

Can exergaming improve mental health of university students?

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## **Abstract**

The academic, financial, and social pressures that emerge when adults begin university may lead them to encounter mental health challenges (American College Health Association [ACHA], 2016). In Ontario, 46.2% of university/college students have reported ‘excessive’ stress whereas 64.5% report ‘overwhelming’ anxiety (ACHA, 2016). One approach that may be useful for enhancing mental health is exergaming which uses motion-sensor technology requiring players to move their bodies to complete the videogame sessions (Huang et al., 2017). However, studies focused on the effectiveness of exergaming for improving mental health of university students are scarce in number and limited in scope. The overall purpose of this dissertation was to examine the role of exergaming in relation to mental health reported by university students. In Study 1, a synthesis of published intervention research using exergaming to change well-being – a psychological concept affiliated with mental health – reported by adults was conducted. Results from Study 1 indicated that less than 50.0% of the coded studies - using either multi- or single-group (pre-post-test) research designs - reported enhanced well-being as a function of exergaming. In Study 2, the link between the amount and intensity of exergaming behaviour per week and mental health reported by university students was evaluated. Results from Study 2 indicated that university students who reported more frequent exergaming behaviour during a typical week displayed lower anxiety and stress plus higher flourishing and vitality. In Study 3, the contributions of exergaming to mental health of university students were investigated using an experimental research design that compared exergaming against other physical activity behaviours and self-management approaches. Results from Study 3 showed that ‘exergamers’ did not present higher or lower mental health scores compared against ‘traditional’ exercisers but displayed less stress and anxiety when compared against pet therapy, as well as,

higher vitality plus lower stress and anxiety compared to ‘non-exercisers’. The results from these studies make it apparent that exergaming may not offer anything ‘unique’ as a stimulus beyond more traditional modes of exercise, but it fosters mental health of university students.

**Keywords:** Active Video Gaming, Mental Health, Quality of Life, Psychosocial Health, Physical Activity

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## List of Abbreviations

ACSM.....	American College of Sports Medicine
ACHA.....	American College Health Association
ANOVA.....	Analyses of Variance
AVG.....	Active Video Games
BRFSS.....	Behavioral Risk Factor Surveillance System
CCMH.....	Center for Collegiate Mental Health
CMHA.....	Canadian Mental Health Association
CAMH.....	Centre for Addiction and Mental Health
CINAHL.....	Cumulative Index to Nursing and Allied Health Literature
DDR.....	Dance Dance Revolution
EXG.....	Exergaming
FS.....	Flourishing Scale
LOI.....	Letter of Invitation
MANOVA.....	Multivariate Analyses of Variance
MHCC.....	Mental Health Commission of Canada
MVE.....	Moderate-to-Vigorous Exergaming
PSS.....	Perceived Stress Scale
RCT.....	Randomized Controlled Trial
REB.....	Research Ethics Board
STAI-SF.....	State-Trait Anxiety Inventory
SVS.....	Subjective Vitality Scale
URL.....	Uniform Resource Locator
WHO.....	World Health Organization

## Chapter 1

### Introduction

Mental health can be defined as a state of well-being in which the individual recognizes their potential, is able to work productively, contributes to the community, and copes with the stresses of life (World Health Organization [WHO], 2014). When young adults begin their studies at university, they may face challenges that lead to diminished mental health (Samuolis & Griffin, 2014). Social, academic, and financial changes are some factors that can weaken university students' mental health (American College Health Association [ACHA], 2019; O'Reilly et al., 2018). Being away from family and friends may evoke social isolation (ACHA, 2019), and the number of classes to be taken and the amount of materials to be learned may be stressful (Bergin & Pakenham, 2015). Furthermore, university students tend to feel stressed about the debts they incur due to payment of tuition and fees (Lange & Byrd, 1998). Research published by the American Psychological Association (American Psychological Association [APA], 2018) showed that more than one-third of first-year university students reported some mental health challenges with a substantial increase from 2007 to 2017 (from 22% to 34%).

To address the escalating problem of mental health challenges reported by university students (see ACHA, 2019 for details), post-secondary education institutions have implemented several campus-wide initiatives. Students have access to programs designed to enhance mental health such as counselling, pet therapy, art therapy, massage therapy, and nap pods (Galante et al., 2018). Active videogames, also known as exergaming, are electronic devices that could be used to improve the mental health of university students. Playing exergaming has shown potential to improve mental health reported by adults living with and without medical conditions (Byrne & Kim, 2019; Chao et al., 2014; Kappen et al., 2019; Li et al., 2016). According to Kooiman and Sheehan (2015), exergaming

motivates game play via fun stemming from story-based, textual, auditory and visual stimuli within the game. Due to the entertainment ‘lure’ of exergaming, players feel motivated to engage in behaviour that subsequently can improve mental health (e.g., higher well-being, lower stress and anxiety; Kooiman & Sheehan, 2015). However, while exergaming may be useful for changing mental health reported by university students, there is limited evidence focused exclusively on the role of exergaming in relation to indicators of mental health reported by this cohort.

The overall purpose of this dissertation was to investigate the role of exergaming in relation to mental health with application to university students. To accomplish this purpose, three studies were conducted in this dissertation. Study 1 was conducted to (a) synthesize the research evidence appraising the utility of exergaming as an intervention modality to change well-being – a psychological concept affiliated with mental health – of adults, and (b) identify the gaps in the published literature supporting the use of exergaming as a tool to promote well-being reported by adults. The objective of Study 2 was to examine links between exergaming performed at both moderate- and vigorous-intensities with dimensions of mental health reported by university students. Specifically, a non-experimental research design tested links between exergaming behaviour at both moderate- and vigorous- intensities with levels of stress, anxiety, flourishing, and subjective vitality reported by university students. Finally, the purpose of Study 3 was to determine if exergaming impacts mental health reported in first-year university students. A randomized experimental research design was used to examine if exergaming impacts levels of stress, anxiety, flourishing, and vitality reported by university students when the targets are first-year university students. Study 3 also compared the impact of exergaming on mental health of first-year university students against other approaches to self-management (e.g., pet therapy, etc.).

### **Mental health challenges amongst university students**

Many young adults enrol in post-secondary education during a key developmental phase of life (Samuolis & Griffin, 2014). This phase – often labelled ‘emerging adulthood’ (Samuolis & Griffin, 2014) – occurs for most people between 18 to 25 years of age (Arnett, 2006). Emerging adulthood is a period of life during which young adults explore their identities and define relationships, education, and career paths (Arnett, 2006). It is also a time of emerging autonomy and self-focus which can bring instability (Arnett, 2006). It is during this period of transition that young adults typically enter university which is a phase that differs from their previous academic experiences (Goodday et al., 2019). University students may encounter debilitating pressures (e.g., financial, academic, etc.; O’Reilly et al., 2018), excessive weight gain (e.g., de Vos et al., 2015), disruptions in normal routine caused by living independently from parents (e.g., Lewis et al., 2015), and reduced sleep quality (e.g., Wilson et al., 2014). Some university students navigate routine changes with optimism, happiness, confidence, and overall high levels of mental health (Arnett, 2006; Samuolis & Griffin, 2014). By contrast, others find it more difficult to adjust to the challenges of being a university student, which may lead to diminished mental health (Samuolis & Griffin, 2014).

Mental health comprises feeling happy (i.e., emotional well-being), searching for personal growth through purpose in life, self-acceptance, positive relations with peers (i.e., psychological well-being), and doing well making individual contributions to society (i.e., social well-being; Keyes, 2005; Ryff, 1989; WHO, 2014). People typically fall along a continuum ranging from low to high mental health (Canadian Mental Health Association [CMHA], 2019). Following this continuum, those with high levels of social, psychological and emotional well-being, flourish often reporting high levels of mental health (Keyes, 2005; Schotanus-Dijkstra et al., 2016). Yet, challenging situations may interfere with this continuum and decrease people’s levels of mental health (Schotanus-Dijkstra et al., 2016). Challenging situations may promote negative mental health such as heightened stress, anxiety, or sadness (Mental Health Commission of Canada [MHCC], 2016). Keyes (2005) argued that everyday

concerns faced by university students may initiate or exacerbate these negative dimensions of mental health.

University students with high levels of stress and/or anxiety often report lower levels of well-being that can deteriorate over time (Ribeiro et al., 2018). Prior research suggests that young adults enrolled in universities do report diminished mental health compared with age-matched peers not attending university (e.g., Ibrahim et al., 2013; Keyes et al., 2012; Larcombe et al., 2016; Leahy et al., 2010; Roberts et al., 1999; Stallman, 2010; Stewart-Brown et al., 2000). For example, higher levels of anxiety and stress (e.g., Ibrahim et al., 2013; McKenzie et al., 2010) plus reduced levels of flourishing (e.g., Keyes et al., 2012) have been reported by university students compared with peers not enrolled in university. Stallman's (2010) research indicated that levels of distress reported by university students were more than five times higher than young adults in the same age group who were not enrolled in university. Longitudinal investigations have shown that university students report better mental health 'before' than 'during' their academic studies which implies post-secondary education can be anxiogenic and stress-inducing (e.g., Andrews & Wilding, 2004; Bewick et al., 2010; Cooke et al., 2006).

In Canada, research conducted by the ACHA in 2019, reported that university students ( $N = 55,284$ ) felt hopeless (63.6%), overwhelmed (88.2%), more than average stress (45.6%), exhausted (87.6%), lonely (69.6%), sad (76.2%), as well as, anxiety (68.9%) within the past 12 months. Other studies focused on university students enrolled in clinical programs (e.g., nursing students, etc.) within Canada report high overall rates of negative mental health in these cohorts (Chernomas & Shapiro, 2013; Matheson et al., 2016). A web-based survey conducted with medical students and residents enrolled at Canadian universities showed that 41.5% reported heightened levels of psychological distress (Matheson et al., 2016). Additional research by Chernomas and Shapiro (2013) with nursing students reported elevated prevalence of mild to severe forms of anxiety (39%) and stress (38%). A

study of college and university students in Ontario by the ACHA in 2016 reported ‘excessive’ stress (46.2%) plus ‘overwhelming’ anxiety (64.5%). Overall, it seems that university students worldwide, as well as in Canada, report levels of mental health that warrant concern for this cohort of society (ACHA, 2016).

Mental health experienced by university students may contribute to various consequences (Hysenbegasi et al., 2005; Winzer et al., 2018). Students with high levels of anxiety and stress have trouble concentrating on assignments and exams, which in turn, can diminish academic performance (Eisenberg et al., 2009; Hysenbegasi et al., 2005). Other mental health variables considered as key predictors to successful learning and academic performance of university students include flourishing and vitality (Abdi & Zandipayam, 2019). According to Parker et al. (2005), over 33% of first-year university students report concerns about new routines (e.g., number of classes, assignments, etc.), concerns about meeting new people, feeling lonely, or becoming homesick. These social, psychological and emotional challenges may affect university students’ commitment to learning, orientation towards personal growth, and social engagement (Gokcen et al., 2012; Knoesen & Naude, 2018; Parker et al., 2005). Furthermore, university students may lack energy to study, attend classes, and/or seek opportunities to further learning (Gokcen et al., 2012). Research by Abdi and Zandipayam (2019) demonstrated that 36% of the variance in academic performance of university students was predicted by levels of flourishing and subjective vitality. Fox et al. (2019) suggest that post-secondary institutions that omit mental health strategies focused on flourishing and vitality should rethink this approach given the centrality of these mental health dimensions to academic success reported by university students.

Over time, university students facing mental health challenges may begin to isolate themselves to a greater degree from their peers and withdraw registration in academic courses (Ishii et al., 2018) possibly as a result of poor mental health. The available research shows that students experiencing greater mental health challenges have more difficulty completing the academic requirements to



graduate (see Ishii et al., 2018, for details). Once a university student graduates it remains evident that mental health challenges can persist after transitioning into the workforce (Goldman-Mellor et al., 2014). Young adults with a history of encountering mental health challenges have been linked with a higher incidence of disability pension, sickness absence, diminished occupational preparedness, and lower performance of their work-related duties (Goldman-Mellor et al., 2014; Niederkrotenthaler et al., 2014; Rudman & Gustavsson, 2012; Winzer et al., 2018). Considering that poor mental health can impact student performance during university and extend throughout life, post-secondary institutions have been tasked with developing then deploying resources to support the mental health of university students (Eisenberg et al., 2007).

### **What on-campus initiatives can be accessed to improve mental health of university students?**

To help address mental health challenges encountered by university students it has become apparent that effective interventions in early stages are considered an important strategy for universities (Harrer et al., 2018). To that end, many universities are beginning to share mental health information with students through approaches such as panel discussions, prevention videos, presentations, and group discussions (Eisenberg et al., 2009). Such approaches can help to reduce the high demand evident in campus-based mental health centers (Wörfel et al., 2016). Campus-based mental health centers have reported increased demand for their professional services between 2008 to 2015 (Pendry et al., 2019). Data reported from over ninety-three post-secondary institutions located in United States of America (USA) showed that counselling appointments between 2008 (5.6%) to 2015 (38.4%) were more than seven times higher (Center for Collegiate Mental Health [CCMH], 2015). While the demand for university students who need on-campus mental health services has risen, previous research shows that only 22.3% of students reported obtaining any mental health or psychological support from a university-based mental health center (CCMH, 2015; Eisenberg et al., 2009). Given the burden levied on campus-based mental health services and the high demand of university students in need of mental

health assistance, it has become more important to expand options to support mental health for university students (Pendry et al., 2019).

Post-secondary institutions may provide a variety of services to support mental health for university students yet the primary source for mental health care offered by universities is counselling (Goodman, 2017). Universities provide counselling services primarily focusing on students with social, physical, and emotional demands effecting performance (Bekere & Tlale, 2019). In counselling sessions, universities offer students qualified professionals who provide confidential, impartial, and private services designed to address mental health challenges (Corey, 2009). Recent studies emphasize that counselling sessions may be effective in post-secondary institutions when students feel annoyed, unhappy, anxious, or lack future aspirations (Bekere & Tlale, 2019). Bekere and Tlale (2019) recommend universities provide counselling services to assist students with mental health challenges as these demands may directly affect students' academic performance. Counselling is just one of many mental health services that could be provided by universities (Corey, 2009).

Universities have also implemented designated places around campus – mainly in libraries – to situate 'nap pods' which offer a protected space that students can use to sleep (Gruber & Cassoff, 2014). The supporting rationale behind introducing nap pods across university campuses is that lack of sleep quality reported by university students is associated with mood impairment, compromised memory, diminished academic performance, and poor learning (Gruber & Cassoff, 2014; Hershner & Chervin, 2014; Killick et al., 2012). On the other hand, university students who use nap pods report higher quality of life and well-being plus lower perceived stress and burnout than students not using this equipment (Hernandez et al., 2019). Installing nap pods in universities helps students in reduce stress and anxiety plus improve exam performance (e.g., Ng et al., 2019; Sterba, 2013).

While nap pods may contribute to the university students' mental health and academic performance (e.g., Hernandez et al., 2019; Ng et al., 2019), universities have also introduced animal-

assisted therapy (AAT) services for students (Barker et al., 2016). AAT – also known as ‘pet therapy’ – has risen in prominence on university campuses as an intervention to promote mental health during times of stress for university students (e.g., exam periods; Barker et al., 2016). Pet therapy involves using trained animals as resources for implementing a therapeutic plan to enhance mental health (Binfet, 2017). Research investigating the use of pet therapy to change mental health reported by university students has shown promise (e.g., Quintana et al., 2019; Thelwell, 2019). For example, university students interacting directly with therapy animals for at least 10 minutes per session report improved mood, diminished anxiety, and lowered stress (Quintana et al., 2019; Thelwell, 2019; Wood et al., 2019). To assist university students during stressful times within the academic term, sessions with AAT usually take place during mid-term and final exam periods (Thelwell, 2019). This strategy is important because high levels of stress and anxiety can affect university students' ability to concentrate thus impacting performance during exams (Quintana et al., 2019).

In order to reduce stress and anxiety during the exams period, some campuses offer massage therapy sessions for university students (Tani & Lee, 2019). This approach is provided to help university students relax, prepare for exams, and reduce stress (Tani & Lee, 2019). Research focused on university students indicates massage therapy has potential to enhance mental health (Katsurada, 2019; Tani & Lee, 2019). For example, a pilot study conducted by Katsurada (2019) using 11 female university students reported a significant decrease in levels of stress after 10-minutes of massage therapy (Katsurada, 2019). These results are consistent with other research that demonstrated 10 minutes of massage therapy in young Japanese athletes improved levels of stress, anger, confusion, depression, vigour, fatigue, and tension (Tani & Lee, 2019).

### **Impact of physical activity on mental health of university students**

Another effective approach to change university students' mental health that is promoted by university campuses is physical activity (Andersen et al., 2019). Physical activity is widely recognized

as one approach to improve mental health of university students given the cost-effective nature of this strategy (e.g., Andersen et al., 2019; Chekroud et al., 2018; Kadariya et al., 2019; Pengpid & Peltzer, 2018; Piggin et al., 2017). Physical activity is the amount of energy resulting from any bodily movement produced by the skeletal muscles (Westerterp, 2013). The total amount of energy varies from low to vigorous (Hills et al., 2014). Exercise is typically considered to be a subcategory of physical activity that constitutes planned, structured, purposive, and repetitive motion aiming to condition the body, as well as, maintain or improve physical fitness and health (Kylasov & Gavrov, 2011; WHO, 2002). Public health agencies (e.g., American College of Sports Medicine [ACSM], etc.) have published evidence-based guidelines recommending the frequency, intensity, duration, and mode of physical activity to prevent disease and/or manage existing health conditions (Zenko & Ekkekakis, 2015). Research has demonstrated that physical activity is effective in minimizing the risk of non-communicable diseases such as diabetes mellitus, cardiovascular diseases, obesity, depression, hypertension, cancer, stroke, chronic lung disease, Alzheimer's, and musculoskeletal diseases (Andersen et al., 2016; Bouchard et al., 1994; Lee & Skerrett, 2001). Published reviews further highlight the positive impact of exercise and physical activity – even at low doses – on improved mental health (e.g., Baker et al., 2016; Bondár et al., 2019; Gordon et al., 2017; Kadariya et al., 2019).

Across the published reviews, it is evident that being physically active decreases negative indicators of mental health reported by university students (e.g., reduced psychological distress after physical activity interventions; Muir et al., 2019). University students with a sedentary lifestyle report higher levels of stress and anxiety (Lee & Kim, 2019). Engagement in physical activity by university students has improved mental health of this cohort (e.g., Dev & Rahman, 2016; Ghrouz et al., 2019; Muir et al., 2019). For example, regular physical activity has decreased university students' levels of stress, depression, anxiety, distress, and fatigue (Ghrouz et al., 2019; Hossain et al., 2020; Muir et al., 2019). Overall, research demonstrates that physical activity is useful for promoting emotional

intelligence, quality of life, and well-being of university students (Dev & Rahman, 2016; Muir et al., 2019).

### **Physical activity in university students**

Despite the benefits of mental health attributable to physical activity, it is widely accepted that the adoption and maintenance of a physically active lifestyle is a challenge across the lifespan (Kelly & Barker, 2016). This is particularly evident in young adults (aged 18-34 years old) where physical inactivity levels exceed current recommendations (Willmott et al., 2019). University students have been identified as the cohort at the highest risk for physical inactivity (Cocca et al., 2014). According to Romaguera et al. (2011), levels of physical activity in university students may decline because physical activity becomes voluntary after high school or due in part to the routine tasks imposed by studying for a university degree (Downes, 2015; Vella-Zarb & Elgar, 2009). To illustrate this point, a survey of university students from 22 universities worldwide (e.g., Nigeria, Mexico, China, etc.) reported the prevalence of engaging in regular physical activity – defined as 2 hours and 30 minutes minimum per week - was only 20.7% (Peltzer et al., 2014). Levels of physical activity in university students appear lower than age-matched peers not pursuing university education (Cocca et al., 2014). Researchers have reported that young people not enrolled in universities may engage, on average, in 103 minutes of moderate-to-vigorous-intensity physical activity per day whereas university students engage on average in only 57 minutes per day (Cocca et al., 2014). In a recent study conducted with university students enrolled at Canadian post-secondary institutions less than half (42%) of the female participants reported exercising regularly (Silver et al., 2019).

Given the potential mental health benefits of regular physical activity for university students, combined with the observed participation rates reported by this cohort, it has become imperative that viable alternatives to encouraging physical activity in university students becomes an important area of research focus. One technology that may prove useful in this regard is exergaming (Huang et al., 2017).

## **What is exergaming?**

Exergaming is a novel approach to physical activity that combines video gaming with motion-sensor technology which mandates that people move their bodies to complete sessions (Witherspoon, 2013). This category of videogame was initially developed in 1980 by a Japanese company (called Bandai) to encourage physical activity in children/adolescents, with subsequent implementation across recreation and health centers, gyms, and videogame facilities (ACSM, 2013; Bogost, 2005). By 2009, exergaming sales worldwide had generated revenues of US\$2 billion (ACSM, 2013; Jonsdottir et al., 2018).

The first known exergame was ‘Power Pad’ (also known as ‘Family Fun Fitness’; Bogost, 2005). Bandai developed this game originally before the Nintendo Entertainment System released the game to a North American market in 1988 (Bogost, 2005). Power Pad is a floor mat that is connected to a Nintendo console via the television (Sinclair et al., 2007). The mat has twelve pressure-sensors which require players to jump and step at speed to move the character within the game (Fell & Ferrier, 1993). Most of the ‘Power Pad’ games are based on Olympic sports (e.g., jumping obstacles, running, etc.) which enhanced this game’s popularity (Fell & Ferrier, 1993; Sinclair et al., 2007).

