Associations Between Stress, Affect, and Physical Activity in Young Adulthood: Stages of Change as Potential Moderators

by

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A Thesis Submitted for the Degree of

MASTER OF SCIENCE

in the Department of Psychology at the University of Victoria

We acknowledge and respect the Lək̓ʷəŋən (Songhees and Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

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Abstract

Current global estimates of physical activity suggest that less than 20% of adolescents are sufficiently physically active, and 28% of adults over 18 are not active enough to stay healthy despite the known physical and mental health benefits. Given the notable short- and long-term benefits of physical activity, paired with insufficient engagement rates, young adulthood (ages 19-25) is a critical time to build and support continued physical activity engagement across the lifespan. Research has identified increased stress and negative mood to impair physical activity efforts, but the associations between stress and affect and physical activity at the daily levels remained largely unexplored. In addition, potential moderating factors of these associations currently lack research. This study aimed to understand the associations between daily stress, positive and negative affect, and physical activity, as well as explore the six Stages of Change (SoC) as potential moderating factors. Undergraduates (N = 74; M_{age} = 20.88, SD = 2.53) responded to surveys administered through a smartphone app for 14 days and wore a Fitbit Charge 2 to gather physical activity data (i.e., daily steps). Multi-level models showed no within-person associations between stress, positive and negative affect, and physical activity. However, two significant interactions were observed: (1) *contemplation* significantly moderated the association between positive affect and physical activity, and (2) *action* significantly moderated the association between negative affect and action. Overall, results concerning the moderating impact of SoC were mixed; yet provide directions for future research. Results can provide new insight for strategies that focus on strengthening personal intentions and promoting individual motivations to engage in health behaviours such as physical activity.

Keywords: physical activity; young adulthood; stages of change; wearable technology

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Introduction

Physical activity, defined as any bodily movement that results in increased energy expenditure above sedentary includes competitive sports, individual exercise, recreational sports, conditioning, and other activities (Caspersen et al., 1985). Physical activity is modifiable and can be tailored to the individual's preferences and capabilities, making it a promising prevention and intervention to target across multiple health domains. Indeed, engagement in physical activity has been shown to have physical, psychosocial, and cognitive benefits (Belcher et al., 2021; Janssen & LeBlanc, 2010; Lubans et al., 2016; Mandolesi et al., 2018). For example, physical activity contributes to autonomy and well-being (Tremblay et al., 2016), is protective for cardiovascular health (Ramakrishnan et al., 2021), improves metabolic and musculoskeletal indicators (Myers et al., 2019), and enhances body awareness and sense of competency (Sudeck et al., 2018). Positive experiences with physical activity have also been associated with promoting a higher and more consistent engagement in physical activity (Sudeck et al., 2018). Yet research shows trajectories of physical activity show stark declines across late adolescence (ages 12-18) into young adulthood (ages 19-29), theorized to result from increased day-to-day demands that compete for youths' time and energy (Ames et al., 2018; Duncan et al., 2007). Given the notable short- and long-term benefits of physical activity, young adulthood is an especially critical time to build and support continued engagement, yet research surrounding when, why, and how young adults engage in physical activity at the daily level remains largely unknown (Agans & Lerner, 2021).

Some research has identified increased stress and negative mood to impair physical activity effort and intention, subsequently reducing engagement (e.g., Stults-Kolehmainen & Sinha, 2014). However, we know little about the factors that may disrupt this association. A

potential factor that may influence the associations between stress, mood, and physical activity is how strongly an individual believes in the benefits of physical activity or lack thereof. This factor can be measured using the Stages of Change model (SoC; Prochaska & DiClemente, 1983), a measure of an individual's belief in the benefits of behavioural change. SoC consists of six distinct stages related to an individual's belief in a specific behavioural change (e.g., engagement in physical activity), with initial stages corresponding to a lack of readiness to change, progressing up to action and maintenance. The stages include: 1) *precontemplation non-believer*, a behaviour has yet to be acknowledged as a problem and no belief that change will be beneficial; 2) *precontemplation believer,* a behaviour has yet to be acknowledged as a problem but belief that change will be beneficial; 3) *contemplation*, acknowledging a behaviour as a problem but not at a point of being ready to change, may lack confidence or want to change; 4) *preparation*, getting ready to engage in behaviour change; 5) *action*, actively changing behaviour; and, 6) *maintenance*, maintaining actions of behaviour change (Prochaska & DiClemente, 1983). Previous research suggests individual physical activity intensity and context may be influenced by an individual's location along the SoC continuum (De Bourdeaudhuij et al., 2005) and that individuals in the earlier stages may have lower physical activity rates due to not being ready to commit to a physically active lifestyle (Gawwad, 2008). Thus, this study examines how within-person internal factors (i.e., stress, mood, affect) may promote or impede physical activity and examines the potential moderating nature of each SoC stage on physical activity within young adulthood.

Benefits of Physical Activity

Physical activity is widely recognized as a critical behaviour for promoting physical and mental health among youth (World Health Organization [WHO], n.d.). Indeed, the WHO

suggests that higher levels of physical activity in late adolescence and young adulthood are related to lower risk of all-cause mortality, risk of cardiovascular disease mortality, incident hypertension, and improved bone health, cardiometabolic health, sleep, cognitive health, and mental health (WHO, n.d.). Consistent with this, a large-scale review of 15 longitudinal studies encompassing 288,724 adults ranging from 18- to 85-years-old (Reiner et al., 2013) examined the long-term health benefits of physical activity into adulthood regarding non-communicable diseases. Findings supported associations between increased physical activity and improved health outcomes for weight gain, obesity, coronary heart disease, type 2 diabetes, Alzheimer's disease, and dementia (Reiner et al., 2013). Current recommendations for adolescents and adults suggest meeting at least 60 minutes per day and 150 minutes per week of moderate-to-vigorous physical activity (MVPA; Tremblay et al., 2016). However, global estimates suggest that less than 20% of adolescents are sufficiently physically active (Guthold et al., 2020), and 28% of adults over 18 are not active enough to stay healthy (WHO, n.d.). Specific to young adulthood, a recent National College Health Assessment (NCHA) survey of Canadian undergraduates showed that only 38% met weekly physical activity guideline recommendations for aerobic and muscle-strengthening activity (American College Health Association, 2022). Engaging in physical activity throughout the lifespan is a vital health recommendation, but rarely followed (Piercy et al., 2018). Due to this, research surrounding how individuals choose to engage in and maintain active lifestyles across the lifespan is an essential area of concern, specifically regarding transitional periods such as the entrance into young adulthood. Further, studies suggest physical activity levels in adolescence are associated with adult activity levels (Telama et al., 2014); however, not all physically active adolescents end up as physically active adults, and physically active adults were not always physically active adolescents (Malina, 2001). These findings point

to a potential disruption in habits across this transitional period, calling for further study into what promotes and prevents declines in physical activity in this developmental period.

Our understanding of when, how, and why a young adult may engage in physical activity (and other health behaviours) is informed by two theoretical approaches, namely the Theory of Planned Behaviour (TPB; Ajzen, 1991) and the Multi-Process Action Control framework (M-PAC; Rhodes, 2021). Each approach has been used to explore the nature of the association between internal factors (i.e., stress, mood and affect) and subsequent physical activity engagement. These frameworks aid in increasing our understanding of the effect daily fluctuations in internal factors, stress, mood, and affect, have on specific behavioural endorsements and engagements, such as physical activity, highlighting how associations with physical activity may be enhanced, disrupted, or influenced.

TPB (Ajzen, 1991) suggests an individual's intention to engage in or perform a behaviour is explained by three constructs: attitude, subjective norms, and perceived behavioural control. TPB posits attitude as based on the individual's affective perception of the behaviour they are engaging in; individuals evaluate the possible outcomes of performing the target behaviour, be it positive or negative (Ajzen, 1991). Ajzen (1991) proposed that attitude is a key factor in determining intention, and that attitude and/or intention and subsequent behaviour engagement is influenced by the likelihood of a positive outcome. It is theorized that the higher value/belief an individual places on the outcome of their target behaviour, the more likely that behaviour is to be endorsed and followed through (Glanz, Rimer, & Viswanath, 2008). TPB has been used to predict physical activity (as the planned behaviour) utilizing the individuals' intentions, attitudes and beliefs behind the physical activity as key elements of behaviour endorsement and eventual engagement (Plotnikoff et al., 2011). This reasoning is consistent with physical activity research

showing the positive benefits experienced by individuals who engage in physical activity result in higher and more consistent engagement in physical activity (Sudeck, 2018). TPB is a foundation to build off of regarding the association between intentions, attitude, beliefs, and behaviour engagement. TPB may not be able to fully account for daily fluctuations in temporal attitudes at the within-persons level, and a more nuanced approach sensitive to the contexts as well as shifting attitudes may be more appropriate.

