

**Young Adults' Mental Health and Commitment to Exercise during the COVID-19
Pandemic**

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Thesis submitted to the University of Ottawa
in partial fulfillment of the requirements for the
Master of Arts in Education degree in Counselling Psychology

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Acknowledgments

I would like to begin by expressing my deepest gratitude to my supervisor, Dr. Tracy Vaillancourt at the University of Ottawa, Tier 1 Canada Research Chair in School-Based Mental Health and Violence Prevention, and Fellow of the Royal Society of Canada. Your guidance and unwavering support throughout my studies have been invaluable. It has been an incredible privilege to work with you over the years. Your passion for science and dedication to making the world a better place is truly inspiring, and I will always cherish the time we have spent together.

I am also immensely grateful to the Brain and Behaviour Lab for their encouragement, assistance, and insight. This research would not have been possible without the support of everyone in the lab. A special thank you to Dr. Amanda Krygsman and Heather Brittain for your ongoing guidance throughout my thesis—your generosity and expertise have meant so much to me.

I extend my sincere appreciation to my thesis committee members, Dr. Cristelle Audet and Dr. Katherine Moreau, for your invaluable knowledge and thoughtful contributions to my work.

To my dear friends, your unwavering support and encouragement throughout these years have been a constant source of strength. I am forever grateful for your kindness and love.

Finally, to my family—thank you for being my foundation, my inspiration, and my greatest supporters. Your belief in me has been my guiding light, and I could not have done this without you. And to my incredible partner, whose love and support have meant the world to me, I am endlessly grateful.

Abstract

Mental health issues, particularly anxiety and depression, continue to show an upward trend among young adults in Canada. This persistent increase has prompted researchers to investigate various treatment modalities, with physical activity emerging as a promising intervention. Evidence shows that engagement in physical activity can alleviate symptoms of anxiety and depression, with neurochemical effects comparable to pharmacological interventions, such as selective serotonin reuptake inhibitors (SSRIs). The COVID-19 pandemic, however, introduced unprecedented challenges through the implementation of non-pharmaceutical interventions (NPIs) that significantly restricted physical activity and increased mental health issues, specifically anxiety and depression. This longitudinal study used a community sample of Canadian young adults (n=443) to examine the association of the COVID-19 pandemic on commitment to exercise and associated effects on individual's mental health outcomes across three time points over four years (from age 22 to 26). Contrary to prevailing literature, our findings did not reveal any consistent or strong associations between commitment to exercise and mental health symptoms within and across time. Although these results do not align with the established literature, they offer valuable insights and direction for future investigations in this domain. Given the insufficient availability of mental health professionals, it remains crucial for individuals and researchers to continue exploring the potential of physical activity and alternative interventions for mitigating mental health symptoms among young adults. Such efforts may contribute to the development of more accessible and cost-effective strategies for promoting psychological well-being among young adults and the general population.

Introduction

Mental health difficulties are the leading cause of disability in adults worldwide (Kieling et al., 2024). In 2019, it was estimated that 4.4 million Canadians aged 12 and older experienced an anxiety or mood disorder, and the percentage of young adults who reported an anxiety or mood disorder increased from 13% in 2015 to 17% in 2019 (Statistics Canada, 2020). The two most common mental health issues in adults are anxiety and depression (Guerrero & Barnes, 2022; Kieling et al., 2024), which are commonly treated with medications such as selective serotonin reuptake inhibitors (SSRIs; McGuine et al., 2021; Ratey & Hagerman, 2013) and psychotherapy such as cognitive behaviour therapy (Chan et al., 2019). Although these treatment methods have been shown to be effective (Chan et al., 2019; McGuine et al., 2021; Ratey & Hagerman, 2013), they are neither available and affordable to everyone, and do not always provide the same beneficial outcomes. Therefore, continuing research and exploring other means of reducing anxiety and depression symptoms is important to help those in need. Physical activity as a mental health intervention has gained popularity given evidence that it is associated with a reduction in anxiety and depression symptoms across all ages and genders, and reductions in the risk of developing a chronic illness, such as cardiovascular disease, type 2 diabetes, colon cancer, and breast cancer (Ahn & Fedewa, 2011; Bertheussen et al., 2011; McGuine et al., 2021; McMahon et al., 2017).

Although it is established that physical activity is associated with lower anxiety and depression symptoms (Ahn & Fedewa, 2011; Bertheussen et al., 2011; Biddle et al., 2019; Hassan et al., 2022), the COVID-19 pandemic was associated with decreased physical activity in children and adolescents (Neville et al., 2022), and adults (Cui et al., 2023; Duncan et al., 2020; Nienhuis & Lesser, 2020; Marashi et al., 2021). This decrease was largely linked to the implementation of non-pharmaceutical interventions (NPIs; e.g., social distancing, gym and school closures, nonessential business closures; Rees et al., 2022) to reduce the spread of the virus. The implementation and duration of specific NPIs were not consistent across countries. In Ontario, Canada, where the current study was conducted, the provincial government implemented some of the longest NPIs in the world (Canadian Institute of Health Information, 2024; Vaillancourt & Brittain, 2024), which restricted access to where people could engage in physical activity such as gyms, parks, schools, and workplaces for prolonged periods of time (Gallagher-Mackay et al., 2021; Vaillancourt & Brittain, 2024). Delaying the re-opening of

environments in which people engage in physical activity may have had a negative impact on the mental health and well-being of Ontario residents (Marashi et al., 2021; Vaillancourt, 2021a). Although this link has been examined, most studies have used cross-sectional designs, which precludes an examination of true change over time (Duncan et al., 2020; McGuine et al., 2021; Nienhuis & Lesser, 2020; Vaillancourt et al., 2021b). For my thesis, I used a longitudinal design to examine young adults' commitment to exercise and symptoms of anxiety and depression during the COVID-19 pandemic, while controlling for anxiety and depression symptoms before the pandemic.

Literature Review

Physical Activity and Mental Health

Physical activity is defined as “any bodily movement produced by skeletal muscles that require energy expenditure” (Faulkner et al., 2021, p. 321). It can include a wide range of activities, such as walking, running, biking, playing a team sport, and weight training. Engaging in physical activity has many physical health benefits, such as reducing the likelihood of cardiovascular diseases, hypertension, and obesity (Happell et al., 2011; Vancampfort et al., 2018). Physical activity also plays a positive role in mental health. Specifically, it is associated with decreased symptoms of anxiety and depression (Ahn & Fedewa, 2011; Bertheussen et al., 2011; Biddle et al., 2019; Breslin et al., 2023; Hassan et al., 2022; Jussila et al., 2022; Ratey & Hagerman, 2013; Ströhle, 2009). In the past, it was believed that the positive association between physical health and mental health was merely a coincidence, and that to treat mental health issues, medication or therapeutic services were required (Lindwall et al., 2014; Maugeri et al., 2020; Ratey & Hagerman, 2013). However, more recent evidence has demonstrated that there are neurological and chemical changes that occur in the brain when an individual engages in physical activity, which contribute to reduced anxiety and depressive symptoms (Maugeri et al., 2020; Recchia et al., 2023). Specifically, when physical activity begins, the body starts to break down fat molecules, which results in fatty acids being sent into the bloodstream. These fatty acids compete with amino acids for slots on transport proteins, which eventually push through the blood-brain barrier, and are used as a building block for serotonin, thus increasing serotonin, which is a chemical in the body that regulates mood (Di Liegro et al., 2019; Ratey & Hagerman, 2013). Additionally, brain-derived neurotrophic factor (BDNF), a key molecule in the brain related to memory and learning, is increased when exercising, which in turn increases serotonin

levels. When these levels increase, the body becomes calmer and people have a higher sense of safety, which reduces anxiety and depressive symptoms (Di Liegro et al., 2019; Maugeri et al., 2020; Ratey & Hagerman, 2013). The brain's major inhibitory neurotransmitter, Gamma-aminobutyric acid (GABA), is the primary target for most anti-anxiety medications, but moving the body also releases GABA. Having stable levels of GABA is vital to stopping the self-fulfilling loop of anxiety at the chemical level (Di Liegro et al., 2019; Ratey & Hagerman, 2013). In moments of high anxiousness, there is an influx of corticotropin-releasing factor (CRF), which induces more anxiety. However, when engaging in physical activity, the muscle cells produce a molecule called an atrial natriuretic peptide (ANP), which is a tool to regulate stress responses within the body, and this molecule works against CRF (Di Liegro et al., 2019; Maugeri et al., 2020).

