The Effects of a Self-Management Treatment Package on Physical Activity in University Students with Depressive Symptoms

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Abstract

Research demonstrates that exercise interventions are effective in decreasing depressive symptoms; however, these treatments are infrequently implemented in clinical practice. Self-management techniques offer an effective, cost-efficient approach to teaching individuals with depression to engage in increased physical activity. This study evaluated a treatment package including goal setting, self-monitoring, and feedback for increasing participants' daily steps. Secondary measures included depressive symptoms, sleep quality and duration. A changing-criterion design within a concurrent multiple baseline design across two participant dyads was used. Results demonstrated that the treatment was efficacious for increasing walking in participants, with varying degrees of consistency. Additionally, increased walking may improve sleep duration. Mid-treatment scores on the *University Student Depression Inventory* showed decreases in some symptoms (i.e., lower total and, or subscale[s] scores) suggesting walking may be associated with a decrease in some symptoms. Clinician ratings on the *Clinical Global Impression Scale* indicated that the change in symptoms were significant.

Keywords: self-management, physical activity, depression, sleep, changing-criterion design

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Table of Contents

List of Tables

List of Figures

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According to the *Diagnostic and Statistical Manual, Fifth edition* (DSM-V), a major depressive episode is characterized by persistent depressed mood, decreased interest in most or all daily activities, significant change in body weight or appetite, insomnia or hypersomnia, fatigue or decreased energy, feelings of worthlessness or undue guilt, reduced ability to think or concentrate or indecisiveness, reoccurring thoughts of death, and suicidal ideation or attempts (American Psychiatric Association, 2013). Clinical depression is a significant mental health concern, affecting more than 300 million people world-wide (World Health Organization, 2018). Prevalence rates are estimated to be between 2% to 15% globally (Nystrom et al., 2015). Ibrahim et al. (2013) conducted a systematic review to examine whether the prevalence of depression is greater among university students than the general population. Twenty-four studies were analyzed that included adult participants (mean age range 14.7-26.1 years) from universities in North America, Europe, and East Asia. The results indicated the mean prevalence rate of depression among university students to be 30.6% compared to 9% in the general population (Ibrahim et al., 2014). Further, a recent survey from the *American College Health Association* (National College Health Assessment II [NCHA II], 2018) involving 88,178 adult students (18-30^{+} years of age) from 140 different institutions, showed that the number of postsecondary students diagnosed with depression and, or receiving treatment for depression is on the rise from 14.7% in 2016 to 18.1% in 2018. From the total student sample, 41.9% reported feeling “so depressed that it was difficult to function,” 12.1% reported considering suicide, and 1.7% reported attempting suicide at

some point in the 12-month-period prior to completing the survey (NCHA II, 2018). The World Health Organization (WHO, 2018) states that depression is the leading "cause of disability" globally. The high prevalence rate, increased risk of mortality, and costs associated with providing care for individuals with depression requires significant economic and societal resources to address factors such as unstable employment and elevated risk of chronic physical health concerns (Carlbring et al., 2013; Jansen et al., 2017; Montano et al., 2018). Compared to more traditional depression treatments (e.g., cognitive behaviour therapy, pharmacology), physical activity is a low-cost intervention (Knapen et al., 2015; Kvam et al., 2016; Nystrom et al., 2015) that generally requires less direct (e.g., in-person, therapist-directed, consultation) support form a clinical or medical professional.

Physical Activity and Depression

Engagement in physical activity has been associated with enhanced cognitive functioning and overall physical and psychological health (Carek et al., 2011; Nysrtrom et al., 2016). Previous studies also indicate that engaging in physical activity improves symptoms associated with depression (e.g., Carek et al., 2011; Cooney et al., 2013; Mead, et al., 2009; Pelletier, et al., 2017; Wolff et al., 2011). For example, it is widely cited that engagement in physical activity improves sleep disturbances associated with depression (Pelletier et al., 2017; Wolff et al., 2011).

Vetrovsky and colleagues (2017) examined the efficacy of a pedometer-based walking program involving progressive weekly step goals set to 15% above each participant's baseline mean for increasing walking in 23 physically inactive (i.e., steps <8000/day) adults aged 18 to 64 years. Comparison of baseline and post-study

assessments of walking frequency, mental health, and quality of life showed that the average daily step count across participants increased from 5043 to 6719 steps per day. Further, participants' mean overall scores on the *Hospital Anxiety and Depression Scale* (Zigmond & Snaith, 1983) decreased from 5.3 (during baseline) to 2.8 post-intervention and mean subscale scores on the *Medical Outcomes Study 36-Item Short-Form Health Survey's* (Ware & Sherbourne, 1992) *quality of life, vitality, physical functioning*, and *general health* subscales increased; all small but statistically significant outcomes.

A study by Doyne et al. (1987) involving 40 adult women diagnosed with a depressive disorder compared the effectiveness of running and weight-lifting exercise as a treatment for depression. Participants were randomly assigned to one of the exercise groups or the control group (waitlist for later treatment) for a duration of eight weeks. Depression was measured using the *Beck Depression Inventory* (BDI; Beck & Beamesderfer, 1974), *Hamilton Rating Scale for Depression* (HRSD; Hamilton, 1960), and *Depression Adjective Check List, Form A* (DACL; Lubin, 1965). Assessments were conducted during baseline, pre-, mid-, and post-treatment, and at 1, 7, and 12 months post-completion of the study. The results showed statistically and clinically significant decreases in overall mean depression scores for both exercise groups across assessments with scores progressively decreasing from baseline to post-treatment. Reduced scores (relative to baseline) across all assessments were maintained up to 12 months post completion of the study. The authors reported no significant differences in change in depression scores between the two exercise groups, suggesting that aerobic and weight-training exercise are equally effective at decreasing depressive symptoms. The waitlist control group showed relatively smaller decreases in mean depression scores from

baseline to post-treatment on the BDI and DACL, and an increase from pre- to post-treatment scores on the HRSD (no baseline assessment was conducted for this measure).

Prathikanti et al. (2017) conducted a study involving 38 adults with mild-to-moderate-major depression. The results of this study showed clinically and statistically significant reductions in depression as a result of increased exercise. Participants in this study were randomly assigned to the exercise (i.e., 90-minutes of yoga) or the "attention control" group which involved a group-based, 90-minute didactic instruction on the history and philosophy of yoga; both groups met twice per week for eight weeks. Both groups were given the BDI to complete once every two weeks, for eight weeks. Results of BDI assessments between groups showed a significantly larger decrease in the exercise group's mean scores from baseline to the final assessment (20.98 to 11.51) than those observed in the control group (19.92 to 16.93), possibly indicating that instruction in exercise is not sufficient to decrease depression.

