Even a Little Goes a Long Way for Health?

Physical Activity, Obesity, Health-Related Quality of Life and Depression

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This report contains no material offered for the award of any other degree or diploma, or material previously published, except where due reference is made in the text.

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Abstract

Overweight, obesity and physical inactivity (PI) are of major public health concern globally and associated with multiple adverse health outcomes. Overweight and obese populations experience diminished health-related quality of life (HRQOL) and greater depression symptoms when compared to their normal weight counterparts. Emerging evidence suggests 'small changes' in physical activity can produce positive health benefits. The aim of this study was to investigate the effects of a little physical activity across body mass index (BMI) status on HRQOL and depression outcomes. Secondary data analysis was conducted using the 'US 2015 Behavioral Risk Factor Surveillance System' survey. A total of 4,442 participants with complete and valid responses were included in the analysis. A two-way MANOVA was conducted with BMI (normal weight, overweight, obese) and physical activity (PI, insufficiently active [IA] < 150 min/week) as independent variables and HRQOL-4 and Patient Health Questionnaire-8 (PHQ-8; depression symptoms) as dependent variables. Statistically significant physical activity main effect revealed the IA groups reported improvements in general health ('very good' versus 'good'), roughly 6.5 days physical health and 3 days mental health, and PHQ-8 ('none-to-minimal depression' versus 'mild depression') compared to PI groups ($p < .001$). The overweight groups had larger improvements across dependent variables (except general health) compared to normal weight and obese groups. These findings add support to the growing small changes research, which suggests engaging in a little physical activity can improve health outcomes in overweight and obese populations.

Keywords: Health-related quality of life, depression, physical activity, overweight, obesity.

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Chapter 1: Introduction

Background

Overweight, obesity and physical inactivity (PI; a lack of exercise or physical bodily movements that require energy expenditure) are recognised as leading causes of global mortality (5% and 6%, respectively; World Health Organization [WHO], 2010). In 2016, 39% of adults were overweight and 13% were obese, globally (WHO, 2018c), which contributes to 2.8 million deaths each year (WHO, 2018b). Overweight and obesity are defined as “abnormal or excessive fat accumulation that may impair health” (WHO, 2018c, "What are obesity and overweight," para. 1) and obesity is considered a chronic disease (WHO, 2000). Body mass index (BMI) calculated by dividing a person’s weight in kilograms by their height in square meters (kg/m^2; WHO, 2018c) is the most frequently used measure of obesity (Ogden, Carroll, Kit, & Flegal, 2012). The WHO (2018c) classify adults $\geq$ 18 years as overweight if their BMI is $\geq 25\ kg/m^2$, and obese when BMI is $\geq 30\ kg/m^2$.

Obesity and PI are associated with considerable economic burden, both direct (medical and non-medical) and indirect costs (e.g., reduced productivity, unemployment, illness, disability, multiple morbidity, early mortality; Katzmarzyk, 2011; Su et al., 2015; Tremmel, Gerdtham, Nilsson, & Saha, 2017). Further, overweight, obesity and PI are related to a broad range of health comorbidities, such as cardiovascular disease, hypertension, cancer, type 2 diabetes, functional limitations and respiratory disorders (Abdelaal, le Roux, & Docherty, 2017; Su et al., 2015). As a result, overweight and obese individuals often experience reduced health-related quality of life (HRQOL; i.e., physical, mental and social well-being; Taylor, Forhan, Vigod, McIntyre, & Morrison, 2013).

Depression is 32% more prevalent among obese adults (Pereira-Miranda, Costa, Queiroz, Pereira-Santos, & Santana, 2017). Further, PI obese adults have a higher likelihood of current and lifetime diagnosis of depression compared to their normal weight counterparts

(Strine, Mokdad, Balluz, et al., 2008). There is consistent evidence suggesting physical activity plays a significant role in reducing obesity-related depression (Ball, Burton, & Brown, 2009; de Wit et al., 2010; Vallance et al., 2011). Despite the best efforts of public health campaigns, the impact of overweight, obesity and PI, continues to be a major health concern with “no national success stories” globally over the past 30 years (The GBD 2013 Obesity Collaboration et al., 2014, p. 1; WHO, 2018d).

Health promotion campaigns targeting the overweight, obese and PI typically prescribe significant reductions in weight (10% weight loss) and increased participation in physical activity. However, these lifestyle changes are often viewed as unachievable or impossible among overweight and obese adults (Wingo et al., 2011). Social cognitive factors that may contribute to this ‘can’t do’ mindset are low self-efficacy and low outcome expectations (Bandura, 2004). However, ‘small changes’ in physical activity (and diet) have been shown to be more realistic and attainable, and lead to improved weight management for obese people (Hills, Byrne, Lindstrom, & Hill, 2013; Lutes et al., 2008). According to Bandura (2004) presenting small achievable goals facilitates the possibility and hope of success, thus increasing self-efficacy and perceived outcome expectations, which in turn leads to a greater likelihood of the target behaviour occurring. While the ‘small changes’ concept is relatively new (Hills et al., 2013), research has demonstrated a little physical activity is better than none (particularly among those who are completely inactive) and engaging in some activity leads to beneficial health gains (Powell, Paluch, & Blair, 2011; Sattelmair et al., 2011; Sparling, Howard, Dunstan, & Owen, 2015). For example, low physical activity was found to reduce all-cause mortality risk in diabetics (Sadarangani, Hamer, Mindell, Coombs, & Stamatakis, 2014), lower heart failure risk in older adults (Florido et al., 2018), and improved HRQOL (Buder, Zick, & Waitzman, 2016). It is equally noted "some [activity] is good, more is better" (Powell et al., 2011, p. 360) and may lead to further increases in health gains.

Physical activity has been found to have an inverse relationship with depression (Adamson, Yang, & Motl, 2016). However, it is yet to be determined if insufficient physical activity, defined as engaging in less than 150 minutes of moderate intensity physical activity per week, is associated with reduced depression symptoms in overweight and obese adults compared to those who are PI. HRQOL measures are frequently used to identify changes in health status and represent one method of determining if 'a little' physical activity can produce a positive health effect (Centers for Disease Control Prevention [CDC], 2000). Another method could include measuring changes in depression.

Research Aim

It is the aim of this thesis to add to this new and growing area of realistic 'small changes' research by investigating the effects of physical activity (PI versus insufficient activity [IA]) and BMI (normal, overweight, obese) on HRQOL and depression symptoms. To determine if even a little physical activity is beneficial for health for this overburdened population who face numerous challenges in daily living.

Biopsychosocial Perspective of Overweight and Obesity

Factors that influence overweight and obesity can be viewed from Engel's (1977) biopsychosocial model (BPS). The BPS model posits the dynamic interaction of biological, psychological, and social processes explain wellness, illness and behavioural phenomena, as all three domains are part of the "real world of health care" (Engel, 1977, p. 135). As such, Engel's (1977) BPS lens takes a holistic view of factors related to overweight and obesity to help explain the disease at the biological (cells, tissue, systems), psychological (behaviour, cognition, emotion), and sociological level (family, society/culture, context/environment). It is noted the current research does not test a theory or model per se, however, conceptualising overweight and obesity-related influencing factors and barriers to physical activity from a BPS perspective may assist in the understanding of the dynamic interplay of these three domains (see Figure 1).

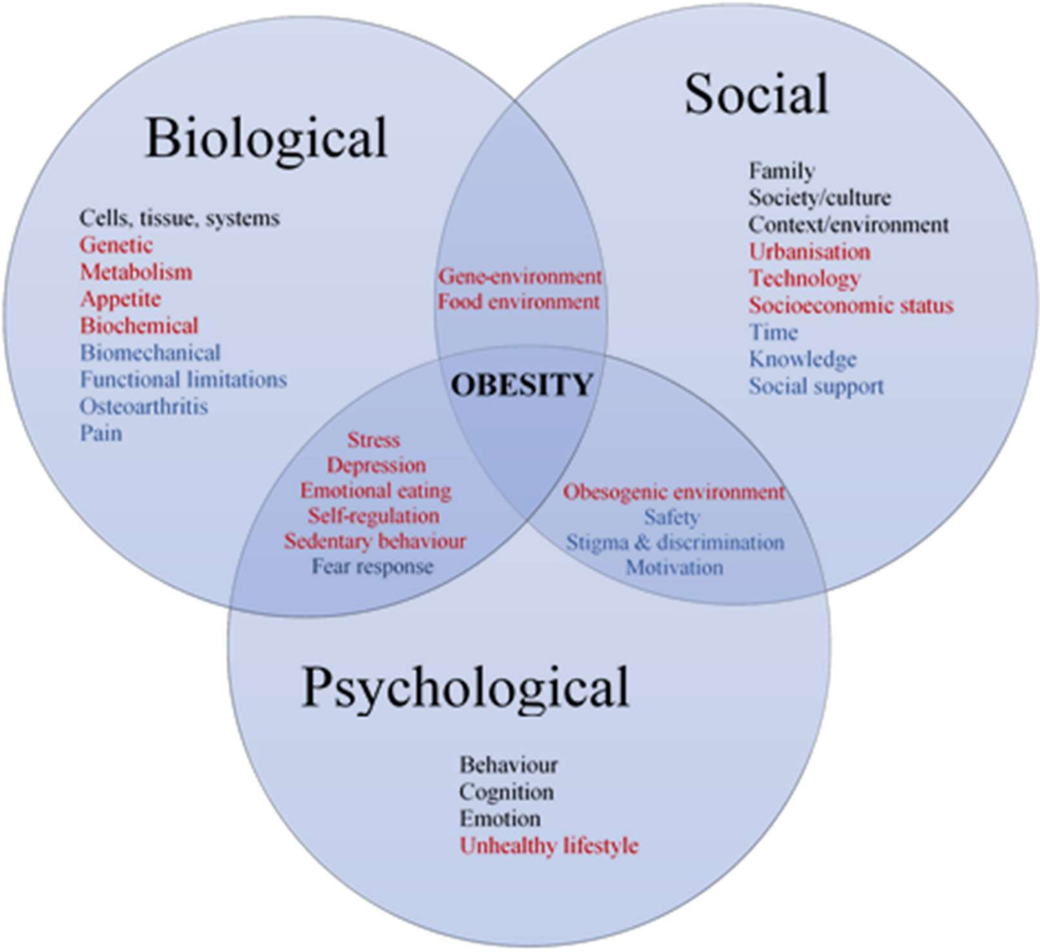

Figure 1. Visual representation of biopsychosocial obesity-related influential factors and barriers to physical activity. Biopsychosocial overarching domains are black. Factors that influence overweight and obesity are red. Overweight and obesity barriers to physical activity are blue.

Factors That Influence Overweight and Obesity

Overweight and obesity is a complex disease and is the result of biological genetic factors (Department of Health & Human Services, 2018); psychological factors such as unhealthy lifestyle and behaviours (Cecchini et al., 2010; Kushner & Choi, 2010; Wingo et al., 2011); social environmental and socioeconomic factors (Department of Health & Human Services, 2018; Garip & Yardley, 2011; Vandevijvere, Chow, Hall, Umali, & Swinburn, 2015; WHO, 2018c). While this brief discussion of factors that influences obesity is far from exhaustive, it elucidates the complexity of obesity and why it has become an increasing global health challenge.