Most health organizations across the globe suggest that individuals should engage in 150 minutes of physical activity per week (Bertheussen et al., 2011; Biddle et al., 2019; Chan et al., 2019; Happell et al., 2011; World Health Organization [WHO], 2022). The Canadian guidelines for physical activity used to be 150 minutes per week, performed in sessions of at least 10 minutes (Statistics Canada, 2021a). However, this has changed in recent years, with the number of minutes per session being removed from the guidelines, and more emphasis being put on obtaining 150 minutes throughout the entirety of the week (Marashi et al., 2021). The findings on how much physical activity is needed to obtain mental health benefits are mixed. Siefken et al. (2019) found in their survey of over 680 recreational athletes that those who did not meet the 150-minute recommendation reported higher anxiety and depression symptoms compared with those who met these requirements. In contrast, Warburton and Bredin (2017) found that meeting the recommended guidelines had no impact on mental health outcomes. Rather, it was simply engaging in any type and duration of physical activity that significantly affected the mental health outcomes of the participants. This study is consistent with others, showing that it is not the type of physical activity one is engaging in or the duration, rather it is the fact that individuals are engaging in any physical activity that matters for mental health benefits (Bertheussen et al., 2011; Hassan et al., 2022; Jussila et al., 2022; McMahon et al., 2017; Warburton & Bredin, 2017). Despite the documented clear benefits of physical activity on mental health, individuals of all ages worldwide report being inactive. In fact, the WHO found that more than a quarter (1.4

billion) of adults are deficient in their activity levels, and since 2001, there has been no improvement in global physical activity rates (WHO, 2022).

Physical activity can be challenging for those with mental health issues such as anxiety and depression. Individuals with depression typically lack motivation, making it difficult for them to find the inspiration and energy to exercise or to see the positive benefits of physical activity (Vancampfort et al., 2018). Similarly, it can be difficult for individuals with anxiety to engage in physical activity, as physical activity can trigger similar physiological sensations to anxiety. Individuals may become frightened by symptoms and misappraise the physiological sensations of exercise as anxiety or panic (Carter et al., 2021; Ratey & Hagerman, 2013). To establish a more comprehensive understanding of why individuals fail to engage in physical activity or disease prevention strategies, the Health Belief Model (HBM) was developed (Champion & Skinner, 2008; LaMorte, 2022). This model emphasizes that an individual's course of action to engage in disease prevention strategies, physical activity, or positive health behaviour depends on their perceptions of the benefits and barriers related to the health behaviour they are evaluating (LaMorte, 2022). Within the HBM, six constructs comprise an individual's thought process: (1) perceived susceptibility (beliefs about the chances of experiencing a health issue), (2) perceived severity (beliefs about how serious the potential health issue is), (3) perceived benefits (beliefs about the efficacy of the advised action to reduce the risk of the potential health issue), (4) perceived barriers (beliefs about the costs of the advised action), (5) cue to action (strategies to activate ones readiness to engage in the behaviour), and (6) self-efficacy (ones confidence in their ability to take action; Champion & Skinner, 2008; LaMorte, 2022; Marashi et al., 2021). It is likely that those with anxiety and depression, when going through this six-step thought process, are placing more emphasis on constructs such as perceived severity, barriers, and less of an emphasis on self-efficacy. When doing this, the benefits of engaging in physical activity likely become blurred and deemed unnecessary.

Although physical activity is a successful form of intervention and treatment for anxiety and depression (Hassan et al., 2022; McMahon et al., 2017), it can do much more than help those already struggling with mental health issues. Indeed, physical activity can act as a protective factor for developing anxiety and depressive symptoms (Lindwall et al., 2014; McMahon et al., 2017). This suggests that it is important to consistently engage in physical activity throughout life, as this can reduce the likelihood of developing anxiety and depression. Despite the benefits

of exercise, there has been a 5% increase in inactivity between 2001 and 2016 in high-income countries (WHO, 2022). Moreover, the COVID-19 pandemic contributed to an increase in physical inactivity (Cui et al., 2023; Neville et al., 2022), driven in large part by the introduction of NPIs which restricted physical activity in children, youth, and adults (Bertrand et al., 2021; Colley & Watt, 2022; Eek et al., 2021; Neville et al., 2022; Rhodes et al., 2020).

Physical Activity and COVID-19

On March 11, 2020, the WHO declared the coronavirus (SARS-CoV-2) outbreak a global pandemic, which dramatically changed the dynamic of everyday life for individuals worldwide (Grocke-Dewey et al., 2021). NPIs were implemented to control the spread of SARS-CoV-2. Across the globe, there were social lockdown periods, but each country and province varied in terms of the duration and specific restrictions in place (Vaillancourt & Brittain, 2024). Some restrictions were consistent across countries, such as social distancing (reducing the number of individuals allowed at public events or public locations), the enactment of online learning for all levels of school (elementary, secondary, college, and university), restrictions on travelling, and the transition to remote work for those who could. Ontario, Canada, where the present study was conducted, had implemented NPIs that were some of the most long-lasting and comprehensive (Vaillancourt & Brittain, 2024). These NPIs began in March 2020 and ended two years later in March 2022, with some policy changes through this time (Canadian Institute for Health Information, 2024; Gallagher-Mackay et al., 2021).

The implementation of NPIs resulted in the loss of availability of numerous avenues to engage in physical activity, or only available under specific instructions and guidelines. For example, individuals who wanted to engage in indoor or outdoor sports such as soccer, basketball, and hockey could not do so due to gym and sports closures. Specifically in Ontario, outdoor physical activity areas such as parks were closed as of March 28, 2020, and were not re-opened until May 20, 2021 (some cities and regions could open earlier; Canadian Institute for Health Information, 2024). Furthermore, Ontario gyms were closed for most of the pandemic, and recreational facilities were ordered by the government to close as of March 30, 2020, and were only able to open to 50% capacity as of January 31, 2022 (Canadian Institute for Health Information, 2024; Foran, 2023). The lack of infrastructure and the inability to engage in physical activity at locations such as gyms, were found to be significant deterrents for people wanting to engage in physical activity (Caputo & Reichert, 2020; Neville et al., 2022). For

example, in one study, 69% of participants emphasized a need to exercise, but could not because of the restrictions put in place by their government (Aktan & Gamsizkan, 2022; see also Caputo & Reichert, 2020; Eek et al., 2021; Elvén et al., 2022). Indeed, the NPIs that were implemented resulted in new barriers for people wanting to engage in physical activity. Engaging in physical activity was difficult, but individuals also struggled with getting out of the house. Aktan and Gamsizkan (2022) found that 24.9% of participants reported not leaving their houses for two months during the lockdown period. Others with financial means, exercised at home (Bell et al., 2023; Meyer et al., 2020; Robinson et al., 2021). During the pandemic, Canadians spent roughly \$211 million on exercise equipment, a 24% increase from sales in 2018 (Colley & Watt, 2022).

Online learning was also implemented in Ontario during the pandemic (Brown, 2022), which had an impact on movement behaviour. Many students engage in daily exercise by commuting to school by walking, biking, rollerblading, or running; by using gym facilities at their school; and/or by participating in mandated physical education classes. These physical activities might not be vigorous, but research suggests that they still have benefits for mental health, such as reducing anxiety and depressive symptoms (Bertheussen et al., 2011; Hassan et al., 2022; Jussila et al., 2022; McMahan et al., 2017; Warburton & Bredin, 2017). Although in-person learning did resume in Ontario on January 17, 2022, students still could not engage in extracurricular activities such as soccer or hockey until February 10, 2022 (Canadian Institute for Health Information, 2024). Even then, students were required to wear masks and follow specific guidelines to participate in such activities, which was likely a deterrent for some students and could be seen as a potential barrier under the HBM. So, for many Ontario elementary, secondary, and post-secondary students during the pandemic, physical activity was not only limited due to the closure of schools, gyms, parks, and the inability to play extracurricular activities in schools, but also their daily physical activity from commuting to and from school was no longer present (Brown, 2022; Hassan et al., 2022; Jussila et al., 2022). Similar to online learning, non-essential employees were required to work remotely, and doing so also contributed to a decline in physical activity. Overall, the implementation of NPIs disrupted individuals' ability to engage in physical activity, and for many, their physical exertion was also reduced (Aktan & Gamsizkan, 2022; Bertrand et al., 2021; Caputo & Reichert, 2020; Eek et al., 2021; Elvén et al., 2022).