Mather et al. (2002) conducted a study with 86 older adults (53 years or older) with depression symptoms and a diagnosis of a mood disorder to compare the effects of exercise (i.e., endurance, muscle-strengthening with weights, and stretching) and health education (i.e., group-based didactic instruction with question and answer period) on depressive symptoms. Prior to participation in the study, all participants completed a minimum of 6 months of antidepressant therapy that did not result in a therapeutic "response" (i.e., symptom reduction >50% on HRSD scores). As such, the researchers identified a 30% reduction in HRSD scores from baseline levels as the criteria to indicate a treatment response to exercise. The results of HRSD assessments indicated that a greater proportion of the exercise group participants (versus control group) reported at

least a 30% reduction in HRSD scores; however, the difference in scores between groups was not statistically significant. Statistically significant reduced scores were maintained for both groups at the 34-week follow-up assessment; however, the exercise group's symptoms further decreased from post-treatment assessment whereas the control group's symptoms remained at post-treatment levels. These results suggest that the effects of increased engagement in exercise may persist post-engagement.

Both the National Institute of Mental Health (NIMH; Depression & College Students, 2003) and the WHO (Mental Health Gap Action Program, 2012) recommend physical activity interventions as part of standard care for individuals with depression. *Physical activity* is defined as any movement involving the contraction of muscles and energy expenditure beyond a resting level (Carek et al., 2011; Pelletier et al., 2017). *Exercise* involves planned, structured physical activity, and the repetition of activities to achieve a specific aim involving improved physical fitness (Carek et al., 2011; Pelletier et al., 2017). Cooney et al. (2013) conducted a meta-analysis of 39 randomized controlled trials (RCTs) including a total of 374 adults (18 years of age or older) with moderate to severe depression. The meta-analysis examined the effectiveness of various forms of physical activity on the reduction of depression symptom severity (among other secondary measures). Results demonstrated that physical activity was *more* effective than no treatment (e.g., social conversation), bright light therapy, and placebo, and *as* effective as psychological (i.e., cognitive therapies) and pharmacological therapies. Finally, in cases where more traditional therapies may be necessary, previous studies have demonstrated that physical activity interventions can effectively supplement

pharmacological (Carek et al., 2011; Mather et al., 2002) and psychological (Carek et al., 2011) treatments to further improve symptoms of depression.

Despite the wealth of support for physical activity as an effective treatment for depression, it is rarely prescribed as a primary or conjunctive treatment (Cark et al., 2011). A potential reason for the limited use of physical activity as a treatment for depression may be the fact that a clear dose-response rate has not been established (Blumenthal et al., 2012; Nystrom et al., 2016). Some researchers have demonstrated reductions in depressive symptoms with mild forms of physical activity such as yoga (Prathikanti et al., 2017) and walking (Vetrovsky et al., 2017), while others have successfully decreased symptoms using moderate to vigorous forms of activity (e.g., running, weight training, resistance exercise, and aerobic exercise; Doyne et al., 1987; Dunn et al., 2001; Wolff et al., 2011). Without a clear understanding of the type, level, and duration of physical activity needed to produce (and maintain) a reduction in depressive symptoms it is difficult to develop criteria for effective physical activity-based treatment. In addition, dose-response rates may vary among individuals within a particular sample (i.e., university students with depressive symptoms). For example, factors such as the severity of depression, age, and weight of the individual may impact the dose-response rate. Further research on the specific factors (e.g., diagnosis, history of engagement in physical activity) that might determine an effective dose-response rate is needed to inform the design of physical activity-based interventions.

Individuals diagnosed with depressive disorders report low engagement in, and little motivation to initiate physical activity (Schneider et al., 2016). Similar findings are true of the general college and university population. A recent survey showed 46.2% of

students engage in less than the minimum recommendation for engagement in physical activity (i.e., a minimum of 30 minutes of moderate-intensity physical activity 5 days per week, or 20 minutes of vigorous-intensity physical activity, 3 days per week; American College Health Association, 2016). Furthermore, fatigue and decreased energy levels characteristic of depression (APA, 2013) may serve as setting events or abolishing operations that decrease the likelihood of engagement in physical activity. A recent meta-analysis by Kvam et al. (2016) examined 23 RCTs involving 977 adults with major depressive disorder, or minor or unipolar depression, or dysthymia and identified physical activity. The results of the analysis indicated that exercise was an effective stand-alone treatment for individuals not currently receiving treatment, and as an adjunctive treatment when combined with antidepressants; albeit, the results of the latter were not statistically significant. The efficacy of exercise plus common psychological therapies (i.e., psychotherapy or cognitive behaviour therapy) was not assessed as the meta-analysis only included one study which compared the treatment types. However, a common limitation across studies was a lack of patient adherence with physical activity prescriptions which impacted the feasibility and effectiveness of implementing such treatments (Kvam et al., 2016). To increase the likelihood of adherence, treatments can be individualized based on a client's abilities and preferences (Nystrom et al., 2015). The majority of studies examining the effectiveness of physical activity-based treatments in the psychological literature involved RCTs where physical activity occurred under the supervision of a researcher, research assistant, or fitness instructor (e.g., Doyne et al., 1987; Mather et al., 2002; Prathikanti et al., 2017). Recognizing the limited generalizability of these results, Kvam et al. (2016) highlighted the need for more applied

research to identify the feasibility and efficacy of physical activity-based treatments in clinical settings.

Self-Management

Behaviour analytic self-management interventions (hereafter referred to as *self-management*) involve the personal use of behavioural methods to alter one's own behaviour (Cooper et al., 2007; Mayer et al., 2012). Self-management interventions have been used to effectively increase various forms of physical activity, across a wide range of populations such as aerobic activity, Powerball©, and pull-ups for a healthy adult (Furlonger et al., 2017), walking for a group of overweight adults (Van Wormer, 2004), and running distance for five college students (Wack et al., 2014). No known studies have used this technology to increase physical activity in university students with depressive symptoms. The use of self-management strategies-including goal setting, self-monitoring, and feedback have the capacity to generalize beyond the context of the research and the specific behaviours being targeted (Cooper et al., 2007; Gajar et al., 1984; Sanders & Glynn, 1981). For example, Gajar et al. (1984) demonstrated that self-recording and feedback effectively increased the rate of positive social interactions (e.g., commenting, asking questions) among two adults with acquired brain injury in a clinical setting, which subsequently generalized to a less structured group setting.

Physical Activity and Self-Management

Self-management interventions targeting physical activity typically involve multi-component treatment packages and the use of wearable devices that measure activity, such as accelerometers, pedometers, and heart-rate monitors. In a review of recent behavioural interventions targeting physical activity, Van Camp and Hayes (2012)

identified goal setting, self-monitoring, and feedback treatment packages as highly successful at increasing physical activity (i.e., daily calorie expenditure & frequency of steps) across a range of sample populations (e.g., obese, overweight, & healthy adults). Goal setting is a self-management technique used to improve future performance of the targeted behaviour. Goal setting involves setting a criterion level for the target behaviour and a specific time frame in which the behaviour should occur (Miltenberger, 2016, p. 418). Self-monitoring includes both observing the occurrences of one's own behaviour and recording each instance (self-recording or via a monitoring device) of those occurrences to assess progress toward one's goal (Miltenberger, 2016, p. 418; Nelson & Hayes, 1981). Studies examining the components of effective goal setting demonstrate that goals should be short-term and detailed (Brobst & Ward, 2002; Mellalieu et al., 2006). Finally, feedback in the context a of self-management intervention often involves another individual (e.g., researchers, therapists) delivering social positive reinforcement in the form of praise for correct performance of the target behaviour, as well as specific information on how to improve the future performance of the target behaviour (Miltenberger, 2016, p. 350).

