Effect of Wearable Activity Trackers and Social Media Use on Day-Level Physical Activity Motivation and Behaviours

by

Rebecca Coulter
BHK, University of British Columbia Okanagan, 2018

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Abstract

Background. Physical activity is integral to maintaining good health and preventing chronic diseases yet physical inactivity remains a concern. Wearable activity trackers (WATs) have dramatically grown in popularity and research recognizes their potential impact on motivation and physical activity behaviours, specifically when combined with additional intervention strategies. Research has also shown positive associations between health-related social media use and physical activity behaviours. While both WATs and social media are potentially effective tools for behaviour change, research in this field has focused on between-person associations. Currently, less is known about within-person associations between WAT use and daily physical activity as well as potential interaction effects with daily health-related social media use.

Objectives. 1) Examine differences in day-level situational motivation for physical activity between WAT users and non-users, 2) Examine within-person associations of day-level situational motivation for physical activity with same-day health-related social media use in WAT users and non-users, 3) Examine differences in day-level physical activity intensity, duration, and moderate-to-vigorous physical activity (MVPA) in WAT users and non-users, and 4) Examine within-person associations of daily physical activity with same-day health-related social media use in WAT users and non-users

Methods. English-speaking Canadian adults (≥ 18 years) who own a smartphone were recruited. Eligible participants completed a baseline survey assessing social media use, WAT status and demographic information. Participants then completed a 14-day daily diary study protocol of up to three (3) daily surveys assessing daily situational motivation for physical activity, daily social media use and self-reported physical activity behaviours. Multi-level modelling was conducted to examine the day-level effect of WAT use and daily health-related social media on day-level situational motivation and physical activity.

Results. 328 participants were included. Mean age of participants was 27.2 (9.1) years, 67% (n=220) of participants were female and 71.3% (n=234) of participants identified as WAT users. WAT use was associated with greater day-level intrinsic and identified situational motivation before engaging in daily physical activity. Daily health-related social media use was not found to be associated with greater autonomous situational motivation. The only significant interaction effect for WAT use and health-related social media on situational motivation was found for external regulation (b=0.23, SE 0.11, p = .03). For daily physical activity behaviours, using a WAT was not associated with greater daily physical activity; however, daily social media use was significantly associated with physical activity intensity (b=0.29, SE 0.10, $p < .01$) and MVPA (b=3.38, SE 1.52, p = .026). No significant interaction effects were observed between health-related social media and WAT use for any physical activity outcome.

Conclusions. Greater autonomous (intrinsic motivation, identified regulation) situational motivation for physical activity in WAT users did not translate to increases in physical activity behaviours. While daily social media use had no association with daily motivation for physical activity, results showed a significant association between health-related social media use and the intensity of physical activity as well as (MVPA). Alone, WATs and health-related social media use may have an impact on situational motivation for physical activity and physical activity but no additional benefits on motivation or behaviours were observed when used in combination. Although WATs should be not discounted as an effective tool, health-related social media platforms could exert a more direct influence on actual physical activity engagement and is a potential low-cost tool, positive addition to physical activity interventions. Future research

should continue to examine the type and timing of health-related social media use to have an optimal effect on physical activity.

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Dedication

This thesis is dedicated to my friends and family who inspired me to pursue higher education and provided unconditional love and support along the way.

Chapter 1 – Introduction

1.1 Overview of Current Literature

Regular physical activity is crucial for both mental and physical health and is associated with a lower risk of all-cause mortality and chronic diseases, including but not limited to hypertension, stroke, Type 2 diabetes, and cancer (Cleven et al., 2020; Kodama et al., 2009; Lee et al., 2012). In addition to physical outcomes, regular physical activity has been shown to improve cognition, attention, and mood, and is effective in improving symptoms of depression and anxiety (Biddle & Asare, 2011; Bize et al., 2007). Despite the benefits, participation in regular physical activity remains low in Canadian adults, where less than half of adults aged 20-69 years are meeting the recommended guidelines of 150 minutes of moderate-to-vigorous physical activity per week (Doyon et al., 2021). Similar levels of physical inactivity in adults are seen across other developed countries (Guthold et al., 2018), as well as within young adult populations and university students (Pengpid et al., 2015; Weatherson et al., 2021). While physical activity levels remain low, the development of digital technologies to combat inactivity has increased, including wearable activity trackers or smartwatches. These digital tools have the potential to effectively increase physical activity within the general population which will have a positive effect on both disease prevention and our healthcare system, making research in this field a crucial step.

Wearable activity trackers (WATs) are self-monitoring devices that have dramatically grown in use and accessibility and are recognized as a tool to increase physical activity (Girginov et al., 2020). Modern versions of WATs are designed as smartwatches, such as the Apple Watch and Fitbit, allowing for sophisticated connectivity features in addition to being a tool used for self-monitoring of physical activity goal setting (Papalia et al., 2018). WATs provide users with a constant stream of self-regulation information and generally have a positive effect on physical activity behaviours including daily steps, movement, and limiting sedentary behaviour (Ferguson et al., 2022). Following Self-Determination Theory (SDT), using WATs has been shown to satisfy the need for relatedness, competence, and autonomy when individuals are engaging in physical activity, and the satisfaction is what leads to greater autonomous motivation for physical activity and increases in physical activity behaviours (Karapanos et al., 2016; Rupp et al., 2018; Ryan & Deci, 2000; Schaben & Furness, 2018). However, there is mixed evidence in the literature supporting their effectiveness in creating long-term behaviour changes (Lynch et al., 2020). For instance, the literature suggests that while WATs have an overall positive effect on physical activity behaviours, not all users experience wearable devices in the same way (Ferguson et al., 2022). Studies have shown that WATs tend to be most effective in interventions longer than or equal to 12 weeks in length (Yen & Chiu, 2019), however, there is also a notable drop-off in use after approximately four to six months in some individuals (Ledger & McCaffrey, 2014). Further, research suggests that WATs may be more effective for certain types of users or when combined with additional behaviour change techniques (i.e. motivational interviewing) in multi-faceted interventions (Ledger & McCaffrey, 2014; Lynch et al., 2020; Nuss et al., 2021; Rupp et al., 2018). Recently, it is common for activity trackers to be used in combination with mobile applications (mHealth apps) that include additional behaviour-change features (McCormack et al., 2022), such as using social support via social media in behaviour interventions (Maher et al., 2014).

Social media is an online space and community where users can consume information, share content, and engage with online social connections (Hruska & Maresova, 2020). Social media use has also been shown to have a positive impact on health-related knowledge and behaviours (Goodyear & Armour, 2018; Shimoga et al., 2019; Tate et al., 2015) and may be an effective addition to physical activity promotion (Maher et al., 2014; Williams et al., 2014). Specifically, as many young adults are turning to social media to access health information online, social media content related to health and fitness provides users with instant information displayed attractively (Goodyear et al., 2019; Pasko & Arigo, 2021). As well as being an effective addition to physical activity interventions, recent studies suggest that viewing health-related social media content is also associated with physical activity levels (Peng et al., 2019; Rowles, 2021; Welker et al., 2019). Allowing users to personalize how they receive health-related content and information on commonly used social media applications may lead to greater buy-in compared to physical activity interventions that utilize stand-alone applications (Maher et al., 2014). Additionally, combining health-related social media content with the use of WATs may lead to a greater increase in autonomous motivation for physical activity and thus a greater behaviour response compared to using a WAT or viewing health-related social media alone (Chang et al., 2016). As explained through SDT, health-related social media use in addition to using a WAT may further satisfy an individual’s need for autonomy, competence and relatedness leading to greater autonomous motivation for physical activity by engaging with and viewing others who are also physically active (Zhang et al., 2015). In the current literature, however, there is limited research examining the effects of using a WAT when combined with health-related social media use (Pope et al., 2019). As such, more robust evidence in this area of research is required.

Previous research in the field of WATs and health-related social media has focused on between-group associations, such as comparing social media or WAT intervention groups to a control (Kim et al., 2018; Pope et al., 2019). Examining day-to-day variations in situational motivation and physical activity behaviours will further our understanding of the potential effect of WATs and health-related social media use over time as well as in combination. For instance, previous research tells us that daily physical activity can be impacted by other daily factors, such as same-day mood or the contextual environment (Do et al., 2021; Shin, 2020). Thus, using a longitudinal or daily diary study design, we can examine the daily effect that WATs and health-related social media use may have on motivation and physical activity behaviours. Finally, understanding how individuals vary in response to using WATs and viewing health-related social media over time will allow researchers to better personalize future physical activity interventions.

1.1.1. Statement of Purpose

Both wearable trackers and health-related social media have the potential to be innovative solutions to deliver scalable and personalized physical activity programs. While there is evidence supporting the effect of both technologies on physical activity, the combination of these tools may result in greater or more effective changes in behaviour (Cadmus-Bertram et al., 2015; Chang et al., 2016; Drehlich et al., 2020; Pope et al., 2019). Thus, this study aims to explore whether physical activity levels and motivation are influenced by daily health and fitness social media consumption and WAT use. Knowing how health-related social media use can interact with self-regulating tools to impact daily physical activity will help design future adaptive physical activity interventions.

1.2. Research Objectives

1. Examine differences in day-level situational motivation for physical activity between WAT users and non-users.

2. Examine within-person associations of day-level situational motivation for physical activity with same-day health-related social media use in WAT users and non-users.

3. Examine differences in day-level physical activity intensity, duration, and moderate-to-vigorous physical activity (MVPA) in WAT users and non-users.

4. Examine within-person associations of daily physical activity with same-day health-related social media use in WAT users and non-users.

1.2.1 Hypotheses

1. Using WATs will be associated with greater day-level situational intrinsic motivation and identified regulation for physical activity.
2. There will be a significant association between daily health-related social media use and increased day-level situational intrinsic motivation and identified regulation for physical activity in WAT users compared to non-users.
3. Using WATs will be associated with increased daily physical activity intensity, duration, and MVPA.
4. There will be a significant association between daily health-related social media use and increased daily physical activity behaviours in WAT users compared to non-users.

1.3 Limitations

1. Burden on participants to remember to complete up to three daily surveys for 14 consecutive days.
2. Reliance on participants to accurately self-report physical activity behaviours; wearable activity tracker users will have greater insight into physical activity due to the nature of using a self-monitoring device and may provide a more accurate self-reported measure of physical activity compared to non-users. This difference in self-report measures cannot be avoided.
3. Although some participants are wearable activity tracker users, physical activity will not be objectively measured.

1.4 Assumptions

1. Participants will answer daily survey questions truthfully and to the best of their ability.
2. Survey responses will be completed at the intended time, for instance before and following physical activity.
3. Daily social media habits are similar to self-reported averages on the baseline survey.

1.5 Definition of Terms

MVPA: Moderate-to-vigorous physical activity is defined as physical activity that increases heart rate above resting to a rate where talking while exercising is difficult. Research suggests that MVPA is a significant predictor of long-term health.

Wrist-worn Wearable Activity Trackers (WATs): A wrist-worn device that captures the movement and activity of the user, including step count, minutes of activity, heart rate, standing minutes and calories burned. Also referred to as wearable technology, these devices collect activity data and provide real-time feedback and self-monitoring for users.

Social Media: Multi-media platforms designed for connecting online, sharing images or videos of all content and engaging will content in the form of likes, comments and shares. Social media is used on across multiple devices such as smartphones and computers, and examples of popular social media platforms include Instagram, Facebook, Snapchat, YouTube, WhatsApp and LinkedIn.

Daily Diary: A longitudinal research design in which participants answer daily surveys over a specific research period. The purpose of this design is to assess changes in behaviours or psychological predictors over time. Multiple surveys are released to participants to be answered at various times of the day.

Chapter 2 Literature Review

2.1 Prevalence of Physical Activity

Physical activity plays an integral role in the maintenance of good health and is associated with a lower risk of all-cause mortality and chronic diseases (Cleven et al., 2020; Kodama et al., 2009). Specifically, greater physical activity has been linked to a reduced risk of coronary heart disease, stroke, high blood pressure, metabolic syndrome, and colon cancer (Lee et al., 2012). Further, greater physical fitness from increasing physical activity has been shown to be related to better health outcomes, such as waist circumference and improved life satisfaction (Fowles et al., 2014). In addition to physical benefits, regular physical activity has also been shown to be positively associated with mental health and quality of life outcomes (Biddle & Asare, 2011; Bize et al., 2007). In children and adolescents, physical activity is associated with improvements in cognitive performance, self-esteem, and reduced anxiety, however, the effect size is small (Biddle & Asare, 2011). In adults, a systematic review of primarily cross-sectional studies found a positive association between increased physical activity and greater health-related quality of life (Bize et al., 2007).

Despite the overwhelming benefits of physical activity, approximately one in four adults are meeting physical activity guidelines worldwide (Doyon et al., 2021; Guthold et al., 2018). In Canada, less than half of adults aged 20-69 years are meeting the Canadian physical activity guidelines for moderate-to-vigorous physical activity (MVPA) of 150 minutes per week (Doyon et al., 2021). A similar trend of physical activity can be seen in the United States, where only half (53%) of adults greater than 18 years were meeting physical activity guidelines for MVPA in 2018 (*Products - NHIS Early Release - 2018*, n.d.). Physical inactivity is not only common among adults but is also a concern among young adults and student populations (Cocca et al., 2014; Pengpid et al., 2015). A study from 2015 suggests that, on average, only 40% of university students from countries around the world are meeting physical activity guidelines for moderate-to-vigorous physical activity (Pengpid et al., 2015; Cocca et al., 2014). Recent research suggests that 61% of Canadian post-secondary students are meeting guidelines for MVPA, however, only about 10% of students are meeting all four components of the 24-Hour Movement Guidelines which include sleep and limits on sedentary behaviours (Weatherson et al., 2021). Of most concern, studies using objective measurements of physical activity suggest that activity levels in university students are lower than what is self-reported by participants (Bai et al., 2022). MVPA is positively associated with health outcomes including musculoskeletal health (Wu et al., 2017) and continues to be a focus of physical activity research; however, all increases in physical activity are beneficial for health outcomes (Chaput et al., 2014).

Recently, physical activity behaviours were reported to decrease due to pandemic lockdowns and social distancing measures (Caputo & Reichert, 2020). A study from the United States showed that adults who were previously active reported lower levels of physical activity following COVID-19 lockdowns compared to pre-pandemic levels (Meyer et al., 2020). In Canada, a study on adults (18 + years) found that while participants perceived a decrease in weekly MVPA, 36% saw decreases in MVPA with factors such as availability of home equipment and identity as significant predictors of change (Rhodes et al., 2020). Similar outcomes have been documented for Canadian university students, including decreases in the percentage of students meeting guidelines for MVPA and sedentary behaviours during the pandemic (Bertrand et al., 2021). Decreases in physical activity behaviours from pre-pandemic levels have also been well-documented in children and adolescents, where Canadian children had less outdoor time and lower physical activity levels at the beginning of the pandemic (Moore et al., 2020; Neville et al., 2022). Of most concern, moderate-to-vigorous physical activities saw one of the greatest declines across all age groups when compared to low-intensity activities such as walking, playing outside or gardening (Wunsch et al., 2022). As the repercussions of heavy pandemic restrictions are still emerging, longitudinal studies that have examined behaviours over the last two years indicate that physical activity levels are still being impacted (Ortega et al., 2022). When asked about their current behaviours (July 2022) in comparison to pre-COVID levels, 20.5% of Italian adults reported spending less time being active and 14.9% reported stopping engaging in physical activities altogether (Ortega et al., 2022). The same study also suggests that preferences for physical activity have changed, shifting from gyms and indoor facilities to engaging in exercise outdoors. Based on this evidence, research that focuses on increasing physical activity behaviours in all populations remains crucial.

2.1.1 Factors Predicting Physical Activity

There are many well-documented variables that have consistently been shown to be associated with physical activity on multiple, interacting levels of influence (Bauman et al., 2012). At the individual level, age, sex, and psychological factors such as self-efficacy and exercise intention have been shown to be correlates of physical activity (Reynolds et al., 1990). In adults, self-efficacy has been shown to be a strong predictor of physical activity participation along with perceived fitness being positively correlated with activity (Choi et al., 2017). In children and adolescents, male sex and self-efficacy are also positively correlated with physical activity behaviours (Sallis et al., 2016). While previous studies have shown positive correlations between male sex, age and physical activity in high-income countries (Bauman et al., 2012), there is mixed evidence for these associations in adults in low- and middle-income countries (Sallis et al., 2016). In addition to individual factors, one's physical and social environments have also been shown to be predictors of physical activity across countries of all incomes (Reynolds et al., 1990; Sallis et al., 2016). In adults, there is evidence that physical activity is related to environmental variables, such as proximity to recreational facilities, open space, and neighbourhood aesthetics (Bauman et al., 2012; Choi et al., 2017). In low- and middle-income countries, socioeconomic status and urban environments were found to be inversely correlated with physical activity in adults and youth (Sallis et al., 2016). In high-income countries, a positive correlation can be seen. When measured objectively, levels of physical activity in university students have also shown to be dependent on living environments and days of the week, where physical activity behaviours are highest on weekdays due to class schedules and decrease on weekends, during holidays, and throughout post-secondary programs (Bai et al., 2022; Clemente et al., 2016; Small et al., 2013). Regarding the social environment, friendships and social networks are shown to be strong predictors of physical activity and other health behaviours in children and adolescents (MacDonald-Wallis et al., 2012). In adults, social support from friends and peers has also been identified to be positively associated with physical activity whereas support from family members or partners is not a correlate of physical activity (Sallis et al., 2016). Research on individuals with chronic conditions such as multiple sclerosis, chronic depression and substance abuse found that access to healthcare facilities, severity of condition, and low self-efficacy were inverse correlates of physical activity (Rhodes et al., 2017). Finally, there is evidence of the influence of global factors on physical activity behaviours, such as public policy supporting active environments or urbanization (Bauman et al., 2012).

In our modern times, digital technology has emerged as a regular component in the average life and can influence physical activity (Fanning et al., 2012). Due to the development and accessibility of smartphone technology, screen time has been rapidly increasing and has been identified as a correlate of physical inactivity (Panahi & Tremblay, 2018). In youth and young adults, increased screen time has been identified as a predictor of lower physical activity behaviours, low physical fitness, and is positively associated with sedentary behaviours (Lepp et al., 2013; Towne et al., 2017). However, it is important to identify that not all digital technologies are harmful (Lepp et al., 2013), and that digital technology can be supportive of physical activity behaviours (Colberg & Scheiner, 2022). For instance, smartphones and social media increase access to health information and can increase the reach and engagement with physical activity campaigns (Goodyear et al., 2021). Further, technologies such as wearable activity trackers have become popular across populations and can have a positive impact on behaviour (Ferguson et al., 2022).