The popularity of exergaming increased in 1998 when Dance Dance Revolution (DDR) was released for purchase (Murphy et al., 2009). DDR is considered a pioneer in the genre of dance-based exergames with the original version released as a coin-operated game for arcade venues (Behrenshausen, 2007). Like ‘Power Pad’, home-based versions of DDR include a mat connected to sensors and platforms (e.g., Nintendo, PlayStation, Xbox, etc.). To activate this game, players must step on arrows in sequence to complete choreographed dance movements (Unnithan et al., 2006). Players are guided by on-screen prompts to step on corresponding arrows with the speed of the game based on the accompanying song’s beat (Murphy et al., 2009).

There are several categories of exergames (e.g., action, dance, adventure, etc.) that vary how play is developed based on the genre of game and specific console used per game (Sheehan & Katz, 2013). For example, when using the Xbox console with Kinect to exergame, a person engages in ‘hands-free’ mode (Witherspoon, 2013). The motion-sensor technology of the Kinect captures the player’s movement without a hand-held controller (Siegel et al., 2009). Exergaming that uses Nintendo Wii, Nintendo Switch or mobile requires players to hold the controller (or cellphone) in a manner that movements are recognized by the game (Van Diest et al., 2013). Different playability features (e.g., hands-free of holding a motion-sensor controller, etc.) may impact players' feelings of control which leads to different levels of within-game immersion and enjoyment (Tanaka et al., 2012).

Exergaming may also engage players with opportunities to participate using various game modes combined with diverse themes (e.g., play with family and friends, play in single-play mode at home; compete online against other players; choose between Zumba, walking, running themes; Witherspoon, 2013). According to Bogost (2005), the components of exergaming – such as diverse game modes for example - could motivate physical activity by individuals that dislike traditional exercise and/or avoid traditional exercise settings (e.g., gyms, etc.). For example, in the exergame called ‘EA Sports: Personal Trainer’ developed Electronic Arts, each player has a virtual personal trainer that provides instructions for various modes of exercise including cardiovascular and strength-based activities (Electronic Arts, 2009). Complimenting the variety elements of exergaming, modern exergames make use of themes not specifically related to exercise or reality (Sheehan & Katz, 2013). The exergame ‘Zombie, Run!’ developed is a mobile game in which the player must run to survive to a zombie apocalypse and help other survivors (Six to Start, 2012). To complete the missions within ‘Zombie, Run!’, each player must collect items virtually by running in outdoor areas in real time. Exergames such as ‘EA Sports: Personal Trainer’ and ‘Zombie, Run!’ can engage people to be physically active by manipulating variety and thematic presentation which may be suitable for

individuals seeking more dynamic ways to exercise while gaming at the same time (Witherspoon, 2013).

### **What is known about exergaming and mental health?**

The release of exergames spurred new research into the effects of videogames on the player behaviour (Bogost, 2005). Several researchers have discussed the potential impact of videogame content in player's lives (da Silva Stroppa et al., 2017). For example, videogames that include violent content have been linked with increased aggressive cognitions, antisocial behaviour and violence expressed by players (e.g., Anderson et al., 2010; Barlett et al., 2008). The interest in studying the effects of exergaming on mental health of players demonstrates that, just as videogames with negative content may negatively affect the player, videogames designed for health promotion (e.g., exergames), may positively affect them (Halbrook et al., 2019). Research using exergaming to promote mental health is evident in early stages of the lifespan (e.g., children, youth, etc.), clinical groups (e.g., Alzheimer's disease, etc.), as well as, non-clinical groups (e.g., older adults, etc.). Exergaming has become popular for interventionists aiming to improve mental health due in part to widespread accessibility of this technology (Lee et al., 2019; Street et al., 2017). Exergaming has also generated a lot of clinical interest over the past decade, both as games designed for specific interventions (e.g., Peng et al., 2012), or as commercially available options used to foster global physical activity behaviours (e.g., Peña et al., 2016; Zayeni et al., 2020).

Benefits of exergaming in terms of improved dimensions of mental health are reported for children/youth in terms of increased self-esteem and well-being (Chao et al., 2015; O'Loughlin et al., 2020; Sun, 2012), as well as, decreased anxiety and social stress (Andrade et al., 2019; Byrne & Kim, 2019; Cacciata et al., 2019). It is evident, based on the systematic review and meta-analysis conducted by Andrade et al. (2019), that exergaming may be used to reduce symptoms of depression and stress, as well as, increase positive mental health outcomes such as self-esteem in children/youth.



Exergaming has shown utility for improving mental health in various clinical groups (i.e., adults living with chronic diseases or health conditions; Padala, Padala, Lensing, Dennis, Bopp, Roberson, et al., 2017). A recent meta-analysis, Cacciata et al. (2019) concluded that exergaming has been used successfully to change mental health of adults with gait instability (Haines et al., 2009) and Alzheimer's disease (Padala, Padala, Lensing, Dennis, Bopp, Parkes, et al., 2017). Tough et al. (2018) synthesized the evidence for exergaming interventions delivered to improve mental health of adults living with cancer. In their study, Tough et al. reported that exergaming reduced both fatigue and stress exhibited by cancer survivors. With other adult cohorts living with unilateral peripheral vestibular loss, Parkinson's disease, or diabetes, researchers have reported that exergaming appears effective in reducing depression (Li et al., 2016). Exergaming has been shown to enhance self-esteem, positive feelings, and self-perception of adults living with cognitive impairments (Van Santen et al., 2018). Finally, Verheijden-Klompstra et al. (2014) reported that exergaming improves quality of life, psychosocial well-being, and empowerment of adults living with heart failure. Overall, the available evidence highlights the potential of exergaming to improve the mental health of adults living with various chronic diseases or health conditions.

There is increasing empirical work – including meta-analyses and systematic reviews – conducted to examine the effect of exergaming on mental health of adults living without specific health issues (e.g., Byrne & Kim, 2019; Li et al., 2016; Pasti et al., 2012). Viana et al. (2017) demonstrated that a single bout of Zumba Fitness performed using Xbox 360 Kinect can reduce anxiety reported by healthy adults. Other studies have indicated that positive outcomes associated with exergaming may include greater subjective vitality (Nani et al., 2019), vigour, happiness, quality of life (Huang et al., 2017), enjoyment, and positive emotions (Naugle et al., 2014). Matallaoui et al. (2017) concluded in their systematic review that adults who played sport, aerobics, cycling, and muscle conditioning exergames reported higher levels of overall enjoyment. The benefits of exergaming for improving

mental health via physical activity reinforce the potential of this option as an intervention tool (Bogost, 2005; Lee et al., 2017) yet gaps in the literature remain evident (Huang et al., 2017).

One gap in exergaming and mental health literature concerns the limited application of relevant theories to advance causal understanding (Kooiman & Sheehan, 2015). Lack of theories in the exergaming literature is pervasive with no specific theory developed to explain the link between exergaming and mental health of players. In the few studies investigating the relation between exergaming and mental health in which theories were used, researchers have relied on existing theories as a guide, but not specific theories pertaining to the role of exergaming and mental health per se (Kooiman & Sheehan, 2015). Chao et al. (2015) investigated the psychological and physical benefits of Nintendo Wii Fit exergames reported by older adults. To design the exergaming intervention, Chao et al. applied elements of Social Cognitive Theory (SCT; Bandura, 1997) that presents four approaches to increase self-efficacy which include verbal persuasion, physiological and affective feedback, enactive mastery experiences, and vicarious experiences. According to Chao et al. (2015), one reason for using SCT to design an exergaming intervention concerns the role of positive psychological feedback noted by Bandura (1997) that can encourage players to continue exercising thus resulting in better physical and mental health. Chao et al. showed that older adults playing exergames displayed improved mobility, balance, and mental health compared to the control group. So far, most studies investigating the mental health benefits from exergaming amongst university-age adults could be defined as ‘atheoretical’ (i.e., not explicitly guided by theory; Douris et al., 2012; Huang et al., 2017; Mackintosh et al., 2016; Monedero et al., 2016; Naugle et al., 2014; Rosipal et al., 2013). Atheoretical interventions do not invalidate the effectiveness of exergaming interventions as a conduit to mental health but may add extra ‘layers’ of evidence to an extended discussion between scholars with varied backgrounds regarding the relevance of particular theories (e.g., Miller, 2007).

According to Miller (2007), theories guide the research, but they may also guide (and/or limit) researchers' perceptions about the phenomena under study. Theories shape the kind of questions pursued in research, as well as, how the results are interpreted which may 'blind' the researcher (Miller, 2007). Researchers may conduct investigations too narrowly which can lead to interpreting any findings exclusively within the confines of a specific theory (Arestis & Chortareas, 2008).

Consequently, promising results may be rationalized inappropriately or ignored to ensure fit with underlying theories guiding the study (Arestis & Chortareas, 2008). Miller (2007) proposes a different approach to deal with the challenges associated of theory-guided investigations: Atheoretical research. Conducting atheoretical research allows scholars to observe, experiment, connect, and ultimately explore key variables (Miller, 2007). Furthermore, atheoretical investigations enable discovery of new facts, arguments, relationships or patterns that promote understanding of the phenomena which could remain concealed if the studies are 'fixed' within a theory (Arestis & Chortareas, 2008).

Glanz and Rimer (2005) argue that utilizing theory in physical activity interventions provides a framework for evaluating and developing behaviour change interventions. Use of theory is endorsed by numerous scholars (e.g., Taylor et al., 2012) and it is often viewed as good practice when applied in behaviour change interventions (Glanz & Rimer, 2005). However, atheoretical interventions compared with theory-based interventions may produce equivalent changes in physical activity behaviour (e.g., Conn et al., 2011; McEwan et al., 2019) which questions over-reliance on theory in physical activity research. Reviews of intervention research targeting physical activity report that atheoretical interventions were no more (or less) effective compared with 'theory-based' interventions designed to improve physical activity (e.g., Rhodes et al., 2017). McEwan et al. (2019) argued that even though the effectiveness of atheoretical (versus theory-based) interventions remains undetermined at this time, atheoretical interventions may improve physical activity to at least the same degree as interventions grounded in theory. As such, physical activity strategies designed to improve mental health – including

the mental health of university students – may not require overt reliance on specific theories to advance research at this juncture. This assertion is corroborated by several investigations conducted without theory in which the benefits of physical activity on mental health of university students have emerged (e.g., Ghrouz et al., 2019).

In addition to the debate on the applicability of theories, Zanna and Fazio (1982) present a pattern in the development of research questions commonplace to psychology which they classify as first-, second-, and third-generation questions. First-generation questions focus on ‘IS’ which typically investigates if (or how) variables are related to one another (e.g., Is there a correlation between exergaming behaviour and mental health of university students?). After investigating the first-generation questions, researchers could investigate ‘WHEN’ that is the focus of second-generation questions (Zanna & Fazio, 1982). Second-generation (or ‘When’) questions determine the point in time a relationship between variables typically emerge (e.g., When does exergaming predict mental health of university students?). Third-generation research questions proposed by Zanna and Fazio (1982) focus on issues of ‘HOW’ variables affect one another or the processes – typically psychological processes - that mediate the phenomena of interest plus any sequelae (e.g., How does exergaming influence the mental health of university students?). Zanna and Fazio propose that the second and third generation questions do not essentially need to be pursued separately or sequentially but answering ‘IS’ questions followed by ‘WHEN’ then ‘HOW’ can be a useful approach for research.

As such, drawing from the current research investigating exergaming and mental health, the studies comprising this dissertation focus on first-generation research questions by testing if exergaming is related to improved mental health as well as its effects (i.e., Is there a relationship between exergaming and mental health?; Does exergaming predict mental health of university students?; Are there differential effects between exergaming and other self-management approaches on mental health of university students?).

## **Exergaming and mental health of university students: What's missing?**

Examination of published work shows gaps in the exergaming and mental health research for university students. These gaps provided the justification for this dissertation. In summary, there are four main gaps in the literature concerning exergaming and mental health of university students that warrant further research. The first gap focuses on sampling. The second gap is related to the measurement of exergaming performed at different intensities. The third gap relates to lack of research comparing exergaming against other self-management approaches (e.g., pet therapy, etc.) used by university students to optimize mental health. The fourth gap concerns lack of 'replication' in this area of research. Each issue will be presented then discussed in greater detail in this section.

The first issue evident in the literature concerning exergaming and mental health of adults that warrants further attention is the limited focus on samples other than persons living with chronic health/medical conditions (e.g., cancer, etc.) or middle-aged/older adults. Most of the research linking exergaming to mental health uses samples of children/youth (Joronen et al., 2017). As exergaming was originally invented to decrease sitting time incurred by screen-based activity in children/youth (e.g., internet use, etc.; Witherspoon, 2013), empirical work concentrated in this cohort is not surprising. Research focused on exergaming and mental health of adults has been mainly restricted to older adults and/or persons living with chronic diseases/health conditions. To illustrate this point, Byrne and Kim (2019) reported that 64.7% of studies investigating the effects of exergaming on mental health were conducted with older adults. Similarly, exergaming research conducted with adults classified as middle-aged focused on mental health outcomes uses mostly clinical groups (e.g., Chiang et al., 2012; Gil-Gómez et al., 2011; Rosenberg et al., 2010). Overall, it seems reasonable to contend that research investigating the role of exergaming for improving mental health is restricted to limited segments of the population omitting university students as a focus.

The samples used in previous studies of exergaming and mental health limit the generalizability of the results (Otzen & Manterola, 2017). Reliance on samples that do not represent the target population – namely university students – hinders the external validity and applicability of the data (Martínez-Mesa et al., 2016). Possible explanations for the limited generalizability of results from previous studies to university students may include differences in known sample characteristics (Elfil & Negida, 2017). Thus, it prevents the researcher from generalizing the results obtained to other cohorts – such as university students – if the evidence-base is generated using non-representative samples (e.g., children/youth, middle-aged/older adults, etc.) or from other contexts (e.g., clinical settings; Otzen & Manterola, 2017). Overall, current research into exergaming and mental health is limited to samples that may not adequately represent university students. The studies comprising this dissertation address this limitation directly by sampling university students.

A second gap in the literature concerns lack of attention to intensity of exergaming play in studies of mental health (Monedero et al., 2016). One explanation for this oversight is the lack of published instruments designed to measure exergaming that quantifies the degree of intensity associated with this behaviour. It is therefore not surprising that researchers do not directly report the intensity of exergaming play in studies (e.g., Huang et al., 2017; Mackintosh et al., 2016) or the measurement of exergaming intensity is extrapolated indirectly from modes of exercise used in a particular study (e.g., Monedero et al., 2016). In one study investigating links between exergaming and mental health reported by university students, Huang et al. (2017) notes the exergaming group exhibited greater happiness and vigour than the control group, yet the intensity of exergaming play was not reported. As the intensity of the exercises may differ (e.g., Tai Chi vs. Yoga, etc.), it remains unclear if university students in this study played exergaming at the same (or different) levels of intensity which ultimately leaves the effect of exergaming on mental health as a function of intensity unexplored (Ekkekakis & Brand, 2019; Huang et al., 2017).

According to Ekkekakis and Brand (2019), the determinants of adherence and participation in exercise are complex with no ‘fixed and positive’ set of affective consequences manifesting automatically for every person during exercise. The affective responses to exercise can range from positive to negative ‘feelings’ (Ekkekakis & Brand, 2019) which are determined partially by the intensity of the exercise stimulus. Vigorous-intensity exercise for many people is often associated with more negative affective responses. Given the lack of focus on measurement of exergaming intensity combined with Ekkekakis and Brand’s synthesis it seems that intensity of play associated with exergaming in relation to mental health of university students is worth exploring. To address this limitation, one of the three studies comprising this dissertation (Study 2, see Chapter 4) tested links between moderate- and vigorous-intensity levels of exergaming with mental health reported by university students

The third gap in evident in the literature concerns the limited work undertaken comparing exergaming to other self-management approaches for promoting mental health in university students. Pet therapy is a promising approach used by some universities to promote mental health of students (Barker et al., 2016). Previous investigations report that university students attending 10 minutes (or more) of pet therapy reported less stress, anxiety, plus improved mood (Quintana et al., 2019; Thelwell, 2019; Wood et al., 2019). According to Quintana et al. (2019), pet therapy could assist university students during stressful times (e.g., examination periods, etc.). Based on this research, it appears there is considerable scope for directly assessing the benefits of exergaming versus other approaches to self-management (e.g., pet therapy, etc.) as a route to mental health for university students. To date, no studies have compared the effects of exergaming on mental health reported by university students against other approaches to self-management (especially pet therapy) implemented by post-secondary institutions. One study of this dissertation (Study 3, see Chapter 5) addressed this gap directly by

comparing the effects of exergaming versus multiple alternative self-management approaches on mental health reported by a typical first year university student.

The fourth gap in the exergaming and mental health literature is concerned with limited attention to replication as a mainstay for advancing research in this area. Replication is a core principle of scientific advancement as it consists of repeating previous research to establish support for, or refutation of, the available evidence (Klein et al., 2014; Schmidt, 2009). According to Bonett (2020), the advantages of replication include counteracting misleading results in previous studies and combining the results from new studies with previous studies to obtain a broader understanding of the phenomena under study. On the other hand, replication also has drawbacks such as the difficulty of controlling within-person and time-based variance (i.e., as individuals go through changes over time, the cohort of interest is likely to respond differently based on when the variables are measured; Guttinger, 2020). Confirming or refuting the results from previous investigations may have the limitation of generalizing the findings due to individual differences and other aspects that shape people's behaviour and that change over time (e.g., culture, memory, experiences; Guttinger, 2020). Despite these disadvantages, replication is important to advance research as it enables scientists to confirm if the effect noted in prior studies is an artifact or consistent phenomena (Avrichir & MacLennan, 2015). Schmidt (2009) proposed two forms of replication which he labelled direct replication and conceptual replication. Direct replication is described by Schmidt as repeating the same protocols and methods of a study while conceptual replication applies different methods to test the same hypotheses or previous results of research studies (Schmidt, 2009).

Currently, the exergaming and mental health literature has no sustained focus on conceptual replication (Schmidt, 2009). For example, previous studies report that exergaming improves mental health of university students (e.g., Huang et al., 2017), while in other studies it has been reported that exergaming has not been more (or less) effective in promoting mental health of this cohort in



comparison to other forms of physical activity (e.g., Monedero et al., 2015). To address this limitation, the dissertation replicated previous research that hypothesized that exergaming could improve mental health of university students (e.g., Huang et al., 2017) including a comparison with more traditional modes of physical activity and extended this idea to examine the feasibility of exergaming compared to other modes of self-management (e.g., pet therapy) for improving the mental health of university students.

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## Chapter 2

### Objectives of Dissertation Research

The global objective of the studies comprising this dissertation was to investigate the role of exergaming in relation to mental health reported by university students. The specific objectives of this dissertation were as follows:

1. To synthesize the research evaluating the utility of exergaming as an intervention platform to enhance well-being of adults (**Study 1**).
2. To examine links between exergaming performed at moderate-and-vigorous-intensities with mental health reported by university students (**Study 2**).
3. To compare the contributions of exergaming behaviour against other self-management behaviours (e.g., pet therapy) for promoting mental health of university students (**Study 3**).

*The global research questions guiding each study comprising this dissertation are listed below:*

1. Does exergaming improve well-being reported by adults? (**Study 1**).
2. Is exergaming at moderate- and vigorous- intensities related to mental health reported by university students? (**Study 2**).
3. Does exergaming improve mental health more than other self-management approaches used by university students? (**Study 3**)



## **Chapter 3**

### **Study 1**

#### **Does exergaming promote well-being in adults?**

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#### **Author contributions:**

Esther S. Santos: Designed the study, conducted the literature search, coded the articles and wrote the manuscript

Philip M. Wilson: Served as the third coder to assist in solving coding conflicts between the other two coders, and contributed to writing the manuscript

Diane E. Mack: Designed the study, coded the articles and contributed to writing the manuscript

## Introduction

Evidence supports the importance of regular physical activity for reducing all-cause mortality risk (e.g., Ekelund et al., 2016; Warburton et al., 2006), improving quality of life (Conn et al., 2009), and supporting healthy ageing (Daskalopoulou et al., 2017). It is also well documented that participation in physical activity is sub-optimal in most countries leading many public health experts to label inactivity (and sedentary living) as a global pandemic (Andersen et al., 2016). Public health advocates have responded to these vexing participation rates with calls for novel ways to promote and sustain physical activity (e.g., Heath et al., 2012). One approach that may hold some appeal for changing physical activity behaviour is exergaming (Witherspoon, 2013).

Exergaming uses e-technology as a platform to encourage physical activity (or movement) while immersed in virtual environments (Witherspoon, 2013). Initially developed to counteract the negative effects of excessive screen time behaviour in children/youth (Witherspoon, 2013), subsequent applications of exergaming have shown to be useful for various clinical (e.g., da Silva Alves et al., 2017) and non-clinical (e.g., Sween et al., 2014) groups across the lifespan. Data from randomized controlled trials (RCT) supports the utility of exergaming as a physical activity intervention to reduce blood pressure (e.g., Huang et al., 2017), increase bone mineral density and reduce total adiposity (e.g., Staiano et al., 2017), improve mobility skills and reduce fear of falling (e.g., Collado-Mateo et al., 2017), optimize postural control (e.g., Barry et al., 2016), and to a lesser degree, enhance cognitive functioning (e.g., Stanmore et al., 2017).