The Fitbit Flex™ has been shown to be a valid and reliable device for tracking steps per day (Diaz et al., 2015; Kooiman et al., 2015). Diaz et al. (2015) analyzed the accuracy and reliability of the Fitbit One™ and Fitbit Flex™ devices by comparing minute-by-minute step count data (as well as energy expenditure) collected by the devices, to manual counts of steps. Manual counts were recorded via post-hoc scoring of video recordings of each participant's physical activity session. Each participant completed a four-component treadmill physical activity protocol including, *slow*,

moderate, and *brisk* walking pace, as well as jogging (Diaz et al., 2015). Correlational analyses demonstrated the mean difference between the Fitbit and manual step counts to be –3.1 to –0.3 for the Fitbit One™, and –26.3 to –2.9 for the Fitbit Flex™. The authors noted that discrepancies between Fitbit data and manual data, during all three walking components of the physical activity protocol, involved the Fitbit devices underestimating the step counts. Kooiman et al. (2015) also examined the validity and reliability of the Fitbit Flex™ (as well as 9 other activity trackers) by comparing step counts obtained from the Fitbit Flex™ to step counts from previously validated devices, the Optogait system™ and the ActivPAL™. Test-retest reliability was assessed via intraclass correlation coefficients between the two testing periods (one week apart) which demonstrated that the Fitbit Flex™ had good test-retest reliability (0.81, p <0.01).

The Fitbit Flex™ has also been shown to be a valid device for measuring sleep (Mautua et al., 2016) however the research in this area is limited. Mantua et al. (2016) examined the validity of the Fitbit Flex™ (as well as four other devices) to record sleep data by comparing data from the Fitbit Flex™ with polysomnography (PSG) recordings – a device that has been shown to yield highly valid and reliable sleep data. Results of Pearson's correlations indicated that measures of total time spent sleeping from Fitbit Flex™ were highly and significantly correlated with that of the PSG (0.97, $p < 0.05$). In addition, results of a Wilcox Signed-Rank test showed that Measures of *sleep efficiency* (total time in bed / total time spent sleeping; Driller et al., 2017) from the Fitbit Flex™ were not different from that of the PSG. However, data from the two devices were not significantly correlated (0.21, $p < 0.05$), suggesting low reliability. Mantua et al. (2016) noted that there was little variation among the participants (40, healthy young adults)

sleep efficiency data which may have contributed to the absence of a significant correlation between Fitbit Flex™ and PSG data. Additionally, the researchers suggested that participants' failure to initiate the "sleep mode" feature on the Fitbit Flex™ (which resulted in a loss of nine participant's sleep data) may have contributed to the poor reliability for sleep efficiency outcomes. These studies indicate that the Fitbit Flex™ is a valid and reliable device for measuring step data but may underestimate step counts. In addition, the Fitbit Flex™ provides valid and reliable measurement of the total duration of sleep per night but data on sleep efficiency may be less reliable, particularly if users do not utilize the sleep mode feature consistently.

Normand (2008) used goal setting, self-monitoring, and feedback to increase the number of steps taken per day in four healthy adults. Normand utilized the New Lifestyles™ 2000 pedometer to track participants' daily step counts. Similarly, Donaldson and Normand (2009) increased the calorie expenditure of five obese adults using a treatment package including goal setting, self-monitoring, and feedback. The Polar F6™ was used to monitor the participants' heart rate and track their daily calorie expenditure.

Using a multiple baseline across participants with reversal design, Salazar (2015) evaluated the same three self-management components (i.e., goal setting, self-monitoring, & feedback) as Normand (2009) with the addition of a contingent monetary incentive to increase the physical activity of 10 healthy adults. Salazar (2015) systematically presented and withdrew monetary incentives across phases to assess the necessity of this component of the intervention. Results indicated that the monetary contingency did not account for the change in physical activity performance as physical

activity increased across all phases (Salazar, 2015). Specifically, the data displayed similar increases in the total duration of physical activity per week in both conditions (i.e., with & without contingent incentive) relative to baseline. The author hypothesized that the feedback or "social approval" from the contingency manager was more likely to be responsible for the increase in the target behaviour however this cannot be determined as no component analyses were performed.

Overall, the self-management literature demonstrates that treatment packages involving goal setting, self-monitoring, and feedback are effective at increasing a wide range of physical activity behaviours (e.g., aerobic activity, cycling, walking) across diverse populations, the majority of which include inactive healthy (e.g., Furlonger et al., 2017; Normand, 2008; Wack et al., 2014), overweight (Van Wormer, 2004), obese (Donaldson & Normand, 2009; Hustyi et al., 2011), or a combination of two of these populations (De Luca & Holborn, 1992). The populations sampled also vary in age (i.e., children-adults) but none include individuals identified as having mental health concerns (i.e., symptoms of or a diagnosed mental health disorder). It is unknown if these self-management strategies can be used for individuals with depressive symptoms to effectively increase their engagement in physical activity. As well, further research is needed to address challenges with client adherence to a physical activity routine, particularly after the intervention is removed. Finally, identification of factors that contribute to an effective dose-response rate for individuals with depressive symptoms is needed to improve the efficiency and effectiveness of physical activity-based interventions in the treatment of depression. The present study will combine components of evidence-based self-management techniques (i.e., goal setting, self-monitoring, and

feedback) to evaluate the impact on changes in physical activity (i.e., steps taken each day) in a novel population (i.e., university students with depressive symptoms), in the individuals' natural settings (i.e., in and around their respective communities).

Purpose and Significance of the Research

A considerable body of research has demonstrated support for engagement in physical activity as an effective treatment for depressive symptoms (e.g., Carek et al., 2011; Cooney et al., 2013; Mead, et al., 2009; Pelletier, et al., 2017; Wolff et al., 2011); however, these implications have not been adapted into clinical practice as these interventions are rarely prescribed to individuals diagnosed with depressive disorders (Cark et al., 2011). In addition, previous literature examining the relationship between engagement in physical activity and depressive symptoms has yet to identify the specific type, intensity, and duration of physical activity that reliably results in a decrease in depressive symptoms (Blumenthal et al., 2012; Nystrom et al., 2016). To address some of these gaps in the literature, the present study examined the efficacy of a self-management treatment package to increase the daily steps of four adult university student with varying levels of depressive symptoms and compared pre- mid- and post-treatment depressive symptoms to determine if increased engagement in walking would show collateral decreases in depressive symptoms. By measuring sleep duration and the frequency and duration of waking and restless periods per night, this study also intended to provide further understanding of the relationship between increased engagement in physical activity and sleep duration and quality.

