gaba et al., 2016). Our study had inconsistent results with existing literature when examining the intention behaviour gap. Our results for daily intentions and PA demonstrated very high intention behaviour concordance. This may be due to our choice of using vector magnitude counts of 5858 based on a recent paper by Rhudy et al. (2020), and this cut-off for what we considered to be MVPA may have been low.

Traditionally, hip-worn accelerometers had been used to assess PA, cut-offs for which are more established (Conroy et al., 2013; Pickering et al., 2016; Maher et al., 2017). However, our study used a wrist-worn accelerometer and there is scarce literature examining the cut-offs for this placement of the device. This limits the comparability of our findings to other studies. Further validation of the use of vector magnitude and cut-offs for what is considered MVPA needs to be conducted. In picking and

choosing different PA cut-offs, there is truly no "objective" measure of PA and it becomes important to clearly disclose how PA is being operationalized by different research groups. This may be one large reason behind some of the discrepant findings for this thesis.

A second limitation of this study is the aforementioned lower EMA compliance. In comparison to previous EMA studies which report compliance to be between 74% to 92% in adult populations (Wen et al., 2017), our study had lower compliance (47%). A lower compliance means that there may not have been a sufficient coverage of the different timepoints during the week, decreasing the ecological validity of the results of this study. It is important to keep in mind that the teenage population has not previously been engaged with EMA and lower compliance in our study may point to this group being particularly difficult to engage. Nonetheless, using the EMA methodology did produce over 3000 data points. This is a significantly higher value than a one-time cross-sectional observation of intentions and behaviour.

Another limitation of this study is the potential response biases for those who chose to participate in the study during recruitment. Individuals who may already be more active may have been more attracted to participating in a study that aimed to examine their activity levels. This may have left out the less active proportions of the adolescent population and contribute to the high intention-behaviour concordance observed in this study. Further, ample research links a social desirability response bias with studies examining PA as participants may subconsciously increase their activity levels for the duration of the study because they may perceive it to be more socially desirable (Adams et al., 2005). This can impact the generalizations that can be made from this study and limit the applications of the findings.

This study measured intentions as a binary (yes/no) item, however there is no validated single item measure for intentions. In fact, recent research has been critical of the way that intentions are

defined and measured, with recommendations to measure intentions as a 2-fold construct with; 1) a decision to perform the behaviour and 2) commitment to actually enact the behaviour (Rhodes & Rebar, 2017). The larger ADAPT study did ask participation to rate their motivations to engage in PA, however it was not included in the analysis of this thesis. Motivation to engage in PA also needs to be analyzed in the context of the intention-behaviour gap and is a future direction for this work.

Finally, while descriptive results outline potential relationships between variables, their generalizability remains limited. In this thesis, intention behaviour concordance and discordance were reported descriptively. Future quantification of the differences between intenders and non-intenders, and investigations of how it may change over time could strengthen our understanding by painting a clearer picture of the intention behaviour gap. Nonetheless, the description of intention PA concordance and discordance in this study sheds light on what needs to be explored further and partially confirms the hypothesis that the intention behaviour gap can be decreased when examining intentions and PA on a more micro temporal scale.

4.5 Strengths

Despite the study limitations, there are a number of strengths that are important to note. First, given that recruitment for the current study was through a partnership with a major school board in Southern Ontario, one of the strengths of this study include our sample being a more representative sample compared to the typical EMA studies. This resulted in a fairly diverse sample. Second, despite its limitations, device-assessed PA is better than asking participants to self-report their PA, which is associated with recall and social desirability bias as participants may misremember their activity levels and may tend to over report their activity due to increased social desirability with being ‘healthy’. Third,

EMA is a relatively recent methodology and has scarcely been used with the adolescent population. Although lower compliance was observed in this study, EMA continues to hold potential as a methodology which reduces recall errors as measures are often in reference to real-time behaviour. Further, EMA allows for the examination of within participant differences by collecting multiple data points for participants over the duration of the study.

Chapter 5: Conclusions and Future Directions

In conclusion, the present thesis contributes to existing research that suggests that there may be variations in intentions over time and accounting for these variations may lead to a better understanding of the intention-behaviour gap. Further, measuring intentions and behaviour closer together in time may also contribute to a better understanding of the intention-behaviour gap. Most notably, variations were observed within the day as intentions to engage in PA decreased over the course of the day. This is consistent with the hypothesis that there may be variations in intentions on a micro-temporal scale. In addition to this, our study found that a high proportion of daily intenders (89%) were successfully active. However, examining this in the context of a high proportion of non-intenders (85%) also being active raises some questions about the activity levels in our sample. Nonetheless, in line with our hypothesis, the intention-behaviour gap was reduced when examining daily intentions. This stark reduction was not observed when examining within day intentions and behaviour. The next step with the current data would be to examine intentions and PA in light of contextual and environmental factors such as mood, fatigue, etc. This could further our understanding of the variation in intentions and PA, and could lead to the identification of factors underpinning this variation.