Overall, there are likely many contributing factors to the reduction in physical activity during the pandemic; however, NPIs played a significant role. Regardless, physical exertion and

the amount of people engaging in any type of physical activity during the pandemic decreased (Aktan & Gamsizkan, 2022; Caputo & Reichert, 2020; Eek et al., 2021; Elvén et al., 2022).

Physical activity was not the only area that was disrupted during the COVID-19 pandemic; there was also a decline in mental well-being. In particular, anxiety and depression increased during the pandemic (Gopal et al., 2020; Krygsman et al., 2023; O'Connor et al., 2021; Samji et al., 2021), most notably for young adults aged 18–25 (Giuntella et al., 2021; Krygsman et al., 2023; Lee et al., 2020; Son et al., 2020; Stroud & Gutman, 2021).

Mental Health and COVID-19

The COVID-19 pandemic not only had negative consequences for physical health and safety, but it also significantly disrupted individual's daily routines and forced them to stay away from loved ones (Gopal et al., 2020), which was associated with declines in mental health (Daly & Robinson, 2021; Dozois, 2021; Farrell et al., 2023). In their systematic review, Samji et al. (2021) found a consistent decline in mental health during the pandemic. They also found that government control policies that limited social interactions (i.e., NPIs) were associated with more anxiety and depression symptoms.

In a Canadian study of young adults aged 18 and older, Dozois (2021) found that anxiety symptoms increased from 16% to 38% from before to during the pandemic, while depression symptoms increased from 12% to 28%. Guerrero and Barnes (2022) reported that the number of Canadians aged 15 and older who reported good mental health decreased by 14% during the pandemic. Statistics Canada (2021b) also examined Canadians' mental health during the pandemic and found that one in four Canadians who were 18 years of age or older had screened positive for symptoms of anxiety and depression. In the same study, looking at each disorder separately, they found that the number of Canadians who screened positive for Major Depressive Disorder (MDD) in 2021, compared to 2020, increased from 15% to 19%. Similarly, the percentage of Canadians who screened positive for Generalized Anxiety Disorder (GAD) was 13% in 2020 versus 15% in 2021. In a longitudinal study looking at anxiety symptoms from pre-pandemic to during the pandemic, using the same data set as the current study, Krygsman et al. (2023) found that young adults who had lower anxiety symptoms before the pandemic showed a larger increase in symptoms during the pandemic. They also found that individuals who had larger decreases in reported symptoms of anxiety before the pandemic were associated with more symptoms during the second year of the pandemic.

Studies have shown that not all Canadians were affected in the same way. Pongou et al. (2022) and Prince et al. (2020) reported that Canadians who earned higher incomes experienced a lower risk of psychological distress than those who reported lower incomes. Age also moderated these associations. Although young adults had the lowest risk of becoming physically unwell from COVID-19, they experienced the most significant adverse effects on their mental health (Lee et al., 2020; Stroud & Gutman, 2021). Wiedemann et al. (2022) also found a significant increase in mental health issues among Canadian young adults during the pandemic, with 9% reporting levels of psychological distress that may lead to functional impairment and interfere with daily activities, compared with 6% before the pandemic. Young adults were likely disproportionately affected because they were entering critical developmental and social milestones, such as attending post-secondary school and moving away from home, both of which were inevitably taken away from them (Stroud & Gutman, 2021). Researchers have found a stable developmental pattern regarding depressive symptoms across the adult lifespan, with the highest reported symptoms occurring in early adulthood, symptom reduction occurring in middle adulthood, and then climbing again in older adulthood (Sutin et al., 2013; Vaillancourt & Brittain, 2024). Sutin et al. (2013) also found that in early adulthood women reported more depressive symptoms than men, but in older adulthood, the reverse was found with men reporting more depressive symptoms than women. So, while all Canadians were affected by the pandemic, there is a need for further investigation into how young adults were affected given the pattern of mental health symptoms observed before the pandemic and implementation of NPIs.

Physical Activity, Mental Health, and COVID-19

The reduction of physical activity during the COVID-19 pandemic and its relation to mental health is an emerging field of study. Results have indicated an association between decreased physical activity levels and increased mental health problems (Grocke-Dewey et al., 2021; Jacob et al., 2020; Rogowska et al., 2020; Savage et al., 2020; Son et al., 2020; Wilson et al., 2021). For example, Grocke-Dewey et al. (2021) found that levels of psychological distress increased significantly during the pandemic compared to before the pandemic, and individuals who reported a higher reduction in physical activity levels reported worse mental health problems than those who had smaller reductions in their physical activity. From the studies available that examined mental health and physical activity during the COVID-19 pandemic, most participants reported that they could not engage in physical activity level recommendations

because of the lockdown restrictions (McGuine et al., 2021; Meyer et al., 2020; Pieh et al., 2020; Rogowska et al., 2020). Furthermore, those who reported the most significant decrease in physical activity levels from before to during the pandemic also reported more mental health issues (Jacob et al., 2020; Rogowska et al., 2020; Savage et al., 2020; Son et al., 2020; Wilson et al., 2021). Of note, these studies were cross-sectional or used mixed methods design, and only one involved Canadian participants (Lesser & Neinhuis, 2020). Lesser and Neinhuis (2020) examined the effect of the pandemic and public health restrictions on Canadians, including the effect it had on their mental health and physical activity. They found that participants who were more physically active had better mental health scores, and participants who became active or increased their physical activity during the pandemic had lower levels of anxiety. Although this study adds to the existing literature, it did not examine the impact of the COVID-19 pandemic or the implementation of NPIs over time, nor did it account for mental health and physical activity levels before COVID-19 lockdown restrictions. Longitudinal studies capturing multiple time points from before, during, and after lockdown measures are needed to understand true change (Vaillancourt et al., 2021b). Thus, the purpose of my thesis was to examine the association between commitment to exercise and mental health during the pandemic while controlling for prior mental health symptoms (before the pandemic).

Current Study

Research Objectives

The effect of the COVID-19 lockdown measures on young adults' mental health in relation to commitment to exercise was examined in the present study. Specifically, the association between commitment to exercise and mental health during the pandemic across three time points over four years, while controlling for participants' self-reported mental health symptoms before the pandemic was investigated. Gender differences were also examined given previous research demonstrating that women consistently report higher anxiety and depression symptoms than men (APA, 2013; Banna et al., 2022; Stroud & Gutman, 2021; Van Droogenbroeck et al., 2018), and men typically engage in more physical activity than women (Statistics Canada, 2023).

Research Questions

The following research questions were addressed in the present study:

1. How did the COVID-19 pandemic impact young adults' symptoms of anxiety and depression?
2. Controlling for prior symptoms, did young adults who had higher symptoms of anxiety and depression during the pandemic have a larger decrease in their commitment to exercise compared to young adults who had lower anxiety and depression scores?

Hypotheses

When the research questions were examined, pre-pandemic baseline mental health issues were accounted for, which permitted the unique effect of the pandemic lockdown to be examined. Consistent with the existing literature on this topic, it was predicted that young adults' anxiety and depression symptoms increased during the pandemic and that young adults' commitment to exercise decreased during the pandemic, even when controlling for prior anxiety and depression symptoms. It was also predicted that anxiety and depression symptoms would be higher, and commitment to exercise levels would be lower during times of greater pandemic restrictions (i.e., year one of the pandemic). Moreover, commitment to exercise levels during the pandemic are expected to be associated with internalizing symptoms such that greater commitment to exercise would be linked with lower internalizing symptoms and lower commitment to exercise would be associated with higher internalizing symptoms. The moderating role of gender was also examined. Consistent with past research findings, women were expected to report more anxiety and depression symptoms than men before and during the pandemic (APA, 2013; Banna et al., 2022; Stroud & Gutman, 2021; Van Droogenbroeck et al., 2018) and men were expected to report exercising more than women (Statistics Canada, 2023).