Cross-sectional studies highlight correlates of behaviour but do not provide insight into determinants of behaviour change over time (Bauman et al., 2012; Rhodes & Quinlan, 2014). Longitudinal designs and observational studies may offer a casual understanding of variables that predict behaviour change (Rhodes & Quinlan, 2014). For instance, while age and sex are consistent correlates of physical activity, a review from Rhodes and Quinlan (2014) found no significant support for the relationships between age or sex and changes in physical activity over time. As discussed in their review, many identified correlates of physical activity were found to have no significant relationship with changes in physical activity except for exercise intention, which was found to be the clearest determinant of physical activity (Rhodes & Quinlan, 2014). The importance of examining behaviour change over time was also seen during pandemic lockdowns where researchers found that day-level physical activity was associated with evening affect but did not buffer stress experienced in the pandemic (Do et al., 2021). Ultimately, physical activity is influenced by the complex interaction of multiple factors, and correlates of physical activity as determined by between-person differences do not account for within-person changes (Rhodes & Quinlan, 2014). As such, research that focuses on longitudinal and observational designs that highlight within-person changes will be most successful at guiding behaviour interventions and public health campaigns.

2.2 Relationship Between the Use of Wrist-Worn Wearable Activity Trackers and Physical Activity Behaviours

Wrist-worn wearable activity trackers (WATs) are a digital health technology that has continued to increase in popularity since the mid-2000s (Girginov et al., 2020). The use of wearable technology in our modern society has many potential benefits in addition to improving the well-being of users (Kalantari, 2017). The ability to objectively measure physical activity not only benefits research and personal health but has also been adopted in the medical field to provide doctors with up-to-date data on patient status and activities (Chan et al., 2022; Rupp et al., 2018). Wearable activity trackers are commonly recognized as tools for self-monitoring or physical activity goal-setting (Papalia et al., 2018). Compared to original self-monitoring tools such as pedometers, recent versions of wrist-worn wearable trackers are designed with improved connectivity features and can provide personalized feedback (Papalia et al., 2018; Sloan et al., 2018). Additional features that are common in modern WATs include step tracking, altitude, activity minutes, energy expended and sleep tracking (Chan et al., 2022). Popular examples of modern wearable activity trackers include Apple Watch, Fit Bit, Garmin, and Samsung. While older models of WATs featured valid measurements of step tracking but overestimations of energy expenditure (Bai et al., 2017), newer models of consumer-based WATs feature overall improved accuracy of measurements (Shin et al., 2019). Overall, WATs are a low-cost and accessible tool to track physical activity and self-monitor health behaviours, with smartwatches offering more sophisticated social connectivity features (Ferguson et al., 2022).

Wrist-worn WATs provide consumers with a continuous stream of self-regulation information (Ferguson et al., 2022). As described by Ajana (2020), the idea of self-tracking has increased in popularity with the advancement of technology, where consumers can automatically track every aspect of their daily lives. WATs allow users to set personalized movement goals, receive instant feedback on their behaviours, and the devices encourage users to meet their goals daily (Kinney et al., 2019). As the ability to self-track has become easier and more accessible, more individuals are turning to technology to monitor health behaviours such as physical activity (Jin et al., 2020). In 2021, the wearable activity tracker industry was valued at USD 45 billion and is expected to grow to $192 billion by 2030 (*Global News Wire, n.d.*). In addition to providing feedback on an individual's movements throughout the day, WATs may be useful to increase motivation and self-efficacy to increase movement and limit sedentary behaviours (Kinney et al., 2019). In their study exploring the experiences of college students with WATs, Kinney and colleagues (2019) found that just under 23% of participants currently used a WAT (most commonly Fitbit and Apple Watch) and that the majority (71%) of users reported using their device to increase their physical activity or steps per day. In the same study, most WAT users reported their confidence to increase their physical activity levels as at least "moderately confident" (61.3%), and if users perceived that their WAT would increase their physical activity, they were 32 times more likely to report higher motivation to exercise (Kinney et al., 2019).

While wearable technology is a growing industry, not all individuals experience wearable technology in the same way, as many factors can influence wearable technology usage, including both technology and individual characteristics (Jin et al., 2020). Specifically, previous studies on the acceptability and adoption of wearable activity trackers note that older adults are less likely to accept and adopt the use of a WAT and may need greater support with set-up regardless of the ease of use (Shin et al., 2019). Supportive of this finding, Rupp and colleagues (2018) found that older adults reported greater difficulty with the use of fitness devices. In addition to acceptability, there are concerns with short-term use and an inconsistent effect across individuals (Girginov et al., 2020). Specifically, a study from 2014 reported that up to one-third of users abandon their device within 4-6 months (Ledger & McCaffrey, 2014), while other studies suggest that up to 50% of users stop using their WAT within the first year (Girginov et al., 2020). This evidence highlights differences in experiences between individuals and may explain the mixed effects that WATs have on behaviours.

2.2.1 Interventions Utilizing Wearable Activity Trackers

In physical activity interventions, the addition of WATs has shown promising results (McCormack et al., 2022). A review and meta-analysis of systematic reviews found that overall WATs have a positive effect on the physical activity levels of users across age groups, concluding that there is enough evidence to support the use of WATs for physical activity (Ferguson et al., 2022). Specifically, the meta-analysis reported a clinically significant increase in MVPA of 6 minutes per day (d=0.3, small effect), as well as an increase in walking by 40 minutes (d=0.4) and 1800 extra daily steps (d=0.6) in interventions that used WATs (Ferguson et al., 2022). Similarly, a systematic review of randomized control trials by Tang et al. (2020) reported that WATs were associated with small increases in physical activity in healthy adults, however, this review reported short-term benefits of WATs on physical activity as the average intervention duration was 21.4 weeks and long-term impacts were not reported (Tang et al., 2020). This is consistent with previous research that found the most success with WATs in short-term interventions (Shih et al., 2015). A systematic review from 2021 also assessed studies that examined the effect of WATs on motivation for physical activity, finding promising results that WATs may be effective at improving motivation for physical activity in adults and older adults (Nuss et al., 2021). Along with positive outcomes, there are inconsistencies in the effectiveness of WATs in physical activity interventions (Lynch et al., 2020; Yen & Chiu, 2019). In a randomized control trial, WATs alone had a null effect on improving physical activity levels in young adults (Kim et al., 2018). When used in physical activity interventions for weight control, wearable technology had a moderately significant effect on body weight and waist circumference but was more effective in interventions with a duration of longer than or equal to 12 weeks (Yen & Chiu, 2019). Overall, while WATs have to potential to increase physical activity behaviours and positively impact motivation for physical activity, evidence of their effectiveness across all age groups remains mixed and more robust research is required (Nuss et al., 2021).

User characteristics may explain the mixed effects and concerns with low rates of long-term adoption as studies have shown differences between successful users and non-users (Friel & Garber, 2020; Nuss & Li, 2021). In a recent mixed-methods study, Nuss and Li (2021) found that while there were no differences in reported physical activity between current and former WAT users, differences between reasons for use and motivation existed. Specifically, successful users reported using their wearable device to measure their activity rather than gain motivation for activity compared to former users who reported feelings of guilt towards their device goals (Nuss & Li, 2021). Similarly, a qualitative study of current and former users also reported differences in motivation between users and that widespread adoption may be impacted by motivation (Burford et al., 2021). However, while a study from 2020 reported that current WATs users had higher self-reported physical levels compared to former users, more than half of the individuals in both groups reported doing enough physical activity to be meeting recommended guidelines (Friel & Garber, 2020). Together, these findings suggest that WATs alone may not be sufficient to support physical activity behaviours in all individuals and additional strategies are required to increase use and long-term adoption.

A consistent finding within the current literature is that WATs may be most effective at improving physical activity when combined with an additional intervention or behaviour change strategies, and alone as a self-regulation device may not be sufficient to create meaningful changes in behaviour (Lynch et al., 2020). This is consistent with research that suggests, in general, using a combination of behaviour change techniques (i.e. demonstration of behaviour, social support, giving feedback) is more effective at supporting positive changes in physical activity for adults compared to stand-alone techniques (Rhodes et al., 2017). For instance, interventions that combined motivational interviewing with the feedback of WATs were shown to be effective at significantly improving physical activity behaviours by supporting autonomous motivation for physical activity (Nuss et al., 2021). Additionally, habit formation is recognized as an effective behaviour change strategy and research highlights that habit education in combination with WAT use can increase physical activity more than wearable use alone (Ellingson et al., 2019). Utilizing smartphone technology, it has become easier to combine multiple behaviour change techniques which can be used in combination with a wearable device to further improve physical activity (Gal et al., 2018). It is common for WATs to be used in combination with mobile applications (eHealth apps), where data collected from the wearable device can be displayed with options for social competition, self-monitoring, and group-based activities (McCormack et al., 2022). In a recent systemic review of mHealth interventions in cancer patients, the most common combination of intervention components was a mobile app with a WAT (Wang et al., 2022). In support of this, a 2018 systematic review and meta-analysis of randomized control trials found that interventions which include wearable devices and smartphone applications had a small to moderate effect on increasing physical activity behaviour and that both technologies have the potential to deliver personalized interventions in the future (Gal et al., 2018). A recent study examining wearable activity trackers and an eHealth app on physical activity included a qualitative component that found wearable device users reported changes to their awareness and motivation for physical activity (McCormack et al., 2022). The study also concluded that providing individuals with a wearable device along with an eHealth platform was an effective strategy to increase physical activity and reduce sedentary behaviours (McCormack et al., 2022). Overall, wearable fitness trackers have the potential to increase physical activity behaviours and may be most effective when combined with other behaviour change techniques, when used in multifaceted interventions or for specific populations (Brickwood et al., 2019; Ellingson et al., 2019; Lynch et al., 2020).

Ecological momentary assessments (EMA) and daily diary studies can provide researchers with a greater understanding of how behaviours change over time, and due to improvements in technology, this type of research has increased in use (Dunton, 2017). The aim of event-sampling or daily measurements of a desired outcome is to limit the bias associated with recall and to measure behaviours as they are happening to provide a more accurate measurement

(Shiffman et al., 2008). Within physical activity research, the use of smartphones and WATs increases a researcher's ability to measure health behaviours subjectively as well as objectively at multiple time points in a set period (Dunton, 2017). For instance, an EMA study from 2022 was able to objectively compare the physical activity levels of university students on structured and non-structured days using WATs (Bai et al., 2022). Through a daily survey, the authors of the study were also able to determine that physical activity was associated with other health behaviours in students (Bai et al., 2022). Furthermore, while previous research has focused on between-group comparisons of behaviour, mixed-method longitudinal study designs allow for within-person comparisons of behaviour by assessing repeated measures which add depth to analysis and a stronger understanding of changes in behaviours over time (Degroote et al., 2020; Yao Lin & Lachman, 2021). As discussed by Rhodes and colleagues (2014), while research on factors that predict physical activity is crucial to understanding group differences, it cannot be used to fully explain individual changes in behaviour over time. While many EMA studies use WATs to objectively measure physical activity over time (C. Wu et al., 2021), longitudinal and observational studies will also be key to examining the effect that WATs themselves have on daily behaviour outcomes.

2.2.2 Theoretical Framework for Changes in Physical Activity as a Result of Wearable Activity Trackers – Self-Determination Theory

Modern wrist-worn WATs, including smartwatches, provide users with a variety of tools as well as a constant stream of self-regulation information and certain theoretical frameworks can be used to explain how these devices influence behaviour. For instance, as these devices are tools for self-regulation, Control Theory is a framework that could be used to explain how continuous feedback loops can influence health behaviours like physical activity (Carver &

Scheier, 1982). In their theory, Carver and Scheier (1982) explain monitoring behaviour through a negative feedback loop where a behaviour or outcome occurs when there is a discrepancy between the current state and a goal state. In practice, behaviour change techniques grounded in control theory, such as behaviour goal setting and self-monitoring, are associated with positive changes in exercise intention but show little effect on autonomous motivation (Knittle et al., 2018). Within control theory and the case of physical activity, the behaviour is not the desired goal itself but it is the outcome of an attempt to maintain a set status (Carver & Scheier, 1982). In the case of wearable devices, when an individual’s physical activity levels are different from the pre-determined goal (i.e. 10,000 steps daily) the resulting outcome will be an increase in physical activity through walking to reach the goal for that day. In their simplest form, wearable devices like pedometers monitor users’ behaviours in relation to a set goal as described by control theory; however, this theory does not incorporate increases in physical activity out of desire and only out of necessity to meet a goal. On the other side of controlled behaviours lies the engagement in behaviours out of feelings of pleasure and enjoyment, rather than as a consequence (Ryan & Deci, 2000). Modern wearable devices provide users with more than basic self-monitoring and can potentially foster engagement in physical activity through encouragement, social connectivity features and choice. Thus, a motivation theory that considers both controlled and autonomous may better explain how wearable devices can influence motivation for physical activity as well as lead to changes in physical activity itself.

Self-determination theory (SDT) is a prominent motivation theory that describes self-determined motivation as the result of basic needs satisfaction (Ryan & Deci, 2000). The three basic needs are defined as autonomy (i.e., feeling of the ability to control decisions), competence (i.e., sense of confidence in abilities and skills) and relatedness (i.e., feeling connected to others). When the social environment satisfies these needs, individuals will be intrinsically motivated for a certain activity. Further, SDT describes motivation on a continuum from amotivation (non-regulation) to extrinsic motivation, followed by intrinsic motivation (self-determined). Within the continuum, extrinsic motivation can be divided into four types of regulation from least self-determined to most: external regulation (i.e., rewards and incentives), introjected regulation (i.e., feelings of guilt), identified regulation (i.e., one's values) and integrated regulation (i.e., part of one's self). Finally, amotivation is defined as a lack of motivation for an activity.

Following SDT, social environments and behaviour techniques that are needs-supporting should lead to positive changes in behaviour through increases in autonomous motivation for that behaviour whereas need-thwarting contexts would lead to a decrease in behaviours (Teixeira et al., 2020). Social environments can refer to the friends, healthcare professionals that one engages with as well as in additional forms such as online connections, messages, or through apps. Interventions using behaviour change techniques grounded in SDT have been shown to be effective at influencing motivation for a particular behaviour leading to positive changes in the behaviours as well (Teixeira et al., 2020). In addition, SDT techniques have been successfully used in other contexts such as within teachers and educational settings (Teixeira et al., 2020).

The literature supports that greater autonomous motivation is associated with positive behaviour changes (Teixeira et al., 2012). Specifically, identified regulation, integrated regulation and intrinsic motivation are generally shown to be associated with increased physical activity (Manninen et al., 2022). Further, greater identified regulation is related to greater engagement and short-term adoption of exercise whereas intrinsic motivation has been shown to be related to long-term adoption and maintenance of exercise (Teixeira et al., 2012). Alternatively, controlled motivation for physical activity, or engaging in activities out of guilt or reward, has been shown to be associated with external goals like appearance or rewards (Teixeira et al., 2012). Additionally, more controlled motivation is associated with less behavioural maintenance, where controlled motivation can regulate short-term behaviour but does not support long-term behaviours, as well as showing null association to exercise behaviours (Knittle et al., 2018; Teixeira et al., 2012). Conversely, some literature has found that more traditionally controlled forms of motivation can be supportive of adaptive outcomes (Howard et al., 2021), such as introjected regulation on exercise intention (Ntoumanis et al., 2021), and does not have a completely negative impact.

From the perspective of needs-support, the three psychological needs have been shown to be positively associated with autonomous motivation as well as physical activity behaviours (Manninen et al., 2022) Autonomy, competence and relatedness have all been shown to be predictive of autonomous motivation with competence being the strongest predictor (Ntoumanis et al., 2021). Similarly, lower perceived competence and autonomy have been shown to be associated with lower self-determined motivation for MVPA in a sample of Canadian nurses, where less self-determined motivation was also associated with lower MVPA (Zhang et al., 2020). In a meta-analysis of studies within healthcare contexts, the satisfaction of autonomy, competence and relatedness were all positively correlated with exercise and physical activity (Ng et al., 2012). In health behaviour interventions, perception of needs support and autonomous motivation were also associated with positive health behaviour changes (Ntoumanis et al., 2021).

Fulfilment of the three basic needs as described within SDT can be used to explain how using wearable activity trackers could influence physical activity motivation and behaviours (Karapanos et al., 2016; Kerner & Goodyear, 2017; Schaben & Furness, 2018). A study on wearable fitness trackers in college-age students suggested that wearable activity trackers increased participants' sense of autonomy from self-selecting goals on the tracker, in addition to an increased feeling of competence from the immediate positive feedback for completing one's goals (Schaben & Furness, 2018). Both positive feedback and autonomy-promoting environments are recognized to be supportive of self-determined motivation leading to greater physical activity (Kerner & Goodyear, 2017). In physical activity interventions, interventions using goal setting that allows for choice will target participant autonomy and potentially support autonomous motivation (Gillison et al., 2018). It is also supported that devices with higher technology affordances – such as perceptions of what the device allows users to do and properties of the device that are aligned with the user's goals - can increase basic needs satisfaction (Zhou et al., 2021). Further, wearable activity trackers have been shown to increase feelings of relatedness, when users can connect with and relate to family members or friends who are also using wearable trackers (Karapanos et al., 2016; Rupp et al., 2018).

Based on this evidence, SDT may be an effective theory to explain changes in physical activity motivation through the satisfaction of basic needs from using wearable activity trackers, and there is the potential for an increased effect in physical activity interventions that use WATs (Nuss et al., 2020). Additionally, the satisfaction of the needs for autonomy, competence and relatedness may help predict future technology use and explain why individuals continue to use the technology (Rupp et al., 2018). When comparing current and former WAT users, those who were successful WAT users (current users) had significantly higher scores for both introjected and identified regulation, which are classified as more autonomous forms of regulation on the motivation continuum (Nuss & Li, 2021).

Conversely, failure to meet these basic needs may lead individuals to be de-motivated for physical activity (Rupp et al., 2018). An 8-week FitBit intervention in adolescents saw a decline in autonomous motivation due to unrealistic goals and competition-driven physical activity (Kerner & Goodyear, 2017). These results, combined with a drop-off in use after the 4-week mark, suggest that the pre-set goals should be tailored to the individual and that social connection among WAT users should be supportive and non-competitive (Kerner & Goodyear, 2017). Additionally, as a behaviour change technique alone self-monitoring or the use of a pedometer have shown to have a small and insignificant effect on autonomous motivation suggesting they do not provide sufficient need satisfaction (Knittle et al., 2018). However, the use of multiple behaviour change techniques is associated with greater changes in motivation for physical activity in interventions (Knittle et al., 2018). Theoretically, WATs have the potential to improve physical activity behaviours through support for more autonomous forms of motivation and if the use of a WAT alone does not fully satisfy one's basic needs, a combination of behaviour change techniques may lead to greater autonomous motivation for physical activity and potentially greater behaviour change (Nuss et al., 2021).

2.3 Influence of Health-Related Social Media on Physical Activity

2.3.1 The Rise of Social Media Use

With the development of smartphone technology, social media use has increased in popularity as a tool for sharing information and online social connection for users (Hruska & Maresova, 2020). In 2021, there were 3.78 billion social media users worldwide, with 84% of adults in the US aged 18-29 years actively using at least one platform of social media (*10 Social Media Statistics You Need to Know in 2022 [Infographic]*, n.d.). The number of social media users continues to increase at a rapid rate with further increases due to the recent COVID-19 pandemic and the need for social connection online (Hayes, 2020). In adults, social media use has been shown to increase with income and education level but has also been shown to decrease with age (Hruska & Maresova, 2020). By comparison, regular social media use is highest in younger individuals where adolescents are the age group that are more likely to use social media compared to other age groups (Shimoga et al., 2019). Social media increases access to information, current events, and is designed to increase personal connections online through various application formats. Further, as new platforms have been created and developed, social media has become more sophisticated than space to share life highlights (Goodyear & Armour, 2018). For young adults including adolescents, social media has become a space to learn, connect with others and engage with content.