Biological factors. Genetic factors that regulate weight and body fat composition play a key role in how a person responds to environmental influences through the mechanisms of physiological metabolism and appetite (Frayling, 2012). Twin and adoption studies suggest a strong genetic component for a portion of the variation found in BMI (Frayling, 2012). Other evidence suggests PI people and those exposed to unhealthy environments may have a genetic predisposition towards weight gain contributing to overweight and obesity (Frayling, 2012). Although, genetics are implicated, this does not fully explain the significant increase in obesity over the past 30 years (Wilding, 2012). The interaction of genetic and environmental factors on obesity is a continuing subject of debate (see Frayling, 2012; Wilding, 2012), confirming the complex nature and interrelationship of factors that influence obesity.

Psychological factors. Lifestyle and behavioural factors include dietary (Giskes, van Lenthe, Avendano-Pabon, & Brug, 2011), physical (in)activity and sedentary behaviour (Cecchini et al., 2010; Kushner & Choi, 2010). Dietary habits play an important role in overweight and obesity as the quality of food consumed directly impacts weight gain (i.e., healthy versus unhealthy; Vandevijvere et al., 2015). The effect of emotional eating or inadequate dietary self-regulation (Garip & Yardley, 2011) contribute to maladaptive eating patterns, such as skipping meals, constant snacking, eating mostly at night and consuming large portions (Kushner & Choi, 2010) all negatively impact weight management.

Behaviour patterns. Several physical activity behavioural patterns related to weight gain include a dislike of physical activity, feeling uncomfortable exercising in public, having a lack of exercise knowledge, an ‘all or nothing’ mindset, activity avoidance due to perceived/actual health-related concerns, and perceptions of ‘no time to exercise’ (Kushner &

Choi, 2010). Each of these behavioural patterns are reported to have a positive relationship with BMI (Kushner & Choi, 2010). Kushner and Choi (2010) have found the cognitive distortions 'all or nothing' and 'no time to exercise' were the most prevalent physical activity patterns reported by overweight and obese participants and the association increased with age. This is consistent with more recent research (Allafi & Waslien, 2014).

Sedentary behaviour. Sedentary behaviour (any sitting, reclining, or lying bodily position while awake with energy expenditure ≤1.5 metabolic equivalents; Sedentary Behaviour Research Network, 2017), as a lifestyle behaviour, is associated with a range of adverse health outcomes (all-cause and cardiovascular mortality; diabetes, cancer and metabolic dysfunction; Gibson-Moore, 2012), and affects appetite control leading to overeating (Blundell, 2011). These adverse health outcomes are a result of the dynamic interactions of biological, psycho-behavioural and social environmental influences. A systematic review by Rezende and colleagues (2014) found associations of sedentary behaviour with weight gain and obesity risk among children and adolescents, however, associations for adults were inconclusive due to inconsistent evidence. This suggests there are additional factors that contribute to the sedentary-obesity association for adults. Nevertheless, the prevalence of sedentary behaviour has been found to increase with age and BMI (Allafi & Waslien, 2014; Kushner & Choi, 2010).

Social factors. An obesogenic environment is one that facilitates and supports weight gain and discourages weight loss (Swinburn, Egger, & Raza, 1999). Environmental factors that contribute to unhealthy weight gain include increasing urbanisation, limited access to parks and walkways, heightened personal safety concerns in neighbourhoods, and accessibility of fitness and weight management centres (Garip & Yardley, 2011). With the advancement of technology people engage in less active forms of transportation (e.g., cars, buses, trains) and leisure time physical activity (e.g., screen time), many workplaces use automated technology, and computers further reducing opportunities for physical activity (Department of Health & Human Services, 2018; WHO, 2018c). Overweight and obese people can experience poor psychosocial functioning and as a result may develop maladaptive stress responses, depression, poor body image, social isolation and difficulty relating to others (Raggi et al., 2010).

Food consumption. Another driving obesogenic environmental factor is the ease of access to and consumption of calorie rich 'junk' foods, particularly in high income countries (Vandevijvere et al., 2015). This is contrasted with the relative unaffordability of healthy foods (Garip & Yardley, 2011). Vandevijvere et al. (2015) conducted a global analysis of food energy supply and obesity across 107 countries between 1971 and 2010 and found a significant association between changes in food intake and mean BMI globally. The authors concluded increased food consumption was "sufficient" in explaining the global increase in obesity (Vandevijvere et al., 2015, p. 452). The co-occurrence of increased unhealthy food supply and decreased physical activity creates a positive energy imbalance, which has major implications for overweight and obesity (Hills et al., 2013).

Socioeconomic status. Research suggest people who live in low-socioeconomic areas, have low education and low income are at increased risk of obesity (Drewnowski et al., 2014). Among low-income households the cost of food is a significant factor on food choice, frequently food purchases focus on quantity rather than quality healthful foods (Wiig Dammann & Smith, 2009). Often health is not a consideration when making food choices, rather "sensory appeal [and] convenience" are reported driving factors reported by Wiig Dammann and Smith (2009, p. 249). Health literacy among economically disadvantaged people is another weighty factor that contributes to unhealthy diets and weight gain, particularly the understanding of nutrition and its impact on health and disease, combined with a lack of food preparation knowledge and skills (Wiig Dammann & Smith, 2009).

Interventions for Obesity

Lifestyle interventions, such as weight management programs, dieting, exercise and behavioural therapy are typically considered front line 'gold standard' treatments for obesity related weight management (Hussain & Bloom, 2011). A review by Puhl and Heuer (2010) revealed current weight management programs (diet and medication) on average had a maximum 10% weight loss efficacy at 12-months post treatment. A third of the weight loss was regained within one year and by 5 years post-treatment, typically all weight loss was regained (Puhl & Heuer, 2010).

When lifestyle interventions fail the alternatives include pharmacotherapy or in more extreme cases (BMI > 40) obesity-related surgery (Hussain & Bloom, 2011). Pharmacotherapy interventions for the weight management of overweight and obesity are controversial, as some medications have been shown to increase the risk of cardiovascular disease, heart attack, stroke and gastrointestinal side effects and are not recommended as a standalone treatment (Balkon, Balkon, & Zitkus, 2011; Hussain & Bloom, 2011); thereby limiting the feasibility of this intervention. Similarly, invasive bariatric surgery (e.g., gastric banding, gastric bypass, biliopancreatic diversion) are not suitable for all cases of obesity and may result in additional health risks and medical complications (Hussain & Bloom, 2011). While bariatric surgery is reported to be the most successful obesity intervention for long-term weight loss, it is associated with high costs, shortage of trained surgical professionals, and a one-in-five risk of adverse events (e.g., cardiac event, hernia, pneumonia, reoperation, stroke, severe hypertension; Hussain & Bloom, 2011; Maggard et al., 2005). Collectively, the potential risks associated with both pharmacotherapy and surgical interventions suggest further research is needed to develop innovative lifestyle interventions targeting patients who are non-responsive to current 'gold standard' interventions.

Overweight and Obesity Barriers to Physical Activity

From a BPS perspective, barriers to physical activity for overweight and obesity have considerable overlap, as shown in Figure 1, and the subheadings in this section are provided as a general guide. Biological barriers include functional limitations (An & Shi, 2015), pain and risk of injury (McIntosh, Hunter, & Royce, 2016; Wingo et al., 2011); psychological barriers include fear responses, reduced motivation (Wingo et al., 2011) and lack of enjoyment (McIntosh et al., 2016); and social barriers include factors such as perceived lack of time, knowledge, social support (Ball, Bice, & Maljak, 2017; McIntosh et al., 2016; Toft & Uhrenfeldt, 2015), stigma and discrimination (Garip & Yardley, 2011).

Biological barriers. Obesity-related functional limitations are primarily caused by physical and biomechanical restraints due to excess weight, tissue and body fat (An & Shi, 2015; Capodaglio et al., 2010; Forhan & Gill, 2013). Obesity is associated with reduced ability to carry out activities of daily living (e.g., walking one block, getting up from a chair, getting out of bed, climbing stairs without rest, showering, eating; An & Shi, 2015; Vásquez, Batsis, Germain, & Shaw, 2014), reduced work-related capacity (e.g., diminished stamina and cardiorespiratory capacity; increased musculoskeletal disorders, such as carpal tunnel syndrome; muscle weakness; slow gross and fine motor fuction; and pain and osteoarthritis in joints; Capodaglio et al., 2010). As BMI increases walking becomes progressively more difficult due to the distribution of excess body fat (particularly abdominal girth) impacting stability and balance control systems, leading to increased risk of tripping and falls (Forhan & Gill, 2013). The presence of pain in the lower back, hips and knees (due to excess weight), not only acts as a barrier for physical activity, it contributes to walking instability, and further increasing the risk of injury (Forhan & Gill, 2013).

Psychological barriers. Psychological responses are an important factor when encouraging overweight and obese people to engage in physical activity, as they tend to experience more extreme responses (e.g., overreacting to pain, exaggerated safety concerns) compared to normal weight counterparts (Wingo et al., 2011). Negative psychological interpretation of cardiorespiratory responses, such as increased heart rate, shortness of or increased effort in breathing, provide strong barriers to physical activity (Wingo et al., 2011). Additionally, the discomfort of fatigue; stiffness and pain in muscles and joints; injuries and physical limitations (McIntosh et al., 2016; Toft & Uhrenfeldt, 2015) may trigger a fear-related or threat to safety response creating additional psychological barriers to physical activity (Wingo et al., 2011). Fear avoidance beliefs among overweight and obese adults driven by pain and fear of injury has been shown to reduce self-efficacy and physical activity program adherence (Wingo et al., 2011). Conversely, overweight and obese people who are able to cope better with negative physiological responses find them facilitative, as they realise over time these responses will decrease and physical activity will become easier (Garip & Yardley, 2011).

Lack of motivation is frequently cited as a barrier to physical activity by overweight and obese people, which is influenced by lack of enjoyment of exercise (McIntosh et al., 2016); low self-esteem (Peacock, Sloan, & Cripps, 2014); embarrassment and humiliation due to body size (Toft & Uhrenfeldt, 2015); and feeling upset due to not being able to keep up with others in exercise classes contribute to reduced motivation (Wingo et al., 2011). Motivational barriers can be explained by Self-Determination Theory (Ryan & Deci, 2000). This theory posits, social-contextual conditions have an effect on intrinsic motivation and psychological well-being and identifies three basic psychological needs: autonomy, competence and relatedness (Ryan & Deci, 2000). Autonomy reflects choice and self-directedness that enhances intrinsic motivation. However, when doctors and fitness professionals prescribe levels of physical activity without seeking input from overweight and obese patients, they are removing choice and the basic psychological need of autonomy. This can be perceived as a lack of support, affecting relatedness to others and reducing internalised competence. Competence involves a sense of mastery and effectiveness within the social environment (Ryan & Deci, 2000). When there is a feeling of failure as opposed to success from engaging in physical activity, accompanied by perceived negative or unsupportive feedback from others, diminishes the psychological need for competence (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Relatedness refers to a sense of belonging and knowledge that others support and care for your well-being (Ryan & Deci, 2000). When environments lack empathy, positive regard and support, relatedness becomes impaired (Teixeira et al., 2012). Research shows that when levels of autonomy, competence and relatedness are high, barriers to physical activity are low (Ball et al., 2017).