Method

Participants and Procedure

Data from the McMaster Teen study, an ongoing longitudinal study that began in 2008, were used for the present study. Using a multi-method, multi-informant approach, this study obtains data on a wide variety of variables, such as mental health, relationships, bullying, and commitment to exercise. Demographic information such as biological sex and race/ethnicity were collected from each participant. Participants were recruited from 51 randomly selected elementary schools within a large southern Ontario public school board. The McMaster Teen study was completed using online or paper format. Participants were compensated for their participation with gift cards or e-transfers worth \$10 to \$100, depending on the year of

participation. Parental consent until age 16 and student assent/consent were received every year. Ethics approval was received from the school board and the associated university every year. For use in the current study, data collected annually from age 22 (2019) to age 24 (2021), and age 26 (2023) were used. Self-report measures of mental health were used from age 22 to 26. Self-report measures of commitment to exercise were used from age 23 to age 26 as commitment to exercise was measured during the pandemic in the McMaster Teen Study.

Measures

Anxiety Symptoms. Self-reported anxiety symptoms were measured using the anxiety subscale of the Behavioural Assessment System for Children-2 (BASC-2), Self-Report of Personality- College Version (SRP-COL; Reynolds & Kamphaus, 2004). This 14-item subscale asks participants to indicate the best response based on the statements provided. Four of the items are rated in a *true* = 2 or *false* = 0 format (e.g., “I worry about little things”), and the remaining ten items are rated on a 4-point Likert-type scale of *never* = 0, *sometimes* = 1, *often* = 2, and *almost always* = 3 (e.g., “I am afraid of a lot of things”). In the current sample, this scale was found to have good internal consistency (age 22 α = .88, age 23 α = .87, age 24 α = .88, and age 26 α = .88), supporting reliability for the scale.

Depression Symptoms. Self-reported depression symptoms were measured using the depression subscale of the BASC-2, Self-Report of Personality- College Version (SRP-COL; Reynolds & Kamphaus, 2004). The BASC-2 depression subscale consists of 13 items that ask participants to indicate the best response based on the statements provided. Nine of the items are rated in a *true* = 2 or *false* = 0 format (e.g., “Nothing is fun anymore”) with the remaining four questions rated on a 4-point Likert scale of *never* = 0, *sometimes* = 1, *often* = 2, and *almost always* = 3 (e.g., “I feel sad”). In the current sample, this scale was found to have good internal consistency (age 22 α = .88, age 23 α = .88, age 24 α = .88, and age 26 α = .89), supporting reliability for the scale.

Commitment to Exercise. Commitment to exercise was measured using the Commitment to Exercise Scale (CES; Derakhshanpoor et al., 2016), which assesses individuals’ dedication to maintaining exercise routines. The CES was included during the first year of the pandemic to understand participants’ exercise commitment, particularly given prior research linking high commitment to exercise with disordered eating behaviors (Anic et al., 2022; Bratland-Sanda & Sundgot-Borgen, 2012; Myers & Crowther, 2007; Murray et al., 2012).

The CES consists of seven items rated on a continuum from 0 (e.g., "not at all important," "never") to 10 (e.g., "very important," "always"). Items included questions such as: (1) "How important do you think it is to your general well-being not to miss an exercise session?"; (2) "Does it upset you if, for some reason or another, you are unable to exercise?"; (3) "If you miss an exercise session, or several sessions, do you try to make them up by putting in more time when you get back?"; (4) "Do you have a set routine for your exercise session (e.g., same time of day, same location, same number of laps, particular exercises)?"; (5) "Do you continue to exercise even when you have sustained an exercise-related injury?"; (6) "Do you feel guilty or as though you have 'let yourself down' when you miss an exercise session?"; and (7) "Are there times when you turn down invitations to interesting social events because they interfere with your exercise schedule?".

The CES demonstrated good internal consistency in the current sample at all measurement points (age 23, $\alpha = .91$; age 24, $\alpha = .91$; age 26, $\alpha = .91$).

Analytic Plan

The statistical analyses for this study were conducted using Mplus Version 8.0 (Muthén & Muthén, 2017), employing full information maximum likelihood estimation (FIML) to effectively handle any missing data. To evaluate model fit, multiple fit indices were used, including the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), chi-square (χ^2) test of significance, and the Akaike Information Criterion (AIC). CFI and TLI values < 0.95 indicate adequate model fit, RMSEA values < 0.06 indicate close fit, SRMR values < 0.08 indicate good fit, and low AIC values indicate a better fitting model (Browne & Cudeck, 1992; Hu & Bentler, 1999).

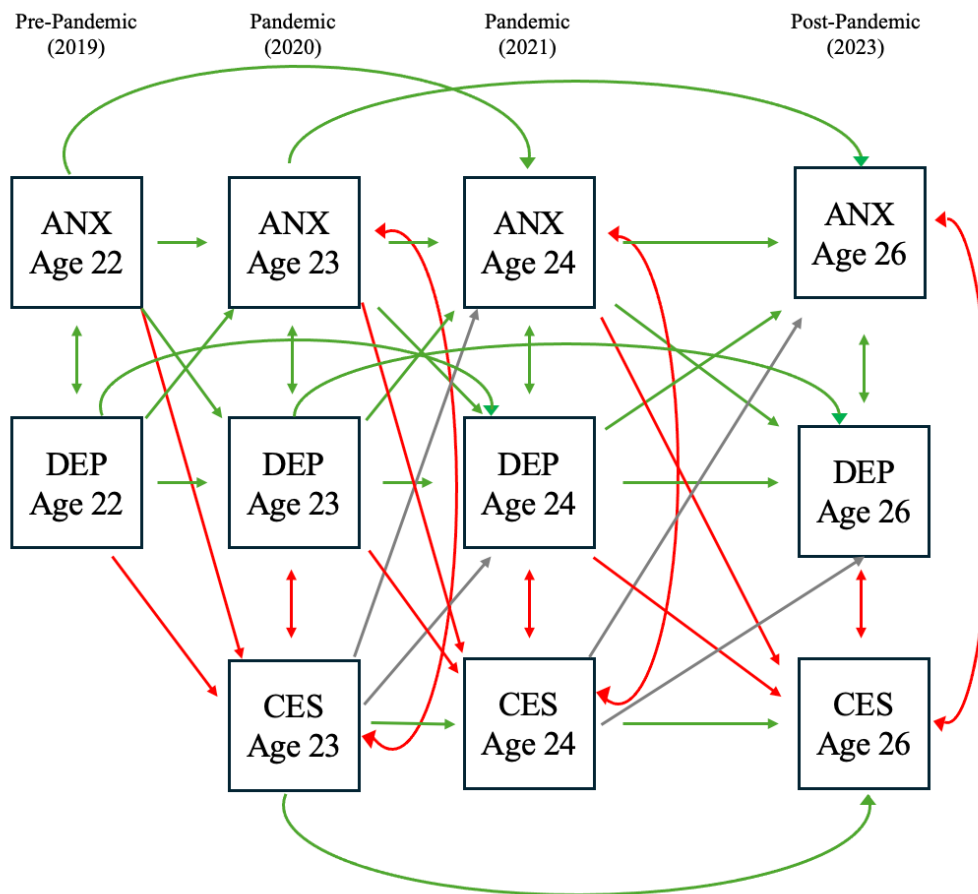
A longitudinal path analysis was used to investigate the associations among anxiety and depression at four time points (ages 22–26) and commitment to exercise at three time points (ages 23–26). The model included autoregressive pathways, which accounted for the stability of each variable over time by regressing each variable (anxiety, depression, and commitment to exercise) at a given time point on its corresponding value from the previous time point, as well as two prior time points. Cross-lagged pathways were incorporated to test directional relationships between variables across sequential time points, allowing the analysis to determine whether changes (e.g., increases or decreases) in one variable, such as commitment to exercise, were

associated with subsequent changes in another variable, such as anxiety or depression. This approach highlighted the potential influence of variables on one another over time. Concurrent associations were also modeled by allowing residuals within the same time point to covary, capturing contemporaneous relationships. By including these three types of pathways (auto-regressive, cross-lagged, and concurrent), the analysis provided a comprehensive understanding of both the stability and change within variables over time, as well as the dynamic interplay between anxiety, depression, and commitment to exercise.