M-PAC (Rhodes, 2021) is a modern, practical approach to physical activity behaviour promotion. M-PAC is a multi-layered framework based on behavioural change and has three layers: (1) decide, relates to an individual being motivated by deliberated and expected consequences to subsequent behaviours; (2) endeavour, behaviour is managed through strategies to transform intention to behaviour; and, (3) sustain, behaviour is maintained through specific circumstances and experiences over time (Rhodes, 2021). Holistically, M-PAC is a framework that can be applied to intentions, motivations, beliefs, and contextual factors that may impede or promote behaviours (i.e., physical activity). The concepts inherent to M-PAC provide a framework to address a common limitation in physical activity research to date: the *intention-behaviour gap*, which describes the failure of an individual to translate intention into actionable behaviour despite motivations (Godin et al., 2005). In the context of this study, M-PAC suggests daily changes in internal factors (i.e., stress, mood and affect) could impede an individual's ability to engage in physical activity despite intentions (Rhodes, 2021). Utilizing TPB and M-PAC as theoretical lenses, this study will not only address the intention-behaviour gap by investigating the influences that within-person (i.e., stress, mood and affect) factors may have on physical activity engagement in young adults but also explore a deeper layer of potential moderators of the association between daily stress and mood and physical activity; namely, SoC.

Young Adulthood

Young adulthood (ages 19 to 25; Higley, 2019) is a unique developmental period that falls between the more concretely defined developmental periods of adolescence and adulthood. Of importance, trajectories of physical activity across late adolescence into young adulthood show consistent declines. thought to be attributed to the increasing daily demands that are vying for the young adults' time, effort, and attention (Ames et al., 2018; Duncan et al., 2007). Young adulthood is an often-overlooked period of development, as many existing institutions and societal structures consider the ages of 18 or 19 to be the end of youth and adolescence and all ages beyond as, simply, adulthood (WHO, n.d.). Developmental theory characterizes young adulthood as a unique period of development, presenting challenges to an age group that may often become obstacles to an individual's life goals. *Emerging adulthood* is a relatively new term that focuses specifically on the ages of 18- to 29-years-old (Arnett, 2000). Arnett (2000) coined this term after interviewing 300 people aged 18-29 and identified a theoretical period to understand better the individuals' reports that they felt they were pulling clear of the challenges of adolescence and beginning to feel responsible for themselves but still feeling closely connected or reliant on their immediate parents and family for many basic needs (Arnett, 2000). Arnett (2000) suggested that young adults often experience challenges reaching their goals or following through with their intentions based on five key features experienced during this timeframe: 1) identity exploration; young people are still deciding who they are and what they want out of life, 2) instability; these years are marked by repeated residence changes, and frequent moves are common based on work, family or schooling opportunities, 3) self-focus; individuals are now free to choose entirely for themselves and are no longer bound by choices made by guardians or educational figures, 4) feeling in-between; young adults want to take

responsibility for their lives but still at times feel not completely an adult, 5) possibilities; young adults believe they have a chance to live better than their parents and make the most out of their lives. In summary, this research situates young adults in a tumultuous period, where young adults want a lot out of life but sometimes feel ill-equipped to get their total desires. This feeling of 'wanting more out of life' and embracing countless new opportunities and taking on more responsibilities are not without consequence and may leave emerging adults vulnerable to the effects of increased stress and decreased affect regarding both physical and mental health concerns.

Young adulthood can also be a formative time in an individual's life, during which young adults find themselves with increased responsibility and potentially less time to maintain a balanced lifestyle and health-promoting behaviours (Bonnie, 2015). During this time, adaptive, health-promoting behaviours may be neglected or forgotten in pursuing the endless avenues a young adult might have the opportunity to explore. Over time, less healthy lifestyle choices and poor behavioural decisions set health trajectories into later adulthood, increasing risks of chronic disease and otherwise avoidable morbidities (Sorgi et al., 2015). Historically, the lack of a clear definition for young adults as a distinct group, compared to adolescence and adulthood, has often led to confusion in program and treatment development for young adults. Research shows young adults engage in lower rates of healthcare utilization (Lau et al., 2014), have worse overall health issues, including substance use concerns, high rates of injury, mental health concerns, sexual and reproductive health concerns, and overall increases in risk-taking behaviours (Higley, 2019). Given the elevated risky behaviour typically seen in this age range, and the known ameliorative benefits of physical activity, it is of concern that most individuals in late adolescence and young

adulthood are not meeting current suggested guidelines for physical activity requirements, as noted above (American College Health Association, 2022; Guthold et al., 2020).

Recent attention has been paid to the stress levels of young adults (American Psychological Association [APA], 2020). For instance, an APA (2020) nationwide survey of stress levels showed that the country's youngest individuals (i.e., teens aged 13-17 and young adults aged 18-23) reported the highest stress levels for the first time in history compared to older age groups. Young adults (ages 18-23) had an average stress rating of 6.1 out of 10 (10 being the highest) compared to 5.6 for ages 24-41, 5.2 for ages 42-55, 4.0 for ages 56-74, and 3.3 for ages 75+ (APA, 2020). Concerning trends overtime, the study reported that stress levels across adult age groups remained consistent from 2018 to 2020; however, young adults' reported stress levels have increased over time (i.e., 5.6 in 2018 to 6.1 in 2020; APA, 2020). Similarly, a second study tracked daily stress across 20 years of adulthood. Among participants ($N = 2845$; ages 22- to 77-years-old at baseline), the authors found that young adults (those ages < 30-years-old) reported the highest level of stress exposure as well as stress reactivity (Almeida et al., 2022). Interestingly, the same study found that, over time, adults' stress profiles improved with age, with young adults displaying a stress reduction rate of 47% over time, and middle-aged adults averaging an 11% reduction in daily stress, while adults aged 54 years and older exhibited relatively stable stress over time (Almeida et al., 2022). Results such as the survey (APA, 2020) and longitudinal study (Almeida, et al., 2022) again highlight young adulthood as a distinct developmental period of increased perceived stress and reactivity in contrast to other age groups.

Alongside stress, mental health concerns are also a significant public health concern for young adulthood (John Hopkins Medicine, n.d.; WHO, n.d.). Notably, it is estimated that 20% of both adolescents and individuals over the age of 18 experience mental health problems (John

Hopkins Medicine, n.d.; Lee et al., 2014); with half of all lifetime mental health diagnoses occurring by age 14 (Kessler et al., 2005). Many youth also suffer from more than one mental health disorder at a time, with depressive disorders tending to be comorbid with substance use and anxiety-related disorders (John Hopkins Medicine, n.d.). In a Canada-wide review, it was observed that approximately 70% of cases for symptoms of mental health concerns began before the age of 18, with a large portion being affected by mental health concerns before they reach the age of 25 (Government of Canada, n.d.). As such, young adulthood is an age range of increased vulnerabilities to mental health concerns, and those who suffer from mental health concerns in their 20s are at an increased risk of suffering from additional concerns ten years later (Gustavson et al., 2018). One consistent challenge in addressing the previously stated issues is access to care and treatment options for mental health concerns among young adults. Indeed, many individuals in Canada report experiencing barriers to accessing mental health care services. Recently the Canadian Institute for Health Information (CIHI) found that half of Canadians waited up to 30 days for counselling services and for 1 in 10 Canadians the wait was more than four months (CIHI, n.d.). Specific concern is warranted for younger Canadians, with less than 20% of adolescents in need of mental health services getting adequate treatment before entering the adult system and wait times of over 60 days for counselling and over 90 days for intensive treatment being typical in larger provinces in Canada (Government of Canada, n.d.; Centre for Addiction and Mental Health, n.d.). Access to evidence-based treatments, such as psychotherapy can be challenging, with up to 44% of young people not obtaining adequate mental health supports, and up to 49% of young people reporting recent and continued mental health service disruptions during COVID-19 (Hawke et al., 2020). Untreated mental health concerns may have significant implications for a young adult's future and affect their ability to receive education, establish

relationships, and contribute to a career in a meaningful manner (WHO, n.d.). Although concerning, these findings highlight a need for a better understanding of how these salient factors influence physical activity engagement. As such, the first objective of this research is to model the day-to-day influences of stress and mood on young adults' physical activity.

Predictors of Physical Activity

Stress

One well-researched predictor of physical activity engagement is stress (Stults-Kolehmainen & Sinha, 2014; Reichert et al., 2022). Typically, stress is seen as the psychological and physiological challenges that an individual experiences due to the circumstances they believe to be difficult, overwhelming, and/or out of their control (Cohen et al., 1983; Stults-Kolehmainen & Sinha, 2014). There is no universal definition for stress; however, McEwen described "stress is a word used to describe experiences that are challenging emotionally and physiologically" (2017; pg. 874). Utilizing a broad definition of stress allows for both acute and chronic stressors to be measured, in both large and small proportions. Stress has been observed to be implicated in the development of an array of negative physical and mental health outcomes, with mounting evidence that health behaviours and beliefs may influence these associations (McEwen, 1998). Physically, stress has been associated with, but not limited to, increased rates of heart disease (Rozanski et al., 1999), acute myocardial infarctions (Rosengren et al., 2004), and alterations in immune system function (Segerstrom & Miller, 2004). Psychologically, stress has been linked to a wide range of mental symptoms ranging from cognitive impairment and increased dementia rates (Sandi 2004) to excessive fatigue (Cho et al., 2012; Hasler et al., 2005; Theorell-Haglow et al., 2006). Stress has also been associated with indirect routes toward poor health outcomes, mainly linked to decreased physical function over time (Cheng et al., 2000).