Social barriers. Stigma and discrimination towards overweight and obese people is widespread (Puhl & Heuer, 2010), even among health professionals (Tomiyama et al., 2018). This is in part due to the erroneous belief that individuals are responsible for their condition due to laziness and/or lack of self-control, when in fact obesity is a disease with many contributing causes (Puhl & Heuer, 2010). This type of "blame and shame" (Tomiyama et al., 2018, p. 3) can result in binge eating, low self-esteem and poor body image which exacerbates obesity, increasing poor physical health (Puhl & Heuer, 2010), psychological distress (Preiss, Brennan, & Clarke, 2013) and depression (Maher, Huh, Intille, Hedeker, & Dunton, 2018), and reduced HRQOL (Taylor et al., 2013). The experience of stigma in public places (e.g., local parks, gym) can serve as a significant barrier for overweight and obese adults engaging in physical activity (Garip & Yardley, 2011) and may contribute to frequently cited lack of motivation (McIntosh et al., 2016; Peacock et al., 2014; Wingo et al., 2011). While feelings of self-consciousness and negativity about size and weight have detrimental psychological effects for most, it can motivate some to engage in weight management physical activities (Garip & Yardley, 2011).

Health-Related Quality of Life

The concept of health is multi-dimensional and defined by the WHO (2018a) as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" ("Constitution of the World Health Organization: Principles," para. 1) and the enjoyment of health is a fundamental right of every person without exception. The promotion of a healthy lifestyle that includes some form of physical activity promotes health and well-being, and reduces the likelihood of illness, injury and disease (US Department of Health and Human Services, 2008). HRQOL is considered "an individual's or a group's perceived physical and mental health over time" (CDC, 2000, p. 8), and comprises four domains: (a) general health (GH), (b) poor physical health (PH; illness and injury), (c) poor mental health (MH; psychological distress, stress, depression, emotional problems), and (d) activity limitations (AL; disability/productivity status; CDC, 2000).

Physical activity, BMI and HRQOL. Physical activity has been shown to improve HRQOL for people with health limitations (Brown, Carroll, Workman, Carlson, & Brown, 2014; Buder et al., 2016), arthritis suffers (Austin, Qu, & Shewchuk, 2012; Brown et al., 2003), independent of weight loss (Megakli, Vlachopoulos, & Theodorakis, 2016), and irrespective of BMI status (Herman, Hopman, Vandenkerkhof, & Rosenberg, 2012). On the other hand, BMI is reported to have an inverse relationship with HRQOL (Apple et al., 2018; Herman et al., 2012; Ibrahim, Moy, Awalludin, Ali, & Ismail, 2014; Jung & Chang, 2015; Wilkins, Ghosh, Vivar, Chakraborty, & Ghosh, 2018). However, the BMI-HRQOL association is complex, where BMI greatly influence HRQOL for some and not others (Apple et al., 2018).

Brown et al. (2014) conducted a cross-sectional study (n = 357,665) investigating the dose-response relationship between physical activity (5 levels: inactive, 10-60, 61-149, 150-300, >300 minutes per week) and HRQOL (PH, MH; cut point of $\geq$ 14 days) among people with and without limitations (activity, functional and disability limitations) and found a positive association between level of physical activity and HRQOL, independent of limitation status. Further, participants who engaged in some activity, although below recommendations of ≥150 minutes per week (i.e., 10-60 and 61-149 minutes), had higher HRQOL than inactive participants. The authors concluded their study demonstrated "some physical activity is better than none for HRQOL" (Brown et al., 2014, p. 7).

Herman et al. (2012) examined the combination of physical activity and BMI with HRQOL self-rated health in a cross-sectional population-based sample of Canadian Adults (*n* = 110,986). It was found self-rated health for active obese participants were comparable (or slightly lower) to those of inactive normal weight participants whom reported fair/poor health. Unsurprisingly, the group with the highest fair/poor self-rated health were inactive obese (and inactive underweight) participants. These results also suggest BMI and physical activity produced independent effects on HRQOL. Research by Dankel, Loenneke, and Loprinzi (2016b) suggests the longer a person is overweight or obese and PI (10+ years) their odds of experiencing reduced HRQOL compared to those who have a shorter history are increased. However, HRQOL was found to improve in the long-term overweight and obese participants with physical activity and resulted in similar levels of HRQOL as normal weight active participants (Dankel et al., 2016b), further highlighting the importance of mobilising this population.

Depression

The associations between depression, overweight and obesity are well studied, and research suggests a bi-directional relationship exists (Luppino et al., 2010; Preiss et al., 2013; Tronieri, Wurst, Pearl, & Allison, 2017). Luppino et al. (2010) conducted a systematic review and meta-analysis of longitudinal studies to examine the relationships between depression, overweight and obesity over time and found obesity increased the risk of depression by 55% and depression increased the risk of obesity by 58%. Preiss et al. (2013)

conducted a systematic review of 46 studies investigating variables related to obesity (BMI > 30) and depression and found a positive relationship between obesity and depression. Further, obesity-related functional limitations, poor physical health, and weight-related stigma were similarly associated with increased depression symptoms (Preiss et al., 2013). This research signifies the importance of preventing weight gain in depressed populations and vigilant monitoring for depression in overweight and obese populations.

PI, overweight, obesity and depression. PI, overweight and obesity has been identified as an adverse health behaviour resulting in frequent mental distress in adults 45 years and over (Strine, Greenlund, Brown, Mokdad, & Balluz, 2004), and significantly associated with current and life time diagnosis of depression (Strine, Mokdad, Balluz, et al., 2008). Strine, Mokdad, Dube, et al. (2008) analysed 2006 US population-based data (n = 217,379) exploring the association between depression and unhealthy behaviours that included obesity and PI in adults. The authors found those with current depression and lifetime diagnosis of depression were more likely to be obese and PI compared to those with no history of depression. They further investigated the effects of five levels of depression (none, mild, moderate, moderately severe, severe) and found as the level of depression increased so did obesity and PI, indicating a positive BMI-depression relationship. This research demonstrates the importance of mobilising and encouraging the overweight and obese to engage in some form of physical activity, even just a little, to increase health and well-being.

Physical activity, overweight, obesity and depression. It is well established that physical activity improves depression (Adamson, Ensari, & Motl, 2015; Adamson et al., 2016; Meng & D'Arcy, 2013; Vallance et al., 2011), and emerging evidence suggests low levels of physical activity can act as a preventative factor for depression (Mammen & Faulkner, 2013). However, less is known about the health-related benefits of incremental behaviour change between PI and low levels of IA (e.g., < 150 min per week) on depression symptoms.

Physical Activity

The WHO (2010) recommend adults aged 18-64 years engage in ≥ 150 min of moderate-to-vigorous physical activity (e.g., brisk walking, running, cycling) per week for prevention of illness and disease, and to increase health and well-being across the lifespan. This broad recommendation does not take into account vast challenges overweight and obese people face, such as functional limitations, high levels of pain and osteoarthritis which can form significant physical (Forhan & Gill, 2013) and psychological barriers (McIntosh et al., 2016) to physical activity. The US Department of Health and Human Services (2008) further acknowledge and recommend, "All adults should avoid inactivity. Some physical activity is better than none, and adults who participate in any amount of physical activity gain some health benefits" (p. vii).

A Little (Physical Activity) for Health

Emerging evidence suggests small changes in lifestyle behaviours (when incorporated into routine and regular daily living) have minimal negative impact (Hills et al., 2013). Further, if these changes are rewarding and perceived beneficial to one's health, individuals become intrinsically motivated to continue engaging in health behaviour change (Hills et al., 2013). Gibson-Moore (2012) suggests the health-related benefits of starting or maintaining physical activity for the overweight and obese can result in lower risks of obesity-related conditions, even when weight is not lost (Gibson-Moore, 2012). Buder and colleagues (2016) found physical activity had a larger effect in boosting HRQOL among participants who had health limitations compared to those who did not. Further, physical activity has been found to control appetite through physiological regulation and increase biological health markers (Blundell, 2011). Helgadóttir, Forsell, and Ekblom (2015) recommend health professionals endorse light physical activity to treat depressed individuals by breaking up sedentary behaviour. These findings are important, given the low success rate of weight loss and long-term weight maintenance, and high levels of functional limitations and depression among the overweight and obese people. Consequently, it may be more realistic to encourage health gains as opposed to weight loss in this population.

Research Questions

Based on the literature reviewed exploring the benefits of small changes in physical activity, the current study aims to investigate three research questions.

Research question 1. Does adult BMI classification (normal weight, overweight, obese) have an effect on the outcome measures of HRQOL (GH, PH, MH, AL) and depression symptoms?

Research question 2. Does the level of physical activity (PI versus IA) have an effect on the outcome measures of HRQOL (GH, PH, MH, AL) and depression symptoms?

Research question 3. Are the effects of physical activity level (PI versus IA) the same for all levels of adult BMI classification (normal weight, overweight, obese) on the outcome measures of HRQOL (GH, PH, MH, AL) and depression symptoms?

More specifically, the current study sought to determine if there are perceived response category differences for GH; differences in the perceived number of days of improved health for PH, MH and AL (if any); and if there are differences in the current level of depression symptom between normal weight, overweight and obese participants when comparing the respective PI and IA groups.

Chapter 2: Methods

Sample

This cross-sectional population-based study utilised the 2015 Behavioral Risk Factor Surveillance System (BRFSS; CDC, 2015a) survey data for secondary analysis, with a total sample size of 441,456 (57.7% female, 42.4% male) American non-institutionalised adults aged 18 years and over. Participants included in this analysis must have had valid and complete responses for each of the independent and dependent variables. However, participants were at liberty to refuse to answer survey questions, resulting in incomplete and missing data. Initially, cases were identified for participants with valid responses for the independent variables (IV) BMI and physical activity (n = 167,529). Then cases were identified for participants with valid responses for the dependent variables (DV) HRQOL-4 and Patient Health Questionnaire-8 (PHQ-8). The final sample with complete data for all variables was n = 4,601 (65% female, 35% male), aged 18-80 years, with a mean age of 54.87 years (SD = 15.90). However, due to the outcome of the preliminary analysis (reported in the results section) and subsequent loss of 159 eligible cases, the demographics data that represents participants included in the analysis are presented in Table 1 in the results section. Ethics exemption was approved by University of Southern Queensland Human Research Ethics Committee to conduct secondary analysis with the 2015 BRFSS for this study.

Data Source

The BRFSS has been administered annually since 1984, with annual survey data publicly available for researchers globally to analyse (accessible via the CDC website https://www.cdc.gov/brfss/annual_data/annual_data.htm). The BRFSS includes both a landline telephone survey and mobile phone survey (the latter commenced in 2011) that utilises random-digit-dialling (CDC, 2016b). Data were collected from all 50 US states and the District of Columbia, Guam and Puerto Rico, and were stratified (CDC, 2016b). The

BRFSS was designed to measure preventative health behaviours, health-related risk behaviours, injuries, diseases, chronic health conditions, mental health, and demographic characteristics (CDC, 2016b). The BRFSS has been reported to provide valid and reliable data for physical activity measures, mental health measures, and overweight and obesity measures (Pierannunzi, Hu, & Balluz, 2013). The landline telephone survey interviewed one randomly selected adult from each residence. The mobile telephone survey interviewed selected adults who resided in either a private residence or college housing. The response rate was 48.2% for landlines and 47.2% for mobile phones (median rates for all states/territories; CDC, 2015b).