Model 1 included auto-regressive paths, within-time associations, and cross-lagged paths among anxiety, depression, and commitment to exercise. Because gender differences were anticipated, Model 1 was estimated as a multi-group model by gender, allowing parameter estimates to vary freely across groups. In Model 2, gender invariance was examined by constraining all auto-regressive paths, within-time associations, and cross-lagged paths to be equal for men and women. A chi-square difference test was used to statistically evaluate differences in model fit. A significant deterioration in fit would indicate that the unconstrained model (Model 1) provided a better fit than the constrained model. If gender non-invariance was identified, a series of chi-square difference tests were conducted to examine gender differences in specific paths. This process involved systematically constraining each pathway individually within the final model while allowing all other pathways to remain freely estimated. Each constrained model was then compared to the unconstrained final model to determine whether the strength of these relationships differed significantly by gender.

Figure 1

Model of Pathways Among Anxiety, Depression, and Commitment to Exercise.



Note: ANX= anxiety; DEP= depression; CES= commitment to exercise. Green arrows represent the hypothesis of a positive relation, red arrows represent the hypothesis of a negative relation, and grey arrows represent paths that were tested but not predicted.

Results

Descriptive Statistics

The analytic sample consisted of 443 participants (40.6% men, $n = 180$; 59.4% women, $n = 263$). Among them, 339 participants (76.5%) identified as White, while 72 participants (16.3%) identified as a racial or ethnic minority. An additional 32 participants did not report their racial identity. Descriptive statistics, including means, standard deviations, and sample sizes for anxiety, depression, and commitment to exercise measured across various time points are presented in Table 1. The zero order correlations between anxiety, depression, and commitment

to exercise across all time points are presented in Table 2. Anxiety and depression were each significantly and positively correlated with themselves over time, as well as with each other at all time points (*Min: r = .48, p = < .01, Max: r = .69, p = < .01*). Commitment to exercise was also identified to have significant positive correlations with itself at all time points (*Min: r = .61, p = < .01, Max: r = .71, p = < .01*). However, no significant correlations were identified between commitment to exercise and either anxiety or depression at any time point.

Table 1

Descriptive and Frequency Statistics [total sample]

Variables	<i>n</i>	Min	Max	<i>M</i>	<i>SD</i>
BASC- Anxiety					
Age 22	383	0.00	37.00	15.19	8.99
Age 23	373	0.00	37.00	15.29	8.80
Age 24	385	0.00	37.00	16.08	8.88
Age 26	359	0.00	36.00	15.66	8.64
BASC- Depression					
Age 22	379	0.00	29.00	5.54	5.75
Age 23)	368	0.00	29.00	5.54	5.84
Age 24	381	0.00	30.00	5.86	5.77
Age 26	356	0.00	30.00	5.40	5.83
Commitment to Exercise					
Age 23	370	1.00	9.71	3.65	2.01
Age 24	380	1.00	9.29	3.41	1.95
Age 26	350	1.00	10.00	3.46	1.97

Table 2*Correlations Among All Study Variables*

Variables	1	2	3	4	5	6	7	8	9	10	11
1.Age 22	-	.80	.77	.72	.69	.54	.53	.48	.07	.03	-.07
ANX		**	**	**	**	**	**	**			
2.Age 23		-	.84	.79	.68	.68	.62	.54	.02	.04	-.07
ANX			**	**	**	**	**	**			
3.Age 24			-	.85	.59	.60	.69	.56	.00	.00	-.08
ANX				**	**	**	**	**			
4.Age 26				-	.59	.56	.63	.66	.01	.00	-.07
ANX					**	**	**	**			
5.Age 22					-	.75	.64	.63	.06	.06	.05
DEP						**	**	**			
6.Age 23						-	.75	.66	-.05	-.03	-.09
DEP							**	**			
7.Age 24							-	.68	-.01	.00	-.07
DEP								**			
8.Age 26								-	.05	.02	.00
DEP											
9.Age 23									-	.69	.61
CES										**	**
10.Age 24										-	.71
CES											**
11.Age 26											-
CES											

Note: * $p < .05$. ** $p < .01$; ANX= anxiety; DEP= depression; CES= commitment to exercise.

Path Model

In Model 1, gender was freely estimated; parameter estimates were allowed to vary across men and women. This model exhibited good fit to the data, $\chi^2(32) = 61.05, p < .001$, RMSEA = .064 [.039, .088], SRMR = .025, CFI = .990, TLI = .965, AIC = 21719.21. In Model 2, parameter estimates were constrained across gender, assuming that men and women were equal across all specified paths. This model also demonstrated adequate fit, $\chi^2(71) = 130.19, p < .001$, RMSEA = .061 [.044, .078], SRMR = .056, CFI = .979, TLI = .968, AIC = 21710.35. The chi-square difference test was statistically significant, $\Delta\chi^2(39) = 69.14, p = .002$, suggesting that imposing gender invariance did not adequately represent the data. Accordingly, Model 1, the multi-group model with free estimates across gender, was selected for the final model (see Figure 2).

To identify significant gender differences in pathways, each individual pathway was systematically examined within the final model. This was achieved by sequentially constraining each of the pathways and comparing the model fit to the unconstrained model using Chi-square difference tests. Results indicated concurrent statistically significant associations between anxiety and depression across time for men and women. The magnitude of the associations was not different for men and women at age 22 (men: $cov = 30.67, r = .69, p < .001$; women: $cov = 37.04, r = .70, p < .001$; $\chi^2(1) = 1.08, p > .05$). At age 23 this association significantly varied by gender, $\chi^2(1) = 9.01, p < .001$, and was stronger for men ($cov = 12.48, r = .69, p < .001$) compared to women ($cov = 5.74, r = .30, p < .001$). The magnitude of the associations was not different for men and women at age 24 (men: $cov = 7.61, r = .51, p < .001$; women: $cov = 8.14, r = .46, p < .001$; $\chi^2(1) = 0.07, p > .05$), or age 26 (men: $cov = 8.75, r = .54, p < .001$; women: $cov = 7.73, r = .43, p < .001$; $\chi^2(1) = 0.216, p > .05$).

There was a relation between anxiety at age 22 to commitment to exercise at age 23, although the magnitude of the associations was not different for men and women (men: $b = 0.06, \beta = .24, p = .038$; women: $b = 0.03, \beta = .14, p = .159$; $\chi^2(1) = 0.67, p > .05$). Additionally, there was a relation between anxiety and commitment to exercise found at age 23 to age 24, although the magnitude of the associations was not different for men and women (men: $b = 0.01, \beta = .04, p = .689$; women: $b = 0.03, \beta = .13, p = .05$; $\chi^2(1) = 0.51, p > .05$). Commitment to exercise and anxiety were not significant at any other time point.

The relation between depression at age 23 and commitment to exercise at age 23 significantly differed by gender, $\chi^2(1) = 4.48, p < .001$. For men, depression at age 23 was more strongly associated with commitment to exercise at age 23 ($cov = -2.04, r = -.28, p = .002$) than for women ($cov = -0.33, r = -.14, p = .522$). The gender difference in the association between depression at age 24 and commitment to exercise at age 24 was also found, $\chi^2(1) = 4.14, p < .001$; however, the effect was not statistically significant for either gender (men: $cov = -0.68, r = -.14, p = .117$; women: $cov = 0.50, r = .09, p = .189$). Commitment to exercise and depression were not significant at any other time point.

Examining the auto-regressive paths, results indicated that anxiety at each time point significantly predicted subsequent anxiety. Anxiety at age 22 positively predicted anxiety at age 23 (men: $b = 0.61, \beta = .65, p < .001$; women: $b = 0.61, \beta = .62, p < .001; \chi^2(1) = 0.01, p > .05$; no gender difference). At age 23, the effect varied by gender, $\chi^2(1) = 6.02, p < .001$. The strength was greater for men ($b = 0.80, \beta = .73, p < .001$) than for women ($b = 0.52, \beta = .54, p < .001$). Age 24 anxiety positively predicted age 26 (men: $b = 0.57, \beta = .60, p < .001$; women: $b = 0.59, \beta = .60, p < .001; \chi^2(1) = 0.03, p > .05$; no gender difference). Age 22 anxiety positively predicted anxiety at age 24 (men: $b = 0.22, \beta = .21, p < .001$; women: $b = 0.24, \beta = .25, p < .001; \chi^2(1) = -0.06, p > .05$; no gender difference). Lastly, anxiety at age 23 positively predicted anxiety at age 26 (men: $b = 0.27, \beta = .26, p = .002$; women: $b = 0.22, \beta = .23, p < .001; \chi^2(1) = 0.24, p > .05$; no gender difference).