Concerningly, evidence has shown that stress is related to impaired health behaviours, and increased stress levels may lead to strengthened negative lifestyle routines, such as reduced rates of exercise engagement and physical activity engagement, which consequently increases rates of sedentarism (Hamer, 2012). For example, Stults-Kolehmaninen and Sinha (2014) reviewed 55 studies and found that most research (76%) supported that psychological stress predicted less physical activity engagement and more sedentary behaviours. Additionally, the review found that both subjective stress (e.g., distress) and objective stress (e.g., life events) were related to reduced levels of observable physical activity (Stults-Kolehmaninen & Sinha, 2014). Unfortunately, among the 55 articles mentioned above, samples were predominately comprised of older adults and studies supporting these results among young adults remain unexplored.

One notable limitation of past research includes the focus on the between-persons effects of stress on physical activity engagement (Cheng et al., 2000; Hamer, 2012; Stults-Kolehmaninen & Sinha, 2014), and there is a need to explore the association between stress and physical activity levels beyond the effects of between-person analyses. Between-persons analysis is the comparison of one individual's stress and physical activity levels compared to other individuals' levels of stress and physical activity engagement. Within-person effects examine differences in behaviour compared to the individual's average (Curran & Bauer 2011) and hold benefits over between-person analyses. For example, within-person analyses can aid in establishing stability trajectories and measure change over periods of time, be it at the daily level, monthly level, or beyond (Curran & Bauer, 2011). Regardless of the time frame, it is crucial to understand the short- and long-term effects of an individual varying from themselves outside of what it means to vary from another individual. This is important, as it can move past the "snapshot" nature of past observed effects, focus on within-person differences, and inform

future prevention and intervention strategies aimed to promote continued or increased physical activity during these critical years.

Some research has provided evidence supporting the association between stress and physical activity at the within-person level. Reichert et al. (2022) explored children's (N = 74, ages 7-11) daily stress and physical activity rates across seven days. Analysis revealed that over 513 assessments, within-children effects supported higher psychological stress predicting decreased physical activity at the daily level (Reichert et al., 2022). Leger et al. (2023) examined stress and physical activity levels among older adults (N = 180, M_{age} = 73.4) and observed that older adults reported experiencing more interpersonal stressors on days with less sedentary time and more light physical activity engagement. Schultchen et al. (2019) explored both stress and affect as predictive factors of physical activity in a sample of university students (N = 51, M_{age} = 23.5, SD = 3.2). Participants were asked daily about items pertaining to their stress, affect, and physical activity duration over the course of seven days. Results showed that higher stress levels were associated with a reduction of physical activity, and high negative affect as well as low positive affect also produced lower rates of physical activity over the course of seven days; the authors concluded more research surrounding the predictive associations of stress and affect would benefit the young adult population (Schultchen et al., 2019).

Although existing research supports the association between stress and physical activity at the within-person level, the influence of stress on physical activity is still particularly unexplored within the context of the daily lives of young adults. The current study will build upon previous findings by examining the effects of stress on physical activity when the young adult is more stressed there their own average or perceived baseline (i.e., within-person differences), as this information may inform intervention and prevention tools.

Mood and Affect

Another potential predictor highlighted in the physical activity literature and the M-PAC framework is mood and affect (Rhodes, 2021). *Mood* can be defined as a prolonged period in which an individual feels a certain set of feelings and has thoughts that reflect those feelings (Watson & Clark, 1997). Typically, moods are defined by two aspects: 1) the mood being positive/pleasant or negative/unpleasant, and the intensity of the mood (Watson & Clark, 1997). Research suggests moods are created and altered by experiences, and moods impact how we perceive and respond to the world around us (Nettle & Bateson, 2012). Moods can be seen as being constructed over numerous experiences, while an individual's *affect* is related to what is happening in the here and now (Mendl et al., 2010). Compared to mood, affect is often seen as what an individual feels in the moment (Martin, 1990). However, an individual's mental health can change in response to shifting affect states and moods, with shifts changing how an individual thinks, feels, and acts (Gross et al., 2019). It is theorized that mental health and health behaviours are associated with an individual's mood and affect states. The M-PAC framework supports this idea, specifically the first and third layer of M-PAC; decide and sustain (Rhodes et al., 2021). The decide layer proposes individuals are motivated by expected outcomes to specific behaviours. The sustain layer of the M-PAC framework postulates behaviour is maintained through circumstances and experiences over time (Rhodes, 2021). Taken together, these layers suggest engagement in a health behaviour such as physical activity could be associated with mood and affect based on an individual's expected outcome gain (i.e., increased mood or alleviated negative affect) and the individual experience with the positive consequences of engaging in physical activity over an extended period. Allowing physical activity engagement to

be maintained due to longer exposure to the benefits of increased engagement in physical activity.

Research generally shows that increased mental health complaints and symptoms result in less physical activity (Roshanaei-Moghaddam et al., 2009). For example, a meta-analysis investigating adult samples in clinical settings (N = 5,646) found that 61% of patients endorsed low mood as one of the most prevalent barriers to being physically active (Firth et al., 2016). Patients also reported desirable outcomes of physical activity to include mood improvement, stress reduction, and increased energy and that depressive symptoms (i.e., low mood, depressed affect, and fatigue) restricted their ability to engage in physical activity (Firth et al., 2016).

Some research has investigated the role of mood and affect on physical activity among young adults at the within-person level. For example, Haas et al. (2017) investigated the within-person associations between affect and physical activity among young adults (N = 189; median age = 23) using daily dairies and accelerometers over the course of 10 days. Findings show that on days young adults expressed less negative affect and more positive affect, they engaged in more physical activity while also reporting increased positive mood states into the evening of that day. Similarly, and as noted above, Schultchen et al. (2019) found high negative affect as well as low positive affect also produced lower rates of physical activity over a seven-day period among their university-based sample. Bourke et al. (2021) conducted a systematic review (n = 10 articles) of studies that examined the association between mood and affect and physical activity in children and adolescents (ages 9-17). The authors reported mixed support for the acute within-person association between physical activity and affect in samples. Bourke et al. (2021) suggested that future research should employ and consider potential moderating factors on the association between physical activity and affect. This study responds to Bourke et al.'s (2021)

call by examining SoC as a potential moderator of the within-person associations between stress, affect, and physical activity among young adults.

Stages of Change as a Potential Moderator

As previously discussed, the TPB (Ajzen, 1991) and M-PAC (Rhodes, 2021) frameworks can be used as foundations to understand physical activity engagement from a social cognitive archetype. These theoretical approaches are built upon the idea that individuals participate in behaviours based on formed intentions and consciously made plans, and psychological and social factors influence how an individual may modify or change their behaviours to fit their previously laid out plans or intentions. Both TPB and M-PAC share the similar idea that intention and motivations towards a target behaviour are key elements in the likelihood of the behaviour being completed and endorsed. The current research supports this, with evidence proposing the intention to exercise as being influential to the psychological outcomes of physical activity engagement (Frederick & Ryan, 1993; Homan & Tylka, 2014; O'Hara et al., 2014; Prichard & Tiggemann, 2008). Although the intention and motivation behind why an individual engages in physical activity may vary, there is strong support for the intention for physical activity to influence the rates of physical activity. For example, Chen et al. (2022) found that exercise intention significantly and positively predicted exercise behaviour among youth (N = 1573; M_{age} = 13.71). Although support exists for intention as a significant predictor of physical activity engagement, the role of the intention-behaviour gap is still a concern in physical activity research. It is possible that additional factors must be considered to fully explain the association between individual internal factors and physical activity. These additional factors may, in fact, play a moderating role in the association between internal factors and physical activity and possibly better explain the association beyond intention alone.

One model considered a benchmark in behaviour change research is the Stages of Change (SoC) theory or the transtheoretical model (TTM), developed by Prochaska and DiClemente in 1983. The SoC theory can be used as a guide to characterize and categorize an individual's thoughts, intentions, or behaviours related to change. In general, the SoC model consists of five main stages: pre-contemplation, contemplation, preparation, action, and maintenance (Prochaska & DiClemente,1983). Typically, the stages are used as measurement devices to assess where on a behaviour change journey an individual currently is and what level of endorsement, belief, or intention they are currently exhibiting towards the process of change. The SoC model proposes that changing an individual's behaviour depends on where they are in relation to the stages, and behavioural change will occur as an individual progresses through the stages (Raihan & Cogburn, 2023). SoC theory has been commonly applied in both clinical and theoretical settings and has become a standard framework through which researchers have explored behavioural change and the predictors or inhibitors of individual activity.