In addition to regular social media uses, social media content related to health and fitness is a growing trend and there is increasing evidence that individuals are using social media to access health information online (Goodyear et al., 2019; Pasko & Arigo, 2021). Commonly referred to as "Fitspiration", the goal of this content is to share fitness inspiration content online including health and fitness tips or motivational posts. In an assessment of why young social media users view fitspiration content, it was found that more than half of users aged 18-24 years viewed fitspiration content as motivation to improve their health as well as for inspiration for improve their body in some capacity (Mayoh & Jones, 2021). While Fitspiration is a specific trend of content, social media use is popular across all age groups and health contexts including accessing health information, sharing physical activity and health experiences, and connecting with social support (Chen & Wang, 2021; Shine et al., 2022).

2.3.2 Impact of Social Media Use on Health Behaviours

Previous research has highlighted link between social support from friends, peers, and social networks with health behaviours (Berkman et al., 2000; Tate et al., 2015). In adolescents, frequency of social media use has been shown to be significantly associated with health behaviours in adolescents (Shimoga et al., 2019). As social media is an online space for connection, social support and sharing information, these links suggest that social media can impact behaviour. It has been argued that social media is a community that provides an opportunity for peer-based learning in two different spaces: friendship-driven and interested-driven spaces (Goodyear & Armour, 2018; Ito et al., 2013). Friendship-driven spaces provide social media users with social support and support for self-expression, through gaining and providing feedback to other peers (Ito et al., 2013). Interest-driven spaces influence learning through interactions with people seen as having more experience as well as mentoring others. Ito and colleagues (2013) further argue that young adults' health-based learning could be enhanced by these social networks, and the idea that social media can have a positive impact on health-related knowledge and behaviours is supported (Goodyear & Armour, 2018). While the technology continues to develop, social media is widely used and has been adopted into society and there is evidence to suggest that social media could be used as an effective health promotion tool.

Social influence may be used to explain the effects of health-related social media on the physical activity behaviours of content viewers (Centola, 2013; Zhang et al., 2015). A study from 2015 assessed the impact of both promotional messaging and social influence on exercise class enrollment compared to a control (Zhang et al., 2015). Results from the study found that promotional messaging was effective at increasing exercise class enrollments at the lower end of exercise frequency, where the promotional messaging group was significantly more likely to enroll in one exercise class compared to the control group. In comparison, social influence had a greater overall influence on exercise class enrollment, where participants in the social network group were 60% more likely to enroll in 4 or more classes compared to the control group. In this study, the media group was provided with visual content that included promotional and motivational messaging, whereas the social network group was provided a network of up to 6 anonymous "peers" with insights into their demographic information and class enrollment progress (Zhang et al., 2015). This research methodology is comparable to social media and results from this study may help explain how different components of health-related social media content (i.e. promotional/ positive messaging and social influence) can influence behaviour.

2.3.3 Theoretical Framework to Explain the Impact of Social Media on Physical Activity

Social media can positively impact physical activity behaviours through social comparison or social support. For instance, Social Cognitive Theory could be used to explain how outcome expectations and modelling could explain changes in physical activity as a result of viewing physical activity-related social media content (Loh et al., 2023). When individuals see successful behaviours online, in this case successful physical activity behaviours, the viewer is likely to model that same behaviour. However, similar to WATs, health-related social media may increase self-determined motivation for physical activity and increases in physical activity behaviour from social media may also be explained through SDT (Cavallo et al., 2012; Zhang et al., 2015). Through the ability to interact with others online, social media allows users to create social networks which may increase feelings of relatedness if others are also engaging in physical activity behaviours leading to an increase in autonomous motivation for physical activity (Zhang et al., 2015). Further, online networks on interactive platforms may increase feelings of social support and relatedness in users which should positively affect autonomous motivation (Cavallo et al., 2012). In a recent study on university students, social support increased was shown to increase exercise intention through increased intrinsic motivation and basic needs satisfaction (Cho et al., 2020). Additionally, previous research has suggested that relatedness can be satisfied through both face-to-face and online connections (Kerner & Goodyear, 2017). In addition to relatedness, health-related social media may be used to satisfy the need for competence and autonomy in viewers. In a review of behaviour change techniques on motivational outcomes, results show that the demonstration of behaviour had a significant yet small effect on autonomous motivation (Knittle et al., 2018). Similarly, non-controlling language has been shown to significantly predict autonomy satisfaction (Gillison et al., 2018), thus social media content that promotes choice and agency should foster autonomy satisfaction in viewers. As shown in adolescents, when used appropriately social media is supportive of autonomy (West et al., 2023). Finally, viewing the successful demonstration of health behaviours online from health-related content or receiving “likes” from other social media users may increase feelings of competence leading to greater self-determined motivation for that behaviour (Rockmann, 2019).

As previously mentioned, social media provides users with access to health information and social support from online connections (Zhou & Krishnan, 2019). Serving as an external motivator, social media increase physical activity behaviours or improve the maintenance of physical activity over time. A cross-sectional study from 2019 examined exercise intention through willingness to communicate about one’s health and social media activity in relation to exercise maintenance. The rationale of the study suggests that individuals who actively use social media related to exercise will have higher intentions to exercise, as well as have greater self-regulation through the social network and accountability through social media use. As a result, both intrinsic motivation and willingness to post on social media had significant and positive effects on social media activity related to exercise (Zhou & Krishnan, 2019). However, neither social media activity nor online support for exercise had a significant effect on exercise maintenance. In comparison, a study from 2015 found that intrinsic motivations such as information-sharing and self-monitoring (compared to social support and connecting with others) had a significant impact on sharing physical activity data online (Stragier et al., 2015). These results suggest that not only may social media be supportive of intention and increasing autonomous motivation for physical activity (Cho et al., 2020), but it may also be supportive for individuals further along their physical activity journey.

2.3.4 Social Media Used in Physical Activity Interventions

As with regular social media use where individuals are turning to online sources for health information (Zhao & Zhang, 2017), adding a social network element to physical activity interventions may aid in sharing health information and potentially have a positive impact on intervention outcomes (Goodyear et al., 2021). Social media increases the reach and accessibility of health information, and as identified by Goodyear and colleagues (2021), can be used to encourage, and support behaviour changes. A systematic review and meta-analysis of social media interventions for diet and exercise examined 22 studies that primarily used discussion boards or social networking sites as the social media component of their interventions (Williams et al., 2014). Of the 22 included studies, two studies used Facebook groups as the social media component of the interventions compared to the remaining studies that used intervention-specific sites. Results of the review found no significant difference in physical activity behaviour or changes in behaviour between the control and social media intervention groups. However, it is important to note that of the 12 studies that included a physical activity outcome measure, the overall effect of the studies favoured the intervention suggesting that social connection and social media may be beneficial to increasing physical activity in users (Williams et al., 2014). Two additional systematic reviews examined the effect of online social network interventions on health behaviours where Facebook was the most used existing social platform for interventions (Larango et al., 2015; Maher et al., 2014). A systematic review and meta-analysis from 2015 of studies that focused on fitness-related health behaviours found a similar result to previously mentioned studies, where interventions using social networking sites had a small but positive overall effect on health behaviours (Larango et al., 2015). Similarly, Maher and colleagues (2014) found that 9 out of the 10 included studies in their review reported a significant effect of online social networks on health behaviour outcomes, including smoking, physical activity, and diet, but of a small overall effect size. Additionally, of the 4 studies examining physical activity, two studies reported a moderate effect size while one study reported a large effect size (Maher et al., 2014). For both BMI and weight loss, a recent meta-analysis reported a small to moderate effect size for social media interventions in overweight adults (Loh et al., 2023). However, of the 5 randomized control trials assessing the effect of social media interventions on MVPA, no significant effect was found (Loh et al., 2023). It is critical to note, however, that in these reviews the included studies utilized both existing social networking platforms (e.g. Facebook) as well as stand-alone platforms within the interventions (e.g. FatSecret). In fact, in a review of 71 studies from 2001 to 2017, Facebook was also the most used mainstream platform (Simeon et al., 2020). As Maher and colleagues mention in their review, using existing social networking sites for health behaviour interventions may be more effective at improving buy-in and retention to interventions as those platforms are already being used in everyday life (Maher et al., 2014). This is echoed in recent research that examined young adults' experiences with social media where authors support the notion that the platform used may have a large effect on the effectiveness of translating information (Lim et al., 2022). While many interventions are delivered via Facebook or stand-alone sites, the authors of this study recognized that many young adults are migrating to video-based platforms (i.e. Instagram and TikTok) and interventions may benefit from using popular platforms (Lim et al., 2022). In addition, more research with study designs that track or promote real-world social media engagement habits would be beneficial to fully understand how media interventions can be effective (Maher et al., 2014).

Currently, interventions utilizing existing social media platforms have evolved to provide social interaction and live feedback components to interventions and may further influence behaviours compared to studies examining older social networking sites (Tate et al., 2015). In social media interventions targeting health behaviours, social support and instruction on how to perform the behaviour were among the most commonly used behaviour change techniques (Simeon et al., 2020). Results from a recent systematic review examining the effectiveness of social media interventions on health behaviours suggest social media interventions can positively impact physical activity behaviours in young adults, noting that social media increased the accessibility of information and interactions of participants, but the impact on physical activity itself is small (Goodyear et al., 2021). Similarly, as social networking sites have become integrated into our daily lives, there is a high potential for engagement and less participant burden in interventions (Laranjo et al., 2014). For instance, a study on undergraduate students found that adherence to a home-based exercise program was significantly higher for the intervention group that viewed and interacted with motivational posts on Instagram for the duration of the program (Al-Eisa et al., 2016). Additionally, as many health promotion interventions target the dissemination of information and increasing social support, the type of platform used in interventions should be determined by the overall goal and the social media behaviours of users to be most effective (Lim et al., 2022). A study that assessed social media diaries of college students reported that Facebook was primarily used for social support (i.e. groups) and gathering information while platforms such as Instagram were used for inspiration or ideas (Lim et al., 2022). Social media interventions that increase the accessibility of positive health information can be an effective addition to physical activity interventions, however, since social media as a tool continues to evolve, more research into this field is required (Goodyear et al., 2021).

Although many health behaviour interventions target social support to positively impact behaviour, the results of these interventions tend to have mixed or small effects on behaviours. Even though social support is a correlate of physical activity in adults (Sallis et al., 2016), physical activity interventions that include social support or social influence as moderators show positive but inconclusive results suggesting that social support does not entirely explain changes in physical activity (Rhodes et al., 2017). Similarly for healthy eating, a systematic review of social media-based nutrition interventions found that only 1 in 9 randomized control trials had a significant positive effect (Klassen et al., 2018). Authors of the review noted that young adults are receptive of receiving health information from online sources but are reluctant to share their experiences online, which has shown to be a key component of social support (Klassen et al., 2018). Overall, social media interventions that have focused on social networking sites and social support seem to have a small effect on behaviour; however, the effect appears to be positive and no negative outcomes have been reported from social media interventions (Petkovic et al., 2021) Furthermore, targeting health information and other behaviour change techniques on popular social media platforms in addition to social support may be key to increasing the effectiveness of social media interventions. For instance, other commonly used behaviour change techniquess in social media interventions, such as the instruction of behaviours, health information consequences and self-monitoring (Simeon et al., 2020), may be more effective and conducive to popular platforms and regular social media use.

Of the limited studies that have examined the effect of viewing social media on physical activity behaviours, there is mixed evidence with some reporting a significant association of viewing health-related social media with increased physical activity (Al-Eisa et al., 2016), while other studies have found no effects (Arigo et al., 2021; Prichard et al., 2020; Robinson et al., 2017). One study reported a significant increase in adherence to a home-based exercise program in the intervention group who viewed and interacted with motivational posts on Instagram for the duration of the program compared to the control group who did not (Al-Eisa et al., 2016). Meanwhile, in a study comparing the effects of fitspiration image captions on exercise behaviour in university students, caption messaging had a significant impact on exercise motivation but there was no difference in recreation centre check-ins between groups (Arigo et al., 2021). Finally, in one study comparing the effects of viewing fitspiration posts on Instagram compared to travel posts, there was no difference in exercise behaviour between groups, however, participants that viewed fitspiration posts reported higher exercise exertion (Prichard et al., 2020).

There is also evidence of an association between health-related social media and exercise behaviours in outside of interventions (Peng et al., 2019; Welker et al., 2019). Welker and colleagues (2019) reported that exercise frequency was significantly greater in those who viewed health-related social media content compared to individuals who do not, however, there was no impact on exercise motivation. This study also reported that many students use social media to access health information (Welker et al., 2019). Further, in adult women who post fitspiration content compared to those who post travel content on social media, those who post fitspiration content were found to have higher compulsive exercise behaviour scores (Holland & Tiggemann, 2017). While most research in this area focuses on females, one study examined both the psychological and behavioural impacts of social influence through Instagram posts on work out intention (Peng et al., 2019). In response to viewing fitspiration images on Instagram, upward social comparison to models in the images led to the highest levels of motivation for self-improvement which was further found to be positively related to workout intention (Peng et al., 2019). However, when discussing engagement with health-related content online, the distinction between active viewing and passive viewing should be made. A recent study out of the United States found that overall, fitness content online had a significant impact on behaviour, however, differences between engagement levels were found (Rowles, 2021). The study concluded that viewing fitness content on social media had a significant impact on physical activity frequency and duration, as well as an individual's interest in exercise (Rowles, 2021).

There is also evidence of a similar influence from athletes and professionals (Hayes, 2020). In the world of sports, social media provides a medium for elite and professional athletes to connect with fans and potentially influence the number of youths playing sports, increasing rates of physical activity (Hayes, 2020). Further, elite athletes sharing workout videos or training routines may increase physical activity from fans of all ages or recreational athletes. More recently, social media has highlighted elite athleticism in female athletes and those who do not receive much traditional media attention. The online presence of female athletes may increase sport participation or physical activity in women and young girls (Hayes, 2020).

As mentioned by Welker and colleagues (2019), when assessing the results of cross-sectional studies, it remains unclear whether viewing social media content related to exercise (i.e. Fitspiration) results in increased exercise behaviour, or if those who are physically active engage more with online content that they relate to. Further, the type of platform used may predict the effectiveness of social media interventions on physical activity. Social media may have the potential to increase the reach of health information and be used in physical activity interventions, however, social media continues to develop and grow in use and more research in this field is required (Pope et al., 2019).

2.3.5 Mental Health Considerations

It is crucial to recognize that previous research has argued that social media use is not entirely positive and can have a negative impact on users (Shimoga et al., 2019). Studies have found excessive social media use to be significantly associated with symptoms of depression, body dissatisfaction, and general anxiety (Sharma et al., 2020). The potentially negative impact of Fitspiration content on social media should also be noted. While upward social comparison can be positively associated with workout intention (Peng et al., 2019), social comparison can lead to body dissatisfaction and negative behaviour outcomes (Tiggemann & Zaccardo, 2015). Exposure to Fitspiration images has been shown to have a negative impact on mood, self-esteem and body satisfaction (Tiggemann & Zaccardo, 2015). Previous content analyses have shown that Fitspiration content tends to adhere to thin and muscular ideals which can be viewed as unattainable to viewers, leading to increased body dissatisfaction (Carrotte et al., 2017; Jerónimo & Carraça, 2022). However, health-related content that highlights diverse body types may have a more positive impact on mental health and physical activity outcomes (Nuss et al., 2023).

In addition to negative mental health outcomes, there is evidence linking social media use with decreased physical activity (Shimoga et al., 2020). More specifically, higher social media use has been shown to be associated with decreased physical activity behaviours in currently low-activity youth, compared to a positive association between social media and physical activity in moderately physically active youth (Shimoga et al., 2019). In addition, an 8-day daily diary study of 782 American adults found that less social media use was associated with greater exercise frequency and greater positive affect (Yao Lin & Lachman, 2021). However, this relationship was only found in middle to older age adults, not in younger adults, and the study included all forms of social media use (Yao Lin & Lachman, 2021). These negative associations are of most concern as younger adults have been shown to be the earliest adopters of social media and the age group with the highest usage (Sharma et al., 2020). Further, the evidence in this field remains mixed and inconclusive as to the true effect of using social media (Sharma et al., 2020). While excessive social media use is associated with negative outcomes, for moderate social media use the advantages may outweigh the risks (Przybylski & Weinstein, 2017). A study examining the relationship between digital technology and mental well-being in adolescents concluded that the relationship was non-linear, and that moderate use did not have a negative impact (Przybylski & Weinstein, 2017). As research on these uses of social media increases, it will be important to consider the negative consequences that have been reported.

2.4 Explanation of Augmenting Effect of Social Media on Wearable Devices and Motivation for Physical Activity

Research suggests that WATs do not have the same effect for all users, but a factor that can influence fitness tracker usage is social influence (Jin et al., 2020). Specifically, social influences such as social connection, social expectations, social comparison, and even social media have been shown to impact usage. Studies also suggest that long-term adoption is supported when the device satisfies one's desire to compete with friends and share their fitness data (Jin et al., 2020). In addition to these findings, a study from 2017 also shows that greater physical activity levels are related to the extent of fitness tracker use and using a higher number of features on the app such as goal setting and social features (Giddens, 2017). As for the relationship between fitness trackers and motivation, there is evidence of a decreased effect when individuals lack support. Finally, Jin and colleagues (2020) also report that there is a positive effect between activity trackers and physical activity levels when a fitness tracker is accompanied by a social feature, social networking sites, or previously existing motivation for activity (Jin et al., 2020).

These findings align with the findings of studies that suggest WATs are most effective when combined with additional behaviour change techniques or intervention elements (Nuss et al., 2021). Combining the potential benefits of health-related social media with WATs may result in a more scalable and personalized approach to targeting physical activity compared to the stand-alone mobile apps typically used in physical activity interventions (Drehlich et al., 2020; Maher et al., 2014). Additionally, one study suggests that WATs alone do not impact motivation for physical activity and should be combined with other intervention tools to have a greater impact (Nuss et al., 2021). Previous studies that have examined the combination of these tools highlight promising results. A qualitative study from 2016 examined the possibility of combining wearable activity trackers with social support from social networking sites to increase physical activity and adherence to WAT use (Chang et al., 2016). Results of the focus group suggested that WATs were most effective at increasing physical activity awareness and that social support from social media could be used to increase engagement with the WAT and physical activity behaviours. Related to the work of Jin and colleagues (2020), social media that leads to increased engagement and use of a WAT should positively impact physical activity. However, this study primarily focused on social messaging applications and social support rather than the image-based social media that is used today (Chang et al., 2016).