In addition to providing preliminary support for the efficacy of the specific self-management treatment package for increasing engagement in walking for individuals

with depressive symptoms, this study also aimed to identify factors (i.e., severity of depression & mean frequency of steps per day) related to a dose-response rate for adult university students with varying levels of depressive symptoms. To extend the literature on physical activity interventions involving individuals with depressive symptoms, the present study employed behaviour analytic techniques (i.e., self-management) to examine whether training participants to self-monitor their walking frequencies, using participant-selected terminal goals, and allowing participants to choose where and when (i.e., the times of day) to engage in walking would increase the likelihood of treatment adherence.

Research Hypotheses

Based on the findings from literature to date we had the following hypotheses:

1) Based on previous studies demonstrating the efficacy of the specific self-management techniques utilized in this study (i.e., goal setting, self-monitoring, and feedback) to increase physical activity (e.g., Donaldson & Normand, 2009; Normand, 2008; Salazar, 2015; Sharpe et a., 2017; Van Wormer, 2004), we hypothesized that the treatment package would lead to an increase in the frequency of steps taken per day compared to the daily frequencies observed in baseline.
2) Based on the literature assessing the relationship between physical activity and depressive symptoms (e.g., Doyne et al., 1987; Mather et al., 2002; Prathikanti et al., 2017; Vetrovsky et al., 2017), we hypothesized that we would observe an inverse relationship between depressive symptoms and physical activity. Specifically, once participants' daily steps increased, we would observe a collateral decrease in depressive symptoms, resulting in a reduction in self-reported depressive symptoms over time.

3) Based on the literature examining the relationship between physical activity and sleep disturbances associated with depression (Pelletier et al., 2017; Wolff et al., 2011), we hypothesized that an increase in the frequency of steps per day would correspond with an increase in sleep duration and an improvement in the quality of sleep (i.e., a decrease in the duration of restless and waking periods per night) .
4) The literature examining the maintenance of behaviours targeted in self-management intervention is limited. However, given the optimal outcomes of previous self-management evaluations (e.g., Donaldson & Normand, 2009; Normand, 2008; Salazar, 2015; Sharpe et a., 2017; Van Wormer, 2004), we hypothesized that the participants would continue to engage in a frequency of steps per day that was above their respective baseline levels for up to one month post-intervention.

Method

Participants and Setting

Participants included four female adults enrolled in graduate programs at Brock University who self-reported experiencing depressive symptoms. The participants were recruited via recruitment posters posted in common areas of the university (e.g., food courts, poster boards) and an email announcement sent to all students in two university departments (see Appendix A). The mean age of the participants was 28.75, ranging from 24 to 33 years. All participants reported persistent depressive symptoms ranging in duration of 18 months to 16 years. Three of four participants shared that they had previously received a clinical diagnosis of a depressive disorder from a professional (i.e., psychologist, psychiatrist), and two of these participants reported that they had comorbid

mental health disorders including general anxiety disorder, obsessive compulsive disorder, and attention-deficit hyperactivity disorder. Each participant was assigned a pseudonym to ensure privacy. The four participants were organized into two dyads based on the time of acceptance in the study: Dyad 1 included Greta and Berta and Dyad 2 included Norma and Sheryl.

During pre-treatment assessment, all participants were deemed eligible to participate in increased physical activity according the *Physical Activity Readiness Questionnaire* (PAR-Q; Canadian Society for Exercise Physiology, 2002) criteria (described later). Other inclusion criteria included access to a cell phone and basic cell phone literacy (i.e., ability to send and receive text messages).

All assessment, training, and treatment-related sessions were conducted in quiet research spaces (i.e., libraries, university research clinic) in the participants' respective communities for their convenience. Each participant engaged in walking in their respective communities (e.g., residential, work, travel destinations).

Materials

The materials required for this study included four Fitbit Flex™ devices and each participant's personal cellphone. The researcher provided each participant with a Fitbit Flex™ to use for the duration of the study (and returned to the researcher post-study). The Fitbit Flex™ devices were used to collect all walking and sleep data for each participant as this device has been shown to be a valid and reliable device for tracking steps per day (Diaz et al., 2015; Kooiman et al., 2015) and sleep (Mantua et al., 2016).

Experimental Design

A changing criterion design embedded within a concurrent multiple baseline design across two participant dyads ($N = 4$) was used to examine the effects of the independent variable (self-management treatment package) on the primary outcome variable (number of steps per day). Dyad 1, Greta and Berta, was recruited approximately one month prior to Dyad 2, Norma and Sheryl. The changing criterion design involves implementation of the treatment in a series of sub-phases (Hartmann & Hall, 1976). Each sub-phase is associated with a *stepwise* change in the mastery criterion for the target behaviour (Hartmann & Hall, 1976). Each time the participant met the criterion level a new criterion or sub-phase is implemented. With repeated demonstrations of the target behaviour meeting the criterion, replication of the treatment effect is established and experimental control of the treatment over the behaviour is indicated (Cooper et al., 2007). Further, when stable responding is observed across multiple sub-phases, the data from each sub-phase can provide a prediction of future behaviour such that behaviour will remain the same until the criterion is changed (Cooper et al., 2007). Experimental control can be enhanced in changing criterion design by varying the length of the sub-phases and by returning to conditions of a previous criterion (Cooper et al., 2007). When the behavior conforms to the criterion regardless of the length of the phase or level of responding, a clear demonstration of the control of the treatment over the behaviour is demonstrated (Cooper et al., 2007).

The multiple baseline and changing criterion designs are suitable for interventions targeting a single behaviour where it is desirable to gradually implement changes to shape the behaviour toward a terminal criterion (Cooper, et al. 2007). A return

to conditions of a previously mastered criterion was also included to further examine the extent of experimental control of the intervention (DeLuca & Holborn, 1992; McDaniel & Bruhn, 2016). Finally, the introduction of the treatment across participants and within dyads was staggered according to a multiple baseline design. Within each dyad, the treatment (independent variable) was introduced to the first participant once she demonstrated stable baseline responding. Subsequently, when a stable, therapeutic trend was observed in the first participant, the treatment package was implemented for the second participant.