In relation to physical activity, a cross-sectional descriptive study of an undergraduate sample (N = 302, M_{age} = 21.28 aged 20 – 26) investigated SoC theory and physical activity (Gawwad, 2008). In this study, students were classified into different categories based on their responses to a SoC statement regarding their commitment to physical activity (e.g., "*I am physically inactive, and I don't want to change"* – Precontemplation). Results showed that individuals with lower levels of physical activity were more often classified in one of the earlier SoC and not ready to become more physically active (Gawwad, 2008). The current study builds on these findings by exploring the nature of the associations between the changes in daily stress and affect and physical activity and whether or not young adult ratings on the six SoC levels influence these associations. Specifically, the study aims to explore the moderating nature of

varying stages of change and each stage's influence on the association between stress and affect and physical activity. Building from Gawwad's (2008) findings, later stages are anticipated to be more likely to display moderated associations based on the intentions and nature inherent to each furthering stage of change. For example, strong endorsement of a beginning stage (e.g., precontemplation non-believer) would suggest that the individual is not considering changing their physical activity, so may be less impacted by changes in internal states (i.e., stress, affect). However, strong endorsement in later stages (e.g., action), suggesting physical activity change may be active, participants may be more impacted by daily fluctuations in their internal states, influencing their associations with physical activity engagement. In the current study, each stage of change is being considered as a potential moderating variable due to the already strongly established association between stress and affect and physical activity. Fluctuations in stress and affect have empirically supported associations with physical activity (e.g., (Firth et al., 2016; Haas et al., 2017; Reichert et al., 2022; Stults-Kolehmainen & Sinha, 2014) therefore the stages of change are unlikely to have a role in explaining the process between which stress and affect and physical activity are associated (i.e., mediation), but more likely having a role that affects the strength and direction of the established association (i.e., moderation).

Limitations of Past Research

Several notable shortcomings of past research limit our understanding of the daily factors that may impede or promote young adults' engagement in physical activity. In sum, the current body of research is limited in three distinct ways, namely: 1) studies are mostly limited to older adult samples; 2) studies examine largely between-person differences, yielding only between-person "snapshots" of factors influencing daily physical activity; with minimal attention to within-person changes (e.g., what is the effect of stress or affect on physical activity when the

individual is more stressed there their average or perceived baseline) (Gomes at al., 2011; Trockel et al., 2000; Wald et al., 2014); and, 3) methods rely on self-report measures of physical activity which has known biases concerns (e.g., poor recall, self-perception bias; Barta et al., 2012; McAuliffe et al., 2007; Schwarz, 2012) as well as, long periods between assessments leading to poor recall (Flueckiger et al., 2014; Ruthig et al., 2011). Due to this, both within-person day-to-day differences and changes in behaviours over time have been obscured and understudied, and the influence of internal (i.e., stress, mood, affect) on physical activity is less understood, particularly within the context of the daily lives of young adults. Although these limitations exist throughout the literature, advances in utilizing innovative ambulatory assessments (i.e., smartphone survey administration and wearable technology) and more modern research methodologies (i.e., ecological momentary assessment) and statistical analyses (multi-level moderation models of within-person effects) offer a unique avenue to explore where previous research has yet to investigate, specifically in adolescent populations.

In recent years, the use and integration of wearable technologies has not only greatly increased in research domains (Niknejad et al., 2020) but public domains as well. Wearable technology (such as a wrist worn trackers), have gained rapid popularity and wide-spread adoption in physical activity use and daily physical activity tracking (Ferguson et al., 2022). One example of such a wearable technology that has been consistently used in existing wearables research is the Fitbit (FitBit, n.d.). The Fitbit wearable has been shown to be an accurate and reliable method for tracking not only physical activity, but heartrate and sleep patterns as well in both adult and adolescent samples (de Zambotti et al., 2016; Diaz et al., 2015). In a recent scoping review of available studies involving wrist-worn wearable technologies and adolescents, the Fitbit brand wearable was the most widely used and popular technology utilized in the

existing wearables research (Ames et al., in prep). Additionally, Fitbit brand devices are widely available and a mass-produced consumer-grade wearable (Fitbit, n.d.). Fitbit's ability to continuously collect physical data from an individual paired with daily diary data across multiple days may allow for the potential to incorporate newer, more advanced statistical analysis of data. Wearable devices can also address retrospective issues that occur through self-report of physical activity engagement. Wearable usage in research has helped lead a shift towards more objective measures of psychophysiological outcomes. Self-report is susceptible to recall inaccuracy and self-perception bias (Barta et al., 2012; McAuliffe et al., 2007; Schwarz. 2012). Proper utilization and incorporation of fitness wearables will open a research avenue to overcome prior limitations in research and highlight more clearly under what conditions and internal factors physical activity is promoted or limited within young adulthood. Thus, this study extends past research by examining how within-person internal factors (i.e., stress, mood, affect) may promote or impede physical activity within young adulthood utilizing innovative ambulatory assessments (i.e., daily diaries and wearable technology).

The Current Study

The current study builds on past research by exploring the within-person associations between internal factors (i.e., stress and affect) and physical activity, and the potential moderating influence of SoC among young adults (ages 17-29). Understanding what effects or factors influence an individual's physical activity behaviour (i.e., high stress, positive or negative affect) can help young adults become more mindful of these daily fluctuations and more appropriately cope in health-promotive ways.

Research Questions:

1. What is the association between daily internal factors (stress, positive affect, negative affect) and physical activity among young adults?

Hypothesis 1, Model 0: There will be a negative association between each separate internal factor (i.e., stress, positive affect, and negative affect) and physical activity.

2. How does the individual's SoC endorsement moderate the association between daily internal factors (stress, positive affect, negative affect) and daily physical activity? Is there a difference in moderation between the earlier and later, more physically engaged, stages?

Hypothesis 2a, Model 1: The association between stress and affect and physical activity will be weakly moderated by the precontemplation non-believer SoC.

Hypothesis 2b, Model 2: The association between stress and affect and physical activity will be weakly moderated by the precontemplation believer SoC.

Hypothesis 2c, Model 3: The association between stress and affect and physical activity will be moderated by the contemplation SoC.

Hypothesis 2d, Model 4: The association between stress and affect and physical activity will be moderated by the preparation SoC.

Hypothesis 2e, Model 5: The association between stress and affect and physical activity will be more strongly moderated by the action SoC.

Hypothesis 2f, Model 6: The association between stress and affect and physical activity will be more strongly moderated by the maintenance SoC.

Method

Participants

This study utilized data from the *Daily Experiences of Affect, Stress, and Health* (DASH) study. Participants were undergraduate students at a Canadian university (ages 17-29; $N = 74$) recruited via online system. All eligible participants were literate and fluent in English and could not have participated in a similar study at the university. Participants who had experienced serious medical or health concerns (e.g., a psychiatric illness or head injury) that might impede sustained participation in the study, or exacerbate pre-existing conditions, were deemed ineligible. Any participants who did not complete the baseline and daily measurement portions of the DASH study (and/or completed < four daily assessments) were also excluded, which resulted in a sample of 74 undergraduate students ($M_{age} = 20.88$, $SD = 2.53$, 70% cisgender women).

Procedure

Participants attended a two-hour baseline laboratory session at the University of Victoria's Institute on Aging and Lifelong Health. Each participant completed a consent form and online self-report surveys via LimeSurvey (2021). During the baseline session, demographic information (age and sex) was collected as well as additional questionnaires including the Stages of Change: Exercise Continuous Measure (SoC;(*Stages of Change (Continuous Measure)*, n.d.). Participants were also orientated to the smartphone ecological momentary assessment [EMA] app, MyCogHealth (Institute on Aging and Lifelong Health, n.d.) and the Fitbit Charge 2s™ (Fitbit, n.d.) wearable technology. During the baseline assessment period, research assistants trained participants to use both technologies to help effectively use the devices and additional take-home guides were provided for participants. Participants were fitted with Fitbit Charge 2s™ (Fitbit, n.d.) to be worn throughout the 14-day assessment period. Over the next 14 days, EMA

portion of the DASH study collected stress, positive and negative affect, and daily physical activity data. Data pertaining to stress, positive and negative affect was collected 4 times per day, and self-reported physical activity was collected at the end of each day. Participants received notifications throughout the day and had to complete short self-report surveys (1-3 minutes in the morning and during the day, with a longer 7-10-minute nightly survey) via Android phones with the MyCogHealth mobile survey software installed (Institute on Aging and Lifelong Health, n.d.). Participants received partial course credit for introductory psychology courses. Ethical approval for this study was approved by the University of Victoria's Human Research Ethics Board (protocol number 18-1069).

Measures

Demographic Characteristics

At the baseline assessment, demographic characteristics (age, sex) were collected. Age was measured in years, and sex was assessed using one question: "What is your sex?" with responses options of Male, Female, or Other.