Previous studies have supported the utility of exergaming for improving physical activity behaviour and bolstering various health parameters (e.g., reduced blood pressure; Huang et al., 2017), yet less is known about the effects of this approach on well-being. One previous review implies that exergaming – representing a subset of videogaming platforms – holds broad appeal for enhancing well-being since enjoyment and engagement are parameters that can be embedded within videogame design

(Jones et al., 2014). Empirical studies (e.g., Mack et al., 2012) and narrative reviews (e.g., Wiese et al., 2017) have substantiated the important role played by leisure-time physical activity as a route to improve well-being; however, these investigations have not addressed the viability of exergaming as an intervention approach. To address this gap, the purpose of this review was to synthesize the research evidence evaluating the utility of exergaming as an intervention modality to change well-being in adults.

## **Methods**

### **Search Strategy**

A comprehensive literature search by two researchers (ESS and DEM) of the following electronic databases was conducted to identify potential studies to include in this review: PubMed, CINAHL, PsycINFO, Cochrane, and Web of Science. Keywords used in the search strategy were as follows: Exergame OR exergam\* OR exer gam\* OR exergaming OR active videogame OR videogam\* OR video-gam\* OR video-based OR computer-based OR Wii OR Nintendo OR X-box NOT protein OR Kinect OR play-station OR PlayStation OR virtua\* realit\* OR dance dance revolution AND wellbeing AND quality of life AND affect AND vitality AND adults. The keyword phrase "NOT Xbox protein" was included as the Xbox console, and the X-box binding protein has similar names that would contaminate the results of this search strategy.

### **Inclusion/Exclusion Criteria**

A series of inclusion (and exclusion) criteria were developed a priori for this review. The inclusion criteria guiding study selection were as follows: (1) Sample of adults (i.e.,  $\geq 18$  years of age) living without any documented health conditions that may limit or contradict physical activity, (2) Use of exergaming as the only intervention modality, (3) Well-being identified as a study outcome, (4) Published in English, and (5) Use of quantitative data. Further restrictions in terms of study design (e.g., only RCT's, comparators, use of pre-posttest designs, etc.) were not inclusion criteria guiding

study selection for this review. Exclusion criteria guiding study selection were as follows: (1) Use of qualitative data, (b) Published in a language other than English, and/or (c) Samples comprised of children/youth (defined as  $\leq 17$  years of age). Published studies including any/all of the aforementioned exclusion criteria were omitted from subsequent consideration in this review. The year of the publication of the papers was not an inclusion/exclusion parameter. All studies – regardless of publication year – meeting the criteria were considered in this review.

### **Study Selection Process**

Each published study identified via the search strategy was imported into EndNote X8 (Clarivate Analytics©, Toronto, Ontario, Canada) and subsequently uploaded to DistillerSR (Evidence Partners, Ottawa, Ontario, Canada) for additional scrutiny. Using the study inclusion/exclusion criteria as a guide, a three-level screening process was defined within DistillerSR using a solitary question per level. Level 1 screening focused on the publication title using this question: “Is this title relevant for our study?”. Level 2 infused the screening process with information from the study abstract using this question: “Should this publication go on to full-text screening?”. Level 3 inspected the contents of the abstract plus the full-text for every published study retained from Level 1 and Level 2 screening in DistillerSR using this final question: “Is this publication relevant for this study?”. A forced-choice response format (i.e., ‘Yes,’ ‘No,’ ‘Cannot tell’) was used at each level of screening. Two authors (ESS and DEM) evaluated all published studies at each level of the screening process. Conflicts between coding for study selection were discussed between coders and the third author (PMW) until full consensus was reached.

### **Data Extraction**

Data were extracted from each study retained for this review using a standard coding form that was developed specifically for this study using recommended best practices for systematic reviews (e.g., Cooper, 1982) combined with previous research (e.g., Mack et al., 2016). Using this standard

coding form, two authors (ESS and DEM) identified then recorded all relevant data published in each study retained following the study selection process. A copy of the standard form used for coding is annexed in the Appendix section (Appendix A).

### **Data Analyses**

Data analyses proceeded in stages using various descriptive statistics. First, univariate mean and standard deviation values were calculated for the following variable clusters: (a) Study characteristics (e.g., sample size); (b) Sample characteristics (e.g., participants' age, etc.); and (c) Intervention characteristics (e.g., duration of treatment, etc.). Second, median scores were calculated for select variables (e.g., sample size) within each variable cluster to aid the interpretation of the data. Finally, percentages were calculated for indices within each the following variable clusters: (a) Study characteristics (e.g., study design); (b) Sample characteristics (e.g., presence/absence of medical condition, etc.); (c) Intervention characteristics (e.g., type of console, etc.); and (d) Exergaming and Well-being (e.g., instrumentation, etc.).

### **Results**

A total of 24 studies met the eligibility criteria for inclusion in this review and were retained following the multi-level screening process (see Figure 1 for details). Table 1 presents a synopsis of the individual studies coded in this review.

**Study Characteristics:** Nine countries were represented across the coded studies with 45.8% originating from the United States of America (see Table 1). Randomized experimental designs ( $n = 13$ ; 54.2%) were the most frequent approach to study design. One coded study did not specify the research design used for the investigation. Sample sizes varied across coded studies ranging from 5 to 335 participants ( $M = 50.5$   $SD = 75.6$ ;  $Median = 26.5$ ). Only two studies used samples exceeding 100 participants in total.

**Sample Characteristics:** Age of participants varied from 20.5 to 83.0 yr ( $M = 54.9$   $SD = 20.4$  yr) with 62.5% of the coded studies using samples aged 50.0 yr or older. Over half (54.2%) of the coded studies ( $n = 13$ ) reported data provided by a sample living with at least one medical condition. Neurological disease was the most common medical condition reported across coded studies ( $n = 7$ ; 53.9%).

**Intervention Characteristics:** Table 2 displays characteristics of the exergaming intervention across coded studies. Nintendo Wii/Wii Fit ( $n = 18$ ; 75.0%) was the most popular mode of exergaming reported followed by Xbox 360 ( $n = 4$ ; 16.7%). A total of eleven (45.8%) coded studies reported details concerning the intensity used as the intervention stimulus when exergaming. ‘Progressive’ ( $n = 6$ ; 54.5%) was the most common metric defining exergaming intensity reported in coded studies followed by ‘moderate’ ( $n = 3$ ; 27.3%) then ‘self-selected’ ( $n = 2$ ; 18.2%). Eighteen studies (75.0%) reported duration of exergaming as an intervention stimulus in terms of days per week. In this subset ( $n = 18$ ), the modal intervention duration was 3.0 d/wk ( $M = 3.0$   $SD = 1.2$  d/wk; Range = 1.0 to 5.0 d/wk). Studies lasting more than one week ( $n = 21$ ; 91.7%) varied from 2.0 to 14.0 weeks ( $M = 7.4$   $SD = 3.49$  wk) in total duration.

**Exergaming and Well-being:** Seven studies (29.2%) assessed well-being using the Medical Outcomes Survey-Short Form 36 (Ware & Sherbourne, 1992). Of the remaining studies, five studies (20.8%) used a disease-specific quality of life instrument while four studies (16.7%) used the brief version of the World Health Organization Quality of Life instrument (World Health Organization [WHO], 2002). The remaining studies ( $n = 8$ ; 33.3%) used seven different instruments to assess well-being. Seventeen of the coded studies used a multiple-groups research design with 35.3% ( $n = 6$ ) reporting greater well-being in the exergaming group compared to other treatments (e.g., cognitive training, ‘do-as-you-do’, etc.; Huang et al., 2017; Karahan et al., 2016; Konstantinidis et al., 2014; Maillot et al., 2010; Monedero et al., 2016; Viana et al., 2014). Over half of the coded studies (62.5%)

using multi-group research designs reported no significant between-groups differences in well-being (da Silva Ribeiro et al., 2017; Karahan et al., 2015; Keogh et al., 2013; Kloos et al., 2013; Mackintosh et al., 2016; Naugle et al., 2014; Padala, Padala, Lensing, Dennis, Bopp, Roberson, et al., 2017; Padala, Padala, Lensing, Dennis, Bopp, Parkes, et al., 2017; Ribas et al., 2017; Simşek et al., 2015). One study using a randomized cross-over design reported greater well-being in participants when engaged in brisk walking compared to exergaming (Douris et al., 2012). Seven of the coded studies reported using single-group (pre-post test) research designs with 42.9% ( $n = 3$ ) reporting improvements in well-being from pre-to-post assessment (Herz et al., 2013; Rosenberg et al., 2010; Seber et al., 2016). One study (14.3%) reported significant decreases in well-being following an exergaming intervention using sport- and dance-based games played via Nintendo Wii (Rosipal et al., 2013). Three studies (42.9%) reported no change in well-being in a single-group post-test only assessment following an exergaming intervention (Chao et al., 2014; Tseng & Hsieh, 2013; Wall et al., 2015).

## Discussion

The aim of this study was to synthesize the published evidence attesting to the role of exergaming in promoting well-being. To address this aim, we conducted a review of published studies (English language only) that reported exergaming as an intervention along with an index of well-being as a key study outcome. A comprehensive search and multi-phase filtering strategy resulted in 24 published studies that met the a priori inclusion criteria used in this review. Overall, it appears that exergaming research targeting well-being in adults has relied on samples at later stages of the lifespan often living with at least one health condition. Nintendo Wii is the most popular console used to evaluate the contributions of exergaming to well-being. Considerable variability was evident in terms of study design that likely confounds the role played by exergaming for bolstering well-being in adults. Finally, it is worth noting that two major trends emerged from this review. First, it appears that exergaming can enhance well-being, especially when compared to a 'do-as-you-do' (or nonexercise)

condition. Second, exergaming does not appear to confer unique benefits to well-being when compared against other (perhaps ‘traditional’) interventions using exercise as a stimulus to change well-being in adults.

Perhaps the most important observation emerging from this review concerns the effects attributable to exergaming on markers of well-being displayed by adults living with (or without) health conditions. The published studies evaluated in this review make it apparent that exergaming has potential to improve well-being in adult gamers; yet, the net effects of using this intervention modality are not guaranteed. Thirteen of the coded studies provided no support for the role of exergaming in changing well-being, whereas nine studies using either between-groups or single-groups designs provided evidence that exergaming can promote well-being in adults. At best, the results of this review imply that exergaming ‘could’ improve well-being in adults yet using this technologically advanced intervention modality to exercise fails to guarantee enhanced well-being.

Considering that exergaming is touted by various organizations – such as the American College of Sports Medicine (Witherspoon, 2013) – as a health promotion tool it seems the findings reported in this study call into question the role of exergaming as a modality to promote well-being in adults. With this in mind, it seems reasonable to question the wide-spread use of exergaming as an approach to improving well-being via exercise when the evidence-base supporting this technique is equivocal at best. Several possible issues emerged from this review that may account for the equivocal findings that warrant further consideration to advance research on exergaming. First, it is evident that insufficient attention has been afforded to various issues that strengthen the integrity of research attesting to the role played by exergaming in boosting well-being. Reliance on single-group designs or post-test only assessments of well-being seriously limit causal inference due to a host of internal validity threats (Shadish et al., 2002). Overuse (or misuse) of statistical significance testing especially in small samples can propagate null findings within the literature concerning exergaming and well-being (Harlow et al.,



1999). Finally, the measurement of well-being is challenging at best (Mack et al., 2016); yet the eclectic nature of the instruments chosen to assess this important outcome of exergaming highlighted by this review leaves much to be desired. Future studies could use more sophisticated research designs (e.g., randomized controlled trials with multiple post-test assessments of outcome variables, etc.), employ a priori statistical power analyses to bolster null hypothesis testing approaches to data analysis, and be mindful of advances in the conceptualization and measurement of well-being to clarify the role of exergaming in promoting (or diminishing) well-being.

### **Study Limitations and Future Directions**

Several limitations of this review deserve attention coupled with plausible directions for future research to advance our understanding of the contributions to well-being stemming from exergaming. First, there is a limited number of published studies that have addressed the relationship between exergaming and well-being in adults. Future research could address this issue by testing the association between exergaming and well-being using both subjective indicators (e.g., self-report) and biological markers (e.g., interleukin-6). Second, the inclusion/exclusion criteria restricted the studies included this review to those published in English. It remains unclear if broadening the scope of the review to include grey literature (e.g., graduate theses, etc.) that may be less susceptible to publication bias plus studies published in any language other than English would alter the main findings of this review. Future studies could explore this issue in greater detail to address the generalizability of the findings reported in this study. Third, substantial heterogeneity emerged from the coding process for both intervention delivery (see Table 2) and the assessment of well-being. While this observation is wholly aligned with other physical activity intervention research focused on well-being as an outcome (see Mack et al., 2016, as an example), it remains a potential confound when trying to unravel the nature of the links between well-being and exergaming. Future work could address this issue, in part, by

mandating greater detail and transparency in reporting of exergaming interventions perhaps using the Consensus on Exercise Reporting Template (Slade et al., 2016) - to advance this vibrant research area.

### **Conclusions**

Overall, the summary findings emerging from this review make it apparent that exergaming 'may' be a novel intervention approach that has the potential to foster well-being of adults. However, it is also evident that deploying exergames as an 'intervention tool' with adults neither guarantees improved well-being nor offer anything 'unique' as a stimulus beyond more traditional modes of exercise behaviour (e.g., walking in 'real' not 'virtual' spaces, etc.).

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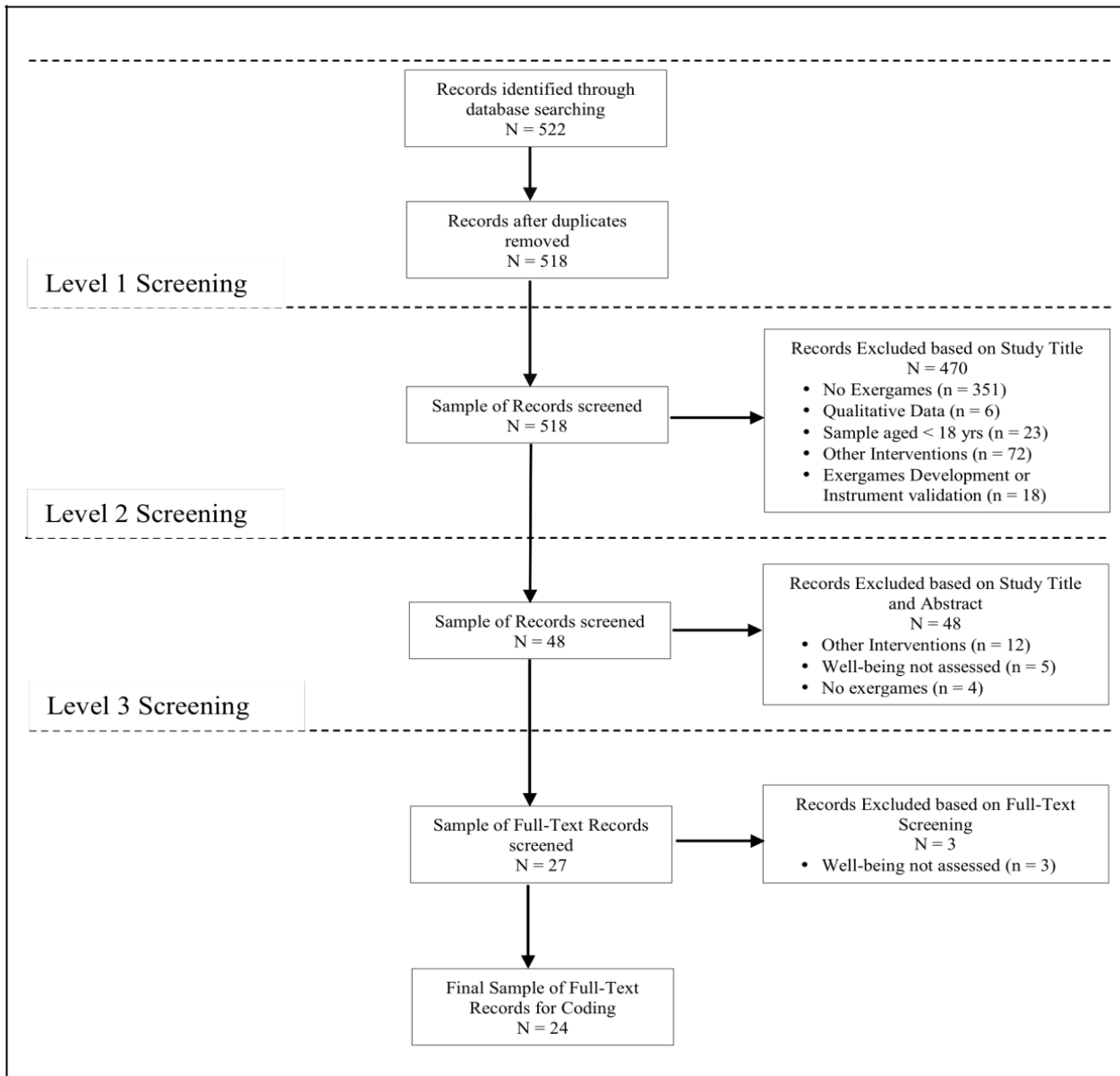
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**Figure 1**

*Flow diagram showcasing decision-making at each screening level of the study selection*



**Table 1***Summary of research design and sampling characteristics*

Study Authors	Year	Country	Design	Sample	Sex	N	Age (yrs)
Rosenberg et al.	2010	US	SGD	C	M/F	19	78.7
Douris et al.	2012	US	RCOD	H	M/F	21	23.2
Herz et al.	2013	US	SGD	C	M/F	33	66.7
Keogh et al.	2013	AU	QED	H	M/F	34	83.0
Kloos et al.	2013	US	SGD	C	M/F	18	50.7
Rosipal et al.	2013	US	SGD	C	M/F	18	22.1
Tseng and Hsieh	2013	CN	SGD	C	M/F	60	59.3
Chao et al.	2014	US	SGD	H	M/F	7	80.0
Konstantinidis et al.	2014	GR	RED	H	M/F	232	69.5
Maillot et al.	2014	FR	N/S	H	M/F	16	74.0
Naugle et al.	2014	US	QED	H	M/F	22	20.5
Viana et al.	2014	BR	RED	C	M/F	20	55.5
Wall et al.	2015	US	ITSD	C	M	5	58.6
Şimşek et al.	2015	TR	RED	C	M/F	42	57.8
Ribeiro et al.	2015	BR	RED	C	M/F	30	52.9
Karahan et al.	2015	TR	RCOD	H	M/F	90	71.4
Serber et al.	2016	US	SGD	C	M/F	14	52.7
Karahan et al.	2016	TR	RED	C	M/F	57	36.3
Monedero et al.	2016	IE	RCOD	H	M/F	23	24.8
Mackintosh et al.	2016	UK	RCOD	H	M/F	36	22.0
Ribas et al.	2017	BR	RED	C	M/F	20	60.9
Padala et al.	2017	US	RED	H	M/F	30	68.3
Padala et al.	2017	US	RED	C	M/F	30	73.0
Huang et al.	2017	TW	RED	H	M/F	335	N/S

Note. RED = Randomized Experimental Design. RCOD = Randomized Cross-Over Design. QED = Quasi-Experimental Design. ITSD = Interrupted Time Series Design. SGD = Single-Group Design (pretest-posttest assessments). H = No diagnosed medical conditions specified by study authors. C = Diagnosed medical conditions specified by study authors. M = Male. F = Female. N/S = Not Specified (or unable to determine based on information provided in the study). *N* = Sample size (this value is the total sample across all conditions within a study reported by the authors). Age = Mean age calculated across any/all groups reported by authors. US = United States of America. AU = Australia. CN = China. GR = Greece. FR = France. BR = Brazil. TR = Turkey. IE = Ireland (Eire). UK = United Kingdom. TW = Taiwan.

**Table 2***Summary of intervention characteristics*

Study Authors	Mode	Duration	Frequency	Intensity	Time
Rosenberg et al.	NWii	12 wk	3 d/wk	N/S	35 mins/wk
Douris et al.	NWiiFit	2 wk	2 d/wk	Mod.	30 mins/d
Her al.	NWii	8 wk	3 d/wk	N/S	60 mins/d
Keogh et al.	NWii	8 wk	SS	N/S	30±24mins/d
Kloos et al.	DDR	6 wk	2 d/wk	Prog.	45 mins/d
Rosipal et al.	NWii	2 wk	SS	SS	60 mins/wk
Tseng and Hsieh	Hot Plus	2 wk	3 d/wk	N/S	20 mins/d
Chao et al.	NWiiFit	8 wk	2 d/wk	N/S	60 mins/d
Konstantinidis et al.	NWiiFit	8 wk	5 d/wk	Prog.	N/S
Maillot et al.	NWiiFit	14 wk	24 sessions	Prog.	60 mins/d
Naugle et al.	NWii	3 d	2 sessions/d	SS	20 mins/session
Viana et al.	NWii	5 wk	3 d/wk	N/S	60 mins/d
Wall et al.	NWii	7 wk	2 d/wk	N/S	60 mins/d
Şimşek et al.	NWii	10 wk	3 d/wk	N/S	45-60 mins/d
Ribeiro et al.	NWii	2 mths	2 d/wk	Prog.	50 mins/d
Karahan et al.	Xbox 360	6 wk	5 d/wk	N/S	30 mins/d
Serber et al.	NWii	12 wk	3 d/wk	Mod.	60 mins/d
Karahan et al.	Xbox 360	8 wk	5 d/wk	N/S	30 mins/d
Monedero et al.	Xbox 360	6 d	4 sessions	Mod.	30 mins/session
Mackintosh et al.	NWii	N/R	2 sessions	N/S	30 mins/session
Ribas et al.	NWii	12 wk	2 d/wk	N/S	30 mins/d
Padala et al.	NWii	8 wk	3 d/wk	Prog.	45 mins/d
Padala et al.	Nwii	8 wk	5 d/wk	Prog.	30 mins/d
Huang et al.	Xbox 360	2 wk	1 d/wk	N/S	30 mins/d

Note. N/S = Not reported by study authors (or unable to determine based on information provided in the study). NWii = Nintendo Wii. NWiiFit = Nintendo WiiFit. Mod. = Moderate Intensity. Prog. = Progressive Intensity. SS = Self-Selected Intensity. Duration is reported in terms of months (mths), weeks (wk) and/or days (d) as noted by the study author(s).