For Greta and Sheryl, the experimental phases included: (a) baseline, (b) treatment package (i.e., goal setting, self-monitoring, and feedback), and (c) follow-up (i.e., a return to baseline conditions for up to one month to assess maintenance of walking behaviour at the level of the individual's terminal step goal). For Berta and Norma, a reversal component and subsequent re-introduction of the independent variable was also included in the design to assess whether their daily steps would decrease when the treatment package was removed and increase when the treatment package was re-introduced. For these two participants, the experimental phases included: (a) baseline, (b) treatment package, (c) reversal, (d) re-introduction of the treatment package. Any participant who demonstrated a stable, decreasing trend or a consistent, low frequency of steps per day (that was below her individual terminal goal) in the follow-up phase was given the opportunity to participate in an additional phase which included a re-introduction of the treatment package. Three participants met these criteria but only two (Berta, Norma) chose to participate in a reversal and re-introduction of the treatment package. Norma chose to briefly pause her participation in the study during the treatment

phase due to factors external to the study. Prior to pausing her participation in the study, Norma's step data displayed a decreasing trend. Subsequently, she resumed her participation and completed reversal and re-introduction of the treatment package.

Measures

Primary dependent variable. Archived Fitbit Flex™ data for the primary dependent variable; frequency of steps per day were obtained from each participant's online Fitbit account. A *step* included any activity that resulted in a single step count that was recorded and stored by the Fitbit Flex™ (Larson et al., 2011; Normand, 2008; VanWormer, 2004). Steps were accumulated from the time the participant woke up in the morning until she went to bed each night.

Secondary dependent variables. Secondary dependent variables included sleep and depressive symptoms.

Sleep. The Fitbit Flex™ recorded: (a) duration of sleep in minutes per night, (b) frequency of waking and restless periods per night, (c) minutes awake/restless which consists of the duration of waking plus restless periods per night in minutes. *Sleep* included any activity that resulted in a single minute of sleep recorded and stored by the Fitbit Flex™. Waking periods were defined as any activity that resulted in a single waking occurrence recorded and stored by the Fitbit Flex™. Restless periods were defined as any activity that resulted in a single restless occurrence recorded and stored by the Fitbit Flex™. Using the sleep data collected from the Fitbit Flex™, *sleep efficiency* scores were calculated to obtain a measure of each participants quality of sleep within and across all phases of the study. In the context of the present study, using the data recorded by the Fitbit Flex™, *sleep efficiency* was defined as the total duration of sleep

(min.) per night divided by the total duration of waking and restless periods (min.) *plus* the total duration of sleep per night.

Depressive symptoms. Data on each participant's self-reported depressive symptoms were measured using the *University Student Depression Inventory* (USDI; Khawaja & Bryden, 2006)**.** This 30-item scale was developed to measure depression symptoms that may be more specific to students versus general clinical depression inventories. The USDI has strong reliability and validity (Habibi et al., 2014; Khawaja & Bryden, 2006; Romaniuk & Khawaja, 2013), showing convergent validity with previously validated measures of depression (i.e., *Beck Depression Inventory 2nd Ed.* [Habibi et al., 2014]; *Depression Anxiety Stress Scale*- depression subscale [Khawaja & Bryden, 2006]). Each item on the USDI is scored using a 5-point Likert scale ranging from 1 ("not at all") to 5 ("all the time"). Total scores range from 30 to 150 with higher scores on the inventory indicating a greater level of depression (Khawaja & Bryden, 2006). A total score between 30-73 indicates "low" symptomology, between 74-95 indicates "moderate" symptomology, 96-118 indicates "high" symptomology, and 119-147 indicates "very high" symptomology (Romaniuk & Khawaja, 2013). Subscales include, *lethargy*, *cognitive- emotional motivation*, and *academic motivation* with subscale scores ranging from 9 to 45, 14 to 70, and 7 to 35, respectively.

The USDI was also designed to include four *severity categories* to aid in the clinical interpretation of overall inventory scores; however, the authors of this measure caution researchers not to use these qualitative labels to interpret the data in research contexts without supplementary interpretation and validation from an appropriate clinical

professional (e.g., registered psychologist; Romaniuk & Khawaja, 2013). As such, the researcher did not analyze individual results in terms of their ranking in *severity category*.

Clinical significance of change in depressive symptoms. The *Clinical Global Impressions Scale* (CGI; Guy, 1976) is an assessment tool that was designed for clinicians to evaluate the overall symptom severity of individuals with mental illness. The CGI consists of two sub-scales, the *CGI-Severity* scale (CGI-S) which is intended for evaluation during the course of treatment, and the *CGI-Improvement* (CGI-I) scale which should be completed post-treatment. Both sub-scales are scored on 7-point scales. The CGI-S scale is scored from 1 ("normal") to 7 ("among the most extremely ill patients") and the CGI-I is scored from 1 ("very much improved since the initiation of treatment") to 7 ("very much worse since the initiation of treatment") (Guy, 1976). A clinical psychologist who was blind to the conditions and experienced in the treatment of depression, assessed the overall clinical significance of each individual's scores (i.e., both total and subscale) on the USDI, across all phases of the study, using the CGI. The researcher administered the USDI at three time points, during pre-treatment assessment, midway through treatment, and post-intervention during the debriefing session.

Physical activity screening questionnaire. The *Physical Activity Readiness Questionnaire* **(**PAR-Q**;** Canadian Society for Exercise Physiology, 2002) was administered to each participant during pre-treatment assessment and was used to determine whether it was safe for her to engage in increased physical activity or if she should first consult with a physician. The PAR-Q is a 7-item questionnaire designed for individuals aged 15 to 69 years. The participant was asked to respond "yes" or "no" to each of the seven questions and return the questionnaire to the researcher. The researcher

used the scoring guidelines on the questionnaire to determine each participant's readiness to participate in the study. Specifically, the guidelines indicate, if the individual responded "yes" to any items on the questionnaire, he or she should seek consultation from a physician before beginning. If an individual responded "no" to all items, it is "reasonably" safe to initiate increased physical activity **(**Canadian Society for Exercise Physiology, 2002).

Social validity. The participant social validity questionnaire (see Appendix B) included items that assessed: (a) participant satisfaction with the training and intervention procedures, (b) the ease of use of the procedures and the Fitbit Flex™ device, (c) whether participants felt that the intervention produced an increase in their daily steps, (d) whether the intervention produced an improvement in the participant's sleep and, or mood, and (e) the likelihood that participant would continue to use the self-management techniques after completion of the study. The questionnaire involved a five-point Likert scoring system, with answers ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The researcher administered this questionnaire twice; half-way through the intervention phase and post-intervention during the debriefing session.

Open-ended questionnaire. The open-ended questionnaire (see Appendix C) is a 10-item qualitative questionnaire developed by the primary researcher and primary student researcher (hereafter referred to as "the researcher") to gather information from participants regarding potential confounding variables that may have influenced their daily and overall walking behaviour during the study. In addition, the questionnaire provided participants with the opportunity to add additional comments about their experience participating in the study (e.g., regarding components of the treatment

package or the Fitbit Flex™) that was not covered in the other items or in the social validity questionnaire. The researcher administered the open-ended questionnaire once, approximately one-month post-intervention during the debriefing session.