Sociodemographic Characteristics

The sociodemographic characteristics reported were age in years (18-24, 25-34, 35-44, 45-54, 55-64, 65 or older), sex (male, female), race (White, Black, Hispanic, Other), education (did not complete high school, graduated high school, some college, graduated college), employment (employed, unemployed, student, homemaker, retired, unable to work), and annual income in US dollars (< $15,000, $15,000 to < $25,000, $25,000 to < $35,000, $35,000 to < $50,000, ≥ $50,000). It is noted sociodemographic characteristics are reported and discussed with BRFSS terminology (e.g. race, white/black for ethnicity).

Independent Variables

The CDC (2016a) provides researchers with a 'code book' itemising each variable by name, value code, value label, frequency, and percentage. The CDC (2016c) provides additional resources on the calculated variables within the data file, including how variables were derived, coded, and labelled. The variables for BMI (_BMI5CAT) and physical activity (_PACAT1) are both 'calculated variables' based on combined data from other existing variables, for example reported weight and height for BMI and items such as, "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?" (CDC, 2016a, p. 37) for physical activity.

Body Mass Index

BMI was determined by dividing a participant's weight in kilograms by height in meters (kg/m^2). Three of the four original _BMI5CAT calculated variable categories were re-coded into a new variable. The new BMI variable was used within the analysis as an IV and was coded 1 = normal weight (BMI $\geq$ 18.50 and < 25.00 kg/m^2); 2 = overweight (BMI $\geq$ 25.00 and < 30.00 kg/m^2); and 3 = obese (BMI $\geq$ 30.00 kg/m^2).

Physical Activity

Two of the four original _PACAT1 calculated variable categories were re-coded into a new variable. This new physical activity variable was used within the analysis as an IV and was coded 1 = 'insufficiently active' (IA; participants who reported doing insufficient physical activity; 11-149 minutes per week); and 2 = 'physically inactive' (PI; participants who reported no physical activity per week over the past month).

Dependent Variables

HRQOL-4

The CDC (2000) HRQOL-4 is a measure of perceived self-rated GH, and recent (past 30 days) perceptions of poor PH, poor MH and AL due to poor physical or mental health. The HRQOL-4 was designed to provide global indicators of GH, PH, MH and AL (Moriarty, Zack, & Kobau, 2003). One advantage of these global indicators are they provide a useful indicator of each unit increase of days (e.g., a score of 4 days is twice as much as 2 days), allowing for meaningful interpretation of statistically significant results (Moriarty et al., 2003). The HRQOL-4 has been used extensively in varied adult populations, and as an assessment tool for identifying health disparities, gaps in health needs and burden of disease for a range of health conditions, such as diabetes (Moriarty et al., 2003). The HRQOL-4, a brief validated measure of HRQOL, is cost effective, time efficient, and widely accepted within public surveillance domains allowing comparability of findings across other studies employing this measure (Moriarty et al., 2003), and has a reported response rate of over 98% (CDC, 2000). The BRFSS HRQOL-4 has been shown to be valid and reliable instrument (CDC, 2000; Mielenz, Jackson, Currey, Devellis, & Callahan Leigh, 2006; Moriarty et al., 2003). Andresen, Catlin, Wyrwich, and Jackson-Thompson (2003) investigated the retest reliability of the BRFSS HRQOL-4 and found moderate to excellent retest reliability for core items (GH Kappa coefficient = .75; PH, MH and AL intraclass correlation coefficient = .58 to .71). Toet, Raat, Ameijden, and van Ameijden (2006) conducted a Dutch validation of the HRQOL-4 and found internal consistency Cronbach's alpha of .77 for PH, MH and AL; concurrent validity with Medical Outcomes Study Short Form 36-item (SF-36; Ware & Sherbourne, 1992) with equivalent domains confirmed by significant Spearman correlations, GH domain $r_s = -.75$, $p = .01$, PH domain $r_s = -.43$ to $-.59$, $p = .01$, MH domain $r_s = -.66$ to $-.71$, $p = .01$, and AL domain $r_s = -.49$ to $-.65$, $p = .01$.

The CDC HRQOL-4: Healthy Days Core Module contains four questions and was added to the BRFSS survey instrument in 1993 (CDC, 2017). The first item assessed GH, "Would you say that in general your health is excellent, very good, good, fair, or poor?" The item had a 5-point response category format that ranged from 1 (*excellent*) to 5 (*poor*). The second item assessed poor PH, "Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?" The third item assessed poor MH, "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" The fourth item assessed AL, "During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?" The response scores for each of these three items ranged from 0-30 days, where higher scores indicate poorer health and lower scores indicate good health.

PHQ-8

The CDC BRFSS Module 24: Anxiety and Depression includes the PHQ-8, an 8-item questionnaire used to assess current levels of depression symptoms relating to lack of interest or pleasure, feeling down/depressed, sleep disturbance, low energy levels, appetite disturbance, feelings of failure, thought disturbance, and movement disturbance (Kroenke et al., 2009). The PHQ-8 is a valid and reliable measure for use in the general population (Kroenke et al., 2009; Strine, Mokdad, Balluz, et al., 2008), and as a diagnostic measure of Major Depressive Disorder equivalent to eight of the nine criteria of the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (Dhingra, Kroenke, Zack, Strine, & Balluz, 2011; Tomitaka et al., 2017). Kroenke, Spitzer, Williams, and Löwe (2010) conducted a systematic review of validation studies and found the PHQ-8 (abbreviated version of PHQ-9) had a criterion validity sensitivity of .77 to .88, and specificity of .88 to .94; with reliability internal consistency alpha of .86 to .89, test-retest .84, and self-rated versus interviewer .84.

The 8-item response set was standardised to be similar to other questions within the BRFSS (i.e., number of days in the past two weeks) and was added as an optional module in 2006 (CDC, 2010). The interviewer instructs the participant: “Now, I am going to ask you some questions about your mood. When answering these questions, please think about how many days each of the following has occurred in the past 2 weeks.” For example, item one “Over the last 2 weeks, how many days have you had little interest or pleasure in doing things?” and item five “Over the last 2 weeks, how many days have you had a poor appetite or eaten too much?” The response scores ranged from 0-14 days, where higher scores indicate elevated levels of current depression and low scores indicate lower levels of current depression. For the current analysis, the standardised response set was converted back to the original response set with assigned values of 0 to 3 (CDC, 2014a). Where 0 to 1 day = 0 (*not at all*); 2 to 6 days = 1 (*several days*); 7 to 11 days = 2 (*more than half the days*); and 12 to 14 days = 3 (*nearly every day*). The individual scores for each item were summed to produce a total score value (continuous variable) from 0 to 24, where a score of 0 indicates no depression and 24 indicates severe depression. Severity of depression can be calculated from the total score using a validated diagnostic algorithm: 0 to 4 (*none to minimal depression*); 5 to 9 (*mild depression*); 10 to 14 (*moderate depression*); 15 to 19 (*moderately severe depression*); and 20 to 24 (severe depression; CDC, 2014a; Dhingra et al., 2011).

Chapter 3: Results

Preliminary Analysis

Data analysis was conducted using Statistical Package for Social Sciences version 21.0 (SPSS; IBM Corp. Released, 2012). Prior to conducting the analysis, the data was examined for univariate and multivariate outliers as MANOVA is not robust to outliers (Tabachnick & Fidell, 2013). Univariate outliers were identified via standardised scores and inspection of boxplots. Twelve cases were identified with z-scores (± 3.29; Field, 2013; Tabachnick & Fidell, 2013) and 124 extreme cases via inspection of boxplots. These cases were deemed outliers due to either data entry error or atypical or inconsistent responding and were removed. Mahalanobis distance checks revealed 23 multivariate cases above the critical value ($\chi^2(5) = 20.52$, $p < .001$), and were removed. A total of 159 cases of univariate and multivariate outliers were identified and removed from the dataset. The final sample for analysis was 4,442.

Tests of normality revealed two DVs across three groups with skewness and kurtosis above ± 2 and one additional DV across one group with kurtosis above ± 2. AL for IA normal weight group had skewness of 2.79 (*SE* = 0.13) and kurtosis of 6.91 (*SE* = 0.26); IA overweight group had skewness of 2.78 (*SE* = .11) and kurtosis of 7.12 (*SE* = 0.22); and IA obese group had skewness of 2.03 (*SE* = .10). Poor MH for IA overweight group had skewness of 2.15 (*SE* = .11) and kurtosis of 3.68 (*SE* = 0.22). Poor PH for IA overweight group had kurtosis of 2.34 (*SE* = 0.22). See Appendix A for descriptive statistics. Visual inspection of the histograms for each group on each DV revealed GH for each group was approximately normal and PHQ-8 showed relative signs of positive skew for each group. The histograms for poor PH, poor MH and AL for each group were more complex with the majority of responses falling in zero days, which is reported to be the most common response pattern for this survey (Slabaugh et al., 2017), thus violating the assumption of normality.

However, due to the central limit theorem in large samples MANOVA is robust to violations of normality (Pituch & Stevens, 2016; Tabachnick & Fidell, 2013). Additionally, the effects of positive kurtosis are no longer apparent when sample sizes are above 100 (Waternaux, 1976). It is noted, due to the large sample size the analysis had more statistical power than needed for the multivariate analysis of group differences.

Assumptions

Linearity. The assumption of linearity was tenable, with convergent agreement of significant correlation coefficients for each pair of DVs for the six IVs and the bivariate scatterplot matrix of DVs for all combinations of IVs.

Homogeneity of variance-covariance matrices. The assumption of homogeneity of variance-covariance matrix was violated, Box's *M* test ($M = 879.61, p < .001$). However, Tabachnick and Fidell (2013) suggest Box's *M* is highly sensitive to large samples. Visual inspection of the variance-covariance matrix cells comparing the smallest sample size cells ($n = 365$) to the largest sample sized cells ($n = 1{,}379$) revealed the cells with the larger sample sizes had the larger variances and covariances, apart from one cell where the difference was 0.40 and deemed comparatively homogeneous (see Appendix B). According to Tabachnick and Fidell (2013), when the larger sample cells have larger variances and covariances the alpha level is conservative and significant findings can be trusted. Considering the unequal group sizes within the analysis and significant Box's *M*, Pillia's Trace was used to interpret the statistical significance of the two-way MANOVA (Tabachnick & Fidell, 2013).

Homogeneity of error variance. Levene's test for homogeneity of variance was statistically significant for each of the DVs at the alpha level of .05, therefore the assumption was violated. Tabachnick and Fidell (2013) suggest a more conservative alpha level (.01) be applied to determine the statistical significance of the univariate *F*-tests when Levene's test is violated.

Multicollinearity and singularity. There was no evidence of multicollinearity, as assessed by Pearson's correlation coefficient $r > .9$ (Tabachnick & Fidell, 2013). The bivariate correlations between each pair of DVs for the six IV groups ranged from $r = .18$ to .59 (see Appendix C).