## Chapter 4

### Study 2

#### **What is the role of exergaming in relation to mental health amongst university students?**

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#### **Author contributions:**

Esther S. Santos: Designed the study, collected and analyzed the data, and wrote the manuscript.

Philip M. Wilson: Assisted with the study design, supervised the work, guided analysis of the data and assisted with manuscript preparation.

Diane E. Mack: Assisted with the study design, provided guidance regarding the selection of mental health variables as well as the theoretical support and reviewed critiqued and the written manuscript.

## Introduction

Mental health challenges – such as heightened anxiety or diminished vitality – have emerged as a global health pandemic (see Eaton et al., 2018, for a synopsis). Combined with increased risk of premature mortality (Eaton et al., 2018), previous studies report that diminished mental health disrupts educational achievement, dietary intake, as well as, annual income per capita (see Patel et al., 2018, for details). Within Canada, estimated treatment costs for the 7.5 million people (or 1 in 5 Canadians) living with mental health challenges approaches a total cost of CAD\$50 billion per annum (Mental Health Commission of Canada [MHCC], 2016). Previous reports indicate 50.0% of young adults living in Canada will report at least one negative mental health indicator (e.g., anxiety disorders, etc.) before reaching the age of 40 (MHCC, 2016) with young adulthood (i.e., 15-24 years old) the most common stage of life where mental health challenges emerge (Ibrahim et al., 2013; Zivin et al., 2009).

University students may be a population at risk for mental health challenges due to escalating academic/financial pressures (e.g., Dogra et al., 2018), diminished sleep quality (e.g., Wilson et al., 2014), excessive weight gain (e.g., de Vos et al., 2015), and disruptions to daily routine caused by living independent of family (e.g., Lewis et al., 2015). Global prevalence of negative mental health indicators reported by university students is challenging to quantify yet up to 46.2% of university/college students in Ontario have reported ‘excessive’ stress whereas 64.5% report ‘overwhelming’ anxiety (American College Health Association [ACHA], 2018). Longitudinal studies corroborate this trend with reports indicating up to 60.0% of university/college students will encounter mental health challenges that persevere over time (Zivin et al., 2009). Suicidal ideation (ACHA, 2018), diminished academic performance, and elevated dropout rates accompany perturbations in mental health reported by university students (e.g., Eisenberg et al., 2009). To address these consequences of declining mental health, universities across North America have instigated various professional services (e.g., counselling, psychotherapy, art/pet therapy, etc.) to improve mental health which remain

underutilized by university students (Hussain et al., 2013). With more than 50% of high school graduates in North America enrolling in post-secondary education yearly (ACHA, 2018), it has become apparent that identifying prevention/treatment strategies to promote mental health for university students is a priority.

One approach that may be useful for enhancing mental health of university students is physical activity (Mammen & Faulkner, 2013). Numerous studies have linked physical activity with improvement in various dimensions of mental health of young adults. For example, reduced stress (Dol, 2019), lower anxiety and depression (Lee & Kim, 2019), diminished hopelessness (Taliaferro et al., 2010), greater self-esteem (Fox & Wilson, 2008), increased flourishing (Watts et al., 2018), and well-being – a psychological concept affiliated with mental health (Kleszczewska et al., 2019) – in cohorts of young adults have all been linked to more frequent physical activity behaviour. Yet prevalence studies indicate at least 50.0% of university students fail to engage in regular physical activity (Harbour et al., 2008) while the initial transition into university is accompanied by a reduction in physical activity rates in first-year students (Bray & Born, 2004). This issue is further exacerbated by reports of increased time devoted to using screen-based technology, as well as, escalating rates of sedentary behaviour(s) which contribute to diminished mental health independent of other factors in university students (Lee & Kim, 2019). Collectively, these trends present a paradox for health professionals (and university administrators): Can screen-based technology (e.g., exergaming) be used to improve mental health of university students by engaging physical activity?

Exergaming is one application of screen-based technology that holds promise for improving mental health reported by university students. Exergaming – also referred to as Active Videogames ([AVG], Benzing et al., 2018) – uses a digital platform (or e-technology) that encourages physical movement within a virtual setting (Cavalli et al., 2014; Limperos & Schmierbach, 2016; Witherspoon, 2013). Initially developed to combat the negative consequences of excessive screen-time in

children/youth (Witherspoon, 2013), subsequent research has shown that exergaming is applicable to a broader spectrum of the lifespan (e.g., older adults, etc.), and could enhance various dimensions of well-being reported by adults (see Santos et al., 2018, for a review).

### **Justification: What do we need to know about exergaming?**

Careful examination of the published research concerning exergaming and mental health provided the impetus for this study. First, the lion's share of research linking exergaming to mental health targets children/youth (Benzing et al., 2018). This is hardly surprising given that exergaming was originally developed to combat excessive screen-time in this cohort (Witherspoon, 2013). Within the small pool of studies testing interventions using exergaming to change well-being reported by adults (Santos et al., 2018), it is evident that 'clinical' samples within health-care systems have been the focus of research (see Benzing et al., 2018, for details). For example, in a review of the exergaming and well-being literature, Santos et al. (2018) indicated that over half (54.2%;  $n = 13$ ) of the published studies testing the effectiveness of exergaming as an intervention to improve well-being relied upon 'clinical' samples (i.e., adults living with a diagnosed medical condition).

Of the remaining 11 studies coded in their review, Santos et al. (2018) reported that 63.7% focused on older adults (e.g., Chao et al., 2014). Only three studies (Douris et al., 2012; Mackintosh et al., 2016; Naugle et al., 2014) it was used samples of college and university students. Across the three studies, a limited range of mental health outcomes was investigated (e.g., positive well-being and distress; Douris et al., 2012). Studies focused on investigating tools to improve flourishing and vitality while minimizing stress and anxiety of university students are important and warranted. High levels of stress and anxiety may directly affect university students' academic performance (Eisenberg et al., 2009; Hysenbegasi et al., 2005). On the other hand, university students with high flourishing and vitality are academically engaged and committed to learning (Battisti et al., 2020; Fox et al., 2019). As such, it seems reasonable to assert based on the existing literature that limited research has investigated



the role of exergaming in promoting mental health within ‘non-clinical’ groups – such as university students – where digital platforms encouraging physical activity behaviour(s) hold practical appeal for improving mental health.

A second line of reasoning that provides justification for this study is based on research testing affective responses to the stimulus properties of exercise in adults (see Ekkekakis & Brand, 2019, for a review). Central to this line of research is the notion that a ‘fixed and positive’ set of affective effects do not automatically stem from exercise participation reported by adults. In brief, Ekkekakis and Brand (2019) note that any individual’s affective responses to exercise can be highly complex in nature spanning the full gamut of negative to positive ‘feelings’ that seem at least partially determined by intensity of the exercise itself. Ekkekakis and Brand (2019) have demonstrated that manipulating exercise intensity such that it feels vigorous to adult participants generates negative affective responses.

It is evident that studies using exergaming as a digital platform to bolster mental health have largely overlooked the issue of exercise intensity. Santos et al. (2018) reported 13 of the 24 studies coded in their review did not report any information pertaining to the intensity of the exergaming activity used within intervention research. Closer inspection of the remaining 11 studies indicated the application of moderate-intensity exergaming ( $n_{studies} = 3$ ) or use of a ‘progressive’ intensity for the exergaming intervention ( $n_{studies} = 6$ ). The remaining studies ( $n_{studies} = 2$ ) reported using a ‘self-selected’ intensity for the exergaming sessions undertaken during the intervention period. Based on these observations (Santos et al., 2018), combined with the work of Ekkekakis and Brand (2019), there seems to be considerable scope for exploring the contributions of exergaming performed at both moderate- and vigorous-intensities to mental health reported by university students.

The aim of this study was to examine the link between exergaming performed at both moderate- and vigorous-intensities with mental health reported by university students. The study hypotheses were based on previous research using exergaming as a digital platform to change mental health of adults

(see Santos et al., 2018, for a review), as well as, investigations focused on the affective responses to exercise reported by adults (Ekkekakis & Brand, 2019). First, it was hypothesized that university students who report more frequent participation in exergaming would also report higher mental health. Second, it was hypothesized that higher mental health would be linked to the intensity of exergaming activity reported by university students. Stated differently, it was anticipated that differential links with mental health would be evident as a function of the intensity level of exergaming behaviour reported by university students. Within this study, ‘higher’ mental health was operationalized as higher scores on flourishing and vitality plus lower scores on stress and anxiety which are considered representative of the conceptual bandwidth defining mental health as a global construct from previous research (e.g., Ward-Griffin et al., 2018). Study 2 builds upon Study 1 of this dissertation by (a) empirically testing the exergaming-mental health link while accounting for variability in intensity of exergaming behaviours, (b) using a broader range of variables to assess mental health than typically reported in studies of exergaming behaviour, and (c) collecting data from current university students who served to represent the population of interest for this line of research.

## **Methods**

### **Participants**

One-hundred and six university students were subdivided into two groups for this study based on their self-reported participation in moderate-intensity and/or vigorous-intensity exergaming (MVE) during a typical week. Group 1 ( $n = 53$ ; 58.49% female; 84.91% White; 54.72% full/part-time employed; 98.07% single) were classified as ‘Exergamers’ because they reported engaging in MVE during a typical week. Group 2 ( $n = 53$ ; 69.81% female; 81.13% White; 54.72% full/part-time employed; 100.00% single) were classified as ‘Non-Exergamers’ because they reported zero minutes of MVE during a typical week. No statistical differences were found between ‘Exergamers’ and ‘Non-

Exergamers' for any demographic variable. Recent and current MVE behaviour was not assessed in this study.

### **Instrumentation**

**Demographics:** The participants completed 7 items to assess personal characteristics (e.g., age, ethnicity, etc.; see Appendix B).

**Exergaming:** Two items modified from the Behavioral Risk Factor Surveillance System ([BRFSS], US Centers for Disease Control & Prevention, 2001) assessed the frequency (sessions per week) and duration (minutes per session) of moderate-intensity (EXG Moderate) and vigorous-intensity (EXG Vigorous) exergaming. Conceptual boundaries defining both EXG Moderate (i.e., "...small increases in breathing and heart rate") and EXG Vigorous (i.e., "...large increases in breathing and heart rate") plus the minimal duration per session (i.e., "...at least 10 minutes") were provided to guide item interpretation by participants. Total scores representing minutes of exergaming behaviour undertaken per typical week at each intensity level were calculated using these formulas: (a) EXG Moderate = [Frequency of moderate-intensity exergaming sessions/week × Duration of moderate-intensity exergaming bouts per session]; (b) EXG Vigorous = [Frequency of vigorous-intensity exergaming sessions/week × Duration of vigorous-intensity exergaming bouts per session]. The items from the BRFSS were modified from their original format and used in previous research (see Wilson et al., 2006, for an example).

**Mental Health:** Participants completed items from 4 instruments designed to capture both positive (i.e., flourishing, vitality) and negative (i.e., stress, anxiety) dimensions of mental health. The 10-item Perceived Stress Scale ([PSS], Cohen et al., 1983) measured the frequency of stress felt over the past month as a university student. The 6-item short form of the State-Trait Anxiety Inventory ([STAI-SF], Marteau & Bekker, 1992) measured feelings of apprehension and tension experienced typically as a university student. The 8-item Flourishing Scale ([FS], Diener et al., 2010) assessed

psychological well-being in terms of perceived success as a university student over areas of importance in life. Finally, the 7-item Subjective Vitality Scale ([SVS], Ryan & Frederick, 1997) assessed the degree of eudemonic well-being felt specific to their life as a university student. The instruments selected to assess mental health in this study were based on two criteria: (a) Use in previous studies investigating the mental health reported by university students, and (b) inclusion of variables to conceptually represent 'positive' and 'negative' facets of mental health. Total scores were created for each mental health variable by summing responses to each item per instrument then dividing this score by the number of items measuring each construct per instrument.

### **Data Collection and Data Analyses**

Verbal presentations were made by the first author (ESS) to intact groups ( $N = 6$ ) using a scripted protocol to minimize variability in participant recruitment. Each participant was e-mailed details about the study, which included a Uniform Resource Locator (URL). Those choosing to participate who selected the URL were directed to a secure website designed using commercial software (i.e., SurveyMonkey®). The first page of the study website contained the Letter of Invitation (LOI), which provided information about this study and encouraged participants to ask questions about the study. After reading the LOI, each participant was then directed to a separate webpage that requested informed consent before permitting access to the questionnaire used to collect the data for this study. Informed consent was secured by asking each participant to check a box indicating they had read the LOI and were consenting to participate in this study. At the end of LOI, the participant had to respond either 'yes' or 'no' to this statement: 'I hereby agree to participate in this research study'. Clicking 'yes' directed participants to the first page of the questionnaire (i.e., Demographic questions). Clicking 'no' directed participants to a random URL (i.e., SurveyMonkey 'Thank you' page) without permitting access to the study questionnaire. All study protocols/procedures were reviewed and cleared by a

university-based Research Ethics Board (REB) prior to initiating participant recruitment (see Appendix C). Recruitment for this study began on October 24<sup>th</sup> (2018) and finished on January 26<sup>th</sup> (2019).

Data analyses were conducted in the following steps. First, the data were screened for missing values, outliers, and evaluated for conformity with assumptions of each statistical test. Second, log transformations were performed for the EXG Moderate and EXG Vigorous scores given the presence of extreme values in the data. Third, missing values were replaced using sample-specific values generated via an expectation-maximization algorithm provided in IBM SPSS® (Version 25). Fourth, score reliability estimates were calculated for the mental health variables using Coefficient alpha ( $\alpha$ ; Cronbach, 1951). Fifth, descriptive statistics were calculated for each mental health variable. Sixth, a series of 4 simple regression models were computed using dummy codes as predictor variables ('Exergamer' = '1'; 'Non-Exergamer' = '0') and stress, anxiety, flourishing, and subjective vitality as criterion variables. Based on the results of the simple regression models, subsequent data analyses using only the subsample of participants who reported exergaming during a typical week at any intensity level ( $n = 53$ ; 'Exergamers') were conducted to examine the link between exergaming behaviour performed at different intensity levels and mental health. These subsequent analyses included (a) computing bivariate correlation (Pearson  $r$ 's) between EXG Moderate and EXG Vigorous with stress, anxiety, flourishing, and subjective vitality, and (b) computing four separate multiple regression models using ordinary least squares estimation procedures. EXG Moderate and EXG Vigorous served as predictor variables in each multiple regression model, whereas stress, anxiety, flourishing, and subjective vitality served as the criterion variable in one of the four regression models. Additional markers of variable importance - structure coefficients ( $r_s$ ; Courville & Thompson, 2001) and squared semi-partial correlation coefficients ( $sp^2$ ; Cohen, 2013) – were calculated to aid interpretation of the results per regression model.

## Results

**Preliminary Analyses:** No more than 1.89% of the data were missing on any item assessed in the Exergamer or Non-Exergamer subsamples. Little's (1989) test ( $\chi^2_{Exergamer} = 110.57, df = 86, p = .04$ ;  $\chi^2_{Non-Exergamer} = 70.46, df = 77, p = .69$ ) provided mixed results concerning the random nature of the missing values in these subsamples. All missing values were replaced prior to subsequent analyses using subsample-specific estimates generated using an expectation-maximization algorithm provided by IBM SPSS (Version 25.0). Internal consistency of score reliability estimates for items measuring stress, anxiety, flourishing, and subjective vitality ranged from 0.82 to 0.93 in the Exergamer subsample ( $M_\alpha = 0.88 SD = 0.05$ ) and 0.88 to 0.92 in the Non-Exergamer subsample ( $M_{\alpha Non-Exergamer} = 0.89 SD = 0.03$ ). Table 1 provides specific estimates for score reliability per subsample and constructs assessed in this study.

Distributional properties of scores representing stress, anxiety, flourishing, and subjective vitality approximated normality in the Exergamer ( $M_{Skewness} = -0.31 SD = 0.96$ ;  $M_{Kurtosis} = 1.13 SD = 2.20$ ) and Non-Exergamer ( $M_{Skewness} = -0.40 SD = 0.78$ ;  $M_{Kurtosis} = 0.72 SD = 1.20$ ) subsamples. Table 1 provides specific values for univariate skewness and kurtosis. Responses to items assessing EXG Moderate ( $M = 145.55 SD = 176.98$ ;  $Skewness = 2.22$ ;  $Kurtosis = 5.21$ ) and EXG Vigorous ( $M = 56.96 SD = 92.76$ ;  $Skewness = 2.98$ ;  $Kurtosis = 9.66$ ) deviated from normality in the subsample of Exergamers. Log(10) transformations were performed on both items which produced distributions approximating normality for both items (EXG Moderate:  $M = 1.91 SD = 0.49$ ;  $Skewness = -0.04$ ;  $Kurtosis = -0.02$ ; EXG Vigorous:  $M = 1.63 SD = 0.46$ ;  $Skewness = -0.01$ ;  $Kurtosis = 1.10$ ). Subsequent analyses with the Exergamer subsample used only the Log (10) transformed scores for both EXG Moderate and EXG Vigorous.

**Multiple Regression Analyses Predicting Mental Health Dimensions:** To evaluate if exergaming versus not exergaming predicted mental health, a series of four simple linear regression models were computed and interpreted. Playing status was dummy coded in these regression models as

follows: (a) '0' = Non-Exergamer; (b) '1' = Exergamer. Stress, anxiety, flourishing, and subjective vitality served as the criterion variables in these regression models while playing status (Non-Exergamer vs. Exergamer) was the only predictor variable. No statistical outliers were identified within the combined Exergamer and Non-Exergamer sample (Mahalanobis D value = 0.99,  $p = .68$ ).

Assessment of the global model fit parameters for each criterion variable in the regression models indicated the following: (a) Stress ( $F_{1,104} = 0.09$ ,  $p = 0.77$ ;  $R^2_{adj.} < .01$ ); (b) Anxiety ( $F_{1,104} = 0.41$ ,  $p = 0.52$ ;  $R^2_{adj.} < .01$ ); (c) Flourishing ( $F_{1,104} = 0.02$ ,  $p = 0.89$ ;  $R^2_{adj.} < .01$ ); and (d) Subjective Vitality ( $F_{1,104} = 0.79$ ,  $p = 0.38$ ;  $R^2_{adj.} \sim .01$ ). Across the four regression models, no standardized beta-coefficient (Range = .02 to .09) was statistically significant ( $p$ 's ranged from 0.38 to 0.89) and all 95% confidence intervals around the unstandardized beta-coefficients included zero (Range = -0.34 to 0.61).

Further data analyses using only the Exergamer subsample ( $n = 53$ ) evaluated the combined and unique contributions to predicting mental health from EXG Moderate and EXG Vigorous during a typical week. In these analyses, the Log(10) transformed scores representing EXG Moderate and EXG Vigorous served as predictor variables while scores for stress, anxiety, flourishing, and subjective vitality served as criterion variables in separate multiple regression models. Simultaneous variable entry was used in each multiple regression model. No statistical outliers were identified (Mahalanobis D values ranged from 0.09 to 11.00; all  $p$ 's  $> .001$ ). Visual inspection of the bivariate scatterplots for each regression model implied that linearity and homoscedasticity were tenable assumptions in this subsample. One standardized residual value exceeded  $|3.00|$  across the four regression models (99.51%  $z$ 's ranged between -2.19 to 2.88). Joint consideration of the Variance Inflation Values (0.68), Tolerance Values (1.47), Condition Indices (Ranged from 1.00 to 10.85) plus Variance Proportion Values (0.98, 0.23) provided no evidence of substantial collinearity between the EXG Moderate and/or EXG Vigorous scores in any of the multiple regression models.

Visual inspection of the bivariate correlation matrix (see Table 2) indicated higher stress and higher anxiety were associated with lower EXG Moderate and EXG Vigorous per week. Conversely, higher flourishing and higher subjective vitality were positively correlated with higher EXG Moderate and EXG Vigorous scores albeit using a liberal probability value ( $p \leq .08$ ) for the correlation between EXG Vigorous with flourishing. Summary observations from the multiple regression analyses are presented (see Table 3). EXG Moderate was the dominant predictor of each mental health variable accounting for between 9.00% to 10.00% of unique variance per criterion. Less frequent EXG Moderate predicted higher stress and anxiety (all  $p$ 's  $< .05$ ). By contrast, more frequent EXG Moderate predicted higher subjective vitality and flourishing (all  $p$ 's  $< .05$ ). The 95% CI for the unstandardized beta-coefficient defining the prediction of stress and anxiety from EXG Moderate and EXG Vigorous included zero in both regression models. Finally, the 95% CI for the unstandardized beta-coefficient defining the prediction of mental health from EXG Vigorous but not EXG Moderate did include zero in each regression model examined in this study ( $p$ -values ranged from .09 to .83; Table 3).