Identifying intentions to be something that varies over the course of the week and day can be an important piece of the puzzle for understanding PA as a continuous health behaviour. Understanding the intention-behaviour gap is the first step in eventually decreasing the gap through planning interventions to keep adolescents active. This has a larger impact on population health, whereby the burden of chronic conditions such as cardiovascular disease, stroke, type II diabetes, etc., can be decreased (Warburton et al., 2011). Additionally, the mental wellbeing of adolescents can also be sustained by effectively keeping this population active.

The concept of EMA can also be evolved to the idea of Ecological Momentary Interventions (EMI), whereby having knowledge of the within person fluctuations of intentions, researchers and clinicians can intervene to motivate individuals to keep them active. With the increased use of mobile technology, the notions of EMA and EMI become more feasible and can be utilized to engage adolescents in PA. Clinicians have already began to use text message reminders to help patients with substance abuse, eating disorders, etc. (Parmar & Sharma, 2017). Health and fitness applications such as Apple Health and Fitbit, have also started developing and using algorithms that remind individuals to move after long periods of sedentary time. This research has implications in improving population health by understanding optimal times during which individuals can be motivated to be active.

References

Adams, S. A., Matthews, C. E., Ebbeling, C. B., Moore, C. G., Cunningham, J. E., Fulton, J., & Hebert, J. R. (2005). The effect of social desirability and social approval on self-reports of physical activity. *American journal of epidemiology*, *161*(4), 389–398. https://doi.org/10.1093/aje/kwi054

Ajzen, I. (2006). Constructing a theory of planned behavior questionnaire.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Ajzen, I., Fishbein, M., & Heilbroner, R. L. (1980). *Understanding attitudes and predicting social behavior* (Vol. 278). Englewood Cliffs, NJ: Prentice-hall.

Biddle, S. J., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise*, *42*, 146-155.

Bray, S. R., & Born, H. A. (2004). Transition to university and vigorous physical activity: Implications for health and psychological well-being. *Journal of American College Health*, *52*(4), 181-188.

Buchan, D. S., Ollis, S., Thomas, N. E., & Baker, J. S. (2012). Physical activity behaviour: an overview of current and emergent theoretical practices. *Journal of obesity*, *2012*.

Canadian Society for Exercise Physiology. (2019). Canadian Physical Activity Guidelines [Internet]. *CSEP*. [cited 2019 Jul 25]. Available from: https://csepguidelines.ca/

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports: Washington, D.C. : 1974)*, *100*(2), 126–131.

Chekroud, S. R., Gueorguieva, R., Zheutlin, A. B., Paulus, M., Krumholz, H. M., Krystal, J. H., & Chekroud, A. M. (2018). Association between physical exercise and mental health in 1· 2 million

individuals in the USA between 2011 and 2015: a cross-sectional study. *The Lancet Psychiatry*, *5*(9), 739-746.

Chyung, S. Y., Roberts, K., Swanson, I., & Hankinson, A. (2017). Evidence-based survey design: The use of a midpoint on the Likert scale. *Performance Improvement*, *56*(10), 15-23.

Communications Monitoring Report 2019. (2019). *Canadian Radio-Television and Telecommunications Commission.*

Comte, M., Hobin, E., Majumdar, S. R., Plotnikoff, R. C., Ball, G. D., McGavock, J., & MIPASS and Healthy Hearts Investigators Teams. (2013). Patterns of weekday and weekend physical activity in youth in 2 Canadian provinces. *Applied Physiology, Nutrition, and Metabolism*, *38*(2), 115-119.

Conner, M. (2015). Extending not retiring the theory of planned behaviour: a commentary on Sniehotta, Presseau and Araújo-Soares. *Health Psychology Review*, *9*(2), 141-145.

Conroy, D. E., Elavsky, S., Doerksen, S. E., & Maher, J. P. (2013). A daily process analysis of intentions and physical activity in college students. *Journal of Sport and Exercise Psychology*, *35*(5), 493-502.