Demographic Characteristics

Table 1 presents demographic characteristics of the study participants. The final sample of 4,442 participants had a mean age of 54.9 years (*SD* = 15.9), were 65% female (35% male), predominantly white (81.1%) and graduated with a college education (73.7%). Forty-one percent were employed, 21.1% were unable to work and 32.6% earned US $50,000 or more per annum. For the BMI groups normal weight, overweight, and obese, participants were 23.3%, 31.8%, and 45%, respectively. Of the physical activity groups, 67% were PI and 33% IA.

Table *1*

Demographic Characteristics of Participants by Physical Activity Level and BMI (N = 4,442)

		Physically inactive (n = 2,973)			Insufficiently active (n = 1,469)		
Characteristic	Total n (%)	Normal weight[a] (n = 669)	Overweight[b] (n = 925)	Obese[c] (n = 1,379)	Normal weight[a] (n = 365)	Overweight[b] (n = 486)	Obese[c] (n = 618)
Age (years)							
18 – 24	215 (4.8)	32	26	33	62	34	28
25 – 34	390 (8.8)	65	63	83	56	63	60
35 – 44	500 (11.3)	61	92	145	34	70	98
45 – 54	833 (18.8)	98	160	275	58	96	146
55 – 64	1,198 (27.0)	173	252	400	80	121	172
65 or older	1,306 (29.4)	240	332	443	75	102	114
Sex							
Male	1,556 (35.0)	202	344	457	97	214	242
Female	2,886 (65.0)	467	581	922	268	272	376
Ethnicity							
White	3,583 (81.1)	565	755	1,069	323	406	465
Black	655 (14.8)	75	130	251	22	57	120
Hispanic	44 (1.0)	5	4	14	5	7	9
Other	135 (3.1)	22	30	40	13	13	17
Education[e]							
< High school	2 (0.1)	1	-	-	-	-	1
High school	158 (7.5)	32	41	49	3	9	24
Some college	391 (18.7)	79	94	138	22	23	35
College	1,542 (73.7)	244	349	539	107	135	168
Employment[f]							
Employed	1,851 (41.8)	233	356	487	192	276	307

Unemployed	174 (3.9)	29	28	58	18	13	28
Student	110 (2.5)	11	11	17	31	21	19
Homemaker	236 (5.3)	37	49	72	26	24	28
Retired	1,126 (25.4)	204	259	377	71	99	116
Unable to work	935 (21.1)	153	219	368	25	52	118
Income[g^]							
< $15,000	714 (18.6)	129	137	263	34	55	96
$15,000 - < $25,000	827 (21.6)	121	187	293	53	57	116
$25,000 - < $35,000	480 (12.5)	72	105	157	39	57	50
$35,000 - < $50,000	562 (14.7)	71	122	174	50	48	91
≥ $50,000	1,248 (32.6)	151	233	319	130	214	201

Note. Due to missing data, the total number of reported characteristics for ethnicity, education, employment and income are listed below and the associated percentage reflects the valid percent.

[a] BMI ≥ 18.5 < 2 5 kg/m^2; [b] BMI ≥ 25 < 3 0 kg/m^2; [c] BMI ≥ 30 kg/m^2; [d] n = 4,417; [e] n = 2,093; [f] n = 4,432; [g] n = 3,831; [^] US dollars.

Two-way MANOVA

A two-way (3 x 2) MANOVA was performed on two IVs: BMI (normal weight, overweight, obese) and physical activity (PI, IA); and five DVs: GH, poor PH, poor MH, AL, and PHQ-8. Due to assumption violations, the criterion used to determine significance was a conservative alpha of .01 and Pillia's Trace was used to interpret the statistical significance of the two-way MANOVA. Further, due to the different measurement scales between DVs, patrial eta-squared statistics are reported according to Cohen's (1969) convention, .01 = small, .06 = medium, and .14 = large, as an index of effect size allowing comparability of results (Sullivan & Feinn, 2012).

The multivariate tests revealed a statistically significant main effect for both BMI, V = .03, F(10, 8,866) = 12.52, $p < .001$, η_p^2 =.01, and physical activity, V = .09, F(5, 4,432) = 85.50, $p < .001$, η_p^2 =.09. Further, the multivariate test revealed a statistically significant interaction effect between BMI and physical activity on the combined DVs, V = .01, F(10, 8,866) = 3.19, $p < .001$, η_p^2 =.00.

Figures 2 to 4 present a summary of the analysis data. The overall feature of Figures 2 to 4 suggests the effects of engaging in some physical activity compared to no physical activity appears to improve self-reported GH, reduce number of days lost due to poor PH, poor MH and AL, and lower PHQ-8 scores for each BMI group. Further, obese participants tended to report more poorly on each of the outcome measures, compared to normal weight and overweight groups. The effects of physical activity for the normal weight and overweight groups appeared to be similar when compared to the obese group on the outcome measures of self-reported GH, poor PH, AL and PHQ-8.

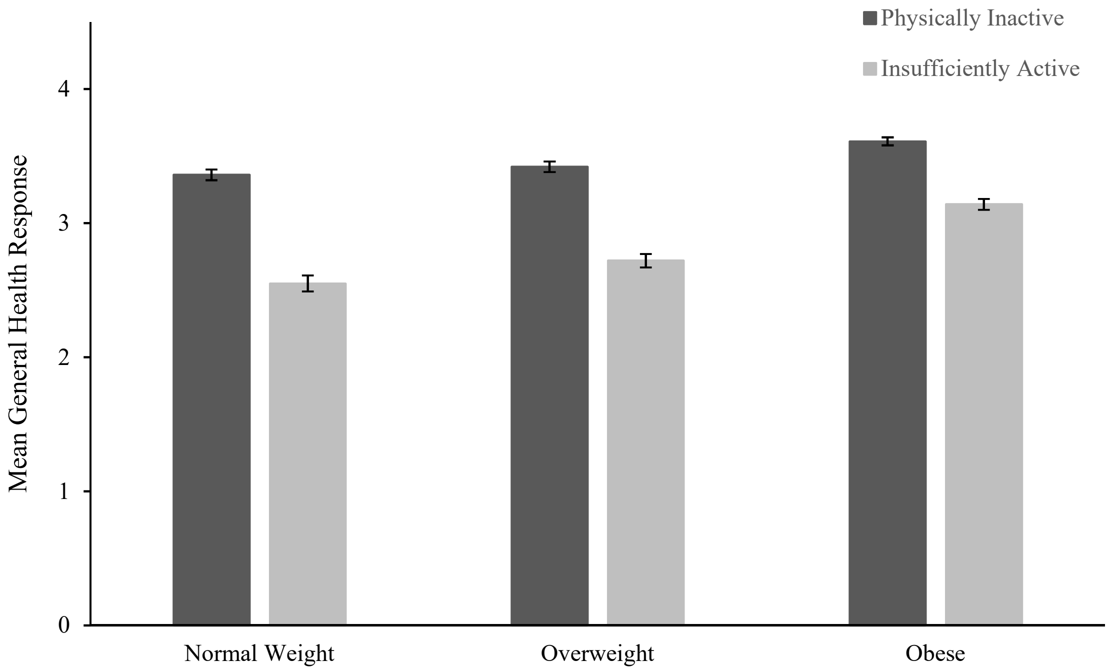

Figure 2. Mean self-reported GH response for BMI by physical activity level. Error bars represent the standard error of the mean.

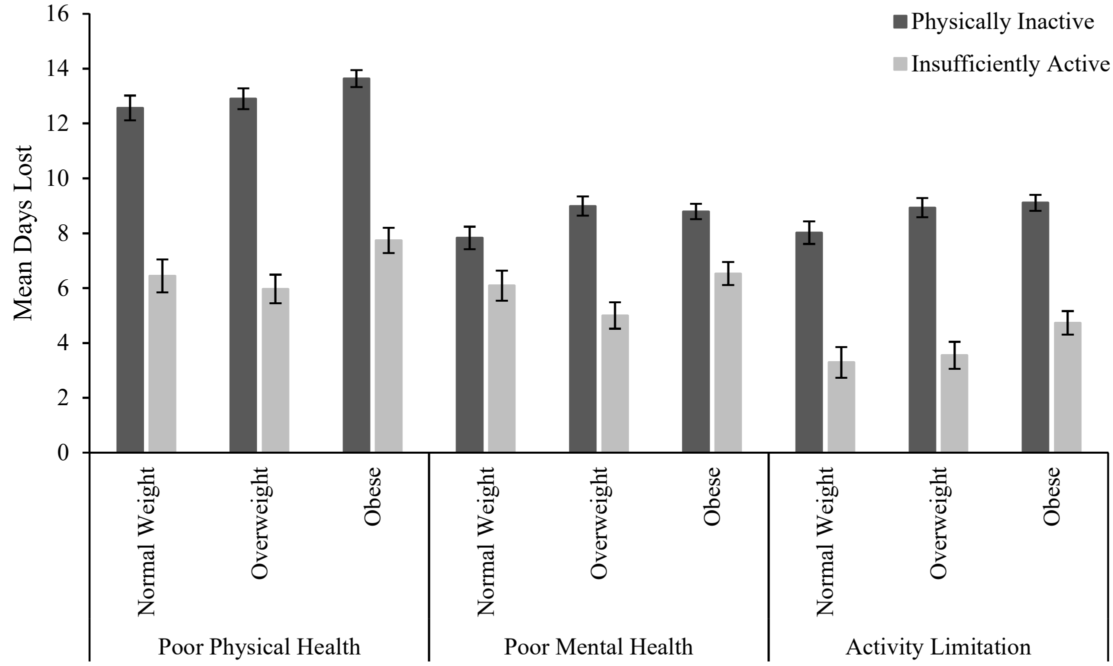

Figure 3. Mean self-reported days lost due to poor PH, poor MH and AL for BMI by physical activity groups. Error bars represent the standard error of the mean.

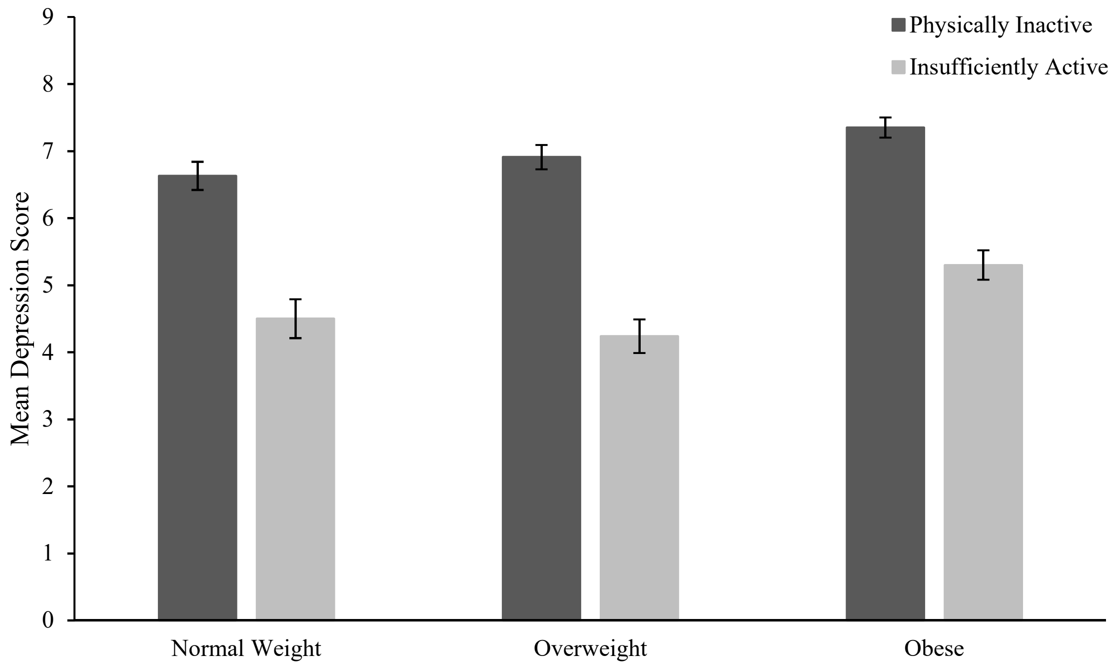

Figure 4. Mean PHQ-8 score for BMI by physical activity groups. Error bars represent the standard error of the mean.