Stages of Change

The Stages of Change: Exercise Continuous Measure (SoC; (*Stages of Change (Continuous Measure)*, n.d.) is a 24-item self-report checklist designed to measure the stage at which an individual is in terms of their likelihood to change their exercise behaviour. The measure using the following definition of exercise for all items: *"Exercise is any planned physical activity (e.g., brisk walking, aerobics, jogging, bicycling, swimming, rowing, etc.) performed to increase physical fitness. Such activity should be performed 3 to 5 times per week for 20-60 minutes per session. Exercise does not have to be painful to be effective but should be done at a level that increases your breathing rate and causes you to break a sweat".* Participants

rate each item of the SoC on a 5-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*) regarding their own belief in exercise. Select items correspond to the six SoC: 1) **precontemplation non-believer** (e.g., non-believers in exercise; 4 items, $\alpha = 0.78$; e.g., "*As far as I'm concerned, I don't need to exercise regularly*"), 2) **precontemplation believer** (i.e., believers in exercise; 4 items , $\alpha = 0.92$; e.g., "*I don't have the time or energy to exercise regularly right now*"), 3) **contemplation** (4 items, $\alpha = 0.84$; e.g., "*I have been thinking that I might want to start exercising regularly"*), 4) **preparation** (4 items, $\alpha = 0.72$; e.g., "*I have set up a day and a time to start exercising regularly within the next few weeks"*), 5) **action** (4 items, $\alpha = 0.91$; e.g., "*I have been thinking that I might want to start exercising regularly"*), and 6) **maintenance** (4 items, $\alpha = 0.91$; e.g., *I have been exercising regularly for a long time and I plan to continue"*). Higher rated scores on items indicates a stronger endorsement and belief in the stage with scores ranging from 4 – 24 for each stage of change individually. Participants were not classified into specific SoC groups, rather their continuous rating on each subscale was used in analysis.

Stress

The Perceived Stress Scale (PSS; Cohen, 1983) is a 10-item self-report scale designed to measure how one's life is appraised as stressful. Five adapted items were used in the daily assessments, $\omega_t = 0.86$, ICC was found to be moderate at a value of 0.73, CI 95%. For each statement, participants rated how often they felt over the past day on a continuous scale (0 = *never* to 100 = *often*). Two items on the scale were reversed scored due to negative wording to indicate higher scores being reflective of more stress. Item responses were summed and divided by four to yield an average stress score from 0 – 100, and higher scores indicated more perceived stress in the individual's life.

Positive and Negative Affect

The Positive Affect and Negative Affect Schedule (PANAS; Watson et al., 1988) is a 20-item self-report questionnaire to measure the individual's emotions over the past few weeks. Items are on two subscales, with 10 items measuring positive and negative affect. Twelve adapted items were used in the daily assessments (6 items reflecting positive affect: *interested, strong, alert, enthusiastic, determined, and proud*, $\omega_t = 0.87$, moderate ICC of 0.51, CI 95%; and 6 items reflecting negative affect: *distressed, guilty, upset, nervous, irritable, jittery*, $\omega_t = 0.79$, moderate ICC of 0.57, CI 95%.). Each item describes a feeling and emotion, and individuals indicate the extent to which they feel this way on average throughout the day. Participants responded to items on a scale that ranged from 0 (*not at all*) to 100 (*extremely*). Higher scores on the rating scale indicated greater intensity of the specified affect. Positive affect items were summed and divided by 6 to yield a daily positive affect score, ranging from 0 – 100. Negative affect items were summed and divided by 6 to yield a daily negative affect score, ranging from 0 – 100.

Physical Activity

Fitbit Charge 2s were used to track participants' daily minutes of MVPA and daily steps. Due to technical syncing issues, only daily steps were collected at an acceptable rate for analysis; daily steps were taken as the single objective physical activity variable. No participants wore their Fitbit and recorded daily steps on less than 80% of the 14 days. Additionally, daily steps were scaled by a factor of 1000 during analyses to assist in convergence and increase interpretability of results in all tables and figures.

Planned Analysis

All analysis was completed in R (R Core Team, 2013) using the "lme4" package in R and RStudio (v1.1-26; Bates et al., 2015). Descriptive statistics for the sample were calculated for each demographic variable and study variable at both baseline and at the daily level averaged across the 14 days. Daily variables collected on over 80% of days recorded were considered a complete data set. Multi-level modelling (MLM; Bollen & Curran, 2005; Hoffman, 2015; Stroup, 2012) was utilized due to the nature of the nested data and the techniques' ability to separate within-person and between-person effects. Maximum likelihood estimation was used for missing data for MLM analyses. Additionally, MLM allowed us to determine if there is an association between individual stress, positive affect and negative affect and steps at the daily level, as well as explore moderation. Age, sex, and SoC of the participant were the level 2 (i.e., between-person) variables, while daily stress, positive affect, and negative affect were the level 1 (i.e., within-person) variables. Based on recommendations (i.e., Hoffman & Walters, 2022), the level 2 variable SoC was grand-mean centred, while the level 1 variables of stress, positive affect, and negative affect were person-mean centred. Centering was done to ensure that between-person differences could not account for covariance between other variables and to promote convergence of models while simultaneously helping the difference in the scale of measures used throughout the study (Hoffman & Walters, 2022). Additionally, the variables of stress, positive affect, negative affect, and steps were divided by 10 for stress and positive and negative affect and by 1000 for steps to aid in model convergence and facilitate interpretation of model estimates.

Six models were run for each of the research questions. All models accounted for age and sex. Model 0 (hypothesis 1): explored the potential associations between internal factors (stress, positive affect, and negative affect) and physical activity (see Equation 1).

$$Steps_{ij} = \beta_0 + \beta_1(Age_i) + \beta_2(Sex_i) + \beta_3(Stress_{ij}) + \beta_4(Positive\ Affect_{ij}) + \beta_5(Negative\ Affect_{ij}) + e_i$$

Models 1-6 (hypothesis 2): a series of multi-level moderation models included interactions between stress, positive affect, and negative affect and the SoC (see Equation 2).

$$Steps_{ij} = \beta_0 + \beta_1(Age_i) + \beta_2(Sex_i) + \beta_2(SoC_i) + \beta_4(Stress_{ij}) + \beta_4(Positive\ Affect_{ij}) + \beta_4(Negative\ Affect_{ij}) + \beta_5(SoC_i \times Stress_{ij}) + \beta_6(SoC_i \times Positive\ Affect_{ij}) + \beta_7(SoC_i \times Negative\ Affect_{ij}) + e_i$$

Results

Demographic and descriptive statistics for the study variables are presented in Table 1 and zero-order correlations are presented in Table 2.

Within-person Associations Predicting Daily Physical Activity

Hypothesis 1 predicted that each of the variables of stress, positive affect, and negative affect would have a weak, negative association with steps on a daily level. Stress, $B = 0.02$, $SE = 0.06$, $p = 0.751$, positive affect, $B = 0.14$, $SE = 0.09$, $p = 0.118$, and negative affect, $B = -0.07$, $SE = 0.12$, $p = 0.558$ were not significant predictors of daily steps at the within-person level (see Table 3; additional models with predictor variables ran independently can also be found in Table 3).

SoC Moderating Associations Predicting Physical Activity (Models 1-6)

Hypothesis 2 predicted that the association between the variables of stress, positive affect, and negative affect and daily steps would be moderated by each of the six SoC. Each SoC was entered as an interaction term with stress, positive affect, and negative affect. In general, Hypotheses 2a-f expected that later stages would be more likely to moderate these associations.

Precontemplation non-believer

In Model 1, precontemplation non-believer did not moderate the association between stress, $B = 0.03$, $SE = 0.17$, $p = 0.863$, positive affect, $B = 0.13$, $SE = 0.09$, $p = 0.158$, or negative affect, $B = -0.07$, $SE = 0.12$, $p = 0.542$ (see Table 4).

Precontemplation believer

In Model 2, precontemplation believer did not moderate the association between stress, $B = -0.02$, $SE = 0.01$, $p = 0.066$, positive affect, $B = -0.01$, $SE = 0.02$, $p = 0.485$, or negative affect, $B = 0.05$, $SE = 0.02$, $p = 0.054$ (see Table 5).

Contemplation

In Model 3, contemplation did not moderate the association between stress, *B* = -0.02, *SE* = 0.01, *p* = 0.219, or negative affect, *B* = 0.03, *SE* = 0.02, *p* = 0.120. Contemplation did moderate the association between positive affect, *B* = -0.04, *SE* = 0.02, *p* = 0.041, providing partial support for hypothesis 2 (see Table 6). A posthoc simple slopes analysis was conducted to investigate the nature of the interaction and moderation with slopes assigned at the high (+1 *SD*), medium (*M*), and low level (-1 SD) of contemplation endorsement. Figure 1 shows that higher levels of contemplation towards changing beliefs about exercise was associated with fewer daily steps in the context of more positive affect. In contrast, lower levels of contemplation belief are associated with more daily steps in the context of more positive affect. In short, individuals who scored higher in contemplation appeared less influenced by changes in positive affect regarding daily steps, whereas those who scored low on contemplation were more effected by changes in positive affect, which in turn effected daily steps.