Interobserver agreement (IOA). The researcher did not calculate IOA for the primary dependent variable (steps) as it is not feasible to manually collect step data over the course of an entire day. In addition, the Fitbit Flex™ has been shown to provide a valid measure of frequency of steps (Diaz et al., 2015; Driller et al., 2017; Kooiman et al., 2015). Two trained independent coders calculated *sleep efficiency* scores for a minimum of 33% of all days (across all phases of the study) using the participant's archived Fitbit™ data in an Excel© spreadsheet. Coder and researcher *sleep efficiency* scores were then used to calculate total duration IOA scores. The results of the assessment for IOA on *sleep efficiency* scores yielded 100% accuracy across all days assessed. The same coders also independently calculated total and subscale USDI scores for 33% of administrations of the test across all participants and assessment time-points (i.e., mid-way through the treatment phase, and post-treatment during the debriefing session). The researcher then used the coders data and the data from her calculations of participants' USDI scores to calculate total count IOA on the participant's s total score and each of the subscale scores (*Lethargy* - 9 items, *Cognitive-emotional Motivation* - 14 items, *Academic Motivation* - 7 items). The IOA for USDI scores was 99.8% accuracy (range 96%-100%) across all phases and assessments sampled.

Procedural integrity on researcher behaviour. A trained independent observer completed task analyses on researcher behaviour in-vivo during pre-treatment training sessions for 33% of all participant training sessions (see Appendix G-H). The

researcher and observer took data on the researcher's performance of each step in the task analysis by scoring each step as correct (+) or incorrect (-). A correct response was defined as accurately completing all behaviours within a specific step of the task analysis. An incorrect response was defined as completing some or all behaviours inaccurately or not completing all behaviours of the task analysis, within a specific step. The researcher then used these data to calculate total count IOA on the researcher's performance of all steps for each task analysis, which yielded 100% accuracy between observers across all observations.

Procedural integrity on participant behaviour. The researcher retroactively recorded data on each participant's correct completion of all three steps of the self-monitoring procedure in the *Participant Self-monitoring Checklist* (see Appendix D) to measure participants' compliance with the self-monitoring procedures. Data were collected for 34% of all days during the treatment phase for each participant. The days included in the analysis were randomly selected using an online list generating software called Lists Randomizer© (http://random.org/lists). Specifically, participants' pseudonyms, and numbers corresponding to the months of the year and days of the month were entered into the Lists Randomizer©, resulting in a list of each which the researcher then combined (in the order provided by the Lists Randomizer©) to create the sequence, participant, month, day. The researcher then reviewed the text message history of the appropriate participant to find the date of interest and scored each step in the checklist as correct (+) or incorrect (-). The analysis yielded an average compliance score of 61.2% across all participants and days analyzed. The highest rate of compliance was observed with Step 2 (capturing the date and daily step count in the screenshot) at 97.7%, followed

by 58.1% compliance for Step 3 (noting in the text message whether she engaged in other physical activity and if so, what type), and 28% for Step 1 (sending the screenshot of their daily steps within 15 minutes of her personal deadline). Berta's mean rate of compliance across all steps was 88% (range 73%-100%). Greta's mean rate of compliance across all steps was 36% (range 0%-100%). Norma's mean rate of compliance across all steps was 43% (range 10%-100%). Finally, Sheryl's mean rate of compliance across all steps was 72% (range from 25%-100%).

Procedure

Consent and Screening

Prior to any assessment or training the researcher obtained informed consent from each participant during a one-to-one pre-baseline assessment meeting. During this meeting the researcher reviewed the consent form (see Appendix E) and provided the participant with the opportunity to ask questions. All participants that met the inclusion criteria provided vocal verbal and written consent. Subsequently, the PAR-Q **(**Canadian Society for Exercise Physiology, 2002) was administered to determine if the participant met the inclusion criteria to participate in the study. Inclusion criteria regarding the PAR-Q involved answering "no" to all questions on the questionnaire. According to the PAR-Q scoring criteria, answering "yes" to any items on the PAR-Q indicated that the participant was reporting the presence of symptoms or conditions that needed to be discussed with his or her doctor before increasing physical activity **(**Canadian Society for Exercise Physiology, 2002). All participants responded "no" to all questions on the PAR-Q and thus were permitted to participate in the study. Results of the PAR-Q are considered valid for 12 months (Canadian Society for Exercise Physiology, 2002).

Observer Training

Prior to baseline, the researcher trained two independent coders to record treatment integrity data on her implementation of behavior skills training (BST; Parsons et al., 2012; Reid et al, 2003) used to train participants on pre-treatment training targets using task analyses (training targets described below). In accordance with the BST model, the researcher used instruction, modelling, rehearsal, and feedback (Parsons et al., 2012; Reid et al, 2003) to train each coder on all steps involved in scoring the treatment integrity data. These individuals collected data during a random selection of pre-determined sessions by scoring each step as correct (+) or incorrect (-) using the appropriate checklist (see Appendix F). The same coders were also trained on how to calculate *sleep efficiency* scores. The researcher obtained all data for *sleep efficiency* calculations (i.e., sleep, waking and restless duration data) from each participant's Fitbit™ archive and entered them manually in into an Excel© spreadsheet which was subsequently provided to the coders via email. Finally, these coders were provided with a written description of the USDI including the purpose and psychometric properties of the USDI, as well as a written instruction on how to score total and subscale scores based on the scoring guidelines described in Romaniuk and Khawaja (2013).

The researcher conducted all coder training using BST (Parsons et al., 2012; Reid et al, 2003) to teach each skill or set of skills until each coder achieved 100% accurate performance across three consecutive trials, on all steps targeted in training. Training occurred in two separate sessions between 30 min. to 1-hr. The researcher held the initial training session in a quiet research space at Brock University and the second training session online via a secure video conferencing technology provided by Brock

University (i.e., Lifesize™). The change in training environment was selected for the convenience of the individuals involved.

Once both coders met mastery criteria for training and all USDI and sleep data were recorded, the researcher calculated IOA scores for both measures. Specifically, using the data collected by the researcher and the coders, the researcher calculated total duration IOA for the sleep efficiency data by dividing the shorter duration by the longer duration and multiplying this value by 100. Total count IOA for total and subscale USDI scores for each participant were calculated using the scores obtained from the researcher and the coders. The researcher calculated total count IOA by dividing the smaller count by the larger count and multiplying this value by 100. This was done for each total and subscale score across all USDI assessments included in the analysis.

Pre-Baseline Assessment

Prior to the baseline phase, each participant was asked to fill out the USDI (Khawaja & Bryden, 2006). At this time, the researcher read the instructions regarding how to fill-out the assessment and answered questions if necessary. Next, the researcher prompted the participant to begin the assessment (e.g., "You may fill-out your inventory") and notified the participant that she would be leaving the immediate area (i.e., approximately 10 feet away) to give her privacy. The researcher also informed the participant to call out her name if she had any questions. Exclusion criteria regarding depressive symptoms included a score of 30 on the USDI as this score indicates the absence of minimal or "low" level depression symptoms (Romaniuk & Khawaja, 2013). No participants met exclusion criteria relating to the USDI.