BMI main effect. To explore the statistically significant main effect for BMI, further inspection of the univariate *F*-tests, as shown in Table 2, indicated there were mean differences for GH, poor PH, and PHQ-8, but not for poor MH, and AL with small effect sizes (η_p^2 = .02 to < .01). A Tukey HSD multiple comparison post hoc procedure, with Bonferroni-adjusted alpha of .01, was used to follow up on the significant univariate *F*-tests to determine where pairwise mean differences existed among BMI groups. Statistically significant mean differences in self-reported GH were found, where participants in the normal weight (M_{diff} = -0.39, 95% CI [-0.49, -0.29], *SE* = 0.04, $p < .001$) and overweight (M_{diff} = -0.28, 95% CI [-0.37, -0.20], *SE* = 0.04, $p < .001$) groups reported better GH than the obese group. However, the practical significance of the BMI group differences for self-reported GH were minimal, as each group mean fell within the response category of 'good'. A similar pattern was found for both poor PH and PHQ-8. Statistically significant mean differences in reported poor PH were found, where participants in the normal weight (M_{diff} = -

1.41, 95% CI [-2.45, -0.37], $SE = 0.44$, $p < .004$) and overweight ($M_{diff} = -1.30$, 95% CI [-2.24, -0.36], $SE = 0.40$, $p < .003$) groups reported less unhealthy days due to poor PH compared to the obese group. Thus, BMI group differences for poor PH indicated a gain of roughly one day of better health for normal weight and overweight participants compared to obese participants. Statistically significant mean differences in PHQ-8 scores were found, where participants in the normal weight ($M_{diff} = -0.84$, 95% CI [-1.34, -0.34], $SE = 0.21$, $p < .001$) and overweight ($M_{diff} = -0.73$, 95% CI [-1.18, -0.27], $SE = 0.19$, $p < .001$) groups scored lower than the obese group. However, the mean BMI group PHQ-8 scores indicated they all fell within the diagnostic classification for ‘mild depression’.

Table 2

BMI Univariate F-tests for Outcome Measures with Means and Standard Deviations (N = 4,442)

	Normal weight		Overweight		Obese					
Outcome measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*df*	*F*	*p*	η_p^2
General health	3.07	1.23	3.18	1.15	3.46	1.04	2, 4,436	54.82	.000	.02
Poor physical health	10.40	11.92	10.51	11.74	11.81	11.99	2, 4,436	5.47	.004	.00
Poor mental health	7.21	10.31	7.62	10.53	8.09	10.81	2, 4,436	1.99	.136	.00
Activity limitation	6.35	10.42	7.08	10.80	7.76	11.26	2, 4,436	4.46	.012	.00
PHQ-8	5.88	5.49	5.99	5.60	6.72	5.75	2, 4,436	8.92	.000	.00
n	1,034		1,411		1,997					

Note. M = mean; *SD* = standard deviation; *df* = degrees of freedom; η_p^2 = partial eta squared effect size; PHQ-8 = patient health questionnaire-8.

Physical activity main effect. To explore the statistically significant main effect for physical activity, further inspection of the univariate *F*-tests, as shown in Table 3, indicated the physical activity main effect was present for all DVs with small to medium effect sizes (η_p^2 = .01 to .07). The physical activity group differences showed the IA group mean (*M* = 2.86, *SD* = 1.07) for self-reported GH fell within the response category of 'very good'. This was a statistically significant relative gain in better health compared to the response category of 'good' for the PI group (*M* = 3.49, *SD* = 1.11). The IA group reported on average, a gain of roughly six and a half days of better health for poor PH, roughly three days of better health for poor MH, and roughly five days of better health for AL when compared to the PI group (see Table 3). For PHQ-8 the IA group (*M* = 4.75, *SD* = 4.44) mean scores fell within the diagnostic classification for 'none to minimal depression', whereas the PI group (*M* = 7.05, *SD* = 6.02) mean scores fell within the diagnostic classification for 'mild depression'. Results indicated the IA group had statistically significant lower depression symptom when compared to the PI group.

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Table 3

Physical Activity Univariate F-tests for Outcome Measures with Means and Standard Deviations (N = 4,442)

	Physically inactive		Insufficiently active					
Outcome measure	*M*	*SD*	*M*	*SD*	*df*	*F*	*p*	η_p^2
General health	3.49	1.11	2.86	1.07	1, 4,436	339.88	.000	.07
Poor physical health	13.17	12.36	6.83	9.64	1, 4,436	278.59	.000	.06
Poor mental health	8.64	11.24	5.91	8.93	1, 4,436	59.39	.000	.01
Activity limitation	8.81	11.81	3.98	7.97	1, 4,436	189.29	.000	.04
PHQ-8	7.05	6.02	4.75	4.44	1, 4,436	157.07	.000	.03
n	2,973		1,469					

Note. M = mean; SD = standard deviation; df = degrees of freedom; η_p^2 = partial eta squared; PHQ-8 = patient health questionnaire-8.

BMI by Physical Activity interaction effect. To explore the statistically significant interaction effect between BMI and physical activity on the combined DVs, a series of independent samples *t*-tests was run to determine where mean differences between physical activity groups existed for each BMI group on the five DVs. As shown in Table 4, significant mean differences were found for all pairs of variables. The results indicate obese group tended to produce a weaker magnitude of effect, according to Cohen's *d,* when compared to the normal weight and overweight groups, except for poor MH and AL. Moderate effect sizes were found for GH and poor PH (d = 0.46 to 0.69), followed by weak to moderate effects sizes for AL and PHQ-8 (d = 0.36 to 0.51). For poor MH the effect of physical activity for overweight group (d = 0.39), while weak was stronger than obese and normal weight groups (d = 0.21, d = 0.17, respectively). A similar pattern was found for AL, the overweight group reported a moderate effect (d = 0.51) of physical activity, while normal weight and obese groups reported weak effects (d = 0.47, d = 0.40, respectively).

Table 4

Independent Samples T-test Between BMI and Physical Activity Groups on Outcome Measures (N = 4,442)

	Physically inactive		Insufficiently active							
Outcome measures	*M*	*SD*	*M*	*SD*	M_{diff}	*t*	*df*	*p*	*d*	95% CI
Normal weight	(*n* = 669)		(*n* = 365)							
General health	3.36	1.21	2.55	1.08	-0.81	-10.67	1,032	.000	0.69	[0.56, 0.83]
Poor physical health	12.57	12.50	6.44	9.6	-6.12	-8.14	1,032	.000	0.53	[0.40, 0.66]
Poor mental health	7.83	10.97	6.09	8.89	-1.74	-2.60	1,032	.010	0.17	[0.04, 0.30]
Activity limitation	8.02	11.40	3.29	7.42	-4.74	-7.15	1,032	.000	0.47	[0.34, 0.59]
PHQ-8	6.63	5.96	4.5	4.15	-2.12	-6.04	1,032	.000	0.39	[0.26, 0.52]
Overweight	(*n* = 925)		(*n* = 486)							
General health	3.42	1.13	2.72	1.04	-0.69	-11.25	1,409	.000	0.64	[0.52, 0.75]
Poor physical health	12.90	12.30	5.97	8.96	-6.94	-10.99	1,409	.000	0.62	[0.50, 0.73]
Poor mental health	8.99	11.33	5	8.18	-3.99	-6.88	1,409	.000	0.39	[0.28, 0.50]
Activity limitation	8.93	11.86	3.55	7.24	-5.38	-9.14	1,409	.000	0.51	[0.40, 0.62]
PHQ-8	6.91	6.04	4.24	4.13	-2.67	-8.73	1,409	.000	0.49	[0.38, 0.60]
Obese	(*n* = 1,379)		(*n* = 618)							
General health	3.61	1.02	3.14	1.02	-0.46	-9.34	1,995	.000	0.46	[0.36, 0.56]
Poor physical health	13.64	12.32	7.74	10.11	-5.90	-10.43	1,995	.000	0.51	[0.41, 0.60]
Poor mental health	8.79	11.29	6.53	9.45	-2.26	-4.34	1,995	.000	0.21	[0.12, 0.31]
Activity limitation	9.11	11.97	4.73	8.74	-4.38	-8.18	1,995	.000	0.40	[0.30, 0.49]
PHQ-8	7.35	6.03	5.3	4.78	-2.06	-7.49	1,995	.000	0.36	[0.27, 0.46]

Note. *M* = mean; *SD* = standard deviation; M_{diff} = mean difference; *df* = degrees of freedom; *d* = Cohen's *d*; CI = confidence interval; PHQ-8 = patient health questionnaire-8.

Chapter 4: Discussion

The aim of the current study was to investigate the effects of a small change in physical activity (PI versus IA) across BMI groups (normal weight, overweight, obese) on the outcome measures of HRQOL-4 and PHQ-8 depression symptoms, using a nationally representative cross-sectional sample of adults. More specifically, the current study sought to identify the potential differences in perceived level of GH, number of days for poor PH, poor MH and AL, and differences in current level of depression symptoms. The findings of the current study will add to the emerging area of research focusing on small changes in physical activity for health-related gains in contrast to weight loss for overweight and obese populations. The current sample characteristics adequately represents the target population of interest, as over 76% participants were classified as either overweight or obese, with 67% PI and 33% IA. The demographic characteristics of the sample suggest these findings are generalisable to a predominantly white, older, well-educated population.

It is noted, direct comparability of the present study with previous research is limited as population-based studies typically dichotomise variables to differentiate between mutually exclusive categories, such as physical activity endorsed as yes (physically active) or no (PI; Adamson et al., 2015; Adamson et al., 2016; Austin et al., 2012), poor GH reported as poor (fair/poor) or good (good, very good or excellent health; Brown et al., 2003; Hassan, Joshi, Madhavan, & Amonkar, 2003; Imai et al., 2012), a cut point of ≥ 14 days to determine PH, MH, AL impairments (Brown et al., 2014; Dankel et al., 2016b), and PHQ-8 score of ≥ 10 to determine the presence or absence of a clinical depressive disorder (Kroenke et al., 2009; Zhao et al., 2009).