### **Discussion**

Drawing on previous research exploring the potential for using exergaming as a platform to improve adult's mental health (e.g., Benzing et al., 2018; Santos et al., 2018), the purpose of this study was to examine the role of moderate-intensity and/or vigorous-intensity exergaming behaviour reported by university students during a typical week in relation to positive and negative dimensions of mental health. Using a non-experimental research design, a total of 106 university students classified as either 'Non-Exergamers' or 'Exergamers' reported the frequency of their own exergaming behaviour during a typical week, as well as, their own feelings of stress, anxiety, flourishing, and subjective vitality that conceptually represented negative and positive dimensions of mental health. Overall, the results of this study make it apparent that exergaming typically on a week-to-week basis provides no unique mental health benefits (or decrements) to university students compared to not exergaming. Yet it is apparent



based on the subsample analyses that more frequent exergaming – especially at a level of intensity perceived as ‘moderate’ in nature by university students – may contribute to greater flourishing and vitality while minimizing stress and anxiety. In summary, it seems plausible to suggest that exergaming on a weekly basis holds potential to improve mental health reported by university students particularly if the intensity of engagement is felt as ‘moderate’ as opposed to ‘vigorous’ in nature.

One key finding emerging from this study concerns the potential link between exergaming during a typical week in relation to mental health reported by university students compared with not exergaming. Based on the simple linear regression analyses conducted in this study, it is tempting to conclude that exergaming is not a viable route to mental health for university students. Certainly, the observation that no ‘better’ (or ‘worse’) levels of mental health were detected when player status – that is ‘Exergamer’ versus ‘Non-Exergamer’ - was the predictor variable does nothing to undermine this claim. This observation aligns with previous reviews of the exergaming and well-being literature. For example, Santos et al. (2018) reported that 62.5% of the published studies testing exergaming interventions versus other modes of physical activity (e.g., treadmill walking, etc.) found no substantive between-group differences in well-being reported by adults. As such, the results of this study reinforce the observations reported by Santos et al. (2018) with data provided by university students.

Second, it is also clear from the results of the simple linear regression analyses conducted in this study that exergaming does not seem to undermine the mental health of university students when compared to ‘non-exergamers’. It is plausible that university students who do not use exergaming on a regular basis to stay active use other forms of physical activity during a typical week (e.g., walking, resistance training, etc.). In this study, global physical activity levels beyond activity completed as a function of exergaming behaviour was not measured. At present, it seems plausible to suggest that ‘non-exergamers’ might partake in physical activity using modes that do not rely on digital platforms

(e.g., walking outside, etc.) that have been linked empirically to better mental health (e.g., Ekkekakis & Brand, 2019) which explains the null findings evident in the simple linear regression analyses.

Aligned with our second hypothesis, it appears that the intensity of exergaming behaviour may be an important consideration when using this digital platform to strengthen mental health of university students. Inspection of the data reported in Table 3 makes it apparent that ‘better’ mental health – demonstrated by higher flourishing and vitality combined with lower stress and anxiety - was predicted from exergaming performed at moderate-intensity and vigorous-intensity levels yet most of the explained variance in the multiple regression models reported in this study was attributed to moderate-intensity exergaming. Previous studies of adults (and university students) neither evaluated nor reported the possibility of intensity-dependent relationships between exergaming and mental health. It is plausible that sensations which accompany more intense physical activities – including vigorous exergaming – can be experienced as unpleasant by university students thereby not contributing favorably to improved mental health. While this explanation remains speculative at best it aligns with research testing the affective responses to exercise summarized by Ekkekakis and Brand (2019) and seems worthy of further scrutiny using exergaming. Future studies may wish to evaluate this speculative account in more detail using rigorous time-series research designs that permit greater understanding of the complex interrelationships between exergaming intensity with variability in mental health reported by university students.

While data in Table 3 make it apparent that exergaming may be a useful conduit to mental health for university students, it is also evident that substantial portions of the variance in each dimension of mental health assessed in this study remain unexplained. A few possibilities could account for these observations. First, it is possible (and likely) that exergaming is merely one of several factors that contributes to mental health reported by university students. Previous research with youth shows that demographic considerations (e.g., biological sex, etc.), medical issues (e.g., depression, etc.), plus other

lifestyle behaviours (e.g., smoking, etc.) may contribute to overall mental health reported by university students. This explanation may render the selection of variables to be included (and omitted) from the regression analyses subject to post-hoc criticism. It is worth noting the principal aim of this investigation was to determine if exergaming was a potential (not necessarily the optimal) conduit to mental health reported by university students. As such, the principal aim was not to ascertain if exergaming was the optimal form of physical activity to promote mental health in this cohort. Ultimately, the inclusion (and omission) of variables in the regression analyses may render the results of this study limited in scope.

A few remarks concerning the measurement of exergaming behaviour seem justified given the observations reported in this study. It is plausible the observed variability in exergaming behaviour undertaken on a weekly basis at both intensity levels reported herein is ‘realistic’ for university students. Previous reviews (e.g., Santos et al., 2018) imply that much greater emphasis has been placed on testing outcomes attributable to exergaming behaviour as a digital-based intervention platform by researchers in lieu of optimizing the measurement of exergaming in ‘free-living’ contexts. Alternatively, it is also plausible that using a modified instrument to assess exergaming behaviour in this study effected comprehension of the items used to measure this construct by study participants. Previous research – albeit focused on the assessment of psychological variables (e.g., Gunnell et al., 2012) – indicates even minor adjustments to item wording can impact participant’s comprehension in studies reliant on self-report data. The findings reported in this study do nothing to undermine the longstanding observation that measuring physical activity behaviour is a vexing problem for researchers (Welk, 2002). Considering both observations seem plausible, it is reasonable to suggest that more research be devoted to optimizing the measurement of exergaming behaviour in observational (i.e., ‘free-living’) plus experimental (i.e., intervention-based) contexts where this digital platform to engage people in physical activity behaviour is popular (Witherspoon, 2013).

## **Study Limitations and Future Directions**

While the results of this study are novel and informative, this study is not without limitations that warrant consideration alongside future directions to advance exergaming research with university students. First, this study relied on the use of modified items to measure exergaming behaviour given the lack of an available instrument to measure this mode of physical activity. The questions to measure frequency and duration of exergaming behaviour were adapted from the BRFSS which originally was designed to assess global physical activity behaviour not exergaming per se. It is not clear if extent instruments measuring global physical activity are well-suited to advancing this line of research focused on exergaming. Future instrument development studies embracing the construct validation approach set forth by Messick (1995) seem justified to create an instrument measuring exergaming behaviour for university students. Second, this study relied on non-probability sampling within a non-experimental research design which limits the generalizability and internal validity of the results. Future studies could use more sophisticated approaches to sampling from known populations, as well as, consider embracing more complex longitudinal research designs that permit some insight into the temporal dynamics between exergaming behaviour and mental health of university students. Such research would do well to assess mental health and exergaming behaviour at multiple time points across the term where university students could logically experience perturbations in their mental health that are worthy of investigation (e.g., mid-term breaks, final exam periods, etc.).

## **Conclusions**

In summary, the aim of this study was to evaluate links between moderate-intensity and vigorous-intensity exergaming performed during a typical week by university students in relation to various facets of mental health. The main findings emerging from this study were that exergaming does not predict any dimension of mental health when contrasted with not exergaming during a typical week in university students. Yet the frequency of moderate-intensity and vigorous-intensity exergaming per

week is linked with better mental health reported by university students classified as ‘exergamers’. A secondary finding of this study concerns the measurement of exergaming behaviour in university students which at least based on this investigation warrants more serious attention by exercise psychology researchers. Collectively, the results of this study do nothing to undermine the assertion that exergaming – as a form of physical activity behaviour – may be a viable route to better mental health for university students and further exploration of this digital platform especially in university students is warranted.

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**Table 1***Descriptive statistics and score reliabilities for each mental health dimension*

Study Variables	Group 1: Exergamers					Group 2: Non-Exergamers				
	M	SD	Skew.	Kurt.	$\alpha$	M	SD	Skew.	Kurt.	$\alpha$
Stress	2.48	0.63	0.46	0.55	0.85	2.48	0.62	0.10	0.89	0.89
Anxiety	2.39	0.67	0.10	-0.05	0.82	2.47	0.62	0.13	-0.28	0.86
Flourishing	5.60	0.96	-1.71	4.38	0.93	5.62	0.96	-1.54	2.35	0.92
Vitality	4.16	1.06	-0.07	-0.37	0.90	4.35	1.14	-0.27	-0.09	0.88

Note. M = Mean. SD = Standard Deviation. Skew. = Univariate Skewness. Kurt. = Univariate Kurtosis.  $\alpha$  = Coefficient alpha estimate of score reliability (Cronbach, 1951).

**Table 2***Bivariate correlations between mental health dimensions and moderate/vigorous exergaming behaviours*

Variable	1.	2.	3.	4.	5.	6.
1. Moderate EXG	-					
2. Vigorous EXG	0.56	-				
3. Stress	-0.50	-0.45	-			
4. Anxiety	-0.45	-0.38	0.63	-		
5. Flourishing	0.38	0.24	-0.51	-0.48	-	
6. Vitality	0.44	0.32	-0.54	-0.64	0.74	-

Note. EXG = Exergaming. Sample size is equivalent within all elements in the diagonal matrix ( $n = 53$ ). All  $r_{12}$ 's displayed in the diagonal matrix are bivariate (Pearson) coefficients. All  $r_{12}$ 's greater than  $|0.25|$  were statistically significant (two-tailed) at  $p < .05$  in this sample.

**Table 3***Multiple regression analyses predicting mental health dimensions from moderate/vigorous*

Variables		<i>B(SE)</i>	<i>95%<sub>CI</sub>B</i>	$\beta$	<i>t-values</i>	<i>r<sub>s</sub></i>	<i>(sp)<sup>2</sup></i>
Stress ( $F_{2,50} = 10.11$ , $SEE = 0.54$ , $R^2 = 0.29$ , $R^2_{adj.} = 0.26$ )							
	Moderate EXG	-0.45(.18)	-0.82 to -0.08	-0.36	-2.46	-0.92	.09
	Vigorous EXG	-0.19(0.11)	-0.41 to 0.03	-0.25	-1.72	-0.84	.04
Anxiety ( $F_{2,50} = 7.32$ , $SEE = 0.56$ , $R^2 = 0.23$ , $R^2_{adj.} = 0.20$ )							
	Moderate EXG	-0.45(0.19)	-0.83 to -0.07	-0.36	-2.36	-0.95	.09
	Vigorous EXG	-0.13(0.11)	-0.36 to 0.10	-0.17	-1.15	-0.79	.02
Flourishing ( $F_{2,50} = 4.31$ , $SEE = 0.90$ , $R^2 = 0.15$ , $R^2_{adj.} = 0.11$ )							
	Moderate EXG	0.71(0.31)	0.09 to 1.33	0.36	2.29	0.99	.09
	Vigorous EXG	0.04(0.19)	-0.33 to 0.41	0.04	0.22	0.63	<.01
Vitality ( $F_{2,50} = 6.14$ , $SEE = 1.03$ , $R^2 = 0.20$ , $R^2_{adj.} = 0.17$ )							
	Moderate EXG	0.88(0.36)	0.16 to 1.59	0.38	2.47	0.98	.10
	Vigorous EXG	0.14(0.21)	-0.29 to 0.57	0.10	0.66	0.71	<.01

Note. F = Univariate F-statistic per regression model. SEE = Standard Error of the Estimate.  $R^2$  = Coefficient of Determination.  $R^2_{adj.}$  = Adjusted R-squared value based on sample size and number of independent variables in the regression equation. B(SE) = Unstandardized beta-coefficient (standard error of unstandardized beta-coefficient).  $95\%_{CI}B$  = Ninety-five percent confidence interval around the point estimate for the unstandardized beta-coefficient.  $\beta$  = Standardized beta-coefficient. t = t-value for each beta-coefficient.  $r_s$  = Structure coefficients calculated from this formula:  $r_{X.Y/R}$  where  $r_{X.Y}$  is the bivariate (Pearson) correlation between the predictor and criterion variable and the R is the multiple correlation coefficient per regression model (Nathans, Oswald, & Nimon, 2012).  $(sp)^2$  = Semi-partial (part) correlation coefficients (squared) expressed as unique variance within each regression model per independent variable in the equation (Nathans et al., 2012). All t-statistics greater than  $|2.00|$  were statistically significant at  $p < .05$  in this sample.

## **Chapter 5**

### **Study 3**

#### **Is exergaming more effective in promoting the mental health reported by university students than other approaches?**

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Esther S. Santos: Designed the study, collected and analyzed the data, and wrote the manuscript.

Philip M. Wilson: Assisted with the study design, supervised the work, guided analysis of the data and assisted with manuscript preparation.

Diane E. Mack: Assisted with the study design, provided guidance regarding the selection of mental health variables as well as the theoretical support and reviewed critiqued and the written manuscript.

## Introduction

Exergaming is a form of active video gaming that requires bodily movement and physical exertion from players (Staiano & Calvert, 2011). In contrast to conventional videogames where play is controlled by hand-held devices, exergaming requires each player to engage in physical activity to facilitate in-game movement and progress (Peña et al., 2016). Exergaming was initially developed to increase physical activity levels in children and adolescents due to concerns about sedentary behaviour caused by excessive screen-time (Joronen et al., 2017). Emerging interest has developed in using exergaming to improve physical, psychosocial, and cognitive dimensions of health in different cohorts and contexts such as rehabilitation following injury or illness (e.g., Bailey & McInnis, 2011; Rosenberg et al., 2010; Wang et al., 2018).

Recent studies have broadened the initial focus of exergaming research to include various target groups such as university students. This is not surprising given reports indicate mental health problems amongst post-secondary students are rising (Auerbach et al., 2016; Blanco et al., 2008) due partially to academic, financial, and lifestyle pressures (Cunningham & Duffy, 2019; Eisenberg et al., 2007; Hunt & Eisenberg, 2010). Diminished academic performance, poor class attendance, more dysfunctional relationships, and suicidal tendencies have been reported due to mental health problems in university students (Bruffaerts et al., 2018; Mortier et al., 2018). As a result, it is incumbent on post-secondary education institutions to provide services that promote the mental health of university students (Auerbach et al., 2016).

Campus health services include a variety of activities to promote mental health for university students (Eisenberg et al., 2009). Some universities offer pet therapy which consists of a dedicated space for students to interact with trained dogs (Barker et al., 2016; Binfet, 2017). Research by Adamle



et al. (2009) with two hundred and forty-six college freshmen showed that 20 minutes per week of pet therapy across one year resulted in a significant decrease in levels of perceived stress (Adamle et al., 2009). Personal counselling and psychotherapy can also be effective resources offered by campuses to support the mental health of university students (Goodman, 2017). Hamdan-Mansour et al. (2009) tested the effectiveness of psychotherapy in 84 university students with depressive symptoms. Results indicated one psychotherapy session per week for a duration of ten weeks reduced depressive symptoms, use of avoidance coping strategies, and perceived levels of stress for university students (Hamdam-Mansour et al., 2009).

Aligned with this work, a growing body of literature indicates positive mental health benefits reported by university students who engage in regular physical activity (e.g., Huang et al., 2017). Positive mental health can include self-esteem, happiness, and/or psychosocial well-being (e.g., Flourishing, etc.; Huang et al., 2017). Research by Tyson et al. (2010) showed that lowest levels of depression and anxiety were reported by university students engaged in the highest levels of physical activity. Emerging research suggests improving mental health of university students from engaging in physical activity may also be derived from exergaming. For example, Huang et al. (2017) evaluated the role of exergaming in changing mood reported by university students and university staff. In this study, participants were randomly assigned to groups. The intervention group participated in exergaming for 30 minutes per session up to twice a week across a two-week period while the control group did not participate in exergaming during this period. Huang et al. (2017) reported greater happiness and vigour in the exergaming group compared to the control group. Further research by Santos et al. (Study 2) demonstrated links between more frequent moderate-intensity and vigorous-intensity exergaming behaviour per week with lower amounts of stress and anxiety plus higher levels of flourishing and subjective vitality in university students from Canada.

Overall, the results of Huang et al. (2017) and Santos et al. (Study 2) provide initial support for the potential of exergaming as one approach to engage in physical activity that can promote mental health reported by university students. However, research testing links between exergaming and mental health in cohorts of young adults without any diagnosed health conditions (e.g., cancer, cerebral palsy; Andersen et al., 2016) and/or specifically in university students remain sparse at best. At present, it is not clear if exergaming is effective compared to other initiatives - such as pet therapy - offered as campus-wide initiatives promoting mental health for university students. Consistent and strong evidence would bring one more alternative to the forefront of campus-wide health services provided by universities to promote mental health.

### **The Present Study**

To date, no studies have compared the effects of exergaming versus pet therapy and/or other self-management approaches (e.g., traditional exercise, etc.) used to promote mental health of university students. As such, the main aim of this study was to evaluate within an experimental design if university students' mental health could be improved by exergaming compared with traditional exercise programs, pet therapy, or no approach to self-management. Study hypotheses were based on previous stress research (e.g., Ward-Griffin et al., 2018), as well as, a systematic review of exergaming and well-being in adults (e.g., Santos et al., 2018). First, it was hypothesized that exergaming would promote superior mental health compared to no self-management approaches but not compared with traditional modes of exercise. This hypothesis was based on the work by Santos et al. (2018) which synthesized published intervention studies demonstrating that exergaming can promote mental health in adults but to no greater degree than other forms of exercise (e.g., walking, etc.). Second, it was hypothesized that no differences in mental health would emerge in comparisons of exergaming with pet therapy. This hypothesis was based on research published by Ward-Griffin et al. (2018) supporting use

of pet therapy to enhance mental health reported by university students during stressful periods in the term (e.g., exam week, etc.).

Study 3 of this dissertation builds upon Study 2 in four ways. First, Study 3 provides a direct assessment of differences in mental health attributed to exergaming versus traditional exercise. Second, Study 3 evaluates potential differences between exergaming and other approaches to self-management (i.e., Pet therapy) designed to boost mental health for university students. Third, Study 3 uses a randomized experimental research design which is less prone to threats from internal validity compared with the non-experimental research design used in Study 2. Fourth, no research to date using exergaming to promote mental health is published that focuses on key periods of the academic calendar where university students typically encounter greater mental health challenges – such as during scheduled final exam periods. Study 3 addresses this gap in the literature that Study 2 ignored.

## **Methods**

### **Participants**

The sample volunteering to participate in this study were full-time university students ( $N = 121$ ) ranging in age from 19.00 to 30.00 years ( $M_{age} = 20.18$  years;  $SD = 1.94$  years). The sample was mostly white (76.86%), single (98.33%), female (57.85%), part/full-time employed (60.33%), and currently pursuing an undergraduate degree (100.00%). Table 1 provides summary data for demographic characteristics and exergaming history of the sample across experimental conditions. The sample was recruited using a non-probability (purposive) approach (see Elfil & Negida, 2017, for details)

### **Procedure**

**Research Design:** This study used a post-test only randomized experimental design (Vogt, et al., 2012).

**Instrumentation:** Participants completed a self-report questionnaire on a single occasion assessing mental health variables (perceived stress, perceived anxiety, perceived flourishing, and perceived

subjective vitality), demographic variables (e.g., age, etc.) and exergaming history. The full instrument is presented in Appendix D. Mental health was assessed with the following instruments: (a) Perceived Stress Scale ([PSS], Cohen, 1994); (b) Flourishing Scale ([FS], Diener et al., 2009); (c) State-Trait Anxiety Scale-Short Form ([STAS-SF], Marteau & Bekker, 1992); (d) Subjective Vitality Scale ([SVS], Ryan & Frederick, 1997). The instructional stem for each set of items comprising [a] through [d] noted above focused on the expected mental health exhibited by a hypothetical target depicted per experimental vignette. Exergaming history was measured using items modified from the Behavioral Risk Factor Surveillance System to gauge the frequency (days/week) and duration (minutes/session) of moderate and vigorous-intensity exergaming ([BRFSS], US Centers for Disease Control & Prevention, 2001).

**Manipulation check:** Four manipulation check items were used to verify the effects of the experimental stimulus. Following an instructional stem (i.e., ‘During the last week of his/her first term at university... ’), each of the following items was accompanied by a Likert-scale ranging from (1) ‘Strongly Disagree’ to (7) ‘Strongly Agree’: (a) ‘...CHRIS was attending pet therapy sessions regularly’; (b) ‘...CHRIS was playing exergames regularly’; (c) ‘...CHRIS was exercising regularly’; and (d) ‘...CHRIS was not engaged in any type of physical activity regularly’. These items were modified from research published by Deck et al. (2018).