The researcher recorded each participant's total score and subscale scores (Habibi et al., 2014; Khawaja & Duncanson, 2018) for this administration of the USDI (Khawaja & Bryden, 2006) and the two subsequent administrations (i.e., mid-way through the treatment phase, and post-treatment during the debriefing session).

Once the assessments were completed, the researcher asked the participant if she believed that she was currently in crisis or in need of acute care (e.g., unable to complete necessary daily tasks such as eating). No participants reported to be in crisis or in need of acute care. Finally, the researcher provided the participant with resources for local counselling services (e.g., *Niagara Distress Centre*) and crisis-support services (e.g., *Canadian Mental Health Association*: Access Line Niagara). The resources provided to the participants were supplied by the *Student Wellness and Accessibility Centre* at the students' university. The primary researcher previously completed an eight-week, intensive, crisis-intervention course including a unit on suicide. The supervising researcher also completed training in suicide risk assessment.

Pre-Treatment Training

Prior to the baseline phase, the researcher assessed each participant's ability to charge the Fitbit Flex™ (see Appendix F) to determine if training was necessary. One participant required training to correctly place the "pebble" (i.e., the part of the Fitbit that records & stores data) to the wristband. Only those skills a participant did not perform with 100% accuracy on the first trial (if any) were taught in the pre-treatment training session(s). The second training session was conducted post-baseline. During this session, the researcher assessed each participant's ability to operate the functions of the Fitbit Flex™ and the Fitbit™ cellphone application that were necessary for participation in the

study (see Appendix F). Again, only those skills a participant did not perform with 100% accuracy on the first trial were then trained.

All training sessions were one-to-one with the researcher and were approximately 1hr. The researcher took data on each participant's performance on all steps involved in all targeted skills during both training sessions using task analyses (see Appendix G-H, researcher integrity data sheet outlines the task analyses). The researcher required each participant to perform all steps with 100% accuracy, across two consecutive trials. The researcher used BST (Parsons et al., 2012; Reid et al, 2003) to teach any unknown or non-mastered skills or set of skills in both training sessions. Once the participants were trained, the researcher created a private password on each participant's Fitbit™ cellphone application that was only known to her to prevent participants from accessing their data via the Fitbit™ application. Specifically, this was done to prevent self-monitoring as this would have confounded the validity of the baseline data. The participants could change their passwords to a personalized password once the baseline phase was completed. Similarly, prior to baseline, the researcher created an email address (and associated password) for each participant and registered the Fitbit™ email notifications (i.e., those that provide the Fitbit™ user with a weekly progress report) to these email addresses so that participants did not receive feedback on their walking behaviour. This procedure was in place for the duration of the entire study as these notifications provided feedback on walking behaviours (among others) that were not included in the treatment package (e.g., weekly activity report, estimated calorie expenditure) and thus would potentially confound the data on walking and sleeping behaviours.

Experimental Phases

Baseline. During the baseline phase, the researcher asked participants to wear a Fitbit Flex™ 24 hours a day (except when showering or swimming) until a stable pattern of responding was observed. The researcher asked participants to engage in their typical daily routines and activities and did not provide any feedback on the number of steps they took. The face of the Fitbit Flex™ device features a five-piece light display that tracks and displayed the participant's progress toward her goal. The light feature denoted when the participant got proportionally closer to her step goal by illuminating a single light each time the participant reached 20% of her step goal. In addition, when the participant achieved 100% of her goal all five lights illuminated and the device vibrated, simultaneously.

Prior to beginning baseline data collection, the researcher set each participant's Fitbit Flex™ daily step goal to an extremely high, unrealistic daily goal (i.e., 70, 000) so that the device would not illuminate or vibrate during baseline assessment, and hence prevented sensory feedback from the illumination and, or vibration of the device. The step goal was later modified during the pre-treatment training session to reflect each participant's initial goal (and subsequently modified each time a new goal was set to reflect that goal). The researcher checked the archived data on the Fitbit Flex™ weekly by meeting with each participant in-person, syncing to her device, and exporting all step and sleep data from the previous seven days to the participant's individual Excel© spreadsheet. Immediately after exporting these data, the researcher graphed the frequency of steps per day for each participant on individual line graphs using Prism 7© graphing technology and analyzed these data for stability, indicating that the participant could

begin the treatment phase. The researcher graphed each participant's sleep data from the previous seven days on individual graphs post-session in the interest of keeping the session duration brief. The baseline phase was terminated when the participant's step data displayed no trend or a contra-therapeutic trend.

Treatment. The intervention consisted of three components: goal setting, self-monitoring, and feedback. During the intervention phase, the researcher required participants to wear the Fitbit Flex™ for 24 hours a day (except when showering or swimming). The *sub-phase progression criterion* was defined as the participant meeting the researcher-determined *sub-phase goal* (i.e., specific frequency of steps) a minimum of four times in a 7-day-period. This *progression criterion* meant that the participant was achieving (or exceeding) her individual criterion levels more often than not (i.e., 57% of days in a 7-day-period) while still permitting the participant to engage in sub-criterion frequencies on days where factors external to the study may have interfered with achieving the criterion (see *Self-monitoring* section*)*. If the participant met the *sub-phase progression criterion*, the subsequent goal involved an increased number of steps (see *Goal setting* in the following paragraph). The *program mastery criterion* was defined as the participant meeting her self-determined terminal goal four times in a 7-day-period. If the participant met the *program mastery criteria* the researcher arranged a brief meeting to discuss follow-up procedures (see *Debriefing* section). The *regression criterion* for sub-phase goals was defined as the participant *not* meeting her goal for three consecutive days, or four times in a 7-day-period. If the participant met the *regression criterion*, the next goal regressed to the previously (most recent) mastered goal. If the participant met the *regression criterion* two times in a 14-day-period, the researcher requested that the

participant attend a one-to-one, in-person or phone meeting (participant-selected based on the most convenient forum for the participant) to discuss challenges that interfered with achieving her step goal and the possible addition of response prompts (e.g., to send screen shot, create a walking schedule) and, or a reinforcement contingency for reaching sub- and, or terminal- goals.

The length of the treatment phase was individualized and depended on the amount of physical activity each participant engaged in. For example, if an individual consistently met *progression criteria* within the first four days of receiving a new goal this participant would subsequently met her terminal goal at a faster rate than an individual whose average rate of goal acquisition was slower (e.g., requiring seven days to meet sub-goal progression criteria). In addition, an individual with a faster rate of goal acquisition would have overall fewer days in the treatment phase than an individual with a slower rate of goal acquisition.