As wearable and social media technology continues to develop, more research is required to fully understand the effect on physical activity and the differences in user experiences that are emerging (Friel & Garber, 2020). A systematic review from 2018 found that user's experiences with social features in mobile health interventions were mixed and the authors concluded that a one-size-fits-all approach is not sufficient to change behaviour (Tong & Laranjo, 2018). Unlike mobile health intervention apps, social media allows for personalization and control of how health information is accessed and used. In addition to this research, studies highlight differences in the way successful and former WAT users tend to share the data that is collected by the device, where successful users tend to track and share their physical activity more than former users (Friel & Garber, 2020). Regular social media use that increases individuals' engagement with their WAT should have a positive effect on physical activity. It is important to understand how these tools interact on a daily level to influence physical activity behaviour as physical activity is not a single occurrence and can fluctuate over time (Dunton, 2017). Examining the cumulative effects of WATs and social media on physical activity and motivation has only been conducted using cross-sectional methods and does not evaluate how these factors interact over time (Pope et al., 2019).

2.4.1 A Shift to Autonomous Motivation for Physical Activity

As explained through self-determination theory, if one's social environment satisfies the three basic needs the result will be an increase in autonomous motivation for a certain behaviour leading to a positive effect on behaviour (Ryan & Deci, 2000). While WATs alone may satisfy the three basic needs (Schaben & Furness, 2018), viewing health-related social media as a current WAT user may lead to more autonomous motivations for a behaviour and potentially increase physical activity by further satisfy the three basic needs (Zhou & Krishnan, 2018). For new WAT device users, viewing health-related social media may further increase feelings of competence from viewing demonstrations of behaviour online which may be solidified when users receive positive feedback from completing a goal on their device. Additionally, engaging with social connections online around health content may increase feelings of relatedness leading to WAT users fully engaging with their device and increasing activity.

Long-term, health-related social media may increase the adoption of WAT and increase the number of successful users. According to SDT, integrated regulation is the most autonomous form of extrinsic motivation before intrinsic motivation (Deci & Ryan, 2000). Integrated regulation, similar to identity, is described as motivation for a behaviour that is regulated by feelings of it being part of oneself or identifying with the behaviour (Strachan et al., 2013). In the case of exercise, individuals who identify themselves as "exercisers" are more likely to be physically active to match their behaviours to the persona they identify with (Strachan et al., 2013). A Canadian study from 2021 aimed to determine an association between Instagram use and exercise identity (Liu et al., 2021). The study found that both the number of fitness-related posts and the number of fitness-related accounts that were followed were significantly associated with exercise identity, further suggesting that the use of fitness-related accounts and health-related social media may have an impact on exercise behaviours (Liu et al., 2021; Strachan et al., 2013). Similarly, a study from 2018 found that for a small sample of runners, social media played a significant role in identity formation (Jansen & Shields, 2018 SCAPPS). As previous research has noted, successful WATs users report greater scores for integrated regulation (Nuss & Li, 2021). Additionally, successful long-term users are more likely to share their data online compared to individuals who did not find success long-term (Friel & Garber, 2020). As such, targeting the social media behaviours of WAT users focusing on autonomous motivation for physical activity, such as identity, may be most effective at positively impacting exercise behaviours over time (Strachan et al., 2013).

A limitation of the current literature on the relationships between health-related social media and WATs is the reliance on a cross-sectional study design. As previously mentioned in the literature, the causation of this relationship has yet to be determined (Welker et al., 2019). The same limitation exists for WATs as it is unclear if long-term use of wearable devices fosters greater autonomous motivation or if those with more self-determined motivation, such as stronger exercise identity, tend to use these tools (Nuss & Li, 2021). In addition, the day-to-day influence of health-related social media consumption is also unknown. Theoretically, WATs and health-related social media should support a shift to greater autonomous motivation for physical activity, however, more research on these relationships is required.

2.5 Study Rationale

Currently, there is evidence to support that both social media and WATs independently and positively impact physical activity behaviours (Ferguson et al., 2022; Pope et al., 2019; Welker et al., 2019). Additionally, there is evidence, although limited, supporting the cumulative effect of WATs and social media on health behaviours (Chang et al., 2016). Examining the effect of both WAT and health-related social media on daily physical activity motivation and behaviours will add valuable evidence to the currently limited body of evidence. Further, much of the current literature focuses on between-person differences and little is known about the daily impact of these tools on physical activity and motivation over time. As individuals interact with these technologies on a daily basis, it is crucial to understand how these tools could interact to impact daily behaviours in addition to understanding who these tools may be most effective on.

Chapter 3 Methods

3.1 Study Design

This was a prospective observational study. Participants completed a 14-day daily diary protocol. Participants were recruited through online advertisements, the ReachBC research portal, University of Victoria email channels, as well as the University of Victoria SONA portal. Recruitment and data collection for this study began in February 2022, following full approval by the University of Victoria Human Ethics Board, and continued until February 2023. Ethics for this study was obtained from the University of Victoria Human Research Ethics Board (HREB #21-0404).

3.1.1 Participants

Inclusion criteria included adults 18+ years of age, who live in Canada, own an Apple or Android smartphone, and were willing to use that smartphone to answer surveys on a mobile application, Pathverse (Liu et al., 2022). Exclusion criteria was not being able to comprehend English.

3.2 Study Procedure

Interested participants were directed to an online survey from links in advertisements where the eligibility screening, participant consent form, and baseline survey were completed. Participants first completed a short screening survey to determine eligibility, followed by providing informed consent to participate in the study if they were determined to be eligible. On the consent form participants provided an email address which was used to enroll them in the daily diary portion of the study. Finally, participants completed a baseline survey of approximately 55 minutes in length. The baseline questionnaire included measurements of social media platform use and time spent on social media, wearable device use, as well as demographic information (age, sex, gender, etc.). Following completion of the baseline survey, eligible participants were enrolled into a fourteen (14)-day daily diary portion of the study within 5 business days using the email provided on the consent form. Participants were enrolled in the daily diary program on the Pathverse mobile application. Once enrolled, participants were emailed instructions, their survey start date, and a detailed study manual providing directions for downloading and logging into the Pathverse mobile application. Participants completed up to three (3) daily mini surveys using the app over the 14-day period, including one pre-exercise survey, one post-exercise survey, and one daily evening survey to be completed regardless of physical activity participation that day. All daily surveys were approximately 5 minutes in length.

3.2.1. Study Incentives

To ensure a high percentage of completion, participants were emailed the Friday before their starting Monday with a reminder of their start date. Participants were also emailed a survey reminder three days into the survey period. Once completed, the number of surveys completed was recorded and participants were awarded their participation incentive via email. Due to the demanding nature of the 14-day protocol, participants were provided monetary incentives for their time. University of Victoria students enrolled in the Psychology program were awarded course credits through the SONA portal. Students were awarded up to a 1.5% course bonus for participating in the study. Non-psychology student participants who were not receiving course credit earned 1$ in Amazon e-gift cards for every evening survey completed, with a $10 bonus for completing at least 10 evening surveys, up to a maximum of $24 in Amazon gift cards per participant. Incentives were only awarded based on completion of the daily evening survey to limit incentivized participation in exercise to complete the pre- and post-exercise surveys.

3.3 Measures

3.3.1 Baseline Survey Measures

Social Media Use. Nine items on the baseline questionnaire were used to assess the typical social media use behaviours of participants. Specifically, participants were asked to report the days and hours they spent engaging with social media in the last two weeks that was related to health, fitness, or wellness information. Further, participants were asked to report the number of accounts and type of accounts they follow related to health and fitness to determine their utilization of social media related to gaining health and fitness information. Finally, participants were asked about their perceptions of the use of social media for accessing health information. All survey questions related to social media use were adapted from previous research in this field assessing social media use in young adults (Goodyear et al., 2021). Baseline social media behaviours were used to determine use on days when participants reported using health-related social media.

Wearable Activity Tracker (WAT) Use. The use of WATs was determined through two items on the baseline questionnaire. As part of the eligibility screening, participants were asked about their wearable activity tracker status, with participants responding if they currently use or do not use a wearable activity tracker. Further, participants who are current users were asked to report additional characteristics of their WAT use through nine additional items. Additional questions include frequency of use, changes in behaviour and goals tracked using the wearable device. Non-users were not asked additional questions regarding WATs.

Demographic Characteristics. Age was collected by asking participants to report their age by responding to one item on the baseline survey and selecting a response from a drop-down menu with possible responses ranging from "18" to "99" years. Participants were also asked to report their biological sex assigned at birth through one item on the baseline survey. The item specifically asked "What is your biological sex (assigned at birth)?" with possible answers including "Male", "Female", "Intersex", "Do not know/ Prefer not to answer", and "Other" with the option to specify. Ethnicity, race, income, education level, and school status were also assessed through the baseline survey.

3.3.2 Daily Diary Measures

Physical Activity Behaviours. Participants were asked to self-report their daily physical activity bout on the post-exercise and evening surveys over the 14-day survey period. Following the completion of their physical activities, participants reported their physical activity duration in categorical increments of 10 minutes, intensity on a 7-point scale from very low intensity to very vigorous intensity, and activity type. Both intensity and minutes of activity were used to calculate daily MVPA.

Daily Health-Related Social Media Use. To measure daily social media use, the daily evening survey asked participants to report whether they used or looked at health-related social media content that day, including social media content related to fitness, wellness, and Fitspiration posts. Specifically, participants were asked "Did you look at fitness/health/nutrition/wellness related social media content today?”. Participants were asked to report their activity as “Yes” or “No”.

14-Day Social Media Use. The proportion of days that a participant reported viewing health-related social media over the 14-day study period was also measured. 14-day social media use scores were calculated by totalling the number of days that a participant reported “Yes” to viewing social media on the evening survey and dividing by 14. Values ranged from 0 to 1.

Situational Motivation for Physical Activity. Daily motivation for physical activity was assessed on the pre-exercise survey through 20 items from the Situational Motivation Scale (SIMS; Guay et al., 2000). Specifically, participants were asked to rate how each statement corresponds to their reason for engaging in physical activity that day, on a sliding 7-point scale from “corresponds not at all” (scored as 1) to “corresponds exactly” (scored as 7) to determine scores for external, identified, and introjected regulation, amotivation, and intrinsic motivation. The SIMS is a validated measure that assesses self-determination theory constructs and has shown to be sensitive enough to capture intraindividual changes in motivation for a behaviour (Guay et al., 2000).

Daily Exercise Check. Two items on the evening survey were used to determine if missing physical activity data was in fact missing or if participants did not exercise that day. Participants were first asked to confirm if they exercised that day and then asked to confirm if they completed the exercise surveys or not.

3.4 Justification of Sample Size

As discussed by Oleson and colleagues (2022), in EMA study designs power is impacted by both the number of subjects per group as well as the number of surveys completed by each subject. In addition, for longitudinal designs both missing data and attrition should be accounted for when determining sample size as it is not realistic to assume that the number of observations nested within subjects will remain constant (Harrall et al., 2023; Hedeker et al., 1999). According to a recent systematic review of smartphone-based EMA studies, of the 30 studies that reported dropout rates, the average rate of attrition was 17.1% (SD = 20.8%; de Vries et al., 2021). The study also reports that the average compliance rate for EMA studies included in the review was 71.6% (de Vries et al., 2021). Additionally, previous research on the effect of WATs on physical activity behaviours reports small to moderate effect sizes (0.3-0.57; (Ferguson et al., 2022). Using this rate of attrition, the expected effect size, and the number of repeated measures I am able to estimate the sample size required to be powered at 0.80. Based on sample size calculations from Hedeker and colleagues (1999), to be adequately powered to detect a small to medium effect I required a sample of approximately 200 participants.

My justification of sample size can also be confirmed based on estimations from previous studies in this field. Literature in this research field shows studies ranging in sample size from 15 participants for qualitative research (Chang et al., 2016), to over 1,500 participants for large-scale observational studies where participants are provided with a wearable activity tracker (C. Wu et al., 2021). For EMA studies over a week in length, sample sizes range from 123 for a seven-day EMA protocol (Marquet et al., 2018), to 200 participants for an 8-week observational period (Massar et al., 2022). At the higher end of study duration, one study included 79 participants in a 12-month EMA protocol (Yoon et al., 2018). Similar to our 14-day daily diary protocol, other physical activity studies utilizing a 28-day daily diary and EMA protocol include sample sizes from 157 (Do et al., 2021) to 390 participants (Courtney et al., 2021). Thus, based on previous estimations and other EMA research in social media and wearable technology, a sample size of 200 participants will ensure this study is adequately powered to detect a small to moderate effect.

3.5 Data Analysis

All analyses for this thesis were completed using R Software (4.2.1). Participants who completed at least one full survey, either one (1) pre-exercise survey, one (1) post-exercise survey, or one (1) evening survey, were included in the analysis. Demographic data was evaluated through chi-square and t-tests to determine characteristic differences between users and non-users of wearable activity trackers, including baseline social media characteristics.

Multi-level modelling was conducted to examine both the within-subject and between-subject associations of WATs and social media use with exercise behaviours and daily situational motivation over the 14-day daily diary period. All statistical techniques used in this study to generate results had significance set at $p < .05$. A fully unconditioned model was conducted for all situational motivation subsets as well as physical activity intensity, duration, and MVPA to determine intra-class correlation and dependency within the models. If a multi-level approach remains warranted, a series of conditioned multi-level models were conducted to evaluate both level-1 and level-2 predicting variables. As it is expected that participants will have different baseline physical activity behaviours, situational motivation profiles, as well as different rates of change over the 14 days, all models allowed for both a random intercept and slope. For data missing at random, maximum likelihood estimation was used.

3.5.1. Multi-level Models

To address the first objective of the study, multi-level models were used to determine if WAT status was associated with day-level motivations for exercise, controlling for covariates such as age and sex. WAT use was coded as 0 for non-users and 1 for WAT users. A separate model was conducted for each subset of situational motivation measured through the pre-exercise surveys for a total of 5 models. Time represents the day that daily survey data was collected and was coded to begin with time 0, the intercept. The second collected day was time 1 and so on. Time was uncentered starting at the intercept of time 0 as this study was examining variations over a 14-day study period. Biological sex (coded as 0 for Males and 1 for Females) and age (grand mean centered) were added as covariates to the model as level-2 variables. The model addressing the first objective was as follows:

Situational Motivation for Physical Activity

Level 1

$$Situational\ Motivation\ Subset_{ij} = \beta_{0j} + \beta_{1j}\left(Time_{ij}\right) + \varepsilon_{ij}$$

Level 2

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(WearableStatus) + \gamma_{02}(Age) + \gamma_{03}(Sex) + \mu_{0i}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1i}$$

To address the study's second objective, daily health-related social media use was added as a level-1 predictor to the model. Daily health-related social media use was recorded as a dichotomous variable, if participants viewed social media that day it was coded as 1. On days when participants reported not using social media, their use was coded as 0. 14-day social media use was also added to the model as a level-2 predictor, where participant's social media use over the 14-day period was measured and scored as values ranging from 0 to 1. If a participant reported "Yes" to viewing health-related social media on 7 of the 14 possible evening surveys (7/14) their 14-day social media use would be scored as 0.5. Biological sex (coded as 0 for Males and 1 for Females) and age (grand mean centered) were added as covariates to the model as level-2 variables. The model addressing the second objective is as follows:

Situational Motivation for Physical Activity and Daily Social Media Use

Level 1

$$Situational\ Motivation\ Subset_{ij} = \beta_{0j} + \beta_{1j}(Time_{ij}) + \beta_{2j}(SMUse_{ij}) + \varepsilon_{ij}$$

Level 2

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(WearableStatus) + \gamma_{02}(Age) + \gamma_{03}(Sex) + \gamma_{04}(14DaySM) + \mu_{0i}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1i}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(WearableStatus) + \mu_{2i}$$

To address the third objective of this study, models were run to determine the association of WAT use with three physical activity outcomes: daily physical activity duration, intensity, and MVPA. A separate model was conducted for each physical activity outcome to determine the effect on each variable, where MVPA was determined based on the reported duration and intensity of participants. Reported bouts of physical activity of any duration at an intensity of moderate or greater were included as MVPA in this model. Since duration was collected as a categorical variable from 1-7, time values from the middle of the category were used to estimate the duration for each reported bout of exercise. For example, if a participant reported completing physical activity for 21-30 minutes, 25 minutes of MVPA was recorded. Time, age and sex were coded the same as within the previous models addressing motivation. The models addressing the third objective were as follows:

Physical Activity Behaviours

Level 1

$$PABehaviour_{ij} = \beta_{0j} + \beta_{1j}(Time_{ij}) + \varepsilon_{ij}$$

Level 2

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(WearableStatus) + \gamma_{02}(Age) + \gamma_{03}(Sex)\ \mu_{0i}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1i}$$

To address the fourth objective of this study, models conducted to determine the effect of daily health-related social media use on physical activity intensity, duration and combined MVPA in both WAT users and non-users. Daily social media use was coded the same as previous models for situational motivation (Y/ N) and added to each physical activity model as a level-1 predictor. Similar to the motivation models, participants' 14-day social media use was also added to the model as a level-2 predictor.

Physical Activity Intensity, Duration, MVPA, and Daily Social Media Use

Level 1

$$PABehaviour_{ij} = \beta_{0j} + \beta_{1j}(Time_{ij}) + \beta_{2j}(SMUse_{ij}) + \varepsilon_{ij}$$

Level 2

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(WearableStatus) + \gamma_{02}(Age) + \gamma_{03}(Sex) + \gamma_{04}(14DaySM) + \mu_{0i}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1i}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(WearableStatus) + \mu_{1i}$$

Chapter 4 Results

4.1 Baseline Demographics

510 participants completed the baseline survey and were enrolled. Of those, 328 participants completed at least one of the daily surveys (36% dropout rate) and were included in this analysis. Baseline demographic information of the participants for both WAT users and non-users can be found in Table 1. The average age of participants was 27.2 (9.1) years, with more than half of the participants being female (67%). While there was no significant difference in self-reported income and ethnicity, significant differences for education level, X^2 (5, N = 328) = 25.37, p < .001, and school status, X^2 (5, N = 328) = 24.1, p < .001, were found. A greater proportion of non-users reported high-school as their highest level of education while a greater proportion of WAT-users reported having graduate degrees (Table 1). Additionally, a greater proportion of WAT-users were not currently in school while a greater proportion of non-users reported being in university or college.

Table 1.