Conroy, D. E., Elavsky, S., Hyde, A. L., & Doerksen, S. E. (2011). The dynamic nature of physical activity intentions: a within-person perspective on intention-behavior coupling. *Journal of Sport and Exercise Psychology*, *33*(6), 807-827.

Corder, K., Winpenny, E., Love, R., Brown, H. E., White, M., & Van Sluijs, E. (2019). Change in physical activity from adolescence to early adulthood: a systematic review and meta-analysis of longitudinal cohort studies. *British journal of sports medicine*, *53*(8), 496-503.

de Bruijn, G. J., Verkooijen, K., de Vries, N. K., & van den Putte, B. (2012). Antecedents of self identity and consequences for action control: An application of the theory of planned behaviour in the exercise domain. *Psychology of Sport and Exercise*, *13*(6), 771-778.

Degroote, L., DeSmet, A., De Bourdeaudhuij, I., Van Dyck, D., & Crombez, G. (2020). Content validity and methodological considerations in ecological momentary assessment studies on physical activity and sedentary behaviour: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1), 1-13.

Dumith, S. C., Gigante, D. P., Domingues, M. R., & Kohl III, H. W. (2011). Physical activity change during adolescence: a systematic review and a pooled analysis. *International journal of epidemiology*, *40*(3), 685-698.

Dunton, G. F. (2017). Ecological momentary assessment in physical activity research. *Exercise and sport sciences reviews*, *45*(1), 48.

Dunton, G. F., Liao, Y., Intille, S. S., Spruijt-Metz, D., & Pentz, M. (2011). Investigating children's physical activity and sedentary behavior using ecological momentary assessment with mobile phones. *Obesity*, *19*(6), 1205-1212.

Faulkner, G., & Biddle, S. (2001). Predicting physical activity promotion in health care settings. *American Journal of Health Promotion*, *16*(2), 98-106.

Gába, A., Dygrýn, J., Mitáš, J., Jakubec, L., & Frömel, K. (2016). Effect of Accelerometer Cut-Off Points on the Recommended Level of Physical Activity for Obesity Prevention in Children. *PloS one*, *11*(10), e0164282. https://doi.org/10.1371/journal.pone.0164282

Hagger, M., Chatzisarantis, N., & Biddle, S. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of sport & exercise psychology*.

Harari, G. M., Lane, N. D., Wang, R., Crosier, B. S., Campbell, A. T., & Gosling, S. D. (2016). Using smartphones to collect behavioral data in psychological science: Opportunities, practical considerations, and challenges. *Perspectives on Psychological Science*, *11*(6), 838-854.

Kwan, M. Y., Dutta, P., Bray, S. R., Brown, D. M., Cairney, J., Dunton, G. F., ... & Rhodes, R. E. (2020). Methods and design for the ADAPT study: Application of integrateD Approaches to understanding Physical activity during the Transition to emerging adulthood. *BMC Public Health*, *20*, 1-8.

Maher, J. P., Dzubur, E., Huh, J., Intille, S., & Dunton, G. F. (2016). Within-day time-varying associations between behavioral cognitions and physical activity in adults. *Journal of Sport and Exercise Psychology*, *38*(4), 423-434.

Maher, J. P., Rebar, A. L., & Dunton, G. F. (2018). Ecological momentary assessment is a feasible and valid methodological tool to measure older adults' physical activity and sedentary behavior. *Frontiers in Psychology*, *9*, 1485.

Maher, J. P., Rhodes, R. E., Dzubur, E., Huh, J., Intille, S., & Dunton, G. F. (2017). Momentary assessment of physical activity intention-behavior coupling in adults. *Translational behavioral medicine*, *7*(4), 709-718.

Norman, P., & Conner, M. (2005). The theory of planned behavior and exercise: Evidence for the mediating and moderating roles of planning on intention-behavior relationships. *Journal of Sport and Exercise Psychology*, *27*(4), 488-504.

Norum, K. R. (2005). World Health Organization's Global Strategy on diet, physical activity and health: the process behind the scenes. *Scandinavian Journal of Nutrition*, *49*(2), 83-88.

Parmar, A., & Sharma, P. (2017). Ecological Momentary Interventions Delivered by Smartphone Apps: Applications in Substance Use Treatment in Indian Scenario. *Indian journal of psychological medicine*, *39*(1), 102–103. https://doi.org/10.4103/0253-7176.198942

Pickering, T. A., Huh, J., Intille, S., Liao, Y., Pentz, M. A., & Dunton, G. F. (2016). Physical activity and variation in momentary behavioral cognitions: an ecological momentary assessment study. *Journal of Physical Activity and Health*, *13*(3), 344-351.