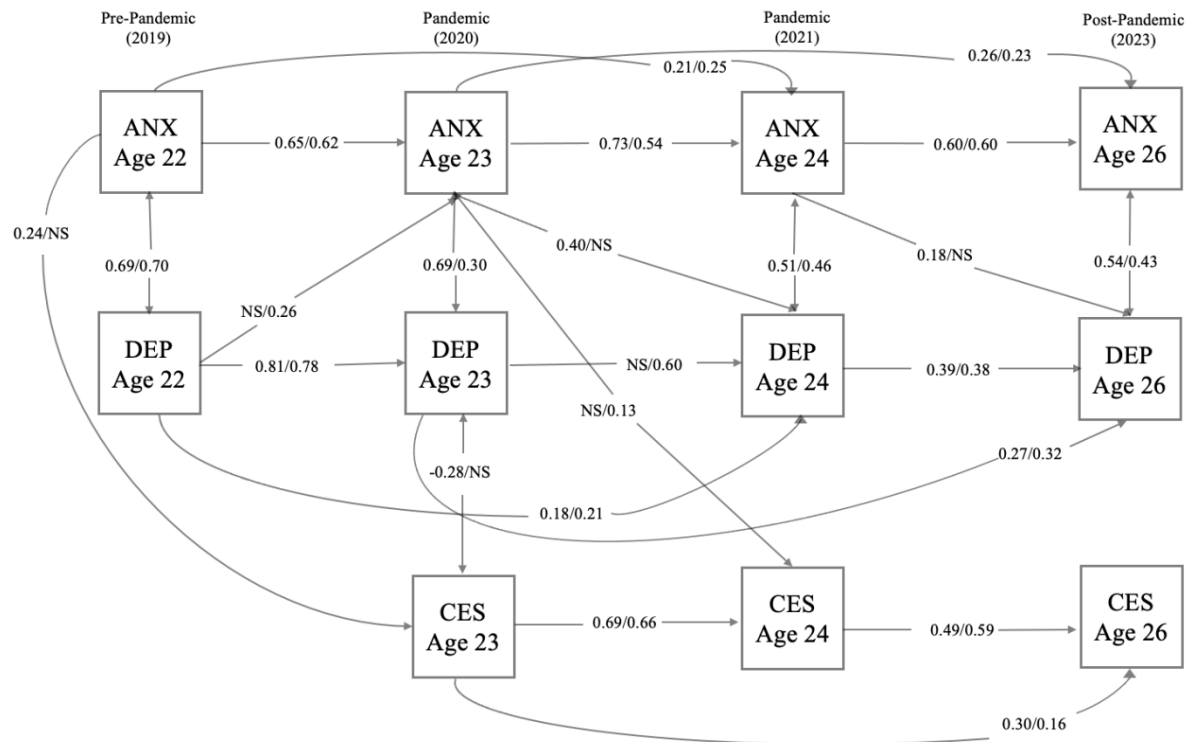
Depression at age 22 positively predicted depression at age 23 (men: $b = 0.80, \beta = .81, p < .001$; women: $b = 0.77, \beta = .78, p < .001; \chi^2(1) = 0.06, p > .05$; no gender difference). Depression at age 23 significantly predicted depression at age 24 for women ($b = 0.61, \beta = .60, p < .001$) but not men ($b = 0.19, \beta = .21, p = .066; \chi^2(1) = 11.22, p < .001$), with a stronger predictive effect observed for women compared to men. Age 24 depression positively predicted depression at age 26 (men: $b = 0.45, \beta = .39, p < .001$; women: $b = 0.36, \beta = .38, p < .001; \chi^2(1) = 0.33, p > .05$; no gender difference). Examining the two lag paths, depression at age 22 positively predicted depression at age 24 (men: $b = 0.17, \beta = .18, p < .001$; women: $b = 0.21, \beta = .21, p < .001; \chi^2(1) = 0.16, p > .05$; no gender difference). Lastly, age 23 depression positively predicted depression at age 26 (men: $b = 0.30, \beta = .27, p < .001$; women: $b = 0.31, \beta = .32, p < .001; \chi^2(1) = 0.01, p > .05$; no gender difference).

Results showed that commitment to exercise at age 23 significantly predicted commitment to exercise at age 24 (men: $b = 0.66$, $\beta = .69$, $p < .001$; women: $b = 0.65$, $\beta = .66$, $p < .001$; $\chi^2(1) = 0.02$, $p > .05$; no gender difference). This remained stable with commitment to exercise age 24 predicting commitment to exercise at age 26 (men: $b = 0.50$, $\beta = .49$, $p < .001$; women: $b = 0.58$, $\beta = .59$, $p < .001$; $\chi^2(1) = 0.55$, $p > .05$; no gender difference). Lastly, looking at the two lag paths, commitment to exercise at age 23 predicted commitment to exercise at age 26 (men: $b = 0.30$, $\beta = .30$, $p < .001$; women: $b = 0.16$, $\beta = .16$, $p < .001$; $\chi^2(1) = 1.54$, $p > .05$; no gender difference).

In terms of the cross-lagged paths, age 22 depression was associated with age 23 anxiety for women ($b = 0.38$, $\beta = .26$, $p < .001$), but not men ($b = 0.22$, $\beta = .16$, $p = .053$), although the paths were not statistically significantly different ($\chi^2(1) = 1.08$, $p > .05$). At age 23 anxiety predicted depression at the following time point, and this prediction significantly differed by gender, $\chi^2(1) = 9.91$, $p = .001$, with the prediction being greater for men ($b = 0.26$, $\beta = .40$, $p < .001$) than women ($b = 0.03$, $\beta = .04$, $p = .463$). At age 24 anxiety predicted depression at the following time point (men: $b = 0.12$, $\beta = .18$, $p = .05$; women: $b = 0.07$, $\beta = .10$, $p = .193$; $\chi^2(1) = 0.54$, $p > .05$; no gender difference). No other cross-lagged paths were significant at any other time point.

Figure 2

Final Model of Anxiety, Depression and Commitment to Exercise from Age 22 to 26



Note. ANX= anxiety; DEP= depression; CES= commitment to exercise; the statistics that are displayed are the standardized betas and men are displayed in the first statistic followed by women (men/women). NS = non-significant.

Discussion

In the present study, the impact of COVID-19 on young adults' mental health, specifically anxiety and depression, in relation to commitment to exercise was investigated. During the pandemic, several social restrictions were put in place to help curtail the spread of SARS-Cov-2 such as closing schools, gyms, parks, and workplaces (Canadian Institute for Health Information, 2024; Foran, 2023). These measures disrupted routines and limited opportunities for regular physical activity, which previous research has shown to protect against anxiety and depression (Aktan & Gamsizkan, 2022; see also Caputo & Reichert, 2020; Eek et al., 2021; Elvén et al., 2022). Young adults may have been particularly affected, as this developmental period is often characterized by increased vulnerability to mental health challenges (Lee et al., 2020; Stroud & Gutman, 2021) and significant reliance on structured physical and social routines for maintaining

well-being (Bertheussen et al., 2011; Biddle et al., 2019; Breslin et al., 2023; Hassan et al., 2022; Jussila et al., 2022; Ströhle, 2009).

Some results of the present study replicated findings from previous studies. Specifically, anxiety and depression symptoms were stable over time and correlated within and across time (Jacobson & Newman, 2014; Jacobson et al., 2017; Kieling et al., 2024; Krygsman et al., 2023). These findings align with prior research and highlight the persistent nature and interconnectedness of anxiety and depression, underscoring the importance of examining them jointly over time. However, contrary to initial predictions, commitment to exercise was not correlated with anxiety or depression at any time point. This result contrasts sharply with robust existing research supporting a link between low physical activity and heightened anxiety and depression symptoms (Ahn & Fedewa, 2011; Bertheussen et al., 2011; Biddle et al., 2019; Breslin et al., 2023; Hassan et al., 2022; Jussila et al., 2022; Ratey & Hagerman, 2013; Ströhle, 2009). Possible explanations for this discrepancy might include measurement differences (e.g., assessing commitment rather than actual behavior), the timing and frequency of assessments (across three years of the pandemic that varied in terms of social restrictions), or the characteristics of the sample studied (single age cohort of young adults). When depression, anxiety, and commitment to exercise were examined simultaneously in a unified cross-lagged path model, results indicated some associations between internalizing problems and commitment to exercise. This finding likely emerged because cross-lagged path modeling captures cascading effects between variables that unfold over multiple time points, thus allowing identification of interconnected developmental trajectories and accounting for both continuity and change (Masten & Cicchetti, 2010). In contrast, correlations simply provide information about concurrent associations without illuminating the directional or temporal relations among variables.