Interpretation of Findings

The first research question investigated the effects of BMI on HRQOL and depression symptom outcomes and was found to be significant. Tukey post hoc procedures found significant differences between BMI levels for GH, poor PH and depression symptoms. However, in terms of meaningfulness, the respective effect sizes were small suggesting there is limited practical significance to these findings. Nevertheless, BMI was shown to have an inverse relationship with GH that is consistent with earlier US population-based studies (Hassan et al., 2003; Imai et al., 2012). While the current study found a very low effect size for poor PH, a sample of Malaysian pre-diabetes patients found those who were overweight or obese had statistically significant poorer PH (reduced physical functioning, increased bodily pain and reduced GH; as measured by SF-36), compared to those who were of normal weight (Ibrahim et al., 2014). Additionally, Hassan et al. (2003) found severely obese (BMI > 35) and obese (BMI > 30) participants had an 87% and 21% increased odds (respectively) of reporting ≥ 14 days of poor PH compared to normal weight participants. Conversely, Austin et al. (2012) found no relationship between BMI and PH. These data suggest overweight and obesity has a negative impact on PH, which is inconsistent across studies. Yet, elevated levels of functional limitations is commonly experienced by this population (An & Shi, 2015) and lends support to poor PH outcomes. Non-significant differences were found for poor MH, which is consistent with previous research (Ibrahim et al., 2014; Wilkins et al., 2018). While BMI differences for AL was not supported in the current study (due to conservative alpha), Hassan et al. (2003) found severely obese and obese participants had 73% and 22% (respectively) increased odds of reporting ≥ 14 days of AL compared to normal weight participants. Of note, the increased odds of poor PH and AL reported by Hassan et al. (2003) emphasise the additional challenges faced by severely obese individuals in maintaining their self-care, work or recreational activities due to poor physical and mental health over the past 30 days. The different findings between studies for AL may result from: (a) the type of variable analysed (i.e., categorical, cut point ≥14 days) versus continuous, and (b) two categories of obesity (obese and severely obese) compared to obese in the current study. The significant findings for depression symptoms are consistent with past research that has found a positive relationship between BMI-depression (Luppino et al., 2010).

Research question two investigated the effects of physical activity on HRQOL and depression symptom outcomes and was found to be significant. Unlike BMI, the effect of physical activity was present for each level of HRQOL and depression symptoms, with small to moderate effect sizes. The current findings are consistent with past research for HRQOL (Brown et al., 2014; Brown et al., 2003; Heesch, van Uffelen, van Gellecum, & Brown, 2012) and depression symptoms (Lambert et al., 2018; Mammen & Faulkner, 2013). In a recent population-based study, Brown and colleagues (2014) investigated the effects of five levels of physical activity (inactive, 10-60, 61-149, 150-300, >300 minutes per week) on HRQOL (combined PH and MH, ≥ 14 days indicating impairment) among adults with and without limitations. The authors found that as physical activity increased the odds of reporting ≥ 14 days of poor HRQOL decreased for adults without and more so for those with limitations. This trend levelled off once 150 minutes of physical activity per week was met. Similarly, Heesch et al. (2012) evaluated seven levels of physical activity ranging from none to very high (none 0-9, very low 10-45, low 45-75, intermediate 75-150, high 150-225, very high 225-275 minutes per week) in two cohorts of older Australian women, across three time points (over six years) with walking as their only physical activity. In concurrent models, it was found engaging in physical activity from as little as 45 to 75 minutes per week, resulted in significant improvements in HRQOL when compared to no physical activity. As with Brown et al. (2014), once 150 minutes of physical activity per week was reached improvements in HRQOL were less prominent. These data provide evidence that 10-60 or 45-75 minutes per week of physical activity (including walking) can produce significant increases in HRQOL in the general population (Brown et al., 2014) and older women (Heesch et al., 2012).

There is a paucity of evidence for depression with changes in physical activity from PI to IA and represents a significant research gap in the literature. Nevertheless, a recent randomised controlled trail among depressed adults found a change in physical activity from 29.5 to 97.6 minutes per week over an eight-week period decreased depression levels from moderate to mild depression in the intervention group (Lambert et al., 2018). While this study with depressed adults is not directly comparable to the current population-based study, these results support the premise that small changes in physical activity can reduce depression symptoms. Additionally, a systematic review by Mammen and Faulkner (2013) adds further support to the current findings with evidence suggesting low levels of physical activity, particularly for those who are PI, can improve or prevent depression.

Research question three was supported. An interaction effect was present for all combinations of BMI by physical activity on HRQOL and depression symptoms. It is interesting to note, the magnitude of effect of physical activity for the overweight group is larger across outcome variables (except GH) when compared to normal weight and obese groups. It may be the case that the overweight group participants were able to engage in a larger volume or higher intensity of IA compared to those in the obese group, which is not captured in the current data. This seems plausible, as BMI increases balance systems are disrupted by additional body mass, increasing risk of falls and injury (Forhan & Gill, 2013). The excess body weight affects large muscle functioning (An & Shi, 2015) and applies pressure to the lower back, knee, and hip joints creating pain in these regions (Forhan & Gill, 2013). Therefore, having a larger body mass and increased weight would impact the obese group more so than those who are overweight. Despite this disadvantage the obese group were found to have a moderate magnitude of effect for PH, equating to a gain of nearly six days (equivalent to 20%) improved PH over the past 30 days. Similarly, AL for the obese group shows gains of over four days with a weak to moderate magnitude of effect. The overweight group, on average, experienced one additional day of better health for PH, MH and AL when compared to the obese group. These findings identify a meaningful significant difference in HRQOL outcomes for overweight and obese participants in the current study. These findings adds support to research that has previously found larger gains in HRQOL for people with limitations compared to those without limitations (Brown et al., 2014; Buder et al., 2016). Consistent with the literature depression symptoms improved in all groups (Adamson et al., 2015; Dankel, Loenneke, & Loprinzi, 2016a; Meng & D'Arcy, 2013). However, more research is needed concerning effects of low levels of physical activity on depression symptoms in overweight and obese populations.

Strengths and Limitations

There are a number of strengths of the current study. The use of global indicators for HRQOL outcome measure (i.e., number of days in the past 30) facilitates not only ease of interpretation of the findings, it also provides the general public with a meaningful outcome that is tangible and relatable. Further, it provides health professionals with scientific evidence they can discuss directly with patients to encourage the reduction of PI and sedentary behaviours and increase physical activity. The use of a large nationally representative sample of US adults enhances generalisability of the findings to other Western contexts with similar levels of overweight, obesity, and PI, such as Australia and the United Kingdom. The BRFSS is a well-established (commenced in 1984) and widely endorsed survey instrument used for measuring and understanding population health and informs the development of health promotion campaigns. Moreover, countries such as Australia, Canada, China, Italy, and South Korea have utilised the BRFSS as a model to inform the technical development of their own national surveillance systems further substantiating its validity (CDC, 2014b).

There are a number of limitations to the current study. The cross-sectional design limits the ability to infer causality. The use of self-report data is subject to socially desirable responding (Adams et al., 2005; Van de Mortel, 2008). While socially desirable responding can lead to overreporting of physical activity (Adams et al., 2005), the BRFSS physical activity modules have been found to be valid and reliable when compared to accelerometer and pedometer data (Yore et al., 2007). Likewise, BMI calculated from self-reported weight and height has been found comparable to objectively measured weight and height (Spencer, Appleby, Davey, & Key, 2002). Participants with incomplete response were excluded from the analysis, therefore potentially introducing selection bias. Additionally, the characteristics and responses of this missed population limits generalisability to people who are inclined to: (a) undertake a lengthy telephone survey, and (b) provide answers to all survey questions. The use of a telephone survey instrument systematically excludes people who do not live in houses or own a mobile phone. Consequently, socioeconomically disadvantaged or homeless people who are reported to have lower HRQOL (Sun, Irestig, Burström, Beijer, & Burström, 2012) and increased prevalence of depression (Fazel, Khosla, Doll, & Geddes, 2008) compared to the general population were likely underrepresented.

The statistical analyses of the current study were subject to various assumption violations; therefore, the findings should be viewed with caution. These violations were compensated with a more conservative alpha (.01) to determine statistical significance. However, when sample sizes are large this can lead to highly statistically significant results purely due to high statistical power that may lead to erroneously rejecting the null hypothesis and making a Type I error (Pituch & Stevens, 2016). The current study sought to evaluate the meaningfulness and practical significance of the results that was determined by effect size (Ferguson, 2009; Pituch & Stevens, 2016). Due to the different measurement scales included across the five outcomes, Cohen's *d* (a standardised measure) was calculated to interpret the interaction effect between BMI and physical activity, as this allowed direct comparison across each of the outcomes (Sullivan & Feinn, 2012).

Implications and Future Research

The steady continued increase of global overweight and obesity over the past three decades (The GBD 2013 Obesity Collaboration et al., 2014) strongly suggests new and innovative ways for increasing positive health outcomes among overweight and obese populations are desperately needed. One such example is a contemporary BPS intervention developed by Nguyen, Bera, Bota, and Hsu (2016) to change the maladaptive eating habits of obese individuals. Briefly, the BPS intervention provided participants with: (a) education that explained the biological contribution of nutrition and insulin to obesity, and its effect on body fat and glucose levels; (b) cognitive behaviour therapy to reframe maladaptive thought processes and faulty cognitions (i.e., focus on insulin control not eating less); and (c) behavioural adaptation techniques to develop new healthy eating habits and avoid physiological sugar cravings (Nguyen et al., 2016). Each domain of the BSP model was systematically applied and participants achieved an average of 10.8% weight loss. This intervention demonstrates a new way of approaching clinical treatment for overweight and obesity that could be adapted for physical activity behaviour change and is an area worthy of future exploration. For example, a physical activity intervention could include: (a) education about obesogenic environments, negative physiological responses to exercise (i.e., fear response), or the impact of weight and mass on physiological and biomechanical processes including functional limitations and pain; (b) reframing cognitive distortions such as 'I'm too fat to exercise', or cognitive behaviour therapy on how to cope with fear responses to exercise and weight stigma to reduce exercise avoidance; and (c) behavioural techniques on how to change sedentary behaviour habits, and develop and maintain achievable physical activity goals.

There are implications for health messages among overweight and obese populations. Everson-Hock et al. (2015) posits initiating physical activity among sedentary and PI people can have a larger effect on improving population health than focusing on increasing the activity levels of those who are already physical activity. Therefore, by changing the health message for overweight and obese populations regarding physical activity from recommended guideline adherence (i.e., ≥ 150 minutes moderate-to-vigorous physical activity per week), to developing more realistic and achievable goals may prove more acceptable and feasible. Such as, breaking up sedentary behaviour and PI with small amounts of physical activity (Sparling et al., 2015) to promote improved HRQOL and reduced depression symptoms. A recent study by Rosenberg et al. (2015) investigating the feasibility of an intervention to reduce sitting time in overweight and obese older adults found a statistically significant reduction in sedentary behaviour by 27 minutes per day (objectively measured) resulted in reduced depression symptoms and improved gait speed. These findings are promising as improvements in depression symptoms and mobility not only improve the lives of overweight and obese people, it may provide sufficient momentum for continued behaviour change.