Goal setting. Once one participant per dyad demonstrated a stable pattern of daily steps in baseline, the researcher arranged a one-to-one meeting to determine her initial step goal. During this meeting the researcher reviewed a graphical representation of the baseline data by vocally describing the data and identifying the participant's mean frequency of steps per day (calculated before session). The researcher set each participant's initial goal to her mean frequency of steps during baseline (Mellalieu et al., 2006; Ward & Carnes, 2002) and provided a rationale for using these criteria that was based in the previous literature. Based on previous interventions involving goal setting, the researcher selected all subsequent sub-phase goals using the mean number of steps from the previous sub-phase *plus* an increase between 5%-15% of that mean (DeLuca &

Holborn, 1992; Furlonger et al., 2017; Geiger et al., 1992; McDaniel, & Bruhn, 2016). During this meeting, the researcher also assisted the participant in writing an individualized behaviour contract (without contrived reinforcement) that outlined the following: (a) a statement of agreement with the overall goal of the program (i.e., increasing frequency of steps to x/day); (b) the initial goal (i.e., reaching x number of steps/day) and the criteria for choosing subsequent goals; (c) the progression criteria to determine when a new goal would be selected; (d) the regression criteria to determine when the participant would regress to a previously mastered goal; (e) when and where the behaviour would occur; (f) how the behaviour would be monitored (i.e., screen shots of the Fitbit Flex™ *Dashboard*); and (g) how often the behaviour would be reported (i.e., daily) and to whom (i.e., the primary researcher). Finally, the contract was signed by the participant and researcher. If there were any changes to the procedures (e.g., addition of response prompts or a reinforcement contingency) or terminal goal the original contract was revised to reflect the changes and both the participant and researcher signed the revised contract.

Self-monitoring. Each day during the treatment phase, each participant monitored and recorded her progress toward her current goal by sending the researcher a text message with a screenshot of her Fitbit™ Dashboard displaying her daily step count and the date. In the same text message, the participant reported if she engaged in any other physical activity that day and if so, the type of physical activity. For example, the text message may read, “I also went swimming today” or “I did not engage in any additional physical activity today.” Approximately halfway through the study during a mid-point assessment meeting, one participant reported that approximately two times per

sub-phase she was choosing not to attempt to achieve her step goal and instead to focus on other schedule demands (e.g., schoolwork). On these days, this participant's step count was well below the criterion level. Similarly, other participants were intermittently reporting when unplanned or unavoidable events occurred that were incompatible with walking (e.g., physical injury, school or work events that required long periods of sitting). As such, when necessary all participants were asked to report if they chose not to actively engage in increased walking to achieve their current goal (reported as a "rest day") and, or if an event(s) occurred that was incompatible with walking (reported as an "unusual event"). *Rest days* were defined as days where the participant chose not to engage in increased walking in an attempt to meet her goal. *Unusual events* were defined as unplanned or unavoidable events that involved the participant engaging in activities that were incompatible with walking. For example, the text message might read "I did not do any additional physical activity today and took a rest day" or "I did not engage in any additional physical activity today and injured my knee at work".

The researcher asked each participant to report her step progress before her personal deadline each evening during the intervention phase. The time that each participant was asked to report her step progress was based on each participant's report of the time that she typically went to sleep. The researcher asked each participant to set a reoccurring, daily reminder in her cell phone for 5 minutes prior to her personal deadline to prompt her to engage in self-monitoring. The researcher suggested that the reminder specify the required self-monitoring behaviours. For example, "Don't forget to send a screenshot of your steps and note if you engaged in any other physical activity today." If any participant did not report her step progress by her personal deadline, the researcher

sent her a reminder to do so via text message (e.g., “Please remember to send your step progress so we can make sure you’re on track to meeting your goal”).

Feedback. Feedback included textual, behaviour-specific praise, encouragement, or constructive feedback (Salazar, 2015; Normand, 2008; Van Wormer, 2004). The researcher delivered feedback via text message each evening during the treatment phase. Feedback was delivered contingent on the participant sending her screenshot. However, if the participant did not submit her screenshot within 15 min of her personal deadline, the researcher would send a text message with corrective feedback (see *inaccurate self-recording* below). Prior to the start of the treatment phase, the researcher determined individualized feedback times that were set to occur just after each participant’s personal deadline for self-monitoring to ensure timely feedback. To increase the likelihood of compliance with feedback procedures, the researcher set a reoccurring, daily reminders (e.g., “Norma feedback”, “Greta feedback”) in her cell phone programmed to signal each participant’s personal feedback deadline to prompt her to deliver feedback to the appropriate participant at that time. The researcher kept feedback times consistent for each participant, for the duration of the study.

The researcher used a series of scripts to ensure the feedback was consistent across all participants. She used four types of scripts to provide participant feedback on meeting or not meeting the goal and capturing or not capturing the step data correctly. The researcher also personalized the script for each participant by including her name and stating the exact number of steps he or she took that day or the number of steps in her current goal (depending on the type of feedback being provided). The researcher created

three variations of each type of script and the same variation was never used twice consecutively, to prevent feedback from being overly repetitive.

The researcher sent the participant a text message under the following four conditions: (a) *met goal*: if the participant met her goal that day (e.g., "Excellent job achieving your goal of 1000 steps, you are doing awesome!"); (b) *did not meet goal:* if the participant did not meet her goal (e.g., "Reaching 1200 steps in a single day is tough, stay focused and you can improve!"); (c) *accurate self-recording:* if the participant took the screenshot correctly and sent it to the researcher via text message (e.g., "Great job, you captured your step count perfectly!"); (d) *inaccurate self-recording:* took the screenshot incorrectly, and, or did not send it to the researcher via text message (e.g., "Please remember to send me your screenshot as this helps me to see how close you are to achieving your goal."); (e) *met regression criteria* (e.g., "You did not meet your goal for three consecutive days. To increase the likelihood that you will be successful let's set your step go to your most recently mastered goal of 8800 steps"); (f) *met progression criteria* (e.g., Congratulations! You met your step goal four times this week; you are ready to progress to your next goal of 9000 steps). In addition, once every four days, each participant received an additional sentence in her feedback message notifying her to charge the Fitbit™ device overnight. Sleep data were not collected while the device was charging overnight.

As mentioned previously, participants also received immediate visual (i.e., illumination of a single light on the five-piece light feature) feedback from the device itself each time the participant achieved 20% of her goal, and visual (i.e., illumination of

all five lights simultaneously) plus and tactile (i.e., vibration) feedback when the participant achieved 100% of her current goal.

Follow-up. The researcher conducted follow-up assessment for a duration of four weeks after each participant reached her terminal goal with the exception of Berta and Norma who completed reversal to baseline. Prior to initiating the follow-up phase, the researcher asked each participant if she would be interested in re-implementing the treatment package in the event that her step data displayed a stable low frequency or decreasing trend during the follow-up phase. If the participant indicated that she was interested, she was instructed to engage in her typical daily activities and not to engage in self-monitoring, and no goal setting or feedback were provided by the researcher at this time. If the participant indicated that she was not interested in potentially re-introducing the treatment package, the procedure was identical with the exception that no instructions regarding engagement in self-monitoring were provided to assess whether the participant would continue to engage in self-monitoring via the Fitbit™ application or online