**Experimental Stimulus:** Each vignette provided generic details of a first-year male ( $n_{vignettes} = 4$ ) or female ( $n_{vignettes} = 4$ ) student entering the final exam week at the end of his/her first term attending university (see Appendix E for details). All vignettes were modified from research published by Arbour et al. (2007). Each vignette featured a unique sentence manipulating the first-year student’s exclusive use of one of the following self-management approaches: (a) Traditional Exercise, (b) Exergaming, (c) Pet Therapy, (d) No Exercise.

## **Data Collection and Data Analyses**

Following clearance by a university-based Research Ethics Board (please see Appendix F for details), participants were recruited from undergraduate classes using a series of verbal presentations. A standard presentation script was used for each class to minimize between-subject effects based on the participant recruitment. Interested participants subsequently contacted the research team via email to schedule data collection in a lab. All data were provided during 1-on-1 sessions between the study participant with the first author (ESS). Upon entering the lab, each participant received a detailed explanation of the study, had a chance to ask questions, then provided informed consent to participate in this study. Subsequently, each participant was randomly allocated to 1 of 8 experimental groups (see Table 2) then asked to read the assigned vignette twice while vividly imaging the target's actions. After reading the assigned vignette twice, each participant was directed to a computer terminal to complete the post-test questionnaire using a secure website designed via a commercial provider (i.e., SurveyMonkey®).

The main hypotheses concerning the effects of exergaming on mental health were evaluated using separate Multivariate Analyses of Variance (MANOVA). Pillai's criterion was used to evaluate the omnibus effects per MANOVA given the unequal cell sizes across experimental groups (Tabachnick et al., 2007). Follow-up univariate Analyses of Variance (ANOVA) were conducted when reliable effects of the independent variables (i.e., presence/absence of exergaming by the target, etc.) were detected in the data for positive (i.e., flourishing and subjective vitality) and negative (i.e., anxiety and stress) components of mental health. Partial eta-squared ( $\eta_p^2$ ) values were calculated to interpret the effect sizes attributed to the experimental manipulation.

## Results

**Preliminary Analyses:** No missing data or out-of-range responses were evident across dependent variables. Score reliability estimates for items comprising each dependent variable ranged across experimental groups albeit not markedly on average ( $M_\alpha = 0.81$   $SD = 0.11$ ; see Table 3). No

grave departures from univariate skewness ( $M_{skew.} = -0.23$ ;  $SD_{skew.} = 0.69$ ) or univariate kurtosis ( $M_{kurt.} = 0.24$ ;  $SD_{kurt.} = 1.42$ ) emerged on average for any dependent variable used in the MANOVA's (see Table 3 for specific values). The non-significant  $F$ -tests associated with each Box's M value supported the assumption of homogeneity of variance-covariance matrices across the MANOVA's ( $p$ 's ranged from .05 to .46 inclusive).

**Manipulation Check:** Separate univariate ANOVA's with Bonferroni post-hoc analyses indicated aggregate differences per manipulation check item across experimental groups (see Table 4 for details). Moderate-to-large effect sizes ( $\eta_p^2$ ) were evident across experimental groups per manipulation check item ( $M = 0.57$ ;  $SD = 0.08$ ). No statistical differences were noted for when varying the hypothetical target's sex portrayed within each vignette for the same self-management approach (e.g., male exergamer vs. female exergamer, etc.). Aggregate differences across experimental groups were in the expected direction per manipulation check item (see Table 4 for details).

**Main Analyses:** Means and standard deviations from the eight MANOVA's evaluating the effect of exergaming compared to traditional exercise, pet therapy, and non-exercising during the end of term final exam period on mental health are shown in Table 3. Results of the MANOVA's comparing exergaming to traditional exercise indicated no statistical differences between groups on stress/anxiety ( $Pillai's Trace = 0.10$ ;  $F(6,114) = 0.97$ ,  $p = 0.45$ , partial  $\eta^2 = 0.05$ ) or flourishing/subjective vitality ( $Pillai's Trace = 0.10$ ;  $F(6,114) = 1.00$ ,  $p = 0.43$ , partial  $\eta^2 = 0.05$ ). MANOVA's comparing exergaming to non-exercise indicated statistical differences between groups on stress/anxiety ( $Pillai's Trace = 0.29$ ;  $F(6,114) = 3.21$ ,  $p < 0.01$ , partial  $\eta^2 = 0.14$ ) and flourishing/subjective vitality ( $Pillai's Trace = 0.25$ ;  $F(6,114) = 2.65$ ,  $p = 0.02$ , partial  $\eta^2 = 0.12$ ). Follow-up univariate ANOVA's indicated aggregate differences across groups on stress ( $F(3,57) = 4.52$ ,  $p < .01$ , partial  $\eta^2 = 0.19$ ), anxiety ( $F(3,57) = 4.56$ ,  $p < .01$ , partial  $\eta^2 = 0.19$ ), and subjective vitality ( $F(3,57) = 5.25$ ,  $p < .01$ , partial  $\eta^2 = 0.22$ ) but not flourishing ( $F(3,57) = 1.32$ ,  $p = 0.28$ , partial  $\eta^2 = 0.07$ ). Targets characterized as

exergamers reported higher subjective vitality as well as lower stress and anxiety compared to non-exerciser targets. Finally, the MANOVA comparing exergaming to pet therapy implied statistical differences across groups on stress/anxiety (*Pillai's Trace* = 0.20;  $F(6,114) = 2.16, p = 0.05$ , partial  $\eta^2 = 0.10$ ) but not flourishing/subjective vitality (*Pillai's Trace* = 0.10;  $F(6,114) = 0.97, p = 0.45$ , partial  $\eta^2 = 0.05$ ). Follow-up univariate ANOVA's indicated possible aggregate differences across groups on stress ( $F(3,57) = 2.62, p = .06$ , partial  $\eta^2 = 0.12$ ), anxiety ( $F(3,57) = 2.86, p = .05$ , partial  $\eta^2 = 0.13$ ) but not either subjective vitality ( $F(3,57) = 1.84, p = .24$ , partial  $\eta^2 = 0.07$ ) or flourishing ( $F(3,57) = 0.45, p = 0.72$ , partial  $\eta^2 = 0.02$ ). Targets presented as exergamers reported less stress and anxiety compared to targets using pet therapy.

### Discussion

The purpose of this study was to provide an experimental test of the contributions made by exergaming to university students' mental health when compared against traditional exercise, pet therapy, or no approach to self-management during the end of term final exam period. Consistent with previous research (Santos et al., 2018), and partially in support of our study hypotheses, this investigation provides overall support for exergaming as a conduit to minimize stress and anxiety during challenging periods in the university calendar while at the same time bolstering flourishing and subjective vitality. When compared with pet therapy or no approach to self-management, it appears that exergaming may hold some potential for bolstering the mental health of first-year university students. By comparison, it seems that exergaming provides nothing unique in terms of stimulating mental health benefits when compared against traditional modes of exercise participation in first-year university students.

Inferential analyses provided mixed support for the initial study hypotheses concerning the potential for exergaming to impact mental health. Building on previous studies using adult samples (e.g., Eggenberger et al., 2016; Huang et al., 2017, etc.) plus a recent synthesis of the well-being

literature using exergaming as an intervention with adults (Santos et al., 2018), this study found no support for the hypothesis that exergaming benefits mental health in university students more (or less) than traditional modes of exercise participation. The likely explanation for this observation is that exergaming and exercise are various forms of physical activity which, in all forms, is likely advantageous for promoting mental health (Fox & Wilson, 2008). Future studies could test this assertion using broader assessments of mental health which include both trait- and state-levels of experience to determine if exergaming and traditional exercise participation offer comparable benefits to mental health for university students.

Perhaps of greater interest in this study concerns the expected role of exergaming in advancing mental health amongst university students in comparison to no exercise and pet therapy – a popular self-management approach provided by many North American-based universities (Ward-Griffin et al., 2018). Consistent with the study hypotheses, and previous research (e.g., Karahan et al., 2015), it is apparent that exergaming offers benefits to mental health in university students compared to no exercise participation during stressful periods of the term such as the week of final exams. While the causal mechanism explaining this phenomenon remains unclear at this juncture, and could include biological models of pleasure/displeasure (Ekekekais & Brand, 2019) and/or key psychological mediators channeling the contribution of exergaming to mental health (e.g., Gunnell et al., 2012), the results of this study combined with the existing support for this notion solidifies the importance of using exercise – which includes exergaming – as a vehicle to advance mental health for university students. Future studies may wish to explore the role of exergaming in promoting acute versus chronic challenges in mental health reported by university students across the entire academic term particularly during stressful periods such as mid-term and final exam weeks that represent periods within the academic calendar when mental health is likely challenged and/or neglected by university students.

### **Study Limitations and Future Directions**



Several limitations warrant acknowledgment with the provision of future directions to advance the study of exergaming and mental health reported by university students. First, this study relied on non-probability sampling that likely minimizes the external validity of this research. Future research could use probability-based approaches to draw more representative samples for exergaming research. Second, this study relied exclusively on the use of vignette-based manipulations as the experimental stimulus distributed in a research lab setting. Future studies may wish to extend this work by comparing the effects on the mental health attributable to exergaming compared against other approaches to self-management - especially pet therapy (Ward-Griffin et al., 2018) - in natural settings across university campuses where students might experience mental health issues (e.g., classroom, etc.). Third, data were collected at different points over the duration of a single academic term rather than at a fixed point of the term. Although participants' responses were based on the hypothetical character portrayed in the vignettes, respondents' specific routines at the time of data collection may have impacted the way they read and interpret the vignettes (Hughes & Huby, 2002). In the vignettes used for this study, the target was portrayed as a first-year student entering the final week of Fall term preparing to write final exams. The final exam period is known to be stressful and anxiogenic for many university students (e.g., Allen et al., 1985; Dayalan et al., 2010). The participants in this study were university students but not recruited at the end of term or during the period of final exams. This aspect of the research design may have impacted the levels of stress, anxiety, flourishing, and vitality expected of the hypothetical target portrayed within each vignette that study participants reported. Future research may wish to consider measuring all study variables at designated periods of the academic term when university students may be likely to experience greater challenges to mental health. Finally, the assessment of mental health in this study was limited to four variables which may not cover the entire conceptual breadth or depth of the content required to represent this broad psychological construct.

Additional studies using both clinical (e.g., depression, etc.) and non-clinical (e.g., happiness, etc.) markers of positive and negative mental health dimensions seem warranted.

### **Conclusions**

Overall, this study presented evidence for the potential of exergaming to advance mental health reported by university students. Targets presented as exergamers displayed higher levels of flourishing and vitality, and lower levels of stress and anxiety in comparison to non-exercisers. Also, targets presented as exergamers reported less stress and anxiety compared with targets engaged in pet therapy. Finally, targets presented as exergamers did not differ from targets presented as exercisers in terms of mental health. Overall, these results provide more evidence favoring the potential benefits of exergaming for improving the mental health of university students.

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**Table 1***Descriptive statistics for sample across experimental conditions*

Variables	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Demographic Factors								
Age (yr.)	20.13±2.13	19.50±0.65	20.00±1.37	20.87±2.50	20.13±1.19	20.47±2.88	19.67±0.62	20.67±2.64
Height (m)	1.68±0.13	1.68±0.14	1.69±0.12	1.70±0.14	1.71±0.12	1.63±0.12	1.67±0.11	1.65±0.09
Weight (kgs)	64.11±10.29	63.89±12.15	72.09±14.44	79.44±19.29	74.91±11.33	60.82±9.35	75.29±12.83	71.12±10.07
BMI (kgs·m <sup>2</sup> )	22.95±4.89	22.96±5.11	25.72±6.73	27.59±7.58	25.78±3.59	23.35±5.11	27.25±4.93	26.32±4.23
Exergaming Behaviour								
Moderate Intensity								
Days/Week	0.33±0.49	0.80±1.01	1.07±1.29	1.67±2.06	0.64±0.93	0.33±0.62	0.87±1.13	0.87±0.74
Minutes/Session	14.67±20.57	21.67±28.01	22.19±23.94	29.00±33.98	22.00±23.59	15.33±21.99	28.33±23.81	39.67±36.96
Vigorous Intensity								
Days/Week	0.13±0.35	0.47±0.74	0.44±0.63	0.73±1.83	0.50±0.76	0.27±0.46	0.67±1.05	0.27±0.59
Minutes/Session	5.00±10.52	8.00±12.51	12.31±17.80	15.00±33.43	16.73±12.31	5.00±9.82	13.00±18.78	4.00±8.28
Moderate-to-Vigorous Intensity								
MVEG-Mins/Week	15.67±24.56	52.33±87.85	61.56±89.18	145.67±318.15	35.80±56.09	20.67±41.48	49.33±66.38	57.00±58.55

Note. Group 1 = Male Target (Traditional Exerciser); Group 2 = Male Target (Non-Exerciser); Group 3 = Male Target (Exergamer); Group 4 = Male Target (Pet Therapy); Group 5 = Female Target (Traditional Exerciser); Group 6 = Female Target (Non-Exerciser); Group 7 = Female Target (Exergamer); Group 8 = Female Target (Pet Therapy). Values presented as Mean (±SD). MVEG-Mins/Week = Self-reported minutes of Moderate-to-Vigorous Exergaming per week.

**Table 2**

*Descriptions of experimental manipulation of target types across groups*

Vignette Components	Description
Opening Stem	Chris is 18 years old and a first-year university student in Ontario. This term he/she is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. He/She has brown eyes and short dark hair. In his/her spare time, Chris listens to music, reads, watches TV, and often gets together with his/her friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where he/she is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term.
Target Types	
Exergamer:	<i>Chris plays exergames regularly on at least 4 or 5 days every week. His/Her exergaming routine includes activities that focus on fitness such as Zumba Fitness or Wii Fit using either XBOX 360 or Nintendo Wii. He/She also enjoys playing exergames that involve sports like basketball (e.g., NBA 2K19) or tennis (e.g., Wii Tennis) with his/her friends.</i>
Traditional Exerciser:	<i>Chris exercises regularly, working out at the gym 4 or 5 days every week. His/Her exercise program consists of jogging, fitness classes, and some weight training. Chris enjoys playing pick-up basketball and tennis with his/her friends.</i>
Non-Exerciser:	<i>Chris is not physically active and does not participate in exercise such as jogging, fitness classes, or weight training. Chris does not play any sports such as pick-up basketball or tennis with his/her friends.</i>
Pet Therapy:	<i>Chris is attending drop-in sessions offered at the university on at least 4 or 5 days this week, so he can pet, groom, and play with therapy dogs. Chris attends these sessions with his/her friends.</i>
Closing Stem	Chris is the oldest of three children and his/her parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with his/her friends.

**Table 3***Descriptive statistics and score reliability values for dependent variables across experimental groups*

Dependent Variables	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
<b>Stress</b>								
M	1.61	1.69	1.54	1.77	1.61	1.99	1.43	1.89
SD	0.52	0.56	0.44	0.65	0.60	0.36	0.39	0.52
$\alpha$	0.83	0.87	0.76	0.83	0.88	0.34	0.68	0.77
Skew.	-0.33	-0.03	-0.37	-0.10	-1.16	-0.64	-0.44	0.05
Kurt.	-0.81	-0.74	0.43	-0.94	2.61	2.35	-0.93	-0.37
<b>Anxiety</b>								
M	2.28	2.49	2.14	2.68	2.51	3.01	2.40	2.70
SD	0.61	0.75	0.79	0.57	0.59	0.50	0.58	0.69
$\alpha$	0.86	0.88	0.91	0.79	0.84	0.81	0.87	0.75
Skew.	-0.91	<0.00	0.09	-0.23	-0.99	-1.58	1.38	-0.69
Kurt.	0.37	-1.82	-1.02	-0.55	1.63	2.59	3.20	0.10
<b>Flourishing</b>								
M	6.08	5.45	5.56	5.65	5.87	5.28	5.84	5.59
SD	0.46	0.61	0.98	0.77	0.71	1.03	0.41	0.61
$\alpha$	0.71	0.76	0.90	0.83	0.84	0.84	0.63	0.71
Skew.	-0.52	-0.27	-1.21	-0.21	-0.69	-0.47	0.20	0.40
Kurt.	-0.16	-1.35	1.04	-0.17	-0.53	-0.03	0.22	0.09
<b>Subjective Vitality</b>								
M	3.99	3.74	4.30	3.55	4.00	2.86	4.28	4.01
SD	1.27	1.27	1.24	1.19	1.25	0.86	1.19	0.87
$\alpha$	0.92	0.91	0.88	0.90	0.90	0.82	0.94	0.83
Skew.	0.32	1.03	-0.15	0.50	0.13	1.23	-1.39	-0.33
Kurt.	-1.50	0.53	-0.22	-0.80	-0.72	2.26	3.47	-0.55

Note. Group 1 = Male Target (Traditional Exerciser); Group 2 = Male Target (Non-Exerciser); Group 3 = Male Target (Exergamer); Group 4 = Male Target (Pet Therapy); Group 5 = Female Target (Traditional Exerciser); Group 6 = Female Target (Non-Exerciser); Group 7 = Female Target (Exergamer); Group 8 = Female Target (Pet Therapy). M = Univariate Mean. SD = Standard Deviation. Skew. = Univariate Skewness. Kurt. = Univariate Kurtosis.  $\alpha$  = Coefficient alpha estimate of score reliability (Cronbach, 1951).

**Table 4***Descriptive statistics for manipulation check items across experimental conditions*

Variables	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Pet Therapy ( $F_{1,7} = 18.89, p < .01, \text{partial } \eta^2 = 0.54$ )								
M	2.47	2.33	2.38	6.47	2.67	3.33	2.86	6.33
SD	1.55	1.68	1.46	1.13	1.54	1.99	1.82	1.23
Exergamer ( $F_{1,7} = 23.28, p < .01, \text{partial } \eta^2 = 0.59$ )								
M	2.67	2.60	6.31	2.32	2.13	1.87	6.20	2.07
SD	1.91	1.68	0.79	1.99	1.25	1.77	1.08	1.22
Traditional Exerciser ( $F_{1,7} = 33.12, p < .01, \text{partial } \eta^2 = 0.67$ )								
M	6.20	1.40	4.50	2.27	6.47	1.40	4.33	2.27
SD	1.21	0.74	1.93	1.39	0.92	1.55	1.63	1.28
Non-Exerciser ( $F_{1,7} = 15.35, p < .01, \text{partial } \eta^2 = 0.49$ )								
M	1.53	5.33	1.94	4.67	1.40	5.80	2.07	4.60
SD	1.25	2.09	1.34	2.26	1.55	2.48	1.39	1.92

Notes. Group 1 = Male Target (Traditional Exerciser); Group 2 = Male Target (Non-Exerciser); Group 3 = Male Target (Exergamer); Group 4 = Male Target (Pet Therapy); Group 5 = Female Target (Traditional Exerciser); Group 6 = Female Target (Non-Exerciser); Group 7 = Female Target (Exergamer); Group 8 = Female Target (Pet Therapy). M = Univariate Mean. SD = Standard Deviation. F = F-statistics per model. Partial  $\eta^2$  = Partial eta-squared values per model.

## **Chapter 6**

### **General discussion**

University students may encounter disruptions to personal routines when starting university combined with financial and academic pressures (Lewis et al., 2015; O'Reilly et al., 2018). Some university students adjust to these changes with confidence, optimism, and retain high levels of mental health (Arnett, 2006; Samuolis & Griffin, 2014). Other university students have more difficulty adapting to these changes and report diminished mental health (Samuolis & Griffin, 2014). According to the World Health Organization ([WHO], 2014), mental health is a state of well-being in which people recognize their own potential, contribute to their community, work productively, and cope with stresses of life. University students with poor mental health – which is often characterized by higher levels of stress and anxiety – often report lower well-being that declines over time (Ribeiro et al., 2018). Previous work reports diminished mental health by university students compared to age-matched peers not enrolled in post-secondary education (e.g., Keyes et al., 2005; Larcombe et al., 2016; Leahy et al., 2010).

Universities and colleges have implemented strategies to combat mental health challenges faced by students (Harrer et al., 2019). These strategies include - but are not limited to - counselling services (Goodman, 2017), massage therapy (Tani & Lee, 2019), nap pods stations (Gruber & Cassoff, 2014), plus animal-assisted therapy (Barker et al., 2016). Physical activity is one alternative strategy promoted by universities to improve mental health of students (Andersen et al., 2019). One approach designed to blend digital technology with health promotion initiatives that can potentially improve mental health is exergaming (Huang et al., 2017). The first exergames were developed to increase levels of physical activity in children and adolescents (Witherspoon, 2013). Due to the variety of exergames currently available (e.g., golf, dance, boxing, running, etc.) using the most popular consoles (i.e., PlayStation, Xbox, and Nintendo), more interest in using exergaming with adults has emerged in the health promotion literature (Witherspoon, 2013). Exergaming provides one alternative to more traditional modes of exercise given the variety of themes and game modes available to the user (Bogost, 2005).

For example, options to play in single-player mode, play cooperatively with peers, play against other players (Witherspoon, 2013), use virtual structured exercise programs (e.g., ‘EA Sports Active: Personal Trainer’), or engage in physical activity using peculiar themes (e.g., ‘Zombie, Run!’; Sheehan & Katz, 2013) render exergaming a versatile option for physical activity promotion. Videogame companies have launched mobile games with augmented reality that are considered exergames because users need to walk in real-time (e.g., catching Pokémon in the game ‘Pokémon Go’; Niantic, 2016). Overall, the array of exergames available in mobile or console-based formats offers plausible alternatives to traditional exercise facilities for being physically active that may be perceived as dynamic and fun by adults (Limperos & Schmierbach, 2016).