Plotnikoff, R. C., Lubans, D. R., Costigan, S. A., Trinh, L., Spence, J. C., Downs, S., & McCargar, L. (2011). A test of the theory of planned behavior to explain physical activity in a large population sample of adolescents from Alberta, Canada. *Journal of Adolescent Health*, *49*(5), 547-549.

Raento, M., Oulasvirta, A., & Eagle, N. (2009). Smartphones: An emerging tool for social scientists. *Sociological methods & research*, *37*(3), 426-454.

Ram, N., Brinberg, M., Pincus, A. L., & Conroy, D. E. (2017). The questionable ecological validity of ecological momentary assessment: Considerations for design and analysis. *Research in Human Development*, *14*(3), 253-270.

Rebar, A. L., Elavsky, S., Maher, J. P., Doerksen, S. E., & Conroy, D. E. (2014). Habits predict physical activity on days when intentions are weak. *Journal of Sport and Exercise Psychology*, *36*(2), 157-165.

Rebar, A. L., Rhodes, R. E., & Gardner, B. (2019). How we are misinterpreting physical activity intention–behavior relations and what to do about it. *International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 71.

Rhodes, R. E. (2014). Bridging the physical activity intention–behaviour gap: contemporary strategies for the clinician. *Applied Physiology, Nutrition, and Metabolism*, *39*(1), 105-107.

Rhodes, R. E. (2017). The evolving understanding of physical activity behavior: a multi-process action control approach. In *Advances in motivation science* (Vol. 4, pp. 171-205). Elsevier.

Rhodes, R. E., & Courneya, K. S. (2003). Investigating multiple components of attitude, subjective norm, and perceived control: An examination of the theory of planned behaviour in the exercise domain. *British journal of social psychology*, *42*(1), 129-146.

Rhodes, R. E., & de Bruijn, G. J. (2013). How big is the physical activity intention–behaviour gap? A meta-analysis using the action control framework. *British journal of health psychology*, *18*(2), 296-309.

Rhodes, R. E., & Dickau, L. (2012). Experimental evidence for the intention–behavior relationship in the physical activity domain: A meta-analysis. *Health Psychology*, *31*(6), 724.

Rhodes, R. E., & Dickau, L. (2013). Moderators of the intention-behaviour relationship in the physical activity domain: a systematic review. *British Journal of Sports Medicine*, *47*(4), 215-225.

Rhodes, R. E., Janssen, I., Bredin, S. S., Warburton, D. E., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychology & Health*, *32*(8), 942-975.

Rhodes, R. E., McEwan, D., & Rebar, A. L. (2019). Theories of physical activity behaviour change: A history and synthesis of approaches. *Psychology of Sport and Exercise*, *42*, 100-109.

Rhodes, R. E., & Rebar, A. L. (2017). Conceptualizing and defining the intention construct for future physical activity research. *Exercise and Sport Sciences Reviews*, *45*(4), 209-216.

Rhodes, R. E., & Yao, C. A. (2015). Models accounting for intention-behavior discordance in the physical activity domain: a user's guide, content overview, and review of current evidence. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 9.

Rhudy, M. B., Dreisbach, S. B., Moran, M. D., Ruggiero, M. J., & Veerabhadrappa, P. (2020). Cut points of the Actigraph GT9X for moderate and vigorous intensity physical activity at four different wear locations. *Journal of Sports Sciences*, *38*(5), 503-510.

Romanzini, C. L. P., Romanzini, M., Batista, M. B., Barbosa, C. C. L., Shigaki, G. B., Dunton, G., ... & Ronque, E. R. V. (2019). Methodology used in ecological momentary assessment studies about sedentary behavior in children, adolescents, and adults: systematic review using the checklist for reporting ecological momentary assessment studies. *Journal of medical Internet research*, *21*(5), e11967.

Sani, S. H. Z., Fathirezaie, Z., Brand, S., Pühse, U., Holsboer-Trachsler, E., Gerber, M., & Talepasand, S. (2016). Physical activity and self-esteem: testing direct and indirect relationships associated with psychological and physical mechanisms. *Neuropsychiatric Disease and Treatment*, *12*, 2617.

Scholz, U., Keller, R., & Perren, S. (2009). Predicting behavioral intentions and physical exercise: a test of the health action process approach at the intrapersonal level. *Health Psychology*, *28*(6), 702.