Demographic Information of Participants by Wearable Status

Variables	WAT Users (n=234)	Non-Users (n=94)	Total (n=328)	p-value
Age (Years)	28.3 [9.3]	24.5 [8.0]	27.2 [9.1]	< .001
Sex (Female)	60%	83%	67%	< .001
Income				.19
< $26,999	35 (14.9%)	19 (20.2%)	54 (16.4%)	
$27,000 - $59,999	48 (20.5%)	16 (17.0%)	64 (19.5)	
$60,000 - $99,999	57 (24.4%)	12 (12.8%)	69 (21.0%)	
More than $100,000	72 (30.8%)	19 (20.2%)	91 (27.7%)	
Don't know/ Prefer not to answer	22 (9.4%)	26 (27.7%)	48 (14.6%)	
Education				< .001
12^{th} grade or less	4 (1.7%)	3 (3.2%)	7 (2.1%)	

High school graduate or GED	42 (17.9%)	31 (33.0%)	73 (22.3%)	
Some college/ Technical school training	47 (20.1%)	28 (29.8%)	75 (22.9%)	
College graduate	68 (29.1%)	24 (25.5%)	92 (28.0%)	
Graduate school: Master's or Doctorate degree	71 (30.3%)	7 (7.4%)	78 (23.8%)	
Do not know / Prefer not to answer	2 (0.9%)	1 (1.1%)	3 (0.9%)	
School Level				< .001
Not in school	121 (51.7%)	25 (26.6%)	146 (44.5%)	
In University or College	92 (39.3%)	63 (67.0%)	155 (47.3%)	
In Graduate School	16 (6.8%)	6 (6.4%)	22 (6.7%)	
Other	5 (2.1%)		5 (1.5%)	
Ethnicity				.08
White or Caucasian	164 (70.1%)	71 (75.5%)	235 (71.6%)	
Black or African American	39 (16.7%)	2 (2.1%)	41 (12.5%)	
First Nations	3 (1.3%)	4 (4.3%)	7 (2.1%)	
Métis	4 (1.7%)	1 (1.1%)	5 (1.5%)	
Asian	27 (11.5%)	18 (19.1%)	45 (13.7%)	
Native Hawaiian or other Pacific Islander	0	1 (1.1%)	1 (0.3%)	
Do not know/ prefer not to answer	3 (1.3%)	2 (2.1%)	5 (1.5%)	
Average Weekly MVPA (minutes)	94.8	68.9	87.4	

Note: Mean[SD]; n(%); For assessment of race, participants were able to select all options that applied to them.

Social media behaviours of all participants are reported in Table 2. Although self-reported social media use in the last two weeks was similar between groups, WAT users reported that a significantly greater percentage of their social media content was related to health and fitness ($t(170.73) = 3.45$, $p < .001$). In terms of social media platforms used, more than half of all

WAT users reported using Facebook as the main social media platform (62%) compared to non-users (43%). Significantly more WAT users ($p<.001$) reported that social media is a good source of health-related information and that social media has a positive influence on behaviour ($p<.01$) compared to non-WAT users (Table 2).

Table 2.

Social Media Characteristics of Participants by Wearable Status

Variable	WAT Users (n=234)	Non-WAT Users (n=94)	Total (n=328)	P value
SM use (Last 2 weeks)[1]	3.02 [1.13]	2.93 [1.23]	2.99 [1.16]	0.43
SM Related to Health[2]	1.88 [0.88]	1.51 [0.89]	1.78 [0.9]	<.001
Platforms				.18
Facebook	144 (61.5%)	40 (42.5%)	184 (56.1 %)	
Twitter	74 (31.6%)	22 (23.4%)	96 (29.3%)	
Instagram	190 (81.2%)	76 (80.9%)	166 (81.1%)	
Youtube	142 (60.7%)	59 (62.7%)	201 (61.3%)	
TikTok	97 (41.5%)	40 (42.5%)	137 (41.7%)	
SnapChat	93 (39.7%)	40 (42.5%)	133 (40.5%)	
Whatsapp	76 (32.3%)	20 (21.3%)	96 (29.3%)	
LinkedIn	44 (18.8%)	12 (12.8%)	56 (17.1%)	
Sources of Info				.82
Government	18 (7.7%)	7 (7.4%)	25 (7.6%)	
Official Health Org	51 (21.8%)	13 (13.8%)	64 (19.5%)	
TV or News	36 (15.4%)	9 (9.6%)	45 (13.7%)	
Influencers/ Celebrities	128 (54.7%)	51 (54.3%)	179 (54.6%)	
Sports/ Athletes	143 (61.1%)	43 (45.7%)	186 (56.7%)	
Friends	90 (38.5%)	23 (24.5%)	113 (34.5%)	
Family	25 (10.7%)	13 (13.8%)	38 (11.6%)	
Someone similar in age or interests	71 (30.3%)	38 (40.4%)	109 (33.2%)	
Research	40 (17.1%)	16 (17.0%)	56 (17.1%)	
SM Content Information				.02
Workout routines	189 (80.8%)	68 (72.3%)	257 (78.4%)	
PA Guidelines	103 (44.0%)	28 (29.8%)	131 (39.9%)	
Benefits of PA	133 (56.8%)	38 (40.4%)	171 (52.1%)	
Positive body image	120 (51.3%)	45 (47.9%)	165 (50.3%)	
Fit/Thinspiration	87 (37.2%)	24 (25.5%)	111 (33.8%)	
PA ideas for family	43 (18.4%)	7 (7.4%)	50 (15.2%)	

SM Perceived Credibility [3]	3.54 [1.25]	2.90 [1.10]	3.36 [1.24]	<.001
SM Influence[4]	3.50 [1.24]	2.94 [1.04]	3.34 [1.22]	<.001

Note: Mean[SD]; n(%); SM = Social Media; PA = Physical Activity; For the assessment of social media platforms, sources, and content, participants were able to select all options that applied to them thus multiple may have been selected.

[1] *SM Use* was measured by asking participants how many hours, on average in the last 2 weeks, they have used social media per day on a 5-point scale from "Less than 1 hour" to "More than 5 hours"

[2] *SM Related to Health* was measured by asking participants what percentage of their total social media content in the last two weeks was related to health, fitness, or wellness on a 5-point scale from "Less than 25%" to "More than 75%"

[3] SM Perceived Credibility indicates how much participants believe social media is a good source of health information on a 5-point scale from "Strongly disagree" to "Strongly agree".

[4] SM Influence indicates how much participants believe viewing social media influences their behaviour

For WAT users, Apple Watch was the most reported wearable device used (65%) followed by Fitbit (33%). Most WAT users (95%) reported having physical activity goals on their device, with active minutes and step tracking being the most common goals reported. For WAT users, monitoring activity was the most reported reason for using their wearable device, followed by wanting to improve fitness levels.

4.2 Multi-Level Models

Of the 328 included participants, missing data for evening surveys was 30% (3823 collected / 5460 possible) and it was determined to be missing at random. Testing to determine if data missing at random indicates that differences between observed and missing data can be explained, and that missing data can be handled (Bhaskaran & Smeeth, 2014). A benefit to multi-level modelling is the ability to handle missing data through maximum likelihood estimation (Lang & Little, 2018). For all evening surveys reported, participants reported viewing social media that day 41% (n= 1320) of the time compared to 59% (n=1900) of instances where social media was not viewed.

4.2.1 Fully Unconditioned Models

Multi-level models were used to address the hypotheses of this study. Fully unconditioned models were first computed for each motivational type and physical activity outcomes to determine the intraclass correlation coefficient (ICC) and to determine if multi-level modeling was warranted for this data. For all situational motivation models, ICCs suggested that at least 55% of the variance is proportionate to between-group differences. For both physical activity intensity and duration models, both 33% and 31% of variance can be explained by between group differences. However, since individuals tend to be more like themselves over time than they are to others, multi-level modeling remained warranted.

4.2.2 Situational Motivation Conditioned by Wearable Status

In line with the first objective of this study, WAT status was added to the models for situational motivation. Using a WAT was found to be associated with greater intrinsic situational motivation prior to engaging in physical activity compared to being a non-user (p<.001; see Table 3 and Figure 1). In addition, females had significantly lower intrinsic motivation prior to starting their bout of physical activity compared to males (p <.05).

Table 3.

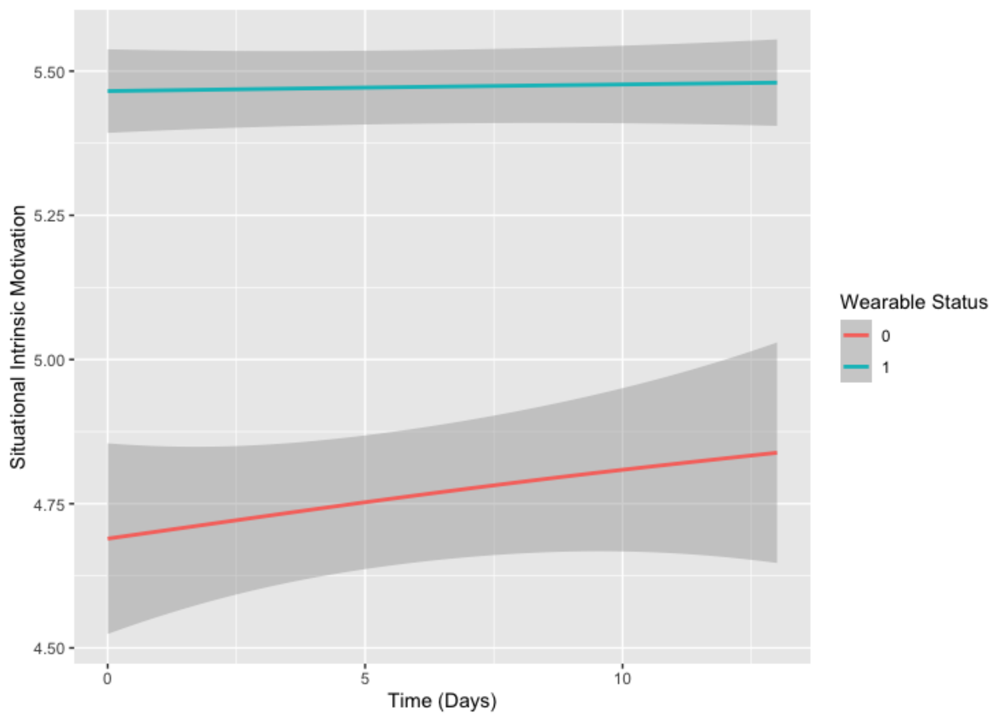
Situational Motivation for Physical Activity in WAT Users and Non-Users

	Situational Motivation Subset									
	Intrinsic		**Introjected**		**Identified**		**External**		**Amotivation**	
	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*
Intercept	4.89 (0.18)	<.001	4.41 (0.23)	<.001	5.46 (0.13)	<.00 1	4.36 (0.19)	<.001	1.72 (0.1)	<.001
Level 1 Variables										
Time	0.01 (0.01)	.21	-0.03 (0.01)	.01	-0.02 (0.01)	.12	-0.02 (0.01)	.04	0.009 (0.01)	.28
Level 2 Variables										
WAT Status	0.62 (0.16)	<.001	0.24 (0.19)	0.23	0.33 (0.12)	.007	0.13 (0.17)	.45	-0.16 (0.1)	.07
Age	-0.001 (0.007)	0.93	0.07	0.07	0.01 (0.005)	.06	0.02 (0.01)	.01	0.003 (0.00)	.44
Sex (At birth)	-0.36 (0.15)	.015	-0.72	<.001	0.06 (0.11)	.61	-1.01 (0.16)	<.001	-0.26 (0.08)	<.01

Note. N = 299; Observations = 2149; Female = 1, Male = 0;

Figure 1.

Situational Intrinsic Motivation for Physical Activity by Wearable Status

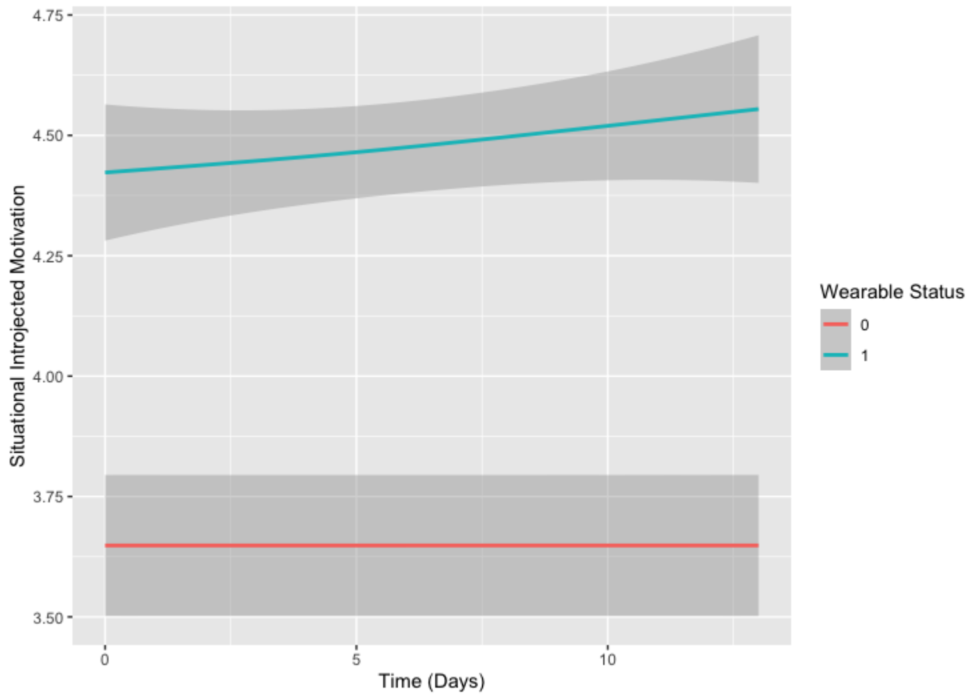


Note: 0= Non-users, 1= WAT users; Situational intrinsic motivation was assessed prior to physical activity on a scale from 1-7.

While there was no effect of WAT use on situational introjected regulation (p = .23), overall introjected regulation decreased over the 14-day period but using a wearable device increased introjected regulation over time (p<.01; see Figure 2). In addition, females had significantly lower introjected situational regulation compared to males (p<.001). No association between wearable status and amotivation prior to exercise was seen; However, females had significantly lower situational amotivation compared to males (p<.01). Like intrinsic motivation, using a WAT was associated with greater situational identified regulation prior to physical activity compared to non-users (0.33, p<.01).

Figure 2.

Situational Introjected Regulation for Physical Activity by Wearable Status



Note. 0= Non-users, 1= WAT users; Situational introjected motivation was assessed prior to physical activity on a scale from 1-7

Situational external regulation was shown to decrease over the 14-day period, however there was no association with wearable status. Females had significantly lower external regulation prior to exercise compared to males (-1.01, $p<.001$), and situational external regulation for physical activity increased by 0.02 units for every year in age above the mean ($p<.05$).

4.2.3 Situational Motivation Conditioned by Wearable Status and Daily Social Media Use

To address the second objective of this study, daily social media use was added to the models for situational motivation. No within-person associations between daily health-related social media use and situational motivation for same-day physical activity were found (Table 4). However, significant between-person associations between 14-day social media use and situational subsets were found. Participants who reported greater social media use over the 14-day period also reported greater intrinsic situational motivation for physical activity (1.22, $p<.001$, see Table 4). Similarly, increased social media use was found to be associated with increased situational introjected regulation ($p<.001$), identified regulation ($p<.01$), and external regulation ($p<.001$).

When both daily social media use and WAT status were added to the models, a significant interaction between WAT status and daily social media use was found for situational external regulation (Table 5). Although external regulation for physical activity decreased on days when health-related social media was viewed, wearable status moderated the association such that being a WAT user increased external regulation on days when health-related social media was viewed ($p<.05$, see Figure 3). While both days of social media use and WAT use were associated with greater intrinsic motivation and identified regulation, no significant interaction effects were observed ($p=.22$ and $p=.27$, respectively).

Table 4.

Associations of Daily Health-Related Social Media Use with Situational Motivation Prior to Physical Activity

	Situational Motivation Subset									
	Intrinsic		**Introjected**		**Identified**		**External**		**Amotivation**	
	Estimate (SE)	*p*	*Estimate (SE)*	*p*	*Estimate (SE)*	*p*	*Estimate (SE)*	*p*	*Estimate (SE)*	*p*
Intercept	4.85 (0.17)	<.001	3.64 (0.21)	<.001	5.47 (0.13)	<.001	3.60 (0.18)	<.001	1.61 (0.09)	<.001
Level 1 Variables										
Time	-0.002 (0.01)	.68	-0.01 (0.01)	.19	-0.03 (0.01)	<.001	-0.01 (0.01)	.12	-0.004 (0.01)	.46
Daily SM Use	-0.07 (0.01)	.28	-0.05 (0.08)	.51	-0.05 (0.07)	.49	-0.07 (0.07)	.34	-0.08 (0.06)	.16
Level 2 Variables										
14 Day SM Use	1.22 (0.26)	<.001	2.17 (0.33)	<.001	0.63 (0.19)	<.01	2.01 (0.28)	<.001	0.04 (0.15)	.79
Age	0.01 (0.007)	0.15	0.02 (0.01)	<.01	0.02 (0.01)	<.01	0.02 (0.01)	<.01	0.002 (0.004)	.63
Sex (at birth)	-0.12 (0.15)	.46	-0.29 (0.19)	.15	0.16 (0.12)	.16	- 0.58 (0.17)	.15	-0.21 (0.09)	.02

Note. N = 286; Observations = 1817; Female = 1, Male = 0; SM = Social media related to health & fitness; 14 Day SM Use = Total number of days where social media was viewed out of the 14 survey days (scored from 0 [0/14] to 1[14/14]).

Table 5.

Interaction of Daily Health-Related Social Media and WAT Use on Situational Motivation for Physical Activity

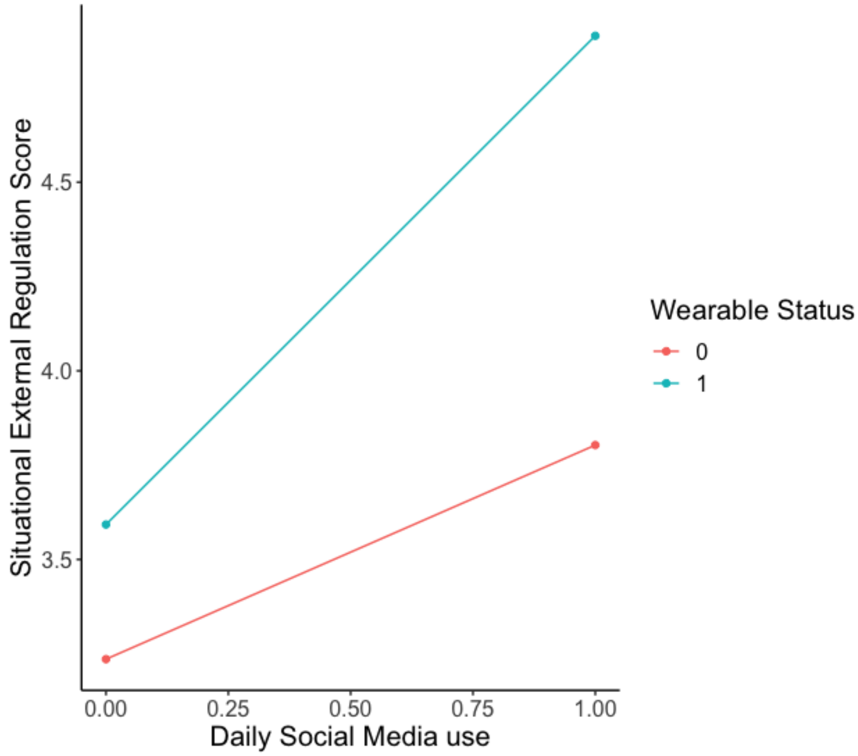
Situational Motivation Subset

	Intrinsic		**Introjected**		**Identified**		**External**		**Amotivation**	
	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*
Intercept	4.54 (0.19)	<.001	3.49 (0.25)	<.001	5.27(0.15)	<.001	3.62 (0.21)	<.001	1.67 (0.12)	<.001
Level 1 Variables										
Time	-0.001 (0.01)	.72	-0.004 (0.01)	.46	-0.02 (0.01)	<.001	-0.01 (0.01)	.34	0.005 (0.004)	.20
Daily SM Use	-0.14 (0.09)	.09	0.01 (0.10)	.89	-0.05 (0.08)	.55	-0.16 (0.09)	.08	0.12 (0.1)	.11
SM*WAT Status	0.12 (0.09)	.22	0.01 (0.12)	.92	0.10 (0.09)	.27	0.23 (0.11)	.03	-0.10 (0.08)	.23
Level 2 Variables										
14 Day SM Use	1.06 (0.26)	<.001	2.05 (0.33)	<.001	0.49 (0.19)	.012	1.91 (0.28)	<.001	-0.003 (0.15)	.98
WAT Status	0.44 (0.15)	.004	0.19 (0.19)	.32	0.26 (0.12)	.025	-0.03 (0.17)	.84	-0.12 (0.1)	.20
Age	0.007 (0.007)	0.32	0.02 (0.01)	0.015	0.01 (0.005)	.012	0.02 (0.01)	.003	0.003 (0.00)	.43
Sex (at birth)	-0.06 (0.16)	.69	-0.27 (0.20)	.17	0.19 (0.12)	.09	-0.57 (0.17)	<.001	-0.23 (0.09)	.010

N = 286, Observations = 1817; Male = 0, Female = 1; SM = Social Media related to health and fitness; WAT = Wearable Activity Tracker; 14 Day SM Use = Total number of days where social media was viewed out of the 14 survey days (scored from 0 [0/14] to 1[14/14]).