Preparation

In Model 4, preparation did not moderate the association between stress, *B* = 0.01, SE = 0.01, *p* = 0.640, positive affect, *B* = -0.01, *SE* = 0.02, *p* = 0.739, or negative affect, *B* = -0.01, *SE* = 0.02, *p* = 0.595 (see Table 7).

Action

In Model 5, action did not moderate the association between stress, *B* = 0.01, *SE* = 0.01, *p* = 0.151, or positive affect, *B* = -0.01, *SE* = 0.02, *p* = 0.595. Action did moderate the association between negative affect, *B* = 0.04, *SE* = 0.02, *p* = 0.048, providing partial support for hypothesis 2 (see Table 8). A post-hoc simple slopes analysis was conducted to investigate the nature of the interaction and moderation with slopes assigned at the high (+1 *SD*), medium (*M*), and low (-1

SD) level of action endorsement. Figure 2 suggests that, for participants who endorsed higher levels on the action SoC, on days when they reported more negative affect than their own average, they also took fewer steps and participants who endorsed lower levels on the action SoC took more steps on days they are experiencing more negative affect.

Maintenance

In Model 6, maintenance did not moderate the association between stress, $B = 0.01$, $SE = 0.01$, $p = 0.221$, positive affect, $B = 0.00$, $SE = 0.02$, $p = 0.943$, or negative affect, $B = -0.04$, $SE = 0.02$, $p = 0.056$ (see Table 9).

Discussion

Despite substantial evidence of the ameliorative effects of physical activity, young adulthood is a distinct developmental period where physical activity engagement tends to decline (Ames et al., 2018; Duncan et al., 2007), putting individuals at risk of a host of health and mental health consequences (WHO, n.d.). Although the above-noted developmental challenges and stressors of young adulthood may partially explain the notable declines in engagement across time, we know little regarding the daily-level predictors of physical activity in this age group and the potential contexts (i.e., moderators) that strengthen these associations. The present study sought to address notable gaps in the literature by employing a person-centred approach, using EMA research design, and accelerometers (i.e., Fitbit Charge 2s^{TM}) to increase our understanding of the within-person daily internal (i.e., stress and affect) factors that lead to or inhibit young adults' physical activity engagement, while also exploring the theory of SoC as a potential moderating factor. Overall, stress, positive affect, and negative affect were not significant predictors of daily steps at the within-person level. The present sample showed similar levels of stress and affect compared to other young adult samples (APA, 2020; Wang et al., 2020). In addition, the sample had comparable steps (M = 7928.83, SD = 3949.88) to the recommended steps for this age group: 7,000 – 10,000 daily steps (Paluch et al., 2022; Paluch et al., 2021; WHO, n.d.). Findings for SoC were mixed with significant interactions for the contemplation and action stages. The significant interactions of the contemplation and action stages provide partial evidence to support the integration of SoC evaluation in physical activity promoting interventions. Evaluating a young adult's SoC could provide insight into potential strategies. For example, motivational interviewing could be helpful to enhance an individual's motivation to

change and strengthen personal intentions to engage in health behaviours (Resnicow & McMaster, 2012).

Stress and Affect as Predictors of Physical Activity

In contrast to Hypothesis 1 and previous research (i.e., Reichert et al., 2022; Stults-Kolehmainen & Sinha, 2014; Schultchen et al., 2019; Thelweell, 2007), stress, positive affect, and negative affect did not predict daily steps. In the presented models, stress, positive and negative were included simultaneously in the analysis, restricting the ability for each variable to uniquely predict physical activity, although models with each predictor variable ran independently can be found in Table 3. When compared to past research, how physical activity was operationalized in the current study may also help to explain these differences. Operationally, daily step count may be a poor substitute for more appropriate objective measures of physical activity levels such as minutes of MVPA (Hajna et al., 2018). MVPA is the standard used for guideline recommendations (Tremblay et al., 2016; WHO, n.d.) and is commonly used in past research (Belcher et al., 2021). For example, of the 26 studies included in Belcher et al.'s (2021) review, 20 (77%) measured physical activity directly through MVPA or measures of the same intensity or greater (e.g., $V0_{2max}$ testing). Unfortunately, due to technical difficulties with the wearable technology in the current study, MVPA minutes could not be collected from enough participants to justify analysis, so daily steps were used as a proxy. Future research could include and compare multiple measures (e.g., daily steps, MVPA, self-report) of physical activity.

SoC as Potential Moderators

The second research question related to investigating the potential moderation of the association between stress, positive affect, negative affect and steps by the individual's

endorsement of the six SoC levels. In general, no interactions were found with stress. Results such as this may be attributed to the overall sample only experiencing *moderate* daily stress, and not endorsing enough daily stress fluctuations above their own average to detect the size of effects present. This tentative theory is based on a 2020 study that surveyed adults (N = 1685) across the globe who endorsed a moderate 47.4 out of 100 on the PSS (Adamson et al., 2020) in comparison to the study's sample score 45.49 out of 100. Future research exploring potential moderation effects between the association of daily stress and daily steps may benefit from a larger sample size to detect smaller effects and focus on a higher stress sample to investigate within-person fluctuations in daily stress.

Findings regarding the interactions between positive and negative affect and SoC were mixed and discussed for each SoC. Scores on the precontemplation non-believer and the precontemplation believer SoC did not moderate the associations between positive and negative affect and physical activity. This is not surprising, given participants who scored higher on earlier SoC may not be ready for behaviour change (Gawwad, 2008). Young adults who are not contemplating (i.e., precontemplation non-believer or believer categories) may not recognize the benefits of such behaviour change. Indeed, Gawwad (2008) observed a similar phenomenon such that they found that individuals in the earlier stages of change were not ready to be physically active or commit to physical activity. Additional research could help to separate the precontemplation non-believer from the precontemplation believer regarding future physical activity engagement likelihood, as the two variables were found to be significantly and highly correlated (i.e., r = 0.74; see Table 2). The moderating effects of the SoC in general is still a relatively unexplored research domain, but high correlations between the first two stages may be obscuring findings.

Scores on the contemplation SoC did not moderate the associations between negative affect and physical activity; however, there was a significant moderation in the association between positive affect and physical activity. Posthoc analysis suggested that participants with lower levels of contemplation SoC took more steps on days when they experienced more positive affect, and participants with higher levels of contemplation took less steps per day when experiencing more positive affect. Although a tentative theory, participants reporting lower levels of contemplation (i.e., not focused on behaviour change), may be less burdened by thoughts surrounding physical activity engagement, compared to those highly contemplating, or over-thinking behaviour change. Lower levels of contemplation individuals can still enjoy the benefits of increased positive affect leading to increasing mood and willingness to engage in physical activity, creating a positive behaviour feedback loop. In which the burden of thinking and contemplating physical activity is low, but rewards from increased engagement is still found. An example of such a feedback loop can be summarized in Sudeck's (2008) work that found individuals who are engaging in physical activity, are experiencing the largest benefits from physical activity and therefore continuing to engage in higher and more consistent rates of physical activity in the future.

Scores on the preparation SoC did not moderate the associations between positive and negative affect and physical activity. The outcome of this moderating association may be because the SoC itself is positioned before the action SoC and individuals endorsing preparation are on the edge of behaviour change but not fully committed (Raihan & Cogburn, 2023). Preparation is a stage that combines intention and behavioural criteria; this stage is defined by wanting to take action in the next month but being unsuccessful in taking action over the past year (Raihan & Cogburn, 2023). Although only a partial explanation, the SoC may not have

moderated any associations due to the SoC being more passive regarding behaviour engagement. This SoC compared to the other stages could be a middle point in behavioural change that is neither against behaviour engagement (i.e. precontemplation non-believer), or in favour of behaviour engagement, (i.e action), leading to non-significant moderation results.

Scores on the action SoC did not moderate of the association between positive affect and physical activity; however, a significant interaction term was found between negative affect and the action SoC. Posthoc analysis suggested that participants with higher scores on action SoC took less steps per day when they reported higher levels of negative affect, and participants who endorsed lower levels of the action stage of change took more steps on days when they reported more negative affect. The action SoC is generally regarded as having the shortest timeframe among all the SoC, but also the stage where true behaviour change can occur requiring total commitment to wanted behaviours (Raihan & Cogburn, 2023). Based on this, individuals in this stage are at a precarious point in their behaviour change journey and are only starting to gain confidence and believe they can begin to create long-term sustainable positive behaviour change (Raihan & Cogburn, 2023). Young adults in the action stage may be deeply committed and on the precipice of what they consider true behavioural change and the path towards continued physical activity; and when they experience high levels of negative affect, they may not yet have the resilience or positive foundations to continue with physical activity engagement. Conversely, those with lower action endorsement may be closer to being categorized in another SoC, and the association between their negative affect and physical activity engagement is less vulnerable to disruptions such as high negative affect experiences.