A growing body of research has shown that exergaming can promote physical, cognitive, social, psychological benefits to adults (e.g., Bailey & McInnis, 2011; Huang et al., 2017; Rosenberg et al., 2010; Stanmore et al., 2017). Studies investigating the psychological benefits stemming from exergaming are scant compare to the lion's share of the evidence documenting various physical benefits stemming from exergaming reported by adults. To date, research testing the role of exergaming in relation to mental health reported by adults has relied on those people living with health conditions, middle-aged/older adults, or children/youth (e.g., Chao et al., 2014; MacIntosh et al., 2017; Santos et al., 2018) with limited attention to research using university students.

The lack of studies targeting university students' use of, and benefits from, exergaming is evident (Huang et al., 2017). The relevance of investigating the link between exergaming by university students with mental health is warranted given the number of individuals enrolled in post-secondary institutions reporting mental health challenges is rising (American College Health Association [ACHA], 2016). University students are exposed to many factors (see Lewis et al., 2015, for details) that make the experiences at university difficult to handle, which in turn, can exacerbate problems with mental health (Huang et al., 2017). Most universities include mental health initiatives to promote students' mental

health (Eisenberg et al., 2007; Hunt & Eisenberg, 2010). However, the role of exergaming as a conduit to promote mental health in university students remains unclear.

Building on this literature, the focus of this dissertation was to investigate exergaming in relation to mental health with application to university students. In total, three studies were conducted with the following objectives: (1) Synthesize the research using exergaming to promote well-being – a psychological concept affiliated with mental health – reported by adults (Study 1); (2) Verify potential links between exergaming performed at moderate-intensity and vigorous-intensity with mental health reported by university students (Study 2); (3) Compare the contributions of exergaming against other self-management behaviours (e.g. pet therapy, etc) to mental health reported by university students (Study 3).

### **Summary of research findings**

This section provides a brief synopsis of the main findings emerging from each study comprising this dissertation. Study 1 (see Chapter 3) addressed this question: Does exergaming improve well-being reported by adults? The main findings from Study 1 were as follows: (a) Evidence supports the utility of exergaming for improving well-being in adults in comparison to no exercise (or ‘do-as-you-do’) conditions; and (b) Exergaming does not benefit well-being reported by adults more (or less) so than other (perhaps ‘traditional’) modes of exercise (e.g., running on treadmills, etc.). Secondary findings emerging from Study 1 included the following: (a) Most of the studies with adults focused on exergaming and well-being used cohorts living with specific health conditions (e.g., neurological disease, etc.) or middle age/older adults, not university students; (b) Overall reporting of details pertaining to the exergaming intervention were minimal at best; and (c) Most published studies omitted details about the intensity of the exergaming intervention used to change well-being in adults.

Study 2 (see Chapter 4) addressed this question: Is exergaming at moderate- and vigorous-intensities related to mental health reported by university students? Using a non-experimental research



design, the main findings emerging from Study 2 were as follows: (a) University students reporting moderate- and vigorous-intensity exergaming behaviour in a typical week also reported lower stress, lower anxiety, higher subjective vitality, and higher flourishing; (b) Moderate-intensity exergaming behaviour during a typical week predicted lower stress, lower anxiety, higher flourishing, and higher subjective vitality typically felt by the university students; and (c) Player status ('Exergamer' vs. 'Non-Exergamer') did not predict mental health reported by university students.

Study 3 (see Chapter 5) addressed the following question: Does exergaming improve mental health more than other self-management approaches used by university students? Using a randomized experimental research design, the main findings of Study 3 were as follows: (a) Exergaming can promote better mental health in university students compared to no exercise; (b) Exergaming might promote less stress and less anxiety in university students compared to pet therapy; and (c) Exergaming does not impact mental health reported by university students in terms of stress, anxiety, subjective vitality, or flourishing more (or less) so than other forms of exercise.

The studies comprising this dissertation contribute to, and extend, the literature focused on exergaming and mental health in several ways. First, the data presented in these studies indicate that exergaming has the potential to be as effective (or no less effective) as traditional modes of exercise in relation to promoting mental health reported by university students. Second, data presented in Study 2 may justify future consideration of exergaming intensity as one key factor to consider when targeting mental health of university students in health promotion. Third, data presented in Studies 1 and 3 confirm that exergaming is more likely to improve mental health than no exercise at all. Fourth, the results of Study 3 extend the exergaming literature to show it may be more beneficial to promoting mental health – especially stress and anxiety dimensions – than using pet therapy. Fifth, Studies 2 and 3 provide direct evidence for the role of exergaming in relation to mental health reported by university students as a target cohort of interest. Finally, the studies comprising this dissertation address in part

the limited focus on conceptual replication proposed by Schmidt (2009) within the exergaming-mental health literature.

### **Implications for future research**

Combined with previous investigations (e.g., Huang et al., 2017; Lee & Skerrett, 2001; Naugle et al., 2014), the results of these dissertation studies imply that exergaming may be a promising way to mental health in university students. Yet a few limitations exist within the studies comprising this dissertation that should be addressed in future work. These limitations are outlined in this section along with future directions for this area of exergaming research.

The first limitation concerns the design of the research studies – especially Study 2 and Study 3 – of this dissertation. Non-experimental research designs provide limited evidence for causation while post-test only research designs provide no evidence of change over time in mental health variables as a function of exergaming. Quality of study design within the published literature on well-being changes attributed to exergaming reported by adults was noted in Study 1. Specifically, randomized experimental designs were used in only 9 of the 24 (37.5%) investigations coded for Study 1. Other studies relied on single-group designs (7 of 24 studies; 29.2%), quasi-experimental design (2 of 24 studies; 8.3%), interrupted time-series designs (1 of 24 studies; 4.2%), and no clear research design (1 of 24 studies; 4.2%). Quality of, and variation in, research design for exergaming studies may impact study results and thus potential implications of the research findings (Madigan et al., 2013). To address this limitation, future research focused on mental health and exergaming should consider using more sophisticated designs (e.g., randomized controlled trials [RCT]) which include longitudinal measurement of mental health variables over time. Using of RCT-based designs have advantages such as the possibility of making causal inferences between the variables which are considered the strongest evidence of the efficacy of an intervention (Spieth et al., 2016). Including longitudinal assessment of

mental health variables over key time periods may also verify the patterns of change between study variables on different occasions with time-lags (Caruana et al., 2015).

The second limitation of the studies comprising this dissertation is concerned with the measurement of variables to represent mental health. Across the literature in this area, the overarching concept of mental health is presented from different perspectives (e.g., Deci & Ryan, 2008; Keyes, 2005; WHO, 2017) which has led to confusion in operationalizing mental health. For example, assessing mental health should not be equated to only assessing mental disorders (Keyes, 2005). In addition, the reliability and validity of scores for instruments used to assess mental health variables should be a priority (Bastos et al., 2014). A mindful conceptualization of mental health involves choosing the best available instrumentation to clarify the role of exergaming in changing mental health of university students. Future studies could assess a broader array of mental health variables, as well as, consider using methods of assessing mental health that do not rely on self-report data. Attention to positive as well as negative dimensions of mental health would be advantageous in future research based on the evidence presented in this dissertation.

The third limitation of these dissertation studies emerged from Study 3 which used a limited number of comparative groups within the vignettes to evaluate the contributions of exergaming to mental health reported by university students. In study 3, exergaming was compared to no exercise, traditional exercise, and pet therapy only. This extends previous research summarized in Study 1 which typically relies on either (a) no exercise or (b) traditional exercise groups to compare well-being changes with against exergaming in adults (Douris et al., 2012). Future studies could use other approaches to self-management designed to promote mental health for university students which include massage therapy or art therapy for example. In addition, little work has been done in terms of cost-effectiveness related to exergaming as a route to promoting mental health for university students. Studies focused on cost-effectiveness aim to compare two or more interventions regarding their

economic consequences (Noyes & Holloway, 2004). Cost-effectiveness analysis comprises information about the effectiveness of the interventions (current and potential) in improving health and the costs required to implement these interventions (WHO, 2017). Future research could address the lack of cost-effectiveness data for exergaming by verifying the cost-to-benefit ration of exergaming in terms of promoting mental health for university students against other therapeutic approaches (e.g., art therapy, pet therapy, massage therapy, etc.). Cost-effectiveness analysis would contribute to providing relevant information to post-secondary institutions regarding the viability of exergaming as a resource to improve mental health of university students within current budgetary constraint models.

The fourth limitation of this dissertation is the use of vignettes as the experimental stimulus in Study 3 (see Chapter 5). Concerns about the use of vignettes in research have been forthcoming. For example, Kirmayer et al. (1997) argued that vignettes may be too hypothetical thereby magnifying the distance between real life and the hypothetical situations depicted by the vignettes. This ‘distance’ may impact study participants’ responses due at least in part to interpretation of the vignettes in different ways. In addition, participants may have difficulty becoming immersed in hypothetical vignettes that deviate from their own life experiences (Hughes, 1998; Hughes & Huby, 2002). Future research could address this issue by testing the efficacy of exergaming interventions directly against other self-management approaches which should include pet therapy because of the results provided in Study 3 of this dissertation.

The fifth limitation of the studies included in this dissertation concerns the lack of theory guiding this work (e.g., Douris et al., 2012; MackIntosh, et al., 2016). The lack of theory may limit a systematic explanation of why exergaming improves mental health of university students. The value of theories is extolled by several academics and researchers (e.g., Fishbein & Yzer, 2003). Theories help to provide well-structured explanations for phenomena (Fishbein & Yzer, 2003). Moreover, theories permit researchers to condense, accumulate, and summarize knowledge that can then predict future

events or behaviours (Sjøberg et al., 2016). At present, there is no specific theory developed to explain the link between exergaming and mental health. Future research based in theory could advance the role of exergaming in changing mental health reported by university students. An example of theory that could be applied in future investigations aiming to investigate why exergaming improves mental health of university students is Self-Determination Theory ([SDT], Deci & Ryan, 1985). Within SDT, the fulfilment of the psychological needs for competence, autonomy, and relatedness explain variation in mental health (Ryan et al., 2008). Competence is satisfied when people experience a sense of optimal challenge in environments; autonomy is fulfilled when people have opportunities to engage in activities by their personal choice; relatedness corresponds to people's feelings of being related (or connected) to a group interaction or social context that can lead to social bonding (Ryan et al., 2008). SDT may be useful for studies in exergaming and mental health of university students because exergames have competitive levels (psychological need competence), options for choice exist in varied intensities (psychological need autonomy), and players can participate with others in the same location or remotely (psychological need of relatedness).

While lack of theory is a limitation of this dissertation, it should be noted that an extensive discussion has emerged between scholars regarding the use of theories (e.g., Arestis & Chortareas, 2008; McEwan et al., 2019; Miller, 2007). Miller (2007) argued that atheoretical research is an alternative that can be used to offset the limitations of theory-based research. Arestis and Chortareas (2008) note that one limitation of theory-based research is 'blinding' of the researcher that essentially narrows the focus of any given study to only the variables or predictions outlined based on a specific theory. Explanations for phenomena then only get interpreted within the parameters of that specific theory which may disregard alternative perspectives to explain the link between variables (Miller, 2007). Atheoretical research should bring a 'neutral' approach to research studies (Arestis & Chortareas, 2008).

Adding to the discussion of theory-based versus atheoretical empirical work, McEwan et al. (2019) conducted a meta-analysis to examine the effectiveness of theory-based versus atheoretical physical activity interventions. Analysis of the effects from intervention research in physical activity, McEwan et al. (2019) found no differences between theory-based versus atheoretical interventions for encouraging physical activity behaviour. Corroborating the findings reported by McEwan et al., beneficial effects of physical activity on mental health reported by university students have been forthcoming in previous atheoretical investigations (e.g., Ghrouz et al., 2019). Likewise, in the few studies found in the literature investigating the effectiveness of exergaming on mental health of university students, this better mental health as a result of exergaming was also noted with atheoretical investigations (e.g., Naugle et al., 2014).

As such, the use of atheoretical methods for this dissertation seems justified due to potential benefits that might accrue from this approach to research using exergaming and mental health of university students. Perhaps it is useful to identify suitable third-generation questions that may advance this line of research pertaining to exergaming and mental health for university students. Zanna and Fazio (1982) describe three-generation question as inquires which address 'HOW' one variable (or variables) influences another variable (or variables) and any relevant sequelae's. Building upon the findings reported in this dissertation, such questions might include but are certainly not limited to, the following: (a) What (if any) variables moderate the effects of exergaming on mental health?; (b) What (if any) variables mediate the effects of exergaming on mental health?; (c) What is the best available moderator/mediator variable framework to explain the effects of exergaming on mental health? Focus group research may prove useful to ascertain candidate moderator and mediator variables for use in exergaming and mental health research.

### **Implications for practical application**

Perhaps the most significant contribution these dissertation studies revolve around the practical application of the findings which reinforce the potential of exergaming as a viable platform to promote mental health for university students. Universities offer various initiatives to promote mental health for students. Some activities focus on diagnosis and treatment (e.g., psychologist and psychiatric appointments, etc.) yet other activities aim to prevent major declines in mental health (e.g., nap pods, pet therapy, etc.; Rickwood & Thomas, 2012). Additionally, campuses usually contain recreational spaces that may include gyms or exercise facilities that contribute to promoting mental health for university students given established links between mental health and physical activity in this cohort (e.g., Mack et al., 2012). Overall, the combined results of these dissertation studies do nothing to undermine or dissuade university officials from offering exergaming as another approach to improve mental health for university students.

Including exergaming on university campuses might occur in several ways including the creation of devoted spaces for exergaming play. The videogames industry currently offers a variety of consoles, equipment, and types of exergames (Klein & Simmers, 2009; Siegel et al., 2009). Highly specialized companies provide services and expertise for environmental design that showcases ways to inculcate exergaming into existing buildings or facilities. Designated rooms could include exergaming bikes, dance games, strength and cardiovascular stations, motion-activated walls, floor games, and interactive climbing (see [exergamefitness.com](http://exergamefitness.com) for details).

An important variable that should be carefully monitored when exergaming interventions are implemented is the intensity of the play. Study 2 provides evidence that exergaming at moderate-intensity levels per week was the key predictor of lower anxiety, lower stress, as well as, higher flourishing, and higher subjective vitality (see Chapter 4). These results are consistent with the literature associating the intensity of physical activity and mental health (e.g., Ekkekakis et al., 2011). Previous studies indicate that higher levels of perceived stress were associated with vigorous physical

activity levels in students (Gerber et al., 2017). Also, self-selecting the exercise intensity provided for more beneficial affective responses than imposed exercise intensities (Ekkekakis et al., 2011). Overall, the results of this dissertation combined with existing literature suggest that an important practical feature of applied use of exergaming to promote mental health in university students is sufficient freedom to select and monitoring intensity of exergaming play to optimize mental health benefits.

While exergaming is considered enjoyable, players might reduce their use over time which may decrease potential mental health benefits from this type of video gameplay (Schwarz et al., 2018). Exergaming can be played using cellphones – a concept known as mobile exergaming – which may offset reduced use over time of exergaming play. Videogame companies are adapting to this reality by increasing the development and release of mobile exergaming options. For example, after releasing the game ‘Just Dance’ for PlayStation and Xbox, Ubisoft also shipped exergaming more ‘easy-to-play’ by releasing the game for smartphones. The players connect the smartphone to a laptop, computer, or Smart TV and choose the song they want to dance (Ubisoft, 2015). An advantage of mobile exergaming is this platform does not require large amounts of space and can be used in almost any existing room (see [exergamefitness.com](http://exergamefitness.com) for more details). Mobile exergaming could be a solution for universities seeking to implement this type of videogame without designated physical space to support this initiative. The post-secondary institutions could provide outdoor exergaming activities – such as multiplayer Just Dance - or provide the map of Pokémon GO to assist players in locating nearby Pokémons across campus. The initiatives from universities should be taken mainly when the students are facing more difficult times such as during final exams.

### **General conclusions**

Exergaming is an alternative way to play videogames that includes the promotion of physical activity behaviour. Physical and cognitive benefits of exergaming have been reported in previous studies but effects on mental health have not been the focus of major research in this area. Limited



research has focused on the role of exergaming in relation to mental health as a possible intervention strategy for use with university students. In summary, the studies comprising this dissertation provide evidence that (a) exergaming may contribute to better mental health for university students (but no more so than other forms of exercise), and (b) the level of intensity that accompanies exergaming behaviour may be an important factor to consider in design and use of interventions that rely on exergaming as the stimulus for change in mental health for university students. Mental health services provided by universities should consider include exergaming as one optional resource for students.

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## Appendix

**Appendix A: Study 1 – Coding Form****CERT Coding Form****STUDY IDENTIFIERS**

---

Column \_\_\_: PUB\_YEAR:  
(Numeric year article was published)

Column \_\_\_: STUDY\_TITLE:  
(Title only)

Column \_\_\_: AUTHORS:

Column \_\_\_: Journal:

Column \_\_\_: Journal Impact Factor

Column \_\_\_: Population

Column \_\_\_: Exergaming n=

--

Column \_\_\_\_: Control n=  
(N/A if necessary)

--

Column \_\_\_\_: Intervention Group mean age reported

- (1) Yes
- (2) No
- NA

If yes, describe
------------------

Column \_\_\_\_: Control Group mean age reported

- (1) Yes
- (2) No
- NA

If yes, describe
------------------

Column \_\_\_\_: Intervention Group % female reported

- (1) Yes
- (2) No

If yes, describe
------------------

Column \_\_\_\_: Control Group % female reported

- (1) Yes
- (2) No

If yes, describe
------------------

---

Column \_\_\_: Primary or Secondary Outcome

- (1) Primary
- (2) Secondary

Column \_\_\_: Risk of Bias

- (1) High
- (2) Low
- (3) Unclear
- (4) N/A

If yes, describe
------------------

---

CERT

Column \_\_\_: Item 1 (Materials: Type of exercise equipment)

- (1) Yes
- (0) No

Column \_\_\_: Item 2 (Provider: Qualifications, teaching supervising expertise, and/or training of the instructor)

- (1) Yes
- (0) No

Identify provider
-------------------

Column \_\_\_: Item 3 (Delivery: Whether exercises are performed individually or in a group)

- (1) Yes
- (0) No

Column \_\_\_: Item 4 (Delivery: Whether exercises are supervised or unsupervised)

- (1) Yes
- (0) No

Column \_\_\_: Item 5 (Delivery: Measurement and reporting of adherence to exercise)

- (1) Yes
- (0) No

Column \_\_\_: Item 6 (Delivery: Details of motivational strategies)

- (1) Yes
- (0) No

If yes, describe

Column \_\_\_: Item 7 (Delivery: Decision rules for progressing the exercise program)

- (1) Yes
- (0) No

If yes, describe

Column \_\_\_: Item 8 (Delivery: Each exercise is described so that it can be replicated---illustrations, photographs, etc.)

- (1) Yes
- (0) No

If yes, describe

Column \_\_\_: Item 9 (Delivery: Content of any home program component)

- (1) Yes
- (0) No

If yes, describe

Column \_\_\_: Item 10 (Delivery: Non-exercise components)

- (1) Yes
- (0) No

If yes, describe

Column \_\_\_: Item 11 (Delivery: How adverse events that occur during exercise are documented and managed)

- (1) Yes
- (0) No

Column \_\_\_: Item 12 (Location: Setting in which exercises are performed)

- (1) Yes

(0) No

Column \_\_\_: Item 13 (Dosage: Detailed description of the exercises (e.g., frequency, sets, reps, duration, intensity, scheduling, etc.).

(1) Yes

(0) No

If no, what missing
---------------------

Column \_\_\_: Item 14 (Tailoring: Whether exercises are generic or tailored to the individual)

(0.5) Yes, generic

(1) Yes, tailored

(0) No

Column \_\_\_: Item 15 (Tailoring: Decision rule that determine the starting level for exercise)

(1) Yes

(0) No

Column \_\_\_: Item 16 (Planned/Actual: Whether the exercise intervention is delivered and performed as planned)

(1) Yes

(0) No

## Appendix B: Study 2 – Study Questionnaire

### PROJECT E-QOL EXERGAMING AND QUALITY OF LIFE

Overview: The following survey is comprised of questions that ask you about your exergaming behaviour and quality of life. Exergaming is a videogame with motion-sensing technology in which the player needs to move his/her body to complete the videogame's sessions. Examples of exergaming include, but are not limited to, Dance Dance Revolution ® and Wii Fit ®.

There are no right or wrong answers to these questions so please respond as openly and honestly as possible to each question. All of your responses will remain anonymous and confidential and shall not be disclosed to others in any way that identifies you.

#### Section 1: Demographics

Instructions: This section contains questions that ask you to provide information to describe the participants who take part in this study.

What is your age: (years)

What is your:

- Height: ft/inches or cm/m
- Weight: lbs or kgs

What is your sex (please check one of the following options)?

- Male     
  Female     
  Transgender Female     
  Transgender Male  
 Gender variant/Non-Conforming   
  Prefer Not to Answer   
  Not listed – Specify:

How would you describe your ethnic origin (please check one of the following options)?

- White     
  South Asian     
  Chinese     
  Black  
 Filipino     
  Arab     
  Korean     
  Latin American  
 West Asian     
  Japanese     
  Aboriginal     
  Southeast Asian



q Other - Specify: \_\_\_\_\_

What is your current marital status (please check one of the following options)?