Figure 3**.**

Situational External Regulation for Physical Activity by WAT Status and Days of Health-Related Social Media Use



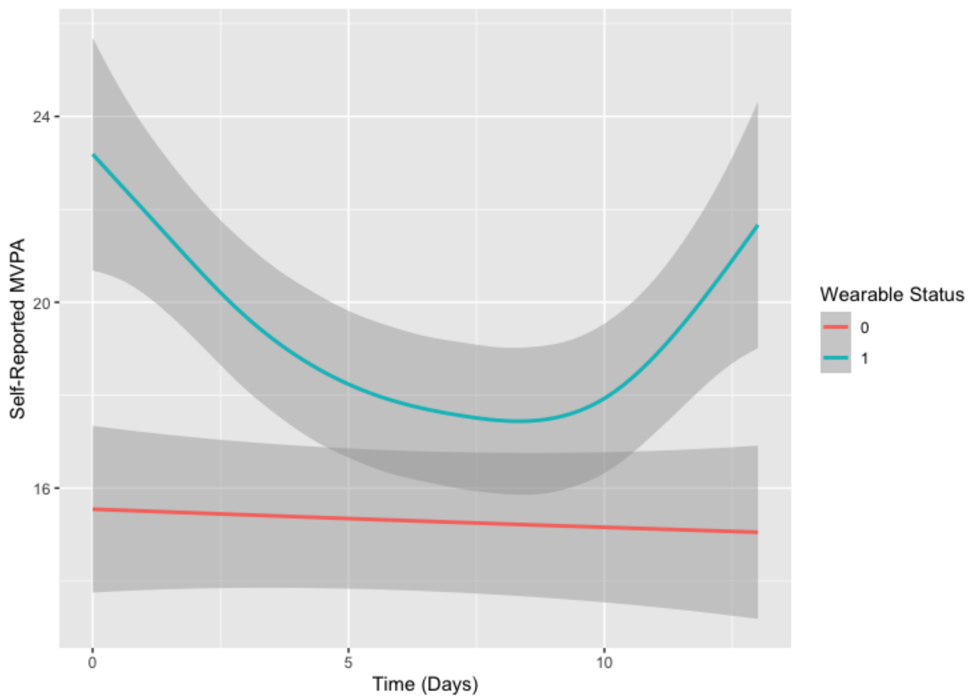
Note: 0= Non-users, 1= WAT users; Situational external regulation was assessed prior to daily physical activity on a scale from 1-7; Daily health-related social media use was assessed on the daily evening survey as 0 = No, 1 = Yes.

4.2.4 Physical Activity Conditioned by Wearable Status

In line with the third objective, WAT status was added to the models for physical activity. Day-level physical activity intensity, duration, and MVPA were computed as three separate models. Using a WAT was not found to be associated with any day-level physical activity outcomes (Table 6). WAT users reported greater physical activity intensity, duration and MVPA but no significant difference was found (Figure 4). For physical activity intensity, females reported both lower physical activity intensity levels, duration and MVPA than males (p<.001). Physical activity duration decreased over the 14 days (p<.05).

Figure 4.

Minutes of Daily Moderate-to-Vigorous Physical Activity by Wearable Status



Note: 0= Non-users, 1= WAT users

Table 6.

Daily Moderate-to-Vigorous Physical Activity, Intensity, and Duration Differences between WAT Users and Non-users

	Physical Activity Outcome					
	Intensity		**Duration**		**MVPA**	
	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*
Intercept	2.12 (0.15)	<.001	3.15 (0.26)	<.001	22.19 (2.26)	<.001
Level 1 Variables						
Time	-0.02 (0.01)	.05	-0.04 (0.02)	.027	-0.27 (0.19)	.15
Level 2 Variables						
WAT Status	0.04 (0.14)	.72	0.11 (0.25)	0.63	1.62 (2.19)	.46
Age	0.02 (0.01)	<.001	0.04 (0.01)	<.001	0.19 (0.08)	.019
Sex (at birth)	-0.45 (0.12)	<.001	-0.49 (0.19)	.008	-5.97 (1.6)	<.001

N= 319, Observations = 2946; Male = 0, Female = 1; WAT = Wearable Activity Tracker; MVPA = Moderate-to-Vigorous Physical Activity

4.2.5. Physical Activity Conditioned by Wearable Status and Daily Social Media Use

To address the final objective of this study, daily social media was added to the models for physical activity. A significant within-person effect between daily health-related social media and same day physical activity intensity was found (0.29, $p<.01$, see Table 7). No significant within-person association between daily social media and physical activity duration was found ($p = .06$). As for daily MVPA, viewing health-related social media increased daily MVPA by 3.4 minutes, however, the effect was non-significant ($p=.026$).

When both daily social media use and WAT status were added to the models, no significant interactions were found for any physical activity outcome. Both physical activity intensity and duration increased on days when health-related social media was viewed and wearable status moderated the increases, however, none of these associations were significant (Table 8). No within-person associations were found between health-related social media and MVPA in either WAT status group.

Table 7.

Associations of Daily Health-Related Social Media and Physical Activity Outcomes

	Physical Activity Outcome					
	Intensity		**Duration**		**MVPA**	
	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p
Intercept	1.79 (0.14)	<.001	2.77 (0.23)	<.001	18.56 (1.98)	<.001
Level 1 Variables						
Time	-0.04 (0.01)	<.001	-0.06 (0.01)	<.001	-0.36 (0.12)	.002
Daily SM	0.29 (0.10)	.005	0.31 (0.16)	.06	3.38 (1.52)	.026
Level 2 Variables						
14 Day SM Use	0.29 (0.21)	.16	0.35 (0.34)	.31	4.77 (2.91)	.10
Age	0.03 (0.01)	<.001	0.04 (0.01)	<.001	0.26 (0.08)	.001
Sex (at birth)	-0.31 (0.12)	.013	-0.28 (0.20)	.16	-3.78 (1.68)	.025

Note. N=314, 2744 Observations; Male = 0, Female = 1; Daily SM = Social Media related to health & fitness; 14 Day SM Use = Total number of days where social media was viewed out of the 14 survey days (scored from 0 [0/14] to 1[14/14]); MVPA = moderate-to-vigorous physical activity, measured as any activity of any duration at an intensity of 3 (moderate) or greater.

Table 8.

Interaction of Daily Health-Related Social Media and WAT Use on Physical Activity Intensity, Duration, and MVPA

Physical Activity Outcome

	Intensity		**Duration**		**MVPA**	
	Estimate (SE)	*p*	Estimate (SE)	*p*	Estimate (SE)	*p*
Intercept	1.88 (0.16)	<.001	2.78 (0.27)	<.001	18.51 (2.28)	<.001
Level 1 Variables						
Time	-0.03 (0.01)	<.001	-0.05 (0.01)	<.001	-0.25 (0.10)	.009
Daily SM	0.18 (0.12)	.12	0.22 (0.20)	0.27	2.32 (1.81)	.20
SM*WAT status	0.25 (0.14)	.07	0.40 (0.23)	.07	3.97 (2.08)	.05
Level 2 Variables						
14 Day SM Use	0.29 (0.22)	.17	0.34 (0.35)	.32	4.72 (2.96)	.11
WAT Status	-0.17 (0.13)	.19	-0.13 (0.21)	.54	-1.03 (1.78)	0.56
Age	0.03 (0.01)	<.001	0.05 (0.01)	<.001	0.26 (0.08)	.001
Sex (at birth)	-0.32 (0.13)	.01	-0.29 (0.20)	.15	-3.82 (1.69)	.02

Note. N=314, 2744 observations; Male = 0, Female = 1; Daily SM = Social Media related to health & fitness; MVPA = moderate-to-vigorous physical activity, measured as any activity of any duration at an intensity of 3 (moderate) or greater; 14 Day SM Use = Total number of days where social media was viewed out of the 14 survey days (scored from 0 [0/14] to 1[14/14])

Chapter 5 - Discussion

5.1 Motivational Differences between WAT Users and Non-Users

This study aimed to explore whether physical activity levels and situational motivation for physical activity are influenced by daily health-related social media and WAT use. The first objective of this study was to examine day-level differences in situational motivation for physical activity between WAT users and non-users. The results partially supported my hypothesis that WAT users have greater autonomous motivation for physical activity compared to those who do not use a wearable device. Results of this study provided robust within-person evidence that adds to previous research highlighting motivational differences between current WAT users and non-users. Specifically, there was a significant between-group effect for situational intrinsic motivation and identified regulation prior to engaging in physical activity. This day-level evidence aligns with a recent study that found contextual motivation differences between current and former WAT users (Nuss & Li, 2021). In their study of current and former users, Nuss and Li (2021) found that current wearable users reported greater levels of integrated and introjected regulation compared to former users.

Results of this study add to the current literature that supports WAT users have greater autonomous motivation for physical activity and that WAT users in this study consistently reported engaging in physical activity for feelings of value or enjoyment. Along with more autonomous motivation for physical activity, WAT users in this study also reported high introjected regulation prior to engaging in their activity. Similarly, a recent longitudinal study found that wearable users reported greater introjected motivation compared to the other groups of non-users (Steel, 2023). These findings are also supported by qualitative research in the field that shows some users of WATs find devices controlling when goals are not met in addition to participants who felt their needs for autonomy and competence were supported (Donnachie et al., 2017). Taken together, using a wearable device is associated with greater autonomous motivation for physical activity, however, the constant stream of self-monitoring information could also lead to increased feelings of guilt for meeting daily goals or "closing their rings" depending on the user.

In the lens of SDT, increased scores of situational identified regulation and intrinsic motivation in WAT users suggest that the psychological needs of individuals in that group are being satisfied more than non-users. It could be suggested that before engaging in their activity, WAT users had greater feelings of autonomy over their decision to be active, increased feelings of competence in their ability to complete the activity at hand, as well as feelings of relatedness to others who engage in similar activities. Additionally, previous studies have suggested that both identified regulation and intrinsic motivation play a key role in adhering to physical activity as well as maintenance of behaviours (Teixeira et al., 2012). Although there was no significant group effect for introjected regulation, the increase in introjected regulation scores over the 14-day survey period may be evidence of controlled motivations regulating short-term behaviours. If users' basic needs are not fully satisfied, short-term regulation of behaviour may be primarily through controlled motivation and controlled goals (i.e. appearance). In addition, while these devices can be needs-supportive, the perception of needs support may not be the same for all participants (Donnachie et al., 2017). This suggests that there may be differences between users and how their device supports motivation. In addition, the type of goal tracked on the wearable device may also be associated with motivation, where users with internal goals (i.e. tracking activity for health or meeting a new personal best) are more autonomously motivated compared to those with more external goals (i.e. calorie tracking; Steel, 2023). As recognized by Kerner and Goodyear (2017), unrealistic goals can be perceived as controlling. Finally, examining wearable users time of use may be an important factor to determine the true effect of wearable devices on motivation for physical activity. Those at the beginning of their wearable journey may be more influenced through controlled forms of motivation and have not used the device long enough to have their needs fully satisfied.

While there are reported differences in motivation between device users (Nuss & Li, 2021), the causal pathway for the relationship between wearable device use and motivation remains unclear. Theoretically, wearable devices should satisfy our basic needs leading to autonomous motivation for exercise meaning that there may be a shift in motivation outcomes after use. However, current research can only determine that differences exist between groups but are unable to determine if there were changes in motivation once participants started using their device. Future ecological momentary assessment studies may be best suited to determine these potential changes in motivation for physical activity. Examining differences in device time of use may also help identify if the devices themselves foster autonomous motivation through meeting basic needs or only support those who are already autonomously motivated for physical activity. For instance, comparing individuals who are within their first year of use to those who are successful long-term users may highlight motivational profile differences. In their recent study, authors only examined those who just started using a WAT and did not include a group of long-term users when examining if WATs are controlling (Steel, 2023). Looking at users across all phases of adoption will aid in our understanding of needs support to increase long-term use.

5.1.1 Effect of Social Media on Situational Motivation for Physical Activity in WAT and Non-users

The second objective of this study was to examine within-person associations of daily situational motivation for physical activity with same-day health-related social media use in WAT users and non-users. Results of this study did not support my hypothesis. For both WAT users and non-users, no within-person associations between daily health-related social media and any subset of situational motivation for physical activity were found. However, between-person associations were found where greater social media use over the 14-day study period was significantly associated with greater situational intrinsic motivation, introjected, identified, and external regulation for physical activity. These findings suggest that simply looking at health-related social media in some capacity has no effect on same-day situational motivation for physical activity; however, consistent health-related social media use may be associated with more autonomous motivation for physical activity at the time of activity.

From the perspective of satisfying needs, these results suggest that one day of viewing health-related social media may be insufficient to satisfy an individual's need for autonomy, competence, and relatedness for physical activity. Depending on the content viewed on social media, perceived social pressure can be negatively associated with basic needs (Halfmann & Rieger, 2019). However, an effect is observed when health-related social media is consistently viewed. This suggests that continuous bouts of viewing health-related social media may satisfy the three basic needs resulting in a shift to more autonomous motivation for physical activity. In addition, while there are increases in more autonomous forms of situational motivation with continued social media use, there are also increases in introjected regulation and external regulation that suggest for some health-related social media may not fully satisfy the basic needs. This may be associated with an individual's goal of looking at health-related social media. In WAT users, those who use health-related social media for external goals, such as appearance or body comparison, would be less autonomously motivated compared to those who use social media for health information, running routes or workout ideas (Steel, 2023), The idea that the type of content impacts motivation differently has been discussed in previous research (Nuss et al., 2023), for instance where athletic ideal images were significantly more inspirational compared to thin-ideal or muscular-ideal images (Robinson et al., 2017).

When further examining the effect of health-related social media in WAT-users and non-users, situational external regulation for physical activity was the only motivational subset to have a significant interaction effect. Specifically, external regulation decreased on days when individuals reported viewing health related social media yet being a WAT user increased external regulation for physical activity on those days. As external regulation is a controlled form of motivation, this finding suggests that WAT-users have greater motivation to be physically active for an external purpose or reward on days when they view health-related content. This suggests that health-related social media may be supportive of autonomous motivation and that perhaps WAT-users were more motivated to be active because of their device's goal compared to those who are not prompted to meet a daily goal. This result is more aligned with a control theory perspective (Carver & Scheier, 1982) and is supported by longitudinal evidence suggesting that wearable devices are more externally regulating (Steel, 2023), contradicting the other findings from this study.

A potential explanation for this lack of interaction effect between daily social media use and physical activity motivation may be the individual differences within WAT users themselves. Individuals who are autonomously motivated for physical activity may be viewing health-related social media content out of interest rather than seeking inspiration or guidance. If autonomous motivation is already high, social media may not increase it but rather maintain it.

There may also be low variability in daily social media use among participants limiting my ability to determine an effect. However, an important interaction effect may be missing from this study as situational integrated regulation was not assessed daily and social media use has been shown to be linked to exercise identity (Liu et al., 2021).

This study is limited by a lack of understanding of if wearable devices foster a shift to more autonomous forms of motivation over time or if individuals with a certain motivational profile tend to find success with wearables long term. Within the group of current users, the stages that individuals are at may vary making it difficult to determine a true effect. Realistically, with concerns of long-term adoption and assuming that wearable devices are only effective for those with a certain motivational profile, it may be more effective to use health-related social media to target autonomous motivation to ultimately make wearable activity trackers more effective for more individuals. Longitudinal or experimental research examining a combination of these tools at different stages of use would aid in explaining the relationships.

5.2 Physical Activity Outcomes and Wearable Status

To address the third objective of this study, I examined the effect of WAT status on daily physical activity intensity, duration, and MVPA. The results of the study did not support my hypothesis as no significant between-person associations between WAT status and any physical activity outcome were found. These results add to the current literature that suggests WATs appear to have a small or mixed effect on physical activity behaviours regardless of between-subject motivational differences (Nuss & Li, 2021).

As previously discussed, there were significant between-group effects between WAT status and identified regulation and intrinsic motivation prior to engaging in physical activity; however, the increase in autonomous motivation for physical activity did not appear to translate to increases in behaviour as was theoretically expected. This could be due to the small effect that the devices have on self-determined motivation for physical activity, as the literature suggests that interventions need to have a large effect size for motivation to see an effect on physical activity behaviour (Knittle et al., 2018). Coupled with increases in introjected regulation in WAT users over the 14-day period, these results may be suggesting that the wearable devices do not fully satisfy the three psychological needs. As competence satisfaction is the need that predicts physical activity behaviour (Teixeira et al., 2012), WATs may not be satisfying users' needs for competence or fostering feelings of self-belief regardless of their satisfaction with autonomy and relatedness. As discussed by Kerner and colleagues (2017), when wearable goals are unrealistic the devices can be perceived as controlling and lead to decreased activity potentially from decreased feelings of competence (Kerner & Goodyear, 2017). Alternatively, as research has shown wearable devices may provide needs support to most individuals but not all (Donnachie et al., 2017), and increases in both controlled and autonomous forms of motivation may also be the result of differences within WAT users. Within the current user group, the time of wearable device use ranged from less than one month to more than one year. While 47% of participants in the current user group reported using their device for longer than one year, 36% of participants reported using their device for less than 6 months which is highlighted in some literature as a threshold where participants stop use. In their study that followed wearable device users, Steel (2023) found that physical activity was not supported in new WAT users, but the study did not include a long-term, or "successful", WAT user group. Perhaps the increase in controlled motivation is the result of newer users whose needs have not yet been fully satisfied or whose goals do not foster feelings of autonomy or competence (Kerner & Goodyear, 2017). A lack of group effect on physical activity aligns with research that suggests wearable devices alone are insufficient in creating meaningful behaviour change.