Scores on the maintenance SoC did not moderate the associations between positive and negative affect and physical activity. Results such as these could be because individuals who

would be categorized in this stage have a stable pattern related to their physical activity and may be less influenced by their internal states. The maintenance SoC corresponds to a new status quo in the individual, in times of increased arousal, be it fluctuating positive or negative affect, the individual can remind themselves of the progress they have made and can resist the temptation to alter course (Raihan & Cogburn, 2023). In this stage individuals have become skilled at identifying potential triggers to derail progress and have more established coping strategies to remain resilient and engaged in their health behaviours (Raihan & Cogburn, 2023).

Limitations

The current study is not without limitations. A common criticism of evaluating the SoC model is that it is built and hinges on the idea that behaviour change happens in discrete stages; however, the difference between the stages can often be seen as arbitrary (West, 2005). One critique proposed that the SoC model assumes the individual is making coherent and concrete plans, and that the model neglects the role of reward, punishment, and associative learning (West, 2005). This critique might be valid as during this study, SoC was only assessed at baseline and may have fluctuated across the study duration. As such, a short-version of the SoC at the daily level may provide more nuanced information. The study's findings may be limited by how SoC was measured and the level of individual SoC endorsement could have corresponded to their immediate experience, context and setting compared to their true stable long-term values and beliefs. Additionally, measuring the SoC as a moderating variable at the between-persons level and the predictor variables at the within-person level limited the statistical modeling options and level of interpretation (Curran & Bauer 2011). For the sake of parsimony, random effects were not included in the models analyzed which could have influenced the results and overall strength of the study. Another limitation of the study (as noted above) was the use of daily steps as the outcome variable responsible for quantifying physical activity. As noted, MVPA has been the more commonly used and appropriate variable to measure physical activity engagement in previous literature (Tremblay et al., 2016; WHO, n.d.) Lastly, the study was limited by the size and generalizability of the sample (i.e., limited to undergraduate students who were predominantly female [72%]). Although the sample did not differ in terms of daily steps, stress, positive or negative affect from individuals in the same age group from the general population (APA, 2020; Wang et al., 2020; Weatherson et al., 2021), the daily choices and

lifestyle of an undergraduate student might be uniquely different than individuals in the same age range outside of university settings in which results and implications from the study may have reduced applications.

Conclusions

This study was novel in its approach to investigating daily within-person associations between internal factors (stress and affect) and physical activity engagement levels in young adults (ages 17-29). Additionally, this study explored the moderating role of SoC and aimed to understand better the predictive factors that influence a young adult's choice to engage in physical activity. Although the SoC results were mixed, findings underscore the potential value of assessing SoC to support physical activity promotion. Incorporation of motivational interviewing alongside problems-solving in the context of stress and low affect could prove beneficial. Findings highlight how young adults could become mindful of the influence daily fluctuations in stress and affect may have on their health-promoting choices. Given the notable declines in physical activity engagement across the transition to young adulthood and the associated physical and mental health consequences, further research is warranted. Results point to replicating the findings in larger, more presentative samples. Future research would also benefit from continued incorporation of innovative research design and technologies, such as EMA and objective wearables, to collect physical activity data.

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Tables

Table 1

*Descriptive Statistics for the Sample (*N *= 74)*

Variable	*M*(SD)	*n* (Range or %)
Age	20.88 (2.53)	17 - 29
Sex		
Biological female		52 (70%)
Biological male		22 (30%)
Stage of Change[a]		
Precontemplation	7.09 (3.17)	4 - 21
Non-Believer		
Precontemplation	11.32 (5.13)	4 - 23
Believer		
Contemplation	16.91 (4.77)	4 - 24
Preparation	12.11 (4.69)	4 - 24
Action	14.33 (5.81)	4 - 24
Maintenance	14.65 (5.62)	4 - 24
Stress[b]	45.49 (29.00)	0 - 100
Positive Affect[b]	39.75 (18.70)	0 – 92.12
Negative Affect[b]	22.63 (17.13)	0 – 86.25
Steps	7928.83 (3949.88)	110 - 26111

[a] SoC variables are measured on a possible scale of 4-24 with higher values indicating stronger endorsement.[b] Predictor variables are reported here as an average score across the 14 days on a possible scale of 0 - 100 with higher values indicating stronger values.

Table 2

Zero order correlations for study variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Age											
2. Sex	-0.28										
3. Precontemplation Non-Believer	-0.18	0.20									
4. Precontemplation Believer	0.18	-0.30	**0.74****								
5. Contemplation	0.05	-0.54	0.30	**0.62***							
6. Preparation	0.02	-0.55	-0.41	-0.19	0.46						
7. Action	-0.19	-0.23	**-0.71****	**-0.71****	-0.10	0.44					
8. Maintenance	-0.28	0.21	**-0.74****	**-0.90****	**-0.68***	0.05	**0.72****				
9. Stress[a]	-0.05	-0.36	-0.20	0.10	0.06	0.00	-0.02	-0.04			
10. Positive Affect[a]	-0.14	0.37	-0.16	-0.53	-0.48	-0.12	0.26	0.38	-0.25		
11. Negative Affect[a]	-0.15	-0.16	-0.15	0.07	-0.02	-0.11	-0.07	-0.03	**0.87****	-0.12	
12. Steps	-0.17	-0.12	-0.22	-0.16	-0.18	0.06	0.07	0.19	0.01	0.06	-0.00

Note. * indicates $p < .05$. ** indicates $p < .01$. [a] Predictor variables are reported here as an average score across the 14 days on a possible scale of 0 - 100 with higher values indicating stronger values.

Table 3

Baseline Multi-level Model Predicting Daily Steps – Model 0

Variable	B	SE	*t*	*p*
Intercept (β_0)	11.44	2.09	5.46	0.001
Age	-0.14	0.09	-1.57	0.119
Sex	-0.91	0.54	-1.67	0.101
Stress	0.02	0.06	0.32	0.751
Positive Affect	0.14	0.09	1.57	0.118
Negative Affect	-0.07	0.12	-0.59	0.558
Independent Models[a]				
Stress	-0.01	0.05	-0.14	0.89
Positive Affect	0.26	0.09	3.00	0.08
Negative Affect	-0.08	0.09	-0.85	0.40

[a]Denotes findings when each predictor variable was ran in a separate model.

Table 4

Multi-level Model Predicting Daily Steps with Precontemplation Non-believer Stage of Change as Moderator – Model 1

Variable	B	SE	*t*	*p*
Intercept (β_0)	12.03	2.09	5.46	0.000
Age	-0.14	0.09	-1.97	0.052
Sex	-0.75	0.55	-1.37	0.176
Precontemplation Nonbeliever	0.03	0.17	0.17	0.863
Stress	0.01	0.06	0.12	0.907
Positive Affect	0.13	0.09	1.41	0.158
Negative Affect	-0.07	0.12	-0.61	0.542
Precontemplation Nonbeliever *Stress	-0.01	0.02	-0.71	0.476
Precontemplation Nonbeliever *Positive Affect	-0.03	0.03	-1.01	0.316
Precontemplation Nonbeliever *Negative Affect	-0.00	0.04	-0.10	0.920

Table 5

Multi-level Model Predicting Daily Steps with Precontemplation Believer Stage of Change as Moderator – Model 2

Variable	B	SE	t	p
Intercept (β_0)	11.32	2.10	5.38	0.000
Age	-0.14	0.09	-1.59	0.115
Sex	-0.80	0.56	-1.43	0.156
Precontemplation Believer	0.04	0.09	0.43	0.666
Stress	0.02	0.06	0.38	0.706
Positive Affect	0.13	0.09	1.41	0.159
Negative Affect	-0.05	0.12	-0.45	0.650
Precontemplation Believer*Stress	-0.02	0.01	-1.84	0.066
Precontemplation Believer*Positive Affect	-0.01	0.02	-0.70	0.485
Precontemplation Believer*Negative Affect	0.05	0.02	1.93	0.054

Table 6

Multi-level Model Predicting Daily Steps with Contemplation Stage of Change as Moderator – Model 3

Variable	B	SE	t	p
Intercept (β_0)	11.43	2.09	5.46	0.000
Age	-0.15	0.09	-1.54	0.127
Sex	-1.00	0.55	-1.81	0.074
Contemplation	0.13	0.11	1.11	0.268
Stress	0.02	0.06	0.41	0.685
Positive Affect	0.13	0.09	1.41	0.159
Negative Affect	-0.04	0.12	-0.37	0.709
Contemplation*Stress	-0.02	0.01	-1.23	0.219
Contemplation*Positive Affect	-0.04	0.02	-2.05	0.041*
Contemplation*Negative Affect	0.03	0.02	1.56	0.120

Note. * $p < 0.05$.