- Married or Common-Law       Widowed       Single       Separated or Divorced

What is your current employment status (please check one of the following options)?

- Full-Time Employed       Part-Time Employed       Unemployed

What type of degree are you currently pursuing at Brock University?

- Undergraduate Degree       Graduate Degree

Section 2: Exergaming

(Drawn from Huang et al., 2018; Kakinami et al., 2015; O’Loughlin et al., 2015; Witherspoon, 2013)

Instructions: The following questions ask you about your participation in exergaming. The American College of Sports Medicine defines exergaming as any form of technology-driven physical activity (e.g., videogame play, etc.) that requires people to move (e.g., exercise) in order to play the game (Witherspoon, 2013). In this section, we will ask you questions about your participation in exergaming during a typical week, as well as, which exergames you use on a regular basis.

Part A: Exergaming History

What console do you typically use when exergaming?

- Nintendo (Wii, Wii U or Switch)
- Xbox (360 or One)
- PlayStation (3 or 4)
- Other: (Please specify)
- I do not participate in exergaming in a typical week

What exergames do you typically use during a week (e.g., Dance Dance Revolution ®)? Please write your responses in the spaces provided with:

1.
2.
3.

Part B: Exergaming Behaviours
-------------------------------

Moderate intensity exergaming is defined as any active game play lasting at least 10 minutes in duration at a time that causes small increases in breathing and heart rate.

	1	2	3	4	5	6	7
In a typical week for you...	day	days	days	days	days	days	days
How many days per week do you play exergames at a moderate level of intensity?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On average, how many minutes do you typically play exergames at a moderate level of intensity per session?	Mins./session						

Vigorous intensity exergaming is defined as any active game play lasting at least 10 minutes in duration at a time that causes large increases in breathing and heart rate.

	1	2	3	4	5	6	7
In a typical week for you...	day	days	days	days	days	days	days
How many days per week do you play exergames at a vigorous level of intensity?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On average, how many minutes do you typically play exergames at a vigorous level of intensity per session?	Mins./session						

### Section 3: Quality of Life

We would like to know more about your quality of life. The following questions ask about different experiences you typically have in your life as a university student. Please respond to each item on the scale provided to tell us more about your quality of life.

Instructions: The questions below ask you about your typical feelings and thoughts as a university student. In each case, you will be asked to answer each question by indicating how often you felt or thought a certain way as a university student during the last month.

In the last month...	Never	Almost Never	Sometimes	Fairly Often	Very Often
• how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
• how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
• how often have you felt nervous and “stressed”?	0	1	2	3	4
• how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
• how often have you felt that things were going your way?	0	1	2	3	4
• how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
• how often have you been able to control irritations in your life?	0	1	2	3	4
• how often have you felt that you were on top of things?	0	1	2	3	4
• how often have you been angered because of things that were outside of your control?	0	1	2	3	4
• how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Instructions: University students can have different experiences as they pursue their degree. We would like to know a little more about those experiences. Please indicate your agreement with each item listed below based on your typical experiences as a university student.

	Strongly Disagree	Disagree	Slightly Disagree	Neither Disagree nor Agree	Slightly Agree	Agree	Strongly Agree
I lead a purposeful and meaningful life	1	2	3	4	5	6	7
My social relationships are supportive and rewarding	1	2	3	4	5	6	7
I am engaged and interested in my daily activities	1	2	3	4	5	6	7
I actively contribute to the happiness and mental health of others	1	2	3	4	5	6	7
I am competent and capable in the activities that are important to me	1	2	3	4	5	6	7
I am a good person and live a good life	1	2	3	4	5	6	7
I am optimistic about my future	1	2	3	4	5	6	7
People respect me	1	2	3	4	5	6	7

Instructions: A number of statements that university students have used to describe themselves are given below. Please read each statement and then check the number to the right of each statement to indicate how you typically feel as a university student. There are no right or wrong answers. Do not spend too much time thinking about any one statement but give the answer that seems to describe your typical feelings as a university student.

I feel...	Not at all	Somewhat	Moderately	Very Much
...calm	1	2	3	4
...tense	1	2	3	4
...upset	1	2	3	4
...relaxed	1	2	3	4
...content	1	2	3	4
...worried	1	2	3	4

Instructions: *To what extent are the following statements true or not true of YOUR life as a university student at this moment in time?*

	Not at all						Very True
I feel alive and vital	1	2	3	4	5	6	7
I don't feel very energetic	1	2	3	4	5	6	7
Sometimes I feel so alive I just want to burst	1	2	3	4	5	6	7
I have energy and spirit	1	2	3	4	5	6	7
I look forward to each new day	1	2	3	4	5	6	7
I feel energised	1	2	3	4	5	6	7
I nearly always feel alert and awake	1	2	3	4	5	6	7

Thank you

Thank you for taking the time to participate in our research study. If you have any questions pertaining to the research study please do not hesitate to ask a member of our research team at any time.

## Appendix C: Study 2 – Ethics Clearance



Brock University  
 Research Ethics Office  
 Tel: 905-688-5550 ext. 3035  
 Email: reb@brocku.ca

Social Science Research Ethics Board

### Certificate of Ethics Clearance for Human Participant Research

DATE: 2/4/2019  
 PRINCIPAL INVESTIGATOR: WILSON, Philip - Kinesiology  
 FILE: 18-196 - WILSON  
 TYPE: Ph. D. STUDENT: Esther Santos Sampaio  
 SUPERVISOR: Philip Wilson  
 TITLE: Project E-QOL-II: Exergaming and Quality of Life-II

#### ETHICS CLEARANCE GRANTED

Type of Clearance: NEW

Expiry Date: 2/1/2020

The Brock University Social Science Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 2/4/2019 to 2/1/2020.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 2/1/2020. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at <http://www.brocku.ca/research/policies-and-forms/research-forms>.

In addition, throughout your research, you must report promptly to the REB:

- a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
- b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
- c) New information that may adversely affect the safety of the participants or the conduct of the study;
- d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Lynn Dempsey, Chair  
 Social Science Research Ethics Board

Robert Steinbauer, Chair  
 Social Science Research Ethics Board

**Note:** Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.

## **Appendix D: Study 3 – Study Questionnaire**

### **PROJECT E-QOL-II EXERGAMING AND QUALITY OF LIFE**

Overview: The survey is divided into two parts. There are no right or wrong answers to these questions so please respond as openly and honestly as possible to each question. All your responses will remain anonymous and confidential and shall not be disclosed to others in any way that identifies you.

Part A: This section is comprised of questions that ask you about the narrative that you just read detailing the week of final exams for a first-year university student named CHRIS.

Part B: This section is comprised of questions that ask for more information about YOU so we can describe in broad terms the people who took part in this study.

## Part A: Quality of Life Assessments

Instructions: The questions below ask about thoughts and feelings likely experienced by CHRIS during the final week of his/her first term as a university student as described in the narrative. In each case, you will be asked to answer each question by indicating how often you think CHRIS felt or thought a certain way as a university student during the week described in the narrative.

In the last month...	Never	Almost Never	Sometimes	Fairly Often	Very Often
• how often has CHRIS been upset because of something that happened unexpectedly?	0	1	2	3	4
• how often has CHRIS felt that he/she was unable to control the important things in his/her life?	0	1	2	3	4
• how often has CHRIS felt nervous and “stressed”?	0	1	2	3	4
• how often has CHRIS felt confident about his/her ability to handle his/her personal problems?	0	1	2	3	4
• how often has CHRIS felt that things were going his/her way?	0	1	2	3	4
• how often has CHRIS found that he/she could not cope with all the things that he/she had to do?	0	1	2	3	4
• how often has CHRIS been able to control irritations in his/her life?	0	1	2	3	4
• how often has CHRIS felt that he/she were on top of things?	0	1	2	3	4
• how often has CHRIS been angered because of things that were outside of his/her control?	0	1	2	3	4
• how often has CHRIS felt difficulties were piling up so high that he/she could not overcome them?	0	1	2	3	4

Instructions: University students can have different experiences as they pursue their degree. We would like to know a little more about the experiences you think CHRIS was experiencing during the final week of his/her first term as a university student as described in the narrative. Please indicate your agreement with each item listed below based on how you think CHRIS was likely feeling as a university student.

	Strongly Disagree	Disagree	Slightly Disagree	Neither Disagree nor Agree	Slightly Agree	Agree	Strongly Agree
Chris leads a purposeful and meaningful life	1	2	3	4	5	6	7
My social relationships are supportive and rewarding	1	2	3	4	5	6	7

Chris is engaged and interested in my daily activities	1	2	3	4	5	6	7
Chris actively contributes to the happiness and mental health of others	1	2	3	4	5	6	7
Chris is competent and capable in the activities that are important to him/her	1	2	3	4	5	6	7
Chris is a good person and lives a good life	1	2	3	4	5	6	7
Chris is optimistic about his/her future	1	2	3	4	5	6	7
People respect Chris	1	2	3	4	5	6	7

Instructions: A number of statements that university students have used to describe themselves are given below. Please read each statement and then check the number to the right of each statement to indicate how you think CHRIS felt as a university student in the narrative you read. There are no right or wrong answers. Do not spend too much time thinking about any one statement but give the answer that seems to describe CHRIS'S feelings as a student during the final week of his/her first term at university.

CHRIS felt...	Not At All	Somewhat	Moderately	Very Much
...calm	1	2	3	4
...tense	1	2	3	4
...upset	1	2	3	4
...relaxed	1	2	3	4
...content	1	2	3	4
...worried	1	2	3	4

Instructions: To what extent are the following statements true or not true of CHRIS's life as a university student during the last week of his/her first term?

	Not at all						Very True
I feel alive and vital	1	2	3	4	5	6	7
I don't feel very energetic	1	2	3	4	5	6	7
Sometimes I feel so alive I just want to burst	1	2	3	4	5	6	7



---

I have energy and spirit	1	2	3	4	5	6	7
I look forward to each new day	1	2	3	4	5	6	7
I feel energised	1	2	3	4	5	6	7
I nearly always feel alert and awake	1	2	3	4	5	6	7

---

## Part B: Demographic Questions

This section contains questions that ask you to provide information that will be used to describe the participants who take part in this study. You are also asked to provide information about the narrative that you read.

### Section 1: Study Participants

These questions are about you – the study participants. They will be used to describe in general term who participated in this study.

What is your age: (years)

What is your:

- Height: ft/inches or cm/m
- Weight: lbs or kgs

What is your sex (please check one of the following options)?

- Male     
  Female     
  Transgender Female     
  Transgender Male  
 Gender variant/Non-Conforming   
  Prefer Not to Answer   
  Not listed – Specify: \_\_\_\_\_

How would you describe your ethnic origin (please check one of the following options)?

- White             
  South Asian     
  Chinese           
  Black  
 Filipino           
  Arab               
  Korean           
  Latin American  
 West Asian       
  Japanese        
  Aboriginal       
  Southeast Asian  
 Other - Specify: \_\_\_\_\_

What is your current marital status (please check one of the following options)?

- Married or Common-Law   
  Widowed   
  Single     
  Separated or Divorced

What is your current employment status (please check one of the following options)?

- Full-Time Employed     
  Part-Time Employed     
  Unemployed

What type of degree are you currently pursuing at Brock University?

- Undergraduate Degree     
  Graduate Degree

Part C: Exergaming Behaviour

Instructions: The following questions ask you about your participation in exergaming. The American College of Sports Medicine defines exergaming as any form of technology-driven physical activity (e.g., videogame play, etc.) that requires people to move (e.g., exercise) in order to play the game (Witherspoon, 2013). In this section, we will ask you questions about your participation in exergaming during a typical week, as well as, which exergames you use on a regular basis.

What console do you typically use when exergaming?

- Nintendo (Wii, Wii U or Switch)
- Xbox (360 or One)
- PlayStation (3 or 4)
- Other: (Please specify)
- I do not participate in exergaming in a typical week

What exergames do you typically use during a week (e.g., Dance Dance Revolution ®)?

Please write your responses in the spaces provided below:

1.
2.
3.

Moderate intensity exergaming is defined as any active game play lasting at least 10 minutes in duration at a time that causes small increases in breathing and heart rate.

	0	1	2	3	4	5	6	7
In a typical week for you...	days	day	days	days	days	days	days	days
How many days per week do you play exergames at a moderate level of intensity?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On average, how many minutes do you typically play exergames at a moderate level of intensity per session?	Mins./session							

Vigorous intensity exergaming is defined as any active game play lasting at least 10 minutes in duration at a time that causes large increases in breathing and heart rate.

	0	1	2	3	4	5	6	7
In a typical week for you...	days	day	days	days	days	days	days	days
How many days per week do you play exergames at a vigorous level of intensity?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On average, how many minutes do you typically play exergames at a vigorous level of intensity per session?	Mins./session							

## Section 2: Manipulation Check Items

Instructions: The following questions pertain to the narrative that you read about CHRIS – a first year university student. Based on your recollection of the information provided in the narrative YOU read, please rate YOUR level of agreement with all of the items presented below on the scale provided:

	Strongly Disagree			Neutral				Strongly Agree
During the last week of his/her first term at university...								
...CHRIS was attending pet therapy sessions regularly	1	2	3	4	5	6	7	
...CHRIS was playing exergames regularly	1	2	3	4	5	6	7	
...CHRIS was exercising regularly	1	2	3	4	5	6	7	
...CHRIS was not engaged in any type of physical activity on a regular basis	1	2	3	4	5	6	7	

## THANK YOU

Thank you for taking the time to participate in our study. If you have any questions pertaining to the research study please do not hesitate to ask a member of our research team at any time.

### **Appendix E: Study 3 – Experimental Stimulus**

The following pages contain the experimental stimulus. These materials have been ‘modified’ from existing (i.e., published) study protocols in the fields of exercise/health psychology (e.g., Arbour et al., 2007), sport psychology (Deck et al., 2018), and general psychology (Wild et al., 1997). The study outlined in 15-008 WILSON used an experimental stimulus that was identical in structure – albeit with different content – to that shown in Appendix 3.

In brief, the experimental stimulus is a narrative that serves as the independent variable for this study. One of eight narratives will be presented to each study participant in person using a printed sheet of white 8 × 11 inch paper. There are eight different versions of the narrative that will be randomized across participants as they enroll in this study based on the protocol outlined by Deck et al. (2018).

Note to Members of the SREB: No headings (i.e., Experimental Condition #1: TRADITIONAL EXERCISER, etc.) will be placed on these stimulus materials when used in the study. They are presented here for clarity only.

## INSTRUCTIONS

This study is investigating the contribution of different activities – including exergaming – to the quality of life reported by university students. You will be asked to read a short story about events that occurred in a university student’s life.

Carefully read the story to yourself ‘TWICE’. Try to vividly imagine each event that is happening as it is portrayed in the story.

After you read the story, you will answer some questions about the content of the story. Even though the story is short and doesn’t contain a lot of information, try to vividly imagine everything that you read about the university student and fill in all the details of the story as you read them in your own mind.

Remember, this study is interested in how YOU understand the story and how YOU vividly imagine the details contained within (and omitted from...) the story.

IF YOU HAVE ANY QUESTIONS, PLEASE ASK THE RESEARCHER NOW

IF YOU HAVE NO QUESTIONS, PLEASE DO THE FOLLOWING:

- TURN TO THE NEXT PAGE THEN READ THE STORY TWICE
- EACH TIME YOU READ THIS STORY PLEASE TRY TO VIVIDLY IMAGINE ALL THE DETAILS

**Experimental Condition #1: TRADITIONAL EXERCISER**

Chris is 18 years old and a first-year university student in Ontario. This term he is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. He has brown eyes and short dark hair. In his spare time, Chris listens to music, reads, watches TV, and often gets together with his friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where he is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris exercises regularly, working out at the gym 4 or 5 days every week. His exercise program consists of jogging, fitness classes, and some weight training. Chris enjoys playing pick-up basketball and tennis with his friends. Chris is the oldest of three children and his parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with his friends.

Please hand this paper back the researchers once you have completed the questionnaire.

**Experimental Condition #2: NON-EXERCISER**

Chris is 18 years old and a first-year university student in Ontario. This term he is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. He has brown eyes and short dark hair. In his spare time, Chris listens to music, reads, watches TV, and often gets together with his friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where he is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris is not physically active and does not participate in exercise such as jogging, fitness classes, or weight training. Chris does not play any sports such as pick-up basketball or tennis with his friends. Chris is the oldest of three children and his parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with his friends.

Please hand this paper back the researchers once you have completed the questionnaire.



**Experimental Condition #3: EXERGAMER**

Chris is 18 years old and a first-year university student in Ontario. This term he is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. He has brown eyes and short dark hair. In his spare time, Chris listens to music, reads, watches TV, and often gets together with his friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where he is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris plays exergames regularly on at least 4 or 5 days every week. His exergaming routine includes activities that focus on fitness such as Zumba Fitness or Wii Fit using either XBOX 360 or Nintendo Wii. He also enjoys playing exergames that involve sports like basketball (e.g., NBA 2K19) or tennis (e.g., Wii Tennis) with his friends. Chris is the oldest of three children and his parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with his friends.

Please hand this paper back the researchers once you have completed the questionnaire.

**Experimental Condition #4: PET THERAPY**

Chris is 18 years old and a first-year university student in Ontario. This term he is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. He has brown eyes and short dark hair. In his spare time, Chris listens to music, reads, watches TV, and often gets together with his friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where he is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris is attending drop-in sessions offered at the university on at least 4 or 5 days this week, so he can pet, groom, and play with therapy dogs. Chris attends these sessions with his friends. Chris is the oldest of three children and his parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with his friends.

Please hand this paper back the researchers once you have completed the questionnaire.

**Experimental Condition #5: TRADITIONAL EXERCISER**

Chris is 18 years old and a first-year university student in Ontario. This term she is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. She has brown eyes and short dark hair. In her spare time, Chris listens to music, reads, watches TV, and often gets together with her friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where she is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris exercises regularly, working out at the gym 4 or 5 days every week. Her exercise program consists of jogging, fitness classes, and some weight training. Chris enjoys playing pick-up basketball and tennis with her friends. Chris is the oldest of three children and her parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with her friends.

Please hand this paper back the researchers once you have completed the questionnaire.

**Experimental Condition #6: NON-EXERCISER**

Chris is 18 years old and a first-year university student in Ontario. This term she is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. She has brown eyes and short dark hair. In her spare time, Chris listens to music, reads, watches TV, and often gets together with her friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where she is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris is not physically active and does not participate in exercise such as jogging, fitness classes, or weight training. Chris does not play any sports such as pick-up basketball or tennis with her friends. Chris is the oldest of three children and her parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with her friends.

Please hand this paper back the researchers once you have completed the questionnaire.

**Experimental Condition #7: EXERGAMER**

Chris is 18 years old and a first-year university student in Ontario. This term she is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. She has brown eyes and short dark hair. In her spare time, Chris listens to music, reads, watches TV, and often gets together with her friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where she is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris plays exergames regularly on at least 4 or 5 days every week. Her exergaming routine includes activities that focus on fitness such as Zumba Fitness or Wii Fit using either XBOX 360 or Nintendo Wii. She also enjoys playing exergames that involve sports like basketball (e.g., NBA 2K19) or tennis (e.g., Wii Tennis) with his friends. Chris is the oldest of three children and her parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with her friends.

Please hand this paper back the researchers once you have completed the questionnaire.

**Experimental Condition #8: PET THERAPY**

Chris is 18 years old and a first-year university student in Ontario. This term she is taking courses in Psychology, French, Calculus, World History, and Chemistry. Chris is of average height and average weight. She has brown eyes and short dark hair. In her spare time, Chris listens to music, reads, watches TV, and often gets together with her friends to go for a drink or to see a movie. Chris is now entering the final week of the Fall term where she is scheduled to write a final exam in each class. Each final exam is cumulative including questions from lectures and readings assigned in each course over the entire term. Chris is attending drop-in sessions offered at the university on at least 4 or 5 days this week, so she can pet, groom, and play with therapy dogs. Chris attends these sessions with her friends. Chris is the oldest of three children and her parents are both schoolteachers. Last summer, Chris worked at a movie theater. Next summer, Chris hopes to tour Canada for a few weeks with her friends.

Please hand this paper back the researchers once you have completed the questionnaire.

## Appendix F: Study 3 – Ethics Clearance



Brock University  
 Research Ethics Office  
 Tel: 905-688-5550 ext. 3035  
 Email: reb@brocku.ca

Social Science Research Ethics Board

### Certificate of Ethics Clearance for Human Participant Research

DATE: 2/4/2019  
 PRINCIPAL INVESTIGATOR: WILSON, Philip - Kinesiology  
 FILE: 18-196 - WILSON  
 TYPE: Ph. D. STUDENT: Esther Santos Sampaio  
 SUPERVISOR: Philip Wilson  
 TITLE: Project E-QOL-II: Exergaming and Quality of Life-II

#### ETHICS CLEARANCE GRANTED

Type of Clearance: NEW

Expiry Date: 2/1/2020

The Brock University Social Science Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 2/4/2019 to 2/1/2020.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 2/1/2020. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at <http://www.brocku.ca/research/policies-and-forms/research-forms>.

In addition, throughout your research, you must report promptly to the REB:

- Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
- All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
- New information that may adversely affect the safety of the participants or the conduct of the study;
- Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Lynn Dempsey, Chair  
 Social Science Research Ethics Board

Robert Steinbauer, Chair  
 Social Science Research Ethics Board

**Note:** Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.