Results indicated that, as anticipated, anxiety and depression demonstrated strong stability over time, with significant pathways observed between consecutive years (e.g., anxiety at age 22 predicting anxiety at age 23). These findings suggest that individuals experiencing heightened anxiety or depression, relative to others, earlier in the pandemic tended to maintain their symptoms in subsequent years. Notably, certain pathways, such as depression at age 23 predicting depression at age 24, were only significant for women, suggesting potential gender differences in the persistence of depressive symptoms. These results align with the existing

literature, which has consistently documented a strong relation between anxiety and depression symptoms and their stability over time, as well as the tendency for women to report higher levels of depressive symptoms than men (APA, 2013; Banna et al., 2022; Jacobson & Newman, 2014; Jacobson et al., 2017; Kieling et al., 2024; Stroud & Gutman, 2021; Van Droogenbroeck et al., 2018).

Beyond examining the stability of these constructs, the cross-lagged longitudinal associations between anxiety and depression were less consistent. Specifically, no statistically significant pathway emerged from anxiety at age 22 to depression at age 23. However, other significant pathways indicated that anxiety and depression remained interconnected over time. For example, anxiety at age 23 significantly predicted depression at age 24, and this relation remained significant the following year, suggesting a lagged effect wherein elevated anxiety symptoms contributed to subsequent depressive symptoms. Conversely, the reciprocal relation (depression predicting future anxiety) was largely non-significant, indicating that although these constructs are interrelated, their temporal influence on each other does not necessarily follow a consistent or reciprocal pattern.

In the path model, commitment to exercise was associated with both anxiety and depression, yet varied by gender. Among men, higher commitment to exercise at age 23 was associated with lower depressive symptoms at the same time point, aligning with previous research indicating that engagement in physical activity can mitigate depressive symptoms (Ahn & Fedewa, 2011; Bertheussen et al., 2011; Biddle et al., 2019; Breslin et al., 2023; Hassan et al., 2022; Jussila et al., 2022; Ratey & Hagerman, 2013; Ströhle, 2009). However, this effect was not observed among women, despite expectations that a similar relation would emerge. One possible explanation for this gender difference is that men, on average, tend to engage in more physical activity than women, leading to more pronounced mental health benefits. Empirical evidence indicates that men are more likely than women to participate in sports and vigorous physical activities, both recreationally and competitively (Azevedo et al., 2007; Deaner et al., 2012; Statistics Canada, 2023). Additionally, differences in coping strategies for mental health concerns may contribute to this pattern. While men may be more inclined to utilize exercise as a primary strategy for managing psychological distress, including symptoms of anxiety and depression, women tend to employ a broader repertoire of coping mechanisms (Azevedo et al., 2007; Deaner et al., 2012). These variations in physical activity levels and coping strategies may, in part,

explain the observed gender differences in the relation between commitment to exercise and depressive symptoms.

Anxiety at age 22 was positively associated with commitment to exercise at age 23 for men only, as well as anxiety at age 23 with commitment to exercise at age 24 for women only. These findings suggest that heightened anxiety in an earlier time point was predictive of greater engagement in exercise. Notably, the observed associations occurred during the COVID-19 pandemic, a period characterized by widespread stress and disruptions to daily life. The link between elevated anxiety and increased commitment to exercise may, in some cases, reflect maladaptive exercise behaviours indicative of disorder eating, particularly given the well-documented rise in such behaviours during the pandemic (Phillipou et al., 2020; Rodgers et al., 2020). Research has shown that individuals experiencing heightened anxiety may turn to exercise as a means of regaining a sense of control, alleviating distress, or compensating for perceived dietary excess, all of which are patterns commonly associated with compulsive exercise and eating disorders (Bratland-Sanda & Sundgot-Borgen, 2012). The gender differences observed in this association may reflect distinct sociocultural pressures related to body image and exercise. Women, for instance, often experience stronger societal reinforcement to engage in exercise for the purpose of attaining an idealized thin physique, a pressure that may contribute to the development of disordered eating behaviours over time (Anic et al., 2022; Myers & Crowther, 2007). Conversely, men may be more likely to engage in compulsive exercise as a means of stress regulation or in pursuit of a muscular physique, a pattern that has also been linked to disordered eating symptoms (Murray et al., 2012). These findings highlight the need to consider not only the potential mental health benefits of exercise but also the risks associated with anxiety-driven exercise, particularly in periods of heightened societal stress such as the COVID-19 pandemic.

However, the association between anxiety or depression and commitment to exercise did not remain significant in subsequent years. This finding suggests a gradual weakening of the relationship rather than a temporary disruption followed by a re-emergence, often known as the decoupling effect, which has been seen in other contexts (Vaillancourt & Brittain, 2024). The decoupling effect refers to a phenomenon in which two variables that were initially associated become temporarily dissociated due to external circumstances, only for the association to later re-establish itself. However, in this study, anxiety or depression may have initially been

associated with commitment to exercise, but other factors likely emerged over time to influence exercise behaviour, leading to a sustained decline in this association. Unlike a typical decoupling effect, which implies a transient weakening of an association, our findings suggest a more persistent disengagement, in which individuals' who initially relied on commitment to exercise as both an adaptative and maladaptive coping mechanism gradually shifted their behaviour as circumstances evolved.

Both men and women demonstrated significant continuity in their commitment to exercise over time, with commitment at an earlier time point predicting continued commitment later. No significant gender differences in commitment to exercise were found. Although prior research has indicated that men engage in higher levels of exercise than women (Statistics Canada, 2023), the current study did not assess actual exercise levels but rather individuals' commitment to exercise. This distinction may account for the lack of observed gender differences in the present findings.

No other significant relations were identified between commitment to exercise and anxiety or depression at any other time point for either gender. This finding stands in contrast to the existing literature, which has generally documented a robust association between physical activity and improved mental health outcomes, specifically anxiety and depression, during the COVID-19 pandemic (Duncan et al., 2020; Faulkner et al., 2021; Grocke-Dewey et al., 2021; Jacob et al., 2020; Krygsman et al., 2023; Lesser & Nienhuis et al., 2020; Marashi et al., 2021; McGuine et al., 2021; Nienhuis & Lesser, 2020; Rogowska et al., 2020; Wilson et al., 2021; Wrucke et al., 2022). For example, Faulkner et al. (2021) conducted a comprehensive study across the United Kingdom, Ireland, New Zealand, and Australia and found that individuals with lower physical activity levels during the pandemic reported greater mental health difficulties. Moreover, those who reported larger decreases in physical activity compared to pre-pandemic levels exhibited poorer mental health outcomes than those with smaller decreases. Similarly, in a Canadian context, Lesser and Nienhuis (2020) found that young adults who engaged in higher levels of physical activity during the pandemic reported fewer mental health difficulties. Notably, they also observed that previously inactive individuals who increased their physical activity levels during lockdown measures demonstrated higher levels of emotional, social, and psychological health compared to inactive individuals who did not increase their activity levels.

The discrepancy between the current study's findings and the existing literature may be attributed to methodological differences, particularly in the measurement of physical activity. Lesser and Nienhuis (2020), which to my knowledge is the only Canadian study on this topic, employed a multifaceted approach to measure physical activity, including the Behavioural Regulations in Exercise, Godin Leisure Questionnaire, and Nature Relatedness Scale. In contrast, in the present study, I focused primarily on commitment to exercise (i.e., how important do you think it is to your general well-being not to miss an exercise session; does it upset you if, for some reason or another, you are unable to exercise) potentially overlooking other crucial aspects of physical activity. Most studies in this area have used measures assessing the frequency of physical activity, often complemented by assessments of motivation or commitment to exercise (Duncan et al., 2020; Faulkner et al., 2021; Grocke-Dewey et al., 2021; Jacob et al., 2020; Lesser & Nienhuis et al., 2020; Marashi et al., 2021; McGuine et al., 2021; Nienhuis & Lesser, 2020; Rogowska et al., 2020; Wilson et al., 2021; Wrucke et al., 2022). The divergence in findings between the current study and the existing literature underscores the importance of comprehensive and multidimensional assessment of physical activity in research examining its relationship with mental health outcomes. Future studies should consider incorporating measures of current physical activity levels and assessments of motivation or commitment to exercise. Furthermore, the temporal relationship between commitment to exercise and mental health measures should be carefully considered in the study design as not having the mental health measures and commitment to exercise measured concurrently may also explain the inconsistency in findings.