Scholz, U., Schüz, B., Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2008). Beyond behavioural intentions: Planning mediates between intentions and physical activity. *British journal of health psychology*, *13*(3), 479-494.

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and personality psychology compass*, *10*(9), 503-518.

Stone, A. A., Shiffman, S., Atienza, A. A., Nebeling, L., Stone, A., Shiffman, S., ... & Nebeling, L. (2007). Historical roots and rationale of ecological momentary assessment (EMA). *The science of real-time data capture: Self-reports in health research*, 3-10.

The 2019 ParticipACTION report card on physical activity for adults. (2019). *ParticipACTION.* Retrieved May 19, 2020 from https://www.participaction.com/en-ca/resources/adult-report-card

The 2020 ParticipACTION report card on physical activity for children and youth. (2020). *ParticipACTION.* Retrieved May 19, 2020 from https://www.participaction.com/en-ca/resources/children-and-youth-report-card

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and science in sports and exercise*, *40*(1), 181.

Warburton, D. E., Charlesworth, S., Ivey, A., Nettlefold, L., & Bredin, S. S. (2010). A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 39.

Wen, C. K. F., Schneider, S., Stone, A. A., & Spruijt-Metz, D. (2017). Compliance with mobile ecological momentary assessment protocols in children and adolescents: a systematic review and meta-analysis. *Journal of medical Internet research*, *19*(4), e132.

Appendices

Appendix A: Participant Consent Package

ADAPT STUDY: Application of integrateD Approaches to understanding Physical activity during the Transition to emerging adulthood

Principal Investigator:
Dr. Matthew Kwan
Department of Family Medicine, McMaster University
David Braley Health Sciences Centre, 5th Floor
1280 Main St. W, Hamilton, ON, L8S 4K1
Phone: (905) 525-9140 ext: 28412
Email: kwanmy@mcmaster.ca
Funding: This project is supported by the Social Sciences and Humanities Research Council of Canada.

Dear Student,

We are inviting you to participate in a research study at McMaster University about the potential changes in physical activity and other health behaviours during the transition out of high school. It is important for you to know that you can choose to NOT take part in this study. Choosing not to participate will not have any negative consequences.

***Why is this study being done*?** The transition out of high school is considered to be the first major transition that an individual faces. Few studies have examined changes in physical activity or other health behaviours that may occur when students leave high school. We are interested in how physical activity patterns change and how your motivations for physical activity may shift during this time, as well as how it impacts your overall wellness.

***Who is doing this study*?** The study team is includes researchers from Kinesiology and Family Medicine from different universities, including from McMaster University.

***If I decide to take part, what will I have to do*?** We will be asking you to participate by completing a questionnaire once a year for 4 years. The questions on the survey will include: some personal information that will be used for matching purposes, as well as for future correspondence only; questions related to your physical activity and other health behaviours; physical education and physical activity motivations; and measures of your overall wellness. You can choose to not answer any of the questions if you are uncomfortable. This questionnaire will take you approximately 20 minutes to complete, and you will receive a $10 gift card for each questionnaire you complete. The follow-up period includes two years after high school, and our investigator team will try and re-contact you through e-mail.

Additionally, some students will be selected to take part in our sub-study. If you are selected, you will be asked you to wear a wrist-worn activity monitoring device for 7 days after you complete the questionnaire. You will be asked to do this each year. We are interested in understanding the factors related to your daily activity in your regular daily life, so we will also be asking you to answer questions on several occasions throughout a day while you're wearing the activity monitor. To participate, you will need to download a smartphone app (at no cost to you), which will prompt you to complete these mini-questionnaires over the 7 days you wear the activity monitor. You will receive an additional $90 gift card for participating in this phase of the study.

***Can I change my mind about being in the study*?** If you choose to take part in this study, you can change your mind and withdraw at any time. You also have the option of asking that we remove your information from the study. You may also decide to not answer any questions but still be in the study.

***Are there any risks to my participation*?** Although there are no obvious harms or risks, it is possible that you may experience some negative emotions when thinking about some of the questions. We have included contact information for the KidsHelpPhone in the questionnaire if you need any immediate help, or you may contact a member of our study team to help direct you. Your participation is completely voluntary, and you do not have to answer any questions being asked.

What are the potential benefits? Your taking part in this study is important because it will help us to better understand the changes in physical activity that occur during the transition after high school and how we can help individuals stay physically active and maintain well-being. This information will directly help the education and health systems identify methods and strategies to help people maintain a healthy active lifestyle as they make their first major transition.