5.2.1 Daily Social Media and Physical Activity Behaviours

The final objective of this study was to examine the within-person associations of health-related social media and physical activity behaviours in WAT users and non-users. As with the models for motivation, both daily social media use and 14-day social media use were added to the model. Results of the study partially support my hypothesis. Daily health-related social media use was shown to be associated with greater same-day physical activity intensity as well as with MVPA. More specifically, viewing health-related social media was associated with an increase in MVPA of 3.38 minutes. No within-person effect for physical activity duration was found. In addition, no between-person associations between 14-day social media use and any physical activity outcome were found. Finally, no interaction effect of WAT status and social media was found. This result does not support my hypothesis and indicates no clear augmentative effect of health-related social media in WAT users, suggesting no further satisfaction of basic needs. While daily social media appears to have some effect on physical activity behaviours, any additional increase in self-determined motivation from needs satisfaction by wearables and social media is insufficient to elicit a behaviour response.

Previous research has found no changes in exercise behaviours immediately following the viewing of social media (Fitspiration) content (Prichard et al., 2020), yet our results suggest that there is a potential physical activity intensity response to same-day social media content consumption. The study from Prichard and colleagues (2020) may also be used to explain why there was only a significant effect for physical activity intensity and not for duration. The study found that although participants did not exercise for longer after looking at Fitspiration content, they reported higher exercise exertion compared to those who did not look at Fitspiration content. A similar trend may explain the result of this study. As intensity in this study was measured through self-reported measures rather than objectively, participants may have been reporting greater exercise exertion after viewing social media content compared to the days when no health-related content was viewed. Similar to the study from Prichard and colleagues (2020), no associations between health-related social media use and physical activity duration were found. This contrasts with research that found an association between health-related social media use and exercise duration (Rowles, 2021). Finally, increased minutes of MVPA on days when health-related social media was viewed could be attributed to the increased self-reported intensity, increasing the number of physical activity minutes that would classify as moderate-to-vigorous. While viewing health related social media had a significant association with intensity and MVPA, a behaviour increase of less than four minutes would not be considered clinically significant.

As previously discussed, social media increases social support, social influence, and feelings of relatedness in its users (Cavallo et al., 2012). Despite increased physical activity intensity on days when social media was viewed, the lack of effect on duration and lack of effect with increasing use suggest that health-related social media does not satisfy the basic needs of users. From the perspective of SDT, needs support from sharing and engaging with health-related content on social networks may be insufficient to lead to increased physical activity behaviours. In college students, social support from friends is associated with basic needs satisfaction (Cho et al., 2020), yet if individuals are engaging with content from strangers the content may not provide enough support. Alternatively, health-related social media can increase feelings of competence but, depending on the content, competence satisfaction could decrease in viewers if the outcome feels out of reach or unrealistic.

Taken together, these results highlight the need for more research on the effect of health-related social media and wearable devices on physical activity. While there appears to be an association between wearable use and more autonomous situational motivation, as well as an association between health-related social media and motivation for physical activity, a gap between motivation and physical activity remains. This gap may be due to the generally small effect that social media and wearable devices have been shown to have on motivation. For instance, some individuals still perceive these tools as controlling or needs-thwarting rather than supportive of behaviours (Donnachie et al., 2017; Halfmann & Rieger, 2019). Additionally, the lack of augmentative effect of social media in WAT users may be explained by user differences and does not explain the full potential of using both social media and wearables in physical activity interventions. While previous research has used self-determination theory to explain the potential benefit of wearable devices on physical activity, other theories may be better suited to explain how health-related social media and wearable devices could be used to increase physical activity. When looking at the cumulative effects of social media and self-regulation, theoretical models like the Multi-Process Action Control Framework may be better suited to explain how these tools can be used to increase physical activity (Rhodes, 2017). For individuals at the beginning of their physical activity journey, health-related social media use that targets reflective processes such as attitudes, perceived capability and opportunity may prime individuals for wearable device use, moving up in the model to target regulatory processes (Rhodes, 2017). As the first layer of the M-PAC framework is largely based on elements of social cognitive theory, there is research that supports social media use in building these concepts grounded in social cognitive theory. For those individuals who have already built intention and are trying to adopt physical activity by using a wearable device, health-related social media use that targets identity may be the key to increasing exercise maintenance and the long-term adoption of wearable devices (Rhodes, 2017). There is potential that these tools can be effectively used in combination to support physical activity behaviours and an alternative theoretical lens may be more suitable to explain changes in behaviour.

5.3 Strengths & Limitations

5.3.1 Strengths

Being part of a larger project, this study has a large sample size and was able to capture the behaviours of many individuals. Additionally, evaluating participants' behaviours over 14 days increased the number of observations and added depth to our current understanding of WATs and social media use. Multi-level modelling not only confirms between-person effects but provides more understanding of how social media use varying within participants can lead to different behaviour outcomes.

5.3.2 Limitations

This study is not without its limitations. This study was conducted using early versions of the Pathverse mobile application which limited the strength of data collection. First, based on the survey design, only one physical activity bout was captured per participant per day. If participants completed more than one bout of physical activity in one day, only one of the bouts would have been captured by the surveys. Depending on which activity was reported (i.e. a low-intensity walk vs moderate intensity strength training) the data may not fully reflect the weekly MVPA of participants. Although a recent review suggests that WAT users have greater weekly MVPA which should have been captured in this study (Li et al., 2021), WAT users also had significantly greater daily steps and unless participants included reported a walking workout on their survey that additional increase in activity would not have been captured. Additional variation may come from which activity bouts participants chose to report, where the wording of the surveys targeted exercise (planned physical activity) and unplanned physical activity would not have been reported limiting the interpretability of these results. A more accurate interpretation of data from this research would be that wearable devices do not increase the intensity or duration of a single exercise bout in participants and future research should focus on total daily behaviours of participants.

Secondly, the method of reporting daily physical activity is recognized as a limitation of this study. On the post-exercise survey, participants were prompted to report the duration of their physical activity bout in increments increasing by ten minutes instead of reporting the actual time of their activity on a continuous scale. If two participants completed bouts of activity 11 and 20 minutes in length, both would be forced to report that the duration of their activity was 11-20 minutes in length. This categorical scale limited my ability to interpret physical activity duration. If the overall group effect is small, capturing a significant effect may have been limited. Additionally, this study was only equipped to capture one bout of physical activity per day of participants (i.e. one pre-and post-exercise survey).

An additional limitation of this study that limits the strength of its findings is the increased knowledge of physical activity levels in the WAT group. Inherently, when asked to self-report their daily activities current wearable users will be able to more accurately report their physical activity behaviours based on their objectively measured behaviour whereas non-users will be self-reporting without receiving any feedback on their activity. As seen in previous research when self-reported activity is compared to objectively measured data, individuals tend to overestimate their activity levels and report greater activity than what is completed (Bai et al., 2022).

While the brands and features of the wearable devices used by participants were recorded at baseline, the specification of behaviour change techniques used within the devices was not recorded or added to the models of this study. Standard features such as feedback, self-monitoring and goal-setting are assumed to be included in the commonly used devices yet the type of the devices used by participants was not within the inclusion criteria and may be a confounding variable. For instance, smartwatches like newer versions of the Apple Watch, while still being considered wearable activity trackers may have more connectivity features that include more self-determination theory behaviour change techniques compared to simplified fitness trackers.

Our lack of knowledge on the type and timing of participant social media consumption is a major limitation of this study. While the type of content that participants view was collected on the baseline survey, the type of health-related content that was viewed daily was not collected and only assumptions about what daily health-related content was viewed can be made. Research suggests that health-related posts on platforms such as YouTube suggest that content includes fitness videos, examples of routines and demonstrations of activities (Osman et al., 2022), and that individuals use social media to access a variety of health content (Shine et al., 2022), yet content can vary in quality and we are unable to confirm if the viewed is in line with effective

BCTs (i.e. social influence, demonstration of behaviour etc.). Experimental designs would be better equipped to evaluate the effect of specific content on behaviours. Additionally, daily social media use was only measured on the evening survey and the survey did not ask participants what time of day they viewed health-related content. Based on this limitation, it may be that participants did view health-related social media content before engaging in their bout of physical activity that day, but the timing of social media use cannot be confirmed based on the survey. Similarly, the amount of social media content viewed on a single day by each participant was not captured so it remains unclear if there is a threshold of daily exposure that would lead to the greatest effect. In social media interventions targeting physical activity, more interactive interventions saw significant increases in weekly MVPA compared to less interactive control groups who also used social media (Petkovic et al., 2021). The potential of a dose-response relationship should be examined with future research.

Our inability to determine a causal pathway has also been recognized by other authors as a limitation on our ability to fully understand the effect of social media (Welker et al., 2019). Greater health-related social media use is related to greater physical activity behaviours, but it is unclear if social media led to increases in behaviour or if already-active individuals tend to view social media content on activities they currently engage in and relate to (Welker et al., 2019). Similarly, it remains unclear whether those with certain motivational profiles tend to use WATs or if the devices themselves can lead to changes in motivation. Despite this, social media remains a powerful tool for increasing the reach of health-related information and WATs continue to increase in use and accessibility. Both tools continue to have the potential to increase motivation for physical activity as well as physical activity behaviours. More research is required to fully understand the relationship between health-related social media and physical activity, including the type and timing of delivered content, and how it can be most effectively used in interventions.

Finally, a limitation of this study is that the assessment of situational motivation prior to daily physical activity did not include an assessment of integrated regulation. With greater reports of the autonomous forms of motivation prior to physical activity it could be assumed that daily motivation for physical activity may be stemming from feelings of identity, however, the results of this study do not confirm that. Additionally, an interaction effect of health-related social media use and WAT use may be missing from this study as integrated regulation was not assessed daily and social media use has been shown to be linked to exercise identity. Integrated regulation may be a key factor in explaining how wearables can support autonomous motivation for exercise and increase long-term adoption and should be examined in future research.

5.4 Implications & Future Directions

This study adds further within-person evidence to the current literature and highlights the associations that health-related social media and wearable devices have with physical activity motivation and their potential influence on behaviours. There are a few limitations previously recognized that limited my ability to interpret the findings, such as categorical and self-reported daily physical activity measures, limited knowledge of daily social media behaviours like type or timing, and missing data. Despite these, findings from this study confirm that a relationship between these variables exists and that continued research is warranted. Overall, wearable devices are recognized as successful in increasing behaviours, however, it is unclear whether using a device over the long term (longer than interventions) stems from changes in motivation or if those with a certain motivational profile are likely to find success. Similarly, greater health-related social media was associated with more autonomous motivation but the type and timing of content as well as the effect on changing behaviours remains unknown. Additionally, while there was a small effect of health-related social media on MVPA, the clinically insignificant increase in behaviour suggests that more research is needed before health-related social media should be adopted into health promotion efforts. Future research should focus on the casual pathways and examine how either social media use or wearable devices can be used to lead to changes in motivation and behaviour over time. Specifically, long-term successful users should not be the focus of future research as these individuals and instead should focus on new users who are either at the beginning stages of exercise adoption or exercise maintenance. This may be done through more experimental research or by examining changes over time between these groups using longitudinal studies. Finally, while SDT may partially explain how wearables and social media can be used in combination to influence motivation, alternative theoretical frameworks should be considered when examining how these tools can be used to target behaviour change.

Results from this daily diary study highlight the importance of examining within-person differences in response to social media and wearable devices along with between-person effects. Multi-level modelling provides depth to our understanding of the effectiveness of these tools and should continue to be used in future studies. This daily diary design may also be used to examine behaviours in other populations where increasing physical activity is crucial such as adolescents and young adults. While the results of this study may be generalizable to adults, more research on additional populations, including younger and more diverse populations, will further aid in our understanding of these relationships.

Chapter 6 - Conclusion

The purpose of this study was to add within-person evidence to the current body of evidence examining the use of WATs and health-related social media on motivation for physical activity and behaviours. Results of this study highlight characteristic differences between WAT users and non-users, as well as the potential influence of daily social media use on motivation and behaviours. Findings of this study confirm that there appears to be significant associations between WAT use and greater autonomous situational motivation for physical activity, suggesting basic needs are being satisfied. Regardless of motivational differences, no effect of WAT use on any physical activity outcomes was found. While same day health-related social media was not associated with changes in any situational motivation sub-type prior to physical activity, increasing the number of days that social media was viewed over the 14-day period was associated with greater situational intrinsic motivation, and introjected, identified, and external regulation prior to engaging in physical activity. While there was a significant association of health-related social media with physical activity, the actual effect of social media on MVPA was insignificant. Regardless of a motivational impact, more research is required to fully understand the effect that social media may have on physical activity before it is utilized in interventions. Finally, with no augmentative effect of WAT use and social media on autonomous forms of motivation for physical activity, the combined use of both tools may not be recommended. Despite this, both tools have the potential to increase in physical activity behaviours but more research is required. This daily diary study highlights both within-person and between-person effects of variations in daily social media use in WAT users and non-users. Ultimately, more research on these tools is required to determine how they can most effectively be used to increase activity in adults, including examining the type of content as well as dose response.

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Appendix

Appendix A. Baseline Survey

University of Victoria

Digital Health Laboratory

Physical Activity, Motivation, and Wearable Activity Tracker Use Questionnaire

The information collected from these questions is very important for both our study and the future services applied to your community. Please answer ALL of those questions that apply to you. **Your answers will be kept confidential**.

Social Media Questions

Please answer the following questions about your social media use.

1. In the last two weeks, on average, how many hours did you use social media per day?
   A. Less than 1 hour.
   B. 1-2 hours
   C. 3-4 hours
   D. 4-5 hours
   E. More than 5 hours.

2. What are the main social media platforms that you use (select multiple answers if applicable)?
   A. Facebook
   B. Twitter
   C. Instagram
   D. LinkedIn
   E. Snapchat
   F. TikTok
   G. Whatsapp
   H. YouTube
   I. Pinterest
   J. None
   K. Other (please indicate)______________________________

3. In a typical week, what percentage of your social media time is spent looking at fitness, wellness, exercise, nutrition, or health related content?
   A. <25%
   B. 25-50%
   C. 51-75%
   D. More than 75%

4. Have you seen, read or watched anything on social media related to physical activity (such as exercise, workouts, information on walks, types of physical activity or benefits) in the last two weeks?
   A. Yes
   B. No

5. Who was that information from (select multiple answers if applicable)?
   A. The government (or equivalent)
   B. Official health organizations (e.g. Health Canada)
   C. News or TV accounts
   D. Celebrities/influencers
   E. Sports performers/athletes
   F. Friends
   G. Family members
   H. Someone of similar age/interest to you
   I. Researchers
   J. Other (please indicate)________________________________

6. What was this information about (select multiple answers if applicable)?
   A. Workouts routines and exercises (e.g. HIIT, yoga, strength workouts)
   B. Physical activity guidelines (e.g. recommended frequency of exercise)
   C. Benefits of physical activity (e.g. mental health, improving fitness)
   D. Positive body image (e.g., addressing pressures of "ideal" bodies, promoting body neutrality or positivity, body inclusivity)
   E. Fitspiration or thinspiration (e.g., content about fit and toned bodies; not information about workouts)
   F. Physical activity ideas to do with family members or friends
   G. Other (please indicate)_______________________________

7. Did the social media posts (select multiple answers if applicable):
   A. Change your attitudes about physical activity.
   B. Provide you with a new understanding about physical activity.
   C. Influence you to act on information in the post (e.g. try a new workout).
   D. Prompt you to like or comment on the post.
   E. Prompt you to re-post or share the post on your own social media.
   F. Other (please indicate)___________________________________

8. To what extent do you agree with this statement: Social media has been a good source of information on physical activity and/or diet during the last two weeks.
   A. Strongly disagree
   B. Disagree
   C. Neutral
   D. Agree
   E. Strongly agree

9. To what extent do you agree with this statement: Social media has had a positive influence on my physical activity engagement during the last two weeks.
   A. Strongly disagree
   B. Disagree
   C. Neutral
   D. Agree
   E. Strongly agree

Wearable Activity Tracker Use Questions

Please answer the following questions about your wearable fitness tracker use.

10. Are you currently using a wearable activity tracker ?
A. Yes, I'm currently using a wearable activity tracker.
B. No, I previously used a wearable activity tracker.
C. No, I do not use a wearable activity tracker.

11. What wearable activity tracker do you/did you use? (Choose all the apply)
A. Apple Watch
B. Fitbit (Charge HR, Alta, Flex, Versa, Zip)
C. Whoop Band
D. Under Armour UA Band
E. Samsung Gear
F. Garmin Vivosport
G. Other (please indicate) ______________________________
H. Do not know/Prefer not to answer
I. Not Applicable

12. Branching logic question:
   a. How long did you use the ______________?
      i. Less than one month
      ii. One to three months
      iii. More than three months
   b. How did you get the_______________?
      i. I bought it for myself
      ii. It was a gift
      iii. It was provided to me by my workplace
      iv. It was provided to me by my health insurance
      v. Other (please indicate) ______________________________
      vi. Do not know/Prefer not to answer
   c. Why did you stop using the______________________________?
      i. It broke
      ii. It got lost
      iii. I did not like it
      iv. It did not help me meet my goals
      v. It was too hard to understand

vi. It got boring
vii. I learned everything I could from it
viii. It was intrusive
ix. Other (please specify) ____________________________
x. Do not know/Prefer not to answer

d. Please put the trackers in order from the first one you used to the latest one you used. For example, if you used an Apple Watch in 2010 and a Fitbit in 2012, Apple Watch will be first, Fitbit will be second.

13. Do/did your wearable activity tracker have a daily physical activity goal?
A. Yes
B. No

14. Please specify your daily physical activity goal as defined by your wearable fitness tracker:
A. Active minutes
B. Step number
C. Hours of sleep
D. Calories burned
E. Calories consumed
F. Other (please specify) ____________________________
G. Do not know/Prefer not to answer

15. Before you got your wearable activity tracker, how many days per week, on average, did you get 30 minutes of moderate to vigorous physical activity?
A. 0 days per week
B. 1-2 days per week
C. 3-4 days per week
D. 5-7 days per week
E. Do not know/Prefer not to answer

16. How many days per week do you use your wearable activity tracker?
A. 6-7 days per week
B. 3-5 days per week
C. 1-2 days per week
D. Less than 1 full day per week

17. How happened to your physical activity after you started using your wearable activity tracker, compared to before you started using it?
A. It did not change
B. It increased a lot
C. It increased a little
D. It decreased a lot

E. It decreased a little
F. Do not know/Prefer not to answer

Please rate your level of agreement with each of these statements:

	Strongly Disagree	Agree	Neutral	Disagree	Strongly Agree
18. Using a wearable activity tracker is important to improve my fitness.	1	2	3	4	5
19. Using a wearable activity is important to improve my health.	1	2	3	4	5
20. Using a wearable activity tracker is important to improve my appearance.	1	2	3	4	5
21. Using a wearable activity tracker is important to monitor my activity.	1	2	3	4	5
22. I use my wearable activity tracker to compete with friends and family on the associated mobile application or website.	1	2	3	4	5
23. I have a wearable activity tracker because I like to keep up with the latest technology.	1	2	3	4	5
24. I use a wearable activity tracker because my friends and/or family members use one.	1	2	3	4	5

Please rate your level of agreement with the following statements, thinking about your wearable activity tracker goal (i.e. getting 10,000 steps, closing your rings, etc.).