Limitations and Future Research Directions

Although the present study has several strengths, including a relatively large sample size, reliable measures for anxiety and depression symptoms, and a longitudinal design, it is not without limitations. First, although a longitudinal approach was used across multiple time points, and mental health (self-reported anxiety and depression symptoms) was measured prior to the pandemic to establish a baseline, commitment to exercise levels were not assessed pre-pandemic. This temporal discrepancy in measurement potentially obscures the dynamic interplay between commitment to exercise and mental health throughout the pandemic's progression. The simultaneous measurement of commitment to exercise levels and mental health symptoms would allow for a more comprehensive examination of temporal changes (i.e. pre-pandemic, early

pandemic, and mid-to-late pandemic as NPI's were lifted). Future studies should aim to assess both mental health and commitment to exercise at consistent time points to elucidate their dynamic association. This methodological refinement would provide a more nuanced understanding of how changes in commitment to exercise levels correspond to fluctuations in mental health symptoms, potentially revealing critical periods for intervention.

Second, while the Commitment to Exercise Scale (CES) is a valid and reliable instrument, it does not directly quantify exercise frequency, instead measuring general exercise commitment. Although this provided valuable insights and allows for reasonable inferences about participants' physical activity levels, it may not capture the full spectrum of physical activity, particularly those that may have emerged or been modified in response to NPIs. Subsequent studies should employ measures that quantifiably assess exercise frequency and commitment to exercise as this will likely provide a better representation of overall physical activity levels.

Third, the current study had missing data, which does not reflect the original sample as shown in other studies using data from the McMaster Teen Study (e.g., Vaillancourt & Brittain, 2024). Missing data and attrition in longitudinal studies can introduce biases if certain participants are less likely to complete the study in subsequent years. Previous research has discussed how missing data may disproportionately affect individuals with higher levels of psychological distress or those experiencing instability in their environments (Halabi et al., 2024). Therefore, it is important to acknowledge that the final sample of the current study differs in significant ways from the original sample (as established previously; e.g., Vaillancourt & Brittain, 2024), potentially influencing the interpretation of the results. Another limitation to consider is that the current study may also be underpowered to detect small effect sizes (Orth et al., 2024).

Finally, an important consideration for future research is the influence of the timing of the COVID-19 pandemic on the relation between commitment to exercise and mental health symptoms. During the first year of the pandemic, widespread lockdowns and the implementation of NPIs significantly disrupted daily life, leading to the closure of gyms, recreational facilities, and other social outlets (Canadian Institute for Health Information, 2024; Foran, 2023). In response to these restrictions, individuals sought alternative means of exercise, such as home workouts and outdoor activities, in an effort to maintain physical health and prevent weight gain

(Colley & Watt, 2022). However, as the pandemic progressed into its second year, many NPIs were either lifted entirely or modified to allow greater accessibility to public spaces, including gyms (Canadian Institute for Health Information, 2024). During this period, individuals likely adapted to the evolving health landscape, which may have contributed to a decline in perceived susceptibility to and severity of the virus, as outlined by the Health Belief Model (LaMorte, 2022). By the final year of the present study and pandemic, all pandemic-related restrictions in Ontario had been lifted (Canadian Institute for Health Information, 2024). The ongoing changes in NPIs throughout the course of the pandemic introduced variability in how individuals engaged in physical activity and experienced mental health symptoms. These fluctuations underscore the complexity of examining the long-term effects of the pandemic on health behaviours and mental health symptoms.

Educational and Clinical Implications

Although the present study identified some associations between anxiety, depression, and commitment to exercise, these relationships were weak in magnitude and did not persist over time. These findings contrast with a substantial body of research demonstrating the efficacy of physical activity in reducing symptoms of anxiety and depression. Despite this discrepancy, it remains essential for educators and mental health professionals to continue promoting regular physical activity among young adults.

There is a pressing need to improve health literacy and expand awareness of the mental health benefits of physical activity. Although some programs already address this connection, incorporating this information more systematically into education curricula could be particularly beneficial at the post-secondary level. Moghimi et al. (2023) in their mixed methods design across different Canadian post-secondary institutions, found that most students perceived their institutions to have inadequate mental health services and a lack of awareness about available resources. The pandemic exacerbated these issues, introducing barriers such as increased financial constraints, extended wait times, and stigma persisting even after the lifting of NPIs in Canada (Moghimi et al., 2023; Murray & Knudson, 2023). Importantly, while structured physical activity formats (e.g., workout classes, weight rooms) often involve financial costs, there is evidence to suggest that there are numerous free alternatives (e.g. walking) that offer the same mental health benefits (Bertheussen et al., 2011; Hassan et al., 2022; Jussila et al., 2022; McMahon et al., 2017; Warburton & Bredin, 2017). This is significant as it addresses financial

barriers, wait times, and stigma concerns, allowing individuals to engage in physical activity discreetly and without any financial burden.

It remains crucial for clinicians and mental health professionals to recognize the role that physical activity can play in managing mental health symptoms. Established therapeutic approaches such as Cognitive Behavioural Therapy (CBT) have demonstrated efficacy in reducing anxiety and depression symptoms (Chan et al., 2019). However, physical activity can act as a complementary tool for symptom management and reduction outside of therapy sessions (Bertheussen et al., 2011; Hassan et al., 2022; Jussila et al., 2022; McMahon et al., 2017; Warburton & Bredin, 2017). For individuals with depression, engaging in physical activity may help counteract the isolating behaviour often associated with depression, providing a behavioural approach to mood improvement. However, recommending physical activity to someone experiencing depressive symptoms can be challenging. Depressive symptoms such as low energy, diminished motivation, and anhedonia can make it particularly difficult for individuals to initiate and maintain physical activity routines (Ratey & Hagerman, 2013). Furthermore, feelings of guilt or failure when unable to engage in physical activity may further exacerbate these depressive symptoms. Therefore, it is important for clinicians to consider individualized, low-barrier strategies that put more emphasis on small, achievable goals and gradual integration of movement into the individual's daily life. Similarly, for individuals with anxiety, physical activity may facilitate an interoceptive exposure by helping them distinguish between exercise induced physiological responses (i.e. increased heart rate) and anxiety-related symptoms (Ratey & Hagerman, 2013).

Given the current shortage of mental health professionals in Canada (Murray & Knudson, 2023), these implications are particularly relevant for individuals unable to access immediate professional support. Encouraging physical activity as a protective strategy may help mitigate symptoms of anxiety and depression while individuals await therapeutic intervention. This is especially important given that mental health difficulties remain the leading cause of disability worldwide, with rates of mental health challenges expected to rise (Kieling et al., 2024). Integrating physical activity into broader mental health strategies may provide an accessible and cost-effective means for supporting young adults' mental well-being in both clinical and educational settings.

Conclusion

Commitment to exercise and mental health symptoms, specifically anxiety and depression, during the COVID-19 pandemic and how commitment to exercise levels were associated with mental health symptoms was examined. Although the present findings did not reveal consistent or strong associations between commitment to exercise and symptoms of anxiety and depression during the pandemic, a substantial body of research supports the role of physical activity in alleviating these mental health concerns (Ahn & Fedewa, 2011; Bertheussen et al., 2011; Biddle et al., 2019; Breslin et al., 2023; Hassan et al., 2022; Jussila et al., 2022; Ratey & Hagerman, 2013; Ströhle, 2009). Given that mental health challenges remain a leading cause of disability worldwide, with prevalence rates expected to rise (Kieling et al., 2024), it is important to prioritize accessible and cost-effective interventions. The promotion of physical activity as a complementary mental health strategy is particularly relevant in contexts where mental health resources were limited and opportunities for engaging in physical activity are scarce, such as during periods of global crisis or social restriction (Marashi et al., 2021; McGuine et al., 2021; Meyer et al., 2020; Pieh et al., 2020; Rogowska et al., 2020). Integrating physical activity into mental health initiatives, public health policies, and educational programs may help mitigate the psychological burden among young adults and provide individuals with an immediate, accessible tool for improving their psychological well-being.

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