From a clinical practice perspective, by presenting clear and easy to understand results (such as the findings from the current study) to overweight and obese patients within a counselling context, could facilitate a cognitive shift from negative to positive outcome expectations. This in turn may increase self-efficacy and the probability of engaging in physical activity. One method of increasing physical activity behaviour change in high-risk groups would be to consider activities that are less emotionally taxing, not thought of as formal ‘exercise’ and are easily acceptable (Shimazaki, Iio, Lee, Konuma, & Takenaka, 2016). This can be achieved through incorporating minute habitual changes to one’s lifestyle (Lutes et al., 2008). Shimazaki et al. (2016) research found walking to be one such activity that produced low psychological burden and high feasibility. Strategies for increasing physical activity incorporated into daily living can be as simple as using stairs, parking further away, take a short walk with family or friends, do some gardening or clean your home. However, efforts are needed to identify various types of physical activities, at the lower end of the continuum, that are feasible and acceptable among overweight and obese populations. This is of great importance as safety concerns and mobility issues are significant barriers to physical activity (Wingo et al., 2011).

Future research targeting ways of reducing barriers to and increasing the acceptability of physical activity are needed for overweight and obese populations. Research suggests externally imposed physical activity goals (e.g., ≥ 30 min per day of moderate-to-vigorous intensity physical activity) can reduce pleasure and contribute to low adherence rates, whereas allowing self-selection of physical activity intensity (e.g., light intensity) increases acceptability (Ekkekakis, 2009). From a Self-Determination Theory perspective allowing an element of choice within weight management and exercise programs facilitates the psychological need of autonomy, which is a critical concept for intrinsic motivation (Garip & Yardley, 2011). This would also foster relatedness and competence, as the individual would feel supported in their choice and feel confident they are able to achieve the negotiated goals. This is crucial in overweight and obese populations as they face significant barriers to physical activity (e.g., fear of pain and injury, low self-efficacy, lack of motivation, embarrassment). The provision of tangible scientific evidence that health gains are realistically achievable from engaging in small amounts of physical activity and reducing sedentary time, may provide sufficient hope and encouragement to overcome some of the reported psychological barriers (Buder et al., 2016).

The issue of weight stigma is another significant barrier to physical activity as it contributes to weight management obstruction (Puhl & Heuer, 2010). The high levels of psychological distress overweight and obese people experience as a result of weight stigma increases body dissatisfaction and low self-esteem, and reduces motivation to engage in physical activity, particularly in public places (Garip & Yardley, 2011; Puhl & Heuer, 2010). To increase the success of physical activity interventions the issue of weight stigma is an important consideration to be included in the development of future interventions.

Current knowledge is limited in the area of small changes in physical activity among overweight and obese populations. Research suggests a physical activity floor effect may exist somewhere between 10-60 or 45-75 minutes per week for adults (Brown et al., 2014; Heesch et al., 2012). Other evidence indicates people with mental and physical health conditions who are PI and sedentary can greatly benefit from commencing any form of physical activity (Everson-Hock et al., 2015). Although, more research is needed to determine the minimum dose-response relationship between physical activity, HRQOL and depression with overweight and obese populations.

Conclusion

Physical activity alone will not decrease the obesity epidemic. However, raising the awareness of the potential health-related benefits of low levels of physical activity would provide a stimulus for health professionals to re-evaluate interventions and develop realistic goals to promote physical activity for health. There is no simple solution to the obesity epidemic, nevertheless, if overweight and obese people are encouraged and supported to make small changes to their lifestyle, such as engaging in a little physical activity, they may achieve significant and meaningful gains in HRQOL and depression symptoms.

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Appendix A

Descriptive Statistics for BMI and Physical Activity Groups by Outcome Measures (N = 4,442)

	Physically inactive			Insufficiently active		
Outcome measures	*M* (*SD*)	Skew (*SE*)	Kurt (*SE*)	*M* (*SD*)	Skew (*SE*)	Kurt (*SE*)
Normal weight	(*n* = 669)			(*n* = 365)		
General health	3.36 (1.21)	-0.21 (0.09)	-0.95 (0.19)	2.55 (1.08)	0.50 (0.13)	-0.33 (0.26)
Poor physical health	12.57 (12.50)	0.47 (0.09)	-1.53 (0.19)	6.44 (9.60)	1.68 (0.13)	1.43 (0.26)
Poor mental health	7.83 (10.97)	1.20 (0.09)	-0.16 (0.19)	6.09 (8.89)	1.72 (.013)	1.83 (0.26)
Activity limitation	8.02 (11.40)	1.09 (0.09)	-0.46 (0.19)	3.29 (7.42)	2.79 (.13)	6.91 (0.26)
PHQ-8	6.62 (5.96)	0.90 (0.09)	-0.11 (0.19)	4.50 (4.15)	1.00 (0.13)	0.35 (0.26)
Overweight	(*n* = 925)			(*n* = 486)		
General health	3.42 (1.13)	-0.17 (0.08)	-0.85 (0.16)	2.72 (1.04)	0.31 (0.11)	-0.47 (0.22)
Poor physical health	12.90 (12.30)	0.40 (0.08)	-1.54 (0.16)	5.97 (8.96)	1.89 (0.11)	2.34 (0.22)
Poor mental health	8.99 (11.33)	0.98 (0.08)	-0.65 (0.16)	5.00 (8.18)	2.15 (0.11)	3.68 (0.22)
Activity limitation	8.93 (11.86)	0.95 (0.08)	-0.81 (0.16)	3.55 (7.24)	2.78 (0.11)	7.12 (0.22)
PHQ-8	6.91 (6.04)	0.94 (0.08)	0.04 (0.16)	4.24 (4.13)	1.33 (0.11)	1.34 (0.22)
Obese	(*n* = 1,379)			(*n* = 618)		
General health	3.61 (1.02)	-0.31 (0.07)	-0.59 (0.13)	3.14 (1.02)	0.07 (0.10)	-0.55 (0.20)
Poor physical health	13.64 (12.32)	0.31 (0.07)	-1.61 (0.13)	7.74 (10.11)	1.34 (0.10)	0.33 (0.20)
Poor mental health	8.79 (11.29)	1.02 (0.07)	-0.57 (0.13)	6.53 (9.45)	1.56 (0.10)	1.15 (0.20)
Activity limitation	9.11 (11.97)	0.90 (0.07)	-0.89 (0.13)	4.73 (8.74)	2.03 (0.10)	2.93 (0.20)
PHQ-8	7.35 (6.03)	0.86 (0.07)	0.02 (0.13)	5.30 (4.78)	1.15 (0.10)	0.85 (0.20)

Note. *M* = mean; *SD* = standard deviation; *SE* = standard error; PHQ-8 = patient health questionnaire-8.

Appendix B

Variance-covariance Matrix, Means, and Standard Deviations for Each Pair of Variables in the Multivariate Model (*N* = 4,442)

	Physically inactive						Insufficiently active					
	M (*SD*)	GH	PH	MH	AL	PHQ-8	*M* (*SD*)	GH	PH	MH	AL	PHQ-8
Normal weight	(*n* = 669)						(*n* = 365)					
General health	3.36 (1.21)	1.47					2.55 (1.08)	1.17				
Physical health	12.57 (12.50)	9.24	156.23				6.44 (9.60)	6.09	92.22			
Mental health	7.83 (11.00)	2.51	13.81	120.30			6.09 (8.89)	2.82	19.35	79.06		
Activity limitation	8.02 (11.40)	6.21	81.67	32.38	129.97		3.29 (7.42)	4.19	44.22	17.70	55.12	
PHQ-8	6.62 (5.96)	2.90	25.10	37.56	30.79	35.57	4.50 (4.15)	1.60	14.24	19.77	12.94	17.25
Overweight	(*n* = 925)						(*n* = 486)					
General health	3.42 (1.13)	1.29					2.72 (1.04)	1.07				
Physical health	12.90 (12.30)	8.77	151.39				5.97 (8.96)	4.34	80.33			
Mental health	8.99 (11.33)	3.06	25.45	128.45			5.00 (8.18)	1.59	12.01	66.88		
Activity limitation	8.93 (11.86)	6.94	89.27	44.75	140.56		3.55 (7.24)	2.87	37.02	17.81	52.34	
PHQ-8	6.91 (6.04)	2.68	23.60	40.56	30.68	36.45	4.24 (4.13)	1.62	11.32	19.69	13.68	17.07
Obese	(*n* = 1,379)						(*n* = 618)					
General health	3.61 (1.02)	1.05					3.14 (1.02)	1.03				
Physical health	13.64 (12.32)	6.65	151.83				7.74 (10.11)	5.34	102.11			
Mental health	8.79 (11.29)	2.42	19.70	127.51			6.53 (9.45)	2.17	16.48	89.33		
Activity limitation	9.11 (11.97)	5.41	79.47	43.43	143.32		4.73 (8.74)	3.68	50.10	31.68	76.40	
PHQ-8	7.35 (6.03)	2.16	20.03	39.11	31.86	36.30	5.30 (4.78)	1.84	18.08	26.07	22.93	22.83

Note. *M* = mean; *SD* = standard deviation; GH = general health; PH = physical health; MH = mental health; AL = activity limitation; PHQ-8 = patient health questionnaire-8. The diagonals represent the variance of each variable with itself and off-diagonals represent the covariance between each variable pair.

Appendix C

Pearson's Bivariate Correlation Matrix, Means and Standard Deviations Between Each Pair of Dependent Variables for the Six Independent Variable Groups (*N* = 4,442)

	Physically inactive						Insufficiently active					
	M (*SD*)	GH	PH	MH	AL	PHQ-8	*M* (*SD*)	GH	PH	MH	AL	PHQ-8
Normal weight	(*n* = 669)						(*n* = 365)					
General health	3.36 (1.21)	-					2.55 (1.08)	-				
Physical health	12.57 (12.50)	.61**	-				6.44 (9.60)	.59**	-			
Mental health	7.83 (11.00)	.19**	.10**	-			6.09 (8.89)	.29**	.23**	-		
Activity limitation	8.02 (11.40)	.45**	.57**	.26**	-		3.29 (7.42)	.52**	.62**	.27**	-	
PHQ-8	6.62 (5.96)	.40**	.34**	.57**	.45**	-	4.50 (4.15)	.36**	.36**	.54**	.42**	-
Overweight	(*n* = 925)						(*n* = 486)					
General health	3.42 (1.13)	-					2.72 (1.04)	-				
Physical health	12.90 (12.30)	.63**	-				5.97 (8.96)	.47**	-			
Mental health	8.99 (11.33)	.24**	.18**	-			5.00 (8.18)	.19**	.16**	-		
Activity limitation	8.93 (11.86)	.52**	.61**	.33**	-		3.55 (7.24)	.38**	.57**	.30**	-	
PHQ-8	6.91 (6.04)	.39**	.32**	.59**	.43**	-	4.24 (4.13)	.38**	.31**	.58**	.46**	-
Obese	(*n* = 1,379)						(*n* = 618)					
General health	3.61 (1.02)	-					3.14 (1.02)	-				
Physical health	13.64 (12.32)	.53**	-				7.74 (10.11)	.52**	-			
Mental health	8.79 (11.29)	.21**	.14**	-			6.53 (9.45)	.23**	.17**	-		
Activity limitation	9.11 (11.97)	.44**	.54**	.32**	-		4.73 (8.74)	.41**	.57**	.38**	-	
PHQ-8	7.35 (6.03)	.35**	.27**	.58**	.44**	-	5.30 (4.78)	.38**	.37**	.58**	.55**	-

Note. *M* = mean; *SD* = standard deviation; GH = general health; PH = physical health; MH = mental health; AL = activity limitation; PHQ-8 = patient health questionnaire-8.

**Correlation is significant at $p < .01$.