Is the information I provide safe? All information you provide will not be shared with anyone outside the study team. No personal information, such as your name, will be kept beyond the study period, and no personal information will be included in reports or publications. All information will be kept in a secure server on an encrypted hard drive at McMaster University until the end of the study, for a period of 10 years. For the purposes of ensuring the proper monitoring of the research study, it is possible that a member of the Hamilton Integrated Research Ethics Board and this institution and affiliated sites may consult your research data for quality assurance purposes. However, no records which identify you by name or initials will be allowed to leave the research office. By signing this consent form, you authorize such access.

Can I see the study results? We expect to have this study completed by June 2023. If you would like a brief summary of the results, please let us know at any point.

Who do I contact if I have questions or concerns with the study?

If you have any questions regarding your rights as a research participant, you may contact the Office of the Chair of Hamilton Integrated Research Ethics Board at 905-521-2100 ext. 42013. Should you have any questions about the study, please contact Dr. Matthew Kwan at kwanmy@mcmaster.ca.

We thank you for your consideration!

- The ADAPT STUDY Team -

ADAPT STUDY: Application of integrateD Approaches to understanding Physical activity during the Transition to emerging adulthood

Principal Investigator:
Dr. Matthew Kwan
Department of Family Medicine, McMaster University
David Braley Health Sciences Centre, 5th Floor
1280 Main St. W, Hamilton, ON, L8S 4K1
Phone: (905) 525-9140 ext: 28412
Email: kwanmy@mcmaster.ca
Funding: This project is supported by the Social Sciences and Humanities Research Council of Canada.

Dear Parent(s)/Guardian(s),

We are inviting your child to participate in a research study at McMaster University about the potential changes in physical activity and other health behaviours during the transition out of high school. It is important for you to know that they can choose to NOT take part in this study. Choosing not to participate will not have any negative consequences.

***Why is this study being done*?** The transition out of high school is considered to be the first major transition that an individual faces. Few studies have examined changes in physical activity or other health behaviours that may occur when students leave high school. We are interested in how physical activity patterns change and how motivations for physical activity may shift during this time, as well as how it impacts overall wellness.

***Who is doing this study*?** The study team is includes researchers from Kinesiology and Family Medicine from different universities, including from McMaster University.

***If they decide to take part, what will they have to do*?** We will be asking your child to participate by completing a questionnaire once a year for 4 years. The questions on the survey will include: some personal information that will be used for matching purposes, as well as for future correspondence only; questions related to physical activity and other health behaviours; physical education and physical activity motivations; and measures of overall wellness. Your child can choose to not answer any of the questions if they are uncomfortable. The questionnaire will take approximately 20 minutes to complete, and they will receive a $10 gift card for each questionnaire completed. The follow-up period includes two years after high school, and our investigator team will try and re-contact them through e-mail.

Additionally, some students will be selected to take part in our sub-study. If they are selected, they will be asked you to wear a wrist-worn activity monitoring device for 7 days after completing the questionnaire. They will be asked to do this each year. We are interested in understanding the factors related to daily activity in regular daily life, so we will also be asking them to answer questions on

several occasions throughout a day while wearing the activity monitor. To participate, your child will need to download a smartphone app (at no cost to them), which will prompt them to

complete these mini-questionnaires over the 7 days you wear the activity monitor. They will receive an additional $90 gift card for participating in this phase of the study.

***Can they change my mind about being in the study*?** If your child chooses to take part in this study, they can change your mind and withdraw at any time, and the option of asking that we remove any information. Your child may also decide to not answer any questions but still be in the study.

***Are there any risks to participation*?** Although there are no obvious harms or risks, it is possible that your child may experience some negative emotions when thinking about some of the questions. We have included contact information for the KidsHelpPhone in the questionnaire if they need any immediate help, or they may contact a member of our study team to help direct them. Their participation is completely voluntary, and do not have to answer any questions being asked.

What are the potential benefits? Your child taking part in this study is important because it will help us to better understand the changes in physical activity that occur during the transition after high school and how we can help individuals stay physically active and maintain well-being. This information will directly help the education and health systems identify methods and strategies to help people maintain a healthy active lifestyle as they make their first major transition.

Is the information they provide safe? All information provided will not be shared with anyone outside the study team. No personal information, such as names, will be kept beyond the study period, and no personal information will be included in reports or publications. All information will be kept in a secure server on an encrypted hard drive at McMaster University until the end of the study, for a period of 10 years. For the purposes of ensuring the proper monitoring of the research study, it is possible that a member of the Hamilton Integrated Research Ethics Board and this institution and affiliated sites may consult the research data for quality assurance purposes. However, no records which identify your child by name or initials will be allowed to leave the research office. By signing this consent form, you authorize such access.

Can I see the study results? We expect to have this study completed by June 2023. If you would like a brief summary of the results, please let us know at any point.

Who do I contact if I have questions or concerns with the study?

If you have any questions regarding the rights of your child as a research participant, you may contact the Office of the Chair of Hamilton Integrated Research Ethics Board at 905-521-2100 ext. 42013. Should you have any questions about the study, please contact Dr. Matthew Kwan at kwanmy@mcmaster.ca.

We thank you for your consideration
- The ADAPT STUDY Team -

To provide electronic consent please go to:
adapt.lumedi.ca/a/parentalconsent.html

WRITTEN CONSENT STATEMENT

Signature of Research Participant:
I have read the above information thoroughly. I have had an opportunity to ask questions and all of my questions have been answered to my satisfaction. By clicking on the box, I agree to allow my child to participate in this study if they wish to.

_____
Name of Participant

_____ _____
Signature of Participant Date (MM/DD/YYYY)

Signature of Person Obtaining Consent:

_____
Name

_____ _____
Signature of Person Obtaining Consent Date (MM/DD/YYYY)

Appendix B: Script for sub-study Recruitment

Research assistants go into English classrooms, describe the extended study and assist in setting students up for the study.
Now that you have completed the larger component of the study. We invite you to take part in an extended study. In this part of the study, we want to look at more moment to moment aspects of your activity and associated motivations.
Your participation will require you to wear an accelerometer for the next 8 days and download an app where you will be prompted to answer mini-questionnaires designed to take 1 -2 minutes of your time 5 times a day. This questionnaire will contain components regarding your context (e.g., what are you are currently doing?), momentary social cognitions (i.e., intentions), and validated questions on acute affect/feeling states. The idea is for you to complete this part of the study four times as well - once right now, in grade 11, once in grade 12 (next year), and then once per year for the two years following graduation (fall 2021 and fall 2022). As a thank-you, you will receive a $90 gift card to the mall after completion of this part of the study.
Are there any questions at this time?
Answer any questions that the students may have.
If you wish to participate in the study, please download the Lumedi app on the app store/google play store. Once you do that, you can come approach me and I will provide you with your study package.
Once all students who want to participate get their study kits, continue.
Now, when you look in your envelope. You should see 2 things; 1 accelerometer and 1 piece of paper with instructions for the week your unique EMA code.
Take the piece of paper with the EMA code out and enter that onto the app that you just downloaded.
Once all students have entered the EMA code into the Lumedi app, continue.
Take the accelerometer out and put it on your non-dominant wrist. We ask that you keep the accelerometer on until we come back and collect it next week. Only take it off during prolonged water exposure (i.e., swimming, bathing, etc.) but remember to put it on after. It is really important that you wear your accelerometer as much as possible, even when you sleep, so we can get information about your activity and sleep levels. We understand that you may not be used to wearing a watch at all times but please try your best. If you have any trouble, you can contact the study team using the e-mail on that instruction sheet.
For the EMA prompts, you will receive notification from the app so ensure that your notifications are on for Lumedi as you will only have a small window to respond to the prompt. Try your best to respond to all prompts.
There is an instruction sheet with everything that I have just said. Are there any questions?
Address any questions, comments or concerns as they arise. If a participant is having trouble downloading and setting up the app, send them to the library. Someone will be stationed there for troubleshooting.
When all students have been set up on Lumedi and have been given their accelerometers, continue.
Alright! You are all set. We will come and collect the accelerometers next week in addition to providing you with your gift cards as a thank-you. Again, our contact information on the instruction sheet so feel free to reach out if you run into any issues!

Appendix C: Participant Instruction Sheet

WHEN DO I WEAR THE ACCELEROMETER?

Wear the accelerometer at **all times** for the next 7 days on the wrist of your **non-dominant hand**. You can wear the accelerometer when playing sports, even contact sports like hockey and football. You should **NOT** wear the accelerometer during water activities (i.e, swimming, bathing, etc.)

DOWNLOADING 'LUMEDI'

1. Go to your App Store and download the 'Lumedi' app
2. Enter your unique EMA code
3. Answer 5 prompts each day for the next week

YOUR UNIQUE EMA CODE IS: _____

Try your best to respond to each prompt. If you have any trouble with the app, please contact study admin at **adaptstudy.mcmaster@gmail.com**

Compensation for participating in this part of the study will be provided after 7 days.

Appendix D: Sociodemographic Questions from the Cohort Questionnaire

SOCIO-DEMOGRAPHIC INFORMATION ----------

What school do you go to? _____

What grade are you in?

❑ 9 ❑ 10 ❑ 11 ❑ 12

What is your age?

	14
	15
	16
	17
	18

Gender

	Male
	Female
	Prefer not to answer

Ethnicity

	Aboriginal people of Canada		Filipino		Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese, etc.)
	Indigenous (outside of Canada)		Japanese		Taiwanese
	Arab		Korean		West Asian (Afghan, Iranian, Syrian, etc.)
	Black		Latin, Central, or South American		White
	Chinese		South Asian (e.g., Indian, Pakistani, Sri Lankan etc.)		None of the above [please specify: - _____]

Parental Education (Highest level of education obtained by a parent): (check one response)

	Some Secondary		Some College		Some University
	Completed Secondary		Completed College		Completed University

Do you currently own/use a smartphone?

	No
	Yes

Appendix E: EMA Questionnaire

Ecological Momentary Assessment (EMA) Questionnaire

Question sequences will be promoted at a random time within each of these time intervals: 7:30am-8:30 am; 3:30pm-4:30pm; 5:00pm-6:00pm; 6:30pm-7:30pm; 8:00pm-9:00pm
All items are to be responded to each time. Each prompt will remain open for 30 minutes and 2 reminders will be sent following the original prompt.

Beginning Message: "Time for a Survey"

Contextual Questions (4 items) ----------

WHAT are you currently doing?

- On Computer/Phone/Tablet – Personal Use
- Watching TV/Movies
- Eating/Drinking
- Studying/Homework
- Walking/Physical Activity
- Other

WHERE are you right now?

- Home
- School
- Outside
- Café/Restaurant
- In Transportation
- Other
    - **If Other:**
    - At the mall/store
    - In a library
    - Sport/recreation facility
    - Somewhere else

WHO are you currently with?

- By Myself
- With Friend(s)
- With Family
- With Classmate(s)
- With Boyfriend/Girlfriend
    - **If with Friends:** How MANY friends are you with?
    - (List 1-5 or more)
    - **If with Family:** How MANY family members are you with?
    - (List 1-5 or more)
    - **If with Classmates:** How MANY classmates are you with?

- (List 1-5 or more)

State, Affect, and Cognitions ----------

(1) Intentions

It is my intention to be physically active today [1st Prompt ONLY]:

- YES/ NO

How motivated are you to be physically activity today? [1st Prompt ONLY]:

Not at all motivated										Extremely motivation
0	1	2	3	4	5	6	7	8	9	10

It is my intention to do at least 10 minutes or more of physical activity sometime over the next hour? (*Prompts 2-5*):

- Yes/No

(2) How motivated are you right now to do physical activity? (*Prompts 2-5*)

Not at all motivated										Extremely motivated
0	1	2	3	4	5	6	7	8	9	10

(3) How fatigued do you feel <u>right now?</u>

Not Fatigued at All										Extremely Fatigued
0	1	2	3	4	5	6	7	8	9	10

(4) How do you feel <u>right now</u>?

Extremely Bad -5	-4	-3	-2	-1	Neutral 0	+1	+2	+3	+4	Extremely Good +5

Extremely Tired -5	-4	-3	-2	-1	Relaxed 0	+1	+2	+3	+4	Extremely Energetic +5

(5)

I feel like my will power is gone.	Not True 1	2	3	4	5	6	Very True 7

(6) How confident are you in your ability to exert self-control (e.g., resist temptation, control emotions, not procrastinate), <u>right now?</u>

Not Confident 0	1	2	3	4	5	6	7	8	9	Totally Confident 10

(7) Could you do >10mins of physical activity in the next hour, even if you are or get busy?

- I know I can
- I probably can
- Not sure
- I probably cannot
- I know I cannot

(8) Could you do >10mins of physical activity in the next hour, even if you feel tired?

- I know I can
- I probably can
- Not sure
- I probably cannot
- I know I cannot

(9) Currently, I am doing something that I would normally be doing on a typical day at this time.

- Strongly Agree
- Somewhat Agree
- Neither Agree nor Disagree
- Somewhat Disagree
- Strongly Disagree