Sociodemographic Questions - please answer the following questions to the best of your ability.

25. **Sex** (Biological sex assigned at birth)
  a. Male
  b. Female
  c. Intersex
  d. Other___________
  e. Do not know/prefer not to answer

26. What is your **gender** identity?
  a. Male
  b. Female

c. Non-binary/Non-gender conforming
c. Other (please indicate):____________________
d. Do not know/prefer not to answer

27. Please enter your **date of birth** ____MM___DD_____Year_

28. Please enter your **age** _________Years

29. Please enter your **body weight** in pounds:_____________

30. Please enter your **height**: _____ feet ________inches

31. Are you pregnant?
    a. Yes
    b. No
    c. Don't know/prefer not to answer

32. Please indicate which, if any, of the following chronic health problems you have. (Check all that apply)
    a. High blood pressure
    b. Cataracts or other eye problems
    c. Heart disease/heart attack
    d. Arthritis or Rheumatism
    e. Stroke
    f. Cancer
    g. Broken or fractured bones
    h. Bronchitis or other respiratory diseases
    i. Diabetes
    j. Chronic foot trouble (bunions, plantar fasciitis, ingrown toenails, etc.)
    k. None
    l. Other, please specify:___________________

33. Are you part of a professional sports team or training for a competitive athletic events (e.g., varsity team, athletic competition)?
    a. Yes
    b. No

34. Which sport or type of event? (Text entry) _____

35. Does this require you to follow a regimented training schedule or diet?
    a. Yes
    b. No

36. I think my physical health is:
    a. Poor

b. Fair
c. Good
d. Very Good
e. Excellent
f. Don't know/Prefer not to answer

Race

37. Please specify your race (Check all that apply)

a. White or Caucasian
b. Black
c. First Nations
d. Métis
e. Inuit
f. Asian
g. Native Hawaiian or Pacific Islander
h. Other
i. Do not know/prefer not to answer

Ethnicity

38. Please specify your ethnicity (Check one)

a. Hispanic or Latino
b. Non-Hispanic or Latino
c. Other
d. Do not know/prefer not to answer

Education

39. What is the highest level of education you have completed? (Check one)

a. 12^{th} grade or less
b. High school graduate or GED
c. Some college/AA degree/Technical school training
d. College graduate (BA or BS degree)
e. Graduate school degree: Master's or Doctorate degree (MD, PhD, JD)
f. Do not know/prefer not to answer

School Status

40. If you are currently in school, please indicate the level you are enrolled?

a. I am NOT in school
b. High school
c. Community college or technical school
d. 4-year college/university
e. Graduate or other professional school

41. Are you a UVic student?

a. Yes
b. No

42. Please type in your Major. If you have not yet declared your Major, please type in which Faculty you are in (text entry): ________

Work Status

43. What is your current work situation?
 a. Working full time (≥ 40 hours/week)
 b. Working part time (20 - 40 hours/week)
 c. Working part time (<20 hours/week)
 d. Not working and not looking for work
 e. Unemployed and looking for work
 f. Disabled or retired and not looking for work
 g. Do not know/prefer not to answer

Income

44. What is your total combined family income for the past twelve months, before taxes, from all sources, wages, public assistance/benefits, help from relatives, alimony, and so on?

If you do not know your exact income, please estimate.
 h. Less than $12,500
 i. $12,500-$26,999
 j. $27,000-$43,999
 k. $44,000-$59,999
 l. $60,000-$74,999
 m. $75,000-$99,999
 n. $100,000-$149,000
 o. More than $150,000
 p. Don’t know/ Prefer not to answer

45. Please enter your zip code ________________

Appendix B. Pre-Exercise and Post-Exercise Daily Surveys

Pre-Exercise Survey

Event-contingent survey- to be filled out before physical activity

1: *corresponds not all*; 2: *corresponds very little*; 3: *corresponds a little*; 4: *corresponds moderately*; 5: *corresponds enough*; 6: *corresponds a lot*; 7: *corresponds exactly*.

Why are you currently engaged in physical activity?

1. Because I think that this activity is interesting.
2. Because I am doing it for my own good.
3. Because I am supposed to do it.
4. Because I would feel bad not doing it.
5. There may be good reasons to do this activity but personally I do not see any.
6. Because I think that this activity is pleasant.
7. Because I think that this activity is good for me.
8. Because it is something I have to do.
9. Because I would feel guilty to not do it.
10. I do this activity but I am not sure if it is worth it.
11. Because this activity is fun.
12. By personal decision.
13. Because I don’t have any choice.
14. Because I want to avoid feeling guilty.
15. I don’t know; I don’t see what this activity brings me.
16. Because I feel good when doing this activity.
17. Because I believe that this activity is important for me.
18. Because I feel I have to do it.
19. Because I would regret not doing it.
20. I do this activity but I am not sure it is a good thing to pursue it.
21. Because I want to build muscle.
22. Because I want to control my weight or prevent weight gain.
23. Because I need to burn off the number of calories I have eaten, or will eat, today.
24. Because I want to lose weight.
25. Because I think it will improve my mood.
26. Because I think it will relieve stress.
27. Because I think it will make me feel better about my body.
28. Because I would feel anxious or distressed if I don’t.
29. I will feel lethargic and/or low energy if I don’t.
30. It’s part of my training schedule.

Post-Exercise Survey

To be filled out after exercise

1.How long did your physical activity session last?
□1-10 minutes
□11-20 minutes
□21-30 minutes
□31-40 minutes
□41-50 minutes
□51-60 minutes
□More than 60 minutes

2. How hard was the activity?
□Very light
□Light
□Moderate/ somewhat hard
□Hard
□Very hard
□My max effort

3. During the first time you did physical activity today: What type of physical activity did you do?
(Please select the most applicable option)

□Walking
□Gardening or yard work
□Housework (i.e. cleaning, vacuuming)
□Jogging or running
□Cardio equipment (i.e. treadmill, elliptical)
□Hiking
□Biking/cycling (indoor or outdoor)
□Swimming or water exercises
□Aerobics or aerobic dancing
□Yoga
□Weightlifting or other strength training
□Sport (i.e. golf, basketball, baseball)
□Playing with children (e.g., running around, playing catch)
□Skiing, snowboarding, or snow-shoeing
□Other activity (specify below)
□Do not know/Prefer not to answer
Please specify the 'other' type of physical activity that you did: ________________

Evening Survey

Did you do physical activity today?

A. Yes, I did physical activity.
B. No, I did not do physical activity today.

If you did PA today, did you fill out the motivation survey prior to the activity? (If you did NOT do physical activity- select answer C).

A. Yes, I filled out the motivation survey prior to the activity.
B. No, I filled out the motivation survey prior to the activity.
C. I did not do PA today.

If you did PA today, did you report what you did post-activity? (If you did not do physical activity, select answer C).

A. Yes, I reported my physical activity.
B. No, I did not report my physical activity.
C. I did not do PA today.

Did you look at fitness/health/nutrition/wellness related social media content on social media today?

A. Yes
B. No

If yes, respond to the fill in the blank in the following statement. If no, select option “F”. Looking at fitness/health/nutrition/wellness related social media content today made me**_________** to do physical activity today/

A. Much more likely
B. More likely
C. Neither more nor less likely
D. Less likely
E. Much less likely
F. I did not look at fitness/health/nutrition/wellness related social media content today.

Appendix C. Participant Consent Form

Assessing physical activity and motivation in wearable activity monitor users and former users.

You are invited to participate in a study entitled "Assessing physical activity and motivation in wearable activity monitor users, former users, and non-users" that is being conducted by Principal Investigators Dr. Sam Liu and Rebecca Coulter.

Dr. Sam Liu is an Assistant Professor with the Digital Health Lab in the School of Exercise Science, Physical and Health Education at the University of Victoria and you may contact him if you have further questions. Rebecca Coulter is a Graduate Student with the Digital Health Lab in the School of Exercise Science, Physical and Health Education at the University of Victoria and you may contact her if you have further questions. Dr. Brianna Turner is also a co-researcher for this study. Dr. Turner is an Assistant Professor with the Risky Behaviour Lab in the Department of Psychology.

Purpose and Objectives
Many people buy and use wearable activity trackers like Fitbits and Apple Watches to keep track of their physical activity. Interestingly, a lot of those people also stop using the devices just a short time after getting them. We want to know if there is a difference in the way people who keep using the devices are motivated for exercise. We also want to know people who quit using the devices do more or less physical activity than those who keep using them.

Importance of this Research
Research of this type is important because despite many people buying wearable activity trackers to monitor their physical activity, many quit using them in a short amount of time. Many health promoting programs, like insurance companies and corporate wellness programs give people wearable activity trackers to encourage them to move more. We wonder, though, if there's a specific type of person for whom a wearable activity tracker is more useful. We think there may be a difference in the way people who keep using the devices are motivated for exercise. We can use these results to personalize interventions for physical activity in the future but giving wearables to those who would benefit from the most.

Participants Selection
You are being asked to participate in the study because you fit these criteria: You are 18 years or older, you speak English, you live in Canada, you currently use, have used a wearable activity tracker (a Fitbit, Apple Watch, etc.) in the past or have never used one, and you own and regularly use an Android or iPhone smartphone that you are willing to use to complete app-based surveys for the duration of the study.

What is involved

If you consent to voluntarily participate in this research, your participation will include: (1) A baseline electronic survey; and (2) A 14-day assessment period, during which you will complete up to two surveys via a smartphone application on a daily basis. These assessments are described in detail below.

Baseline Survey~55 minutes

Following completion of your electronic consent form, you will be asked to complete a baseline survey electronically. Links to these surveys will be sent to the email address you provided during the screening process. Each of these surveys will be completed at the time and location of your choice, remotely from research personnel.

The survey will ask you will ask about your age, sex, race/ethnicity, and other demographic characteristics. It will also ask you about your wearable activity tracker use, either now or in the past, your social media use and mood. Finally, you'll be asked about your eating behaviors, body image, and motivation for, and patterns of, physical activity.

14-Day Phone Survey Period ~ 90 minutes/1.5 hours

You will also complete up to three surveys per day via the free smartphone application for the 14-day phone survey period at the location of your choice, remotely from study personnel. You will need to remember to fill out the motivation survey before you complete any physical activity. You will also need to remember to fill out the physical activity survey when you have finished your activity for the day. You will receive also receive one survey in the evening. The evening survey will ask whether you completed physical activity during the day and if you did or did not fill out the motivation survey beforehand. Each survey should only require no more than 2 minutes of your time.

Inconvenience

Participation in this study may cause some inconvenience to you, including having to remember to fill out a short motivation survey before and a short physical activity after doing a bout of physical activity. You'll also get two reminders on your mobile device (one in the morning to remind you about the motivation and physical activity survey) and one in the evening to remind you to fill out the evening survey. These notices may interrupt your daily life.

Risks

The risk associated with your participation in the baseline and daily surveys is that you may experience some minor psychological discomfort due to the personal nature of some of the questions you will be asked about your eating behaviours, body image, and motivations for exercise. To mitigate these risks, you may choose to leave questions blank or end your participation at any time. You will also be provided with resources that can offer support should you experience any discomfort. If you have any additional concerns, we encourage you to contact Dr. Liu or Rebecca Coulter.

Benefits

There may be no direct benefit to you as a participant in this study, but we hope to learn more about how motivation and physical activity are different between people who persist in using wearable activity trackers and people who stop. This information may help inform future research regarding how wearable activity trackers should be used in interventions to help people move more.

Compensation

As a way to compensate you for any inconvenience related to your participation, you will be given $1 in Amazon gift cards for every evening survey completed over the 14-day survey period. In addition, you will be given a $10 bonus if you complete at least ten (10) of the fourteen (14) evening surveys, up to a maximum of a $24 Amazon gift card. Students who are attending the University of Victoria and are enrolled in an eligible Psychology undergraduate course, will be offered SONA as well as entries into a drawing for their participation. Eligible students will be offered 1.0 SONA credits for their participation in the baseline survey and up to 2.0 SONA credits for their participation in the 14-day phone survey period. SONA credits for the daily survey portion of the study will be pro-rated depending on how many of the end-of-day surveys you complete. For example, if you only complete 7 of the 14 end of day surveys, you will receive half of the maximum SONA credits for the daily survey portion (i.e., 1.0 SONA credits). In total, this study requires approximately 2.5 hours of your time, for which you will be compensated a maximum of 3.0 SONA credits. If you choose to withdraw from the study, you will receive pro-rated SONA credits, rounded up to the nearest 0.5 credit, for the time you spent completing the study. In addition, as a SONA participant, if you complete the baseline survey AND seven (7) of the fourteen (14) evening surveys you will be given one entry into a drawing for one of three $50 Visa giftcards. If you complete ten (10) or more evening surveys, you will be entered five (5) times into the drawing.

Voluntary Participation

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will be removed from the dataset.

Anonymity

In terms of protecting your anonymity, no reference will be made in written or oral materials that could link you to this study. For this study, we will assign a code to your data and we will not collect your name. Your email address will be linked to your code; however, only the research team will have access to the link between your email address, your code, and your data. All of your surveys will be stored in an encrypted, cloud-based storage system. The mobile app will not actively collect or store any geospatial data from your phone, so researchers will not have access to any information regarding your physical location. The mobile application is called Pathverse and the privacy policy can be accessed here: https://pathverse.ca/privacy-policy/. Back-up data files will be stored in a restricted access folder on University of Victoria's secured servers for three years after completion of the study. After the storage time, the information gathered will be archived and locked. We may be asked to share the research files with the University of Victoria Human Research Ethics Board for auditing purposes. Please be advised that this research study includes data storage in U.S.A (via the Pathverse mobile application). As such, there is a possibility that information about you that is gathered for this research study may be accessed without your knowledge or consent by the U.S. government, in compliance with the U.S. Freedom Act.

Researcher's Relationship with Participants

One of the researchers on this study is Dr. Brianna Turner, an Assistant Professor in the Department of Psychology at the University of Victoria. Participants who are currently students at the University of Victoria should be aware that Dr. Turner regularly teaches undergraduate Psychology courses in the Department, and is actively involved in the administration and oversight of the undergraduate Psychology program as a regular faculty member. Thus, it is possible that UVic students who participate in this study may interact with Dr. Turner in a role separate from their responsibilities as a research participant, now or in the future. Although responses are de-identified (i.e., linked to an anonymous code rather than your name or email), it will be possible to link your anonymous code to your email. As such, Dr. Turner will have access to identifying information solely to monitor data quality. Students are reminded that participation in this research study is voluntary, and your consent may be withdrawn and participation discontinued at any time. Students who are earning course credit for their participation can choose to participate in another study if they wish.

Confidentiality

The research team works to ensure confidentiality to the degree permitted by technology. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online. However, your participation in this online survey involves risks similar to a person's everyday use of the internet.

Dissemination of Results

It is anticipated that the results of this study will be shared with others in the following ways: published in scholarly journals, presented at academic conferences, made available on the internet through UVicSpace in the form of a thesis.

Disposal of Data

Data will be stored in the Digital Health Lab secure server and will be erased ten years after the completion of the study.

Contacts

Individuals that may be contacted regarding this study include Dr. Sam Liu and Rebecca Coulter.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria.

Supports

If you are feeling any distress at any point during your participation in this study, we encourage you to contact one of the following resources for additional support. The following resources provide support for emotional crises, general psychological distress, as well as disordered eating.

Canada Wide Supports –Mental Health and Crisis Support

For a list of crisis support services (e.g., crisis phone lines, crisis support chats) nearest to you, please visit:
https://www.crisisservicescanada.ca/en/looking-for-local-resources-support/

To access a free Canadian program called BounceBack that helps you build skills to improve your mental health, please visit:
https://bounceback.cmha.ca/?gclid=Cj0KCQiA8ICOBhDmARIsAEGI6o2gx_-nbHpGzKisC5xNw_IfX86ufzT_W9Fiw-BK2dhiqFFuKIDn6GcaAo5bEALw_wcB

Phone or online chat crisis support through Hope for Wellness is available for all Indigenous Peoples across Canada. Visit the link below for more information about Hope for Wellness and their phone and online chat contact information:
https://www.sac-isc.gc.ca/eng/1576089519527/1576089566478

Canada Wide Supports – Disordered Eating Supports

The National Eating Disorder Information Centre (NEDIC) website has information about eating disorders, as well as contact information for phone or online chat support for eating disorders. Please visit their website at: https://nedic.ca/

NEDIC also has a directory of mental health clinicians that provide support for people coping with eating disorders in different areas of Canada. To find a service provider that specializes in eating disorders near you, please visit: https://nedic.ca/find-a-provider/

The National Initiative for Eating Disorders has information about and links to various resources for eating disorders (e.g., books, articles, videos etc.). Please visit their website for more information and resources: https://nied.ca/resources/

Mental Health and Crises Supports Based in Victoria

Foundry Victoria
Walk-in Counselling appointments for people aged 12-24 are available Monday to Friday between 11 a.m. and 3 p.m. Primary care (physical health) services are also available at this centre.

Location: 818 Douglas Street, Victoria BC
Website: https://foundrybc.ca/victoria

Citizens Counselling
Citizens Counselling provides trained, low-cost Counselling and support regarding:

- Relationship/communication
- Changes in status or roles (grieving, divorce, marriage, career)
- Situational depression, stress, and anxiety management
- Conflict resolution and anger

Website: www.citizenscounselling.com

Disordered Eating Support Based in Victoria

South Vancouver Island Eating Disorders Program

Support for persons dealing with disordered eating and their families. You can self-refer. They offer various programs (including assessment, group and individual treatment options) Website: https://keltyeatingdisorders.ca/south-vancouver-island-eating-disorders-program/

*****University of Victoria Students Only*****

On Campus Support

UVic Student Wellness Centre
UVic Wellness Centre includes medical and counselling services. The Centre provides free counselling for UVic students, including individual and group services. The Centre also provides access to Indigenous counsellors for Indigenous students who are interested. Access to the Uvic Eating Disorder Clinic is also available on referral.

You can attend a single-session walk-in (45 minutes) on a first-come, first-served basis by going to Counselling Services on the day you wish to speak to a counsellor. This is the fastest way to get in to see someone; however, you should be there on-time to maximize your chances of getting a same-day appointment. Morning sessions are booked at 8:30 a.m. (Monday, Wednesday, Fridays only) and afternoon sessions (Monday through Friday) are booked at 12:30 p.m. You can also pre-book a counselling session by going to the front counter or calling the Centre, but there may be a delay between your call and your first appointment.

Location: Student Wellness Centre on McKenzie Ave
Phone: 250-721-8563
Hours: Mon-Fri 8:30-4:30 pm
Websites: UVic Wellness Centre (hyperlinked to the website)

Indigenous Counselling (hyperlinked to the website)

UVic First Peoples House
What is it? The First Peoples House provides a place for community building and social, cultural and academic guidance for Indigenous students at UVic. Students can access Indigenous counselling services, Talking Circles, and Elders in Residence.
How do I access it? Indigenous counselling is accessed through the Wellness Centre (see above). Elders in Residence are available Monday-Thursday 10 a.m.-2 p.m. in the Elders' Lounge (FPH 112).

If you need EMERGENCY assistance and are on campus, please contact Campus Security

By completing and submitting the questionnaire, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please retain a copy of this letter for your reference.