Table 7

Multi-level Model Predicting Daily Steps with Preparation Stage of Change as Moderator – Model 4

Variable	B	SE	t	p
Intercept (β_0)	11.18	2.14	5.23	0.000
Age	-0.13	0.09	-1.49	0.140
Sex	-0.80	0.58	-1.39	0.170
Preparation	0.00	0.11	0.016	0.988
Stress	0.02	0.06	0.33	0.742
Positive Affect	0.14	0.09	1.56	0.114
Negative Affect	-0.08	0.12	-0.65	0.514
Preparation*Stress	0.01	0.01	0.47	0.640
Preparation*Positive Affect	-0.01	0.02	-0.34	0.739
Preparation*Negative Affect	0.01	0.02	0.53	0.595

Table 8

Multi-level Model Predicting Daily Steps with Action Stage of Change as Moderator – Model 5

Variable	B	SE	t	p
Intercept (β_0)	11.62	2.1966	5.2889	0.0000
Age	-0.15	0.09	-1.59	0.114
Sex	-0.90	0.57	-1.57	0.120
Action	0.03	0.09	0.32	0.750
Stress	0.02	0.06	0.30	0.763
Positive Affect	0.15	0.09	1.63	0.105
Negative Affect	-0.08	0.12	-0.72	0.4700
Action*Stress	0.01	0.01	1.44	0.151
Action*Positive Affect	-0.01	0.02	-0.53	0.596
Action*Negative Affect	0.04	0.02	-1.99	0.048*

Note. * $p < 0.05$.

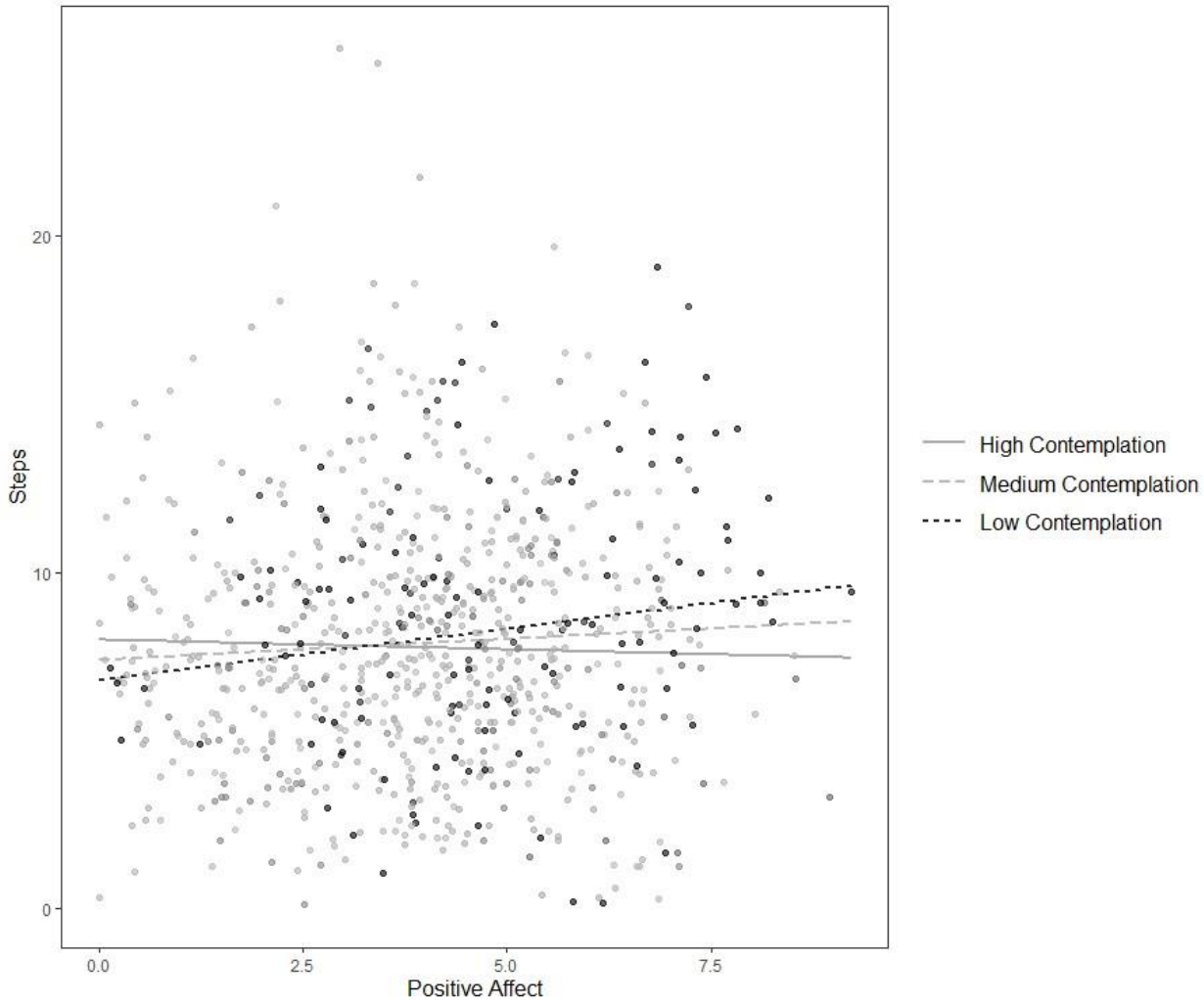
Table 9

Multi-level Model Predicting Daily Steps with Maintenance Stage of Change as Moderator – Model 6

Variable	B	SE	t	p
Intercept (β_0)	10.64	2.20	4.83	0.000
Age	-0.11	0.09	-1.15	0.252
Sex	-0.80	0.55	-1.46	0.150
Maintenance	0.04	0.09	0.45	0.656
Stress	0.01	0.06	0.20	0.844
Positive Affect	0.14	0.09	1.50	0.134
Negative Affect	-0.04	0.12	-0.31	0.754
Maintenance*Stress	0.01	0.01	1.22	0.221
Maintenance*Positive Affect	0.00	0.02	0.07	0.943
Maintenance*Negative Affect	-0.04	0.02	-1.92	0.056

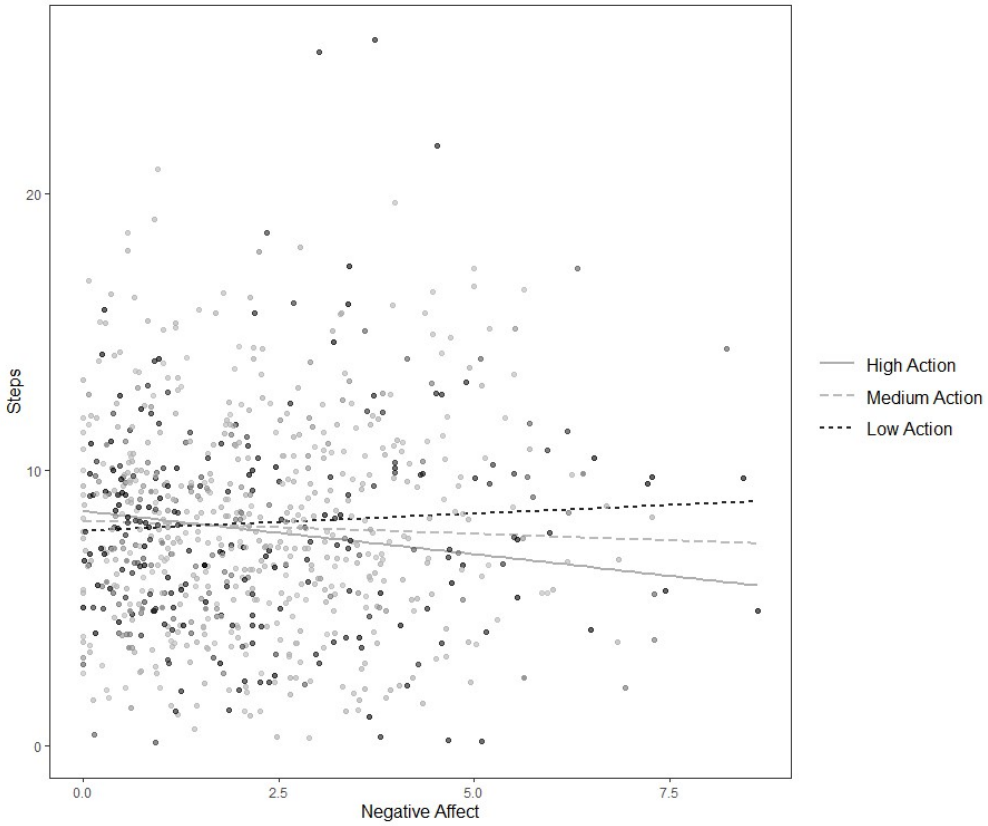
Figures

Figure 1. Simple Slopes Interaction Plot of Positive Affect x Contemplation



Note. Steps have been scaled by a factor of 1000 on the y axis.

Figure 2. Simple Slopes Interaction Plot of Negative Affect x Action



Note. Steps have been scaled by a factor of 1000 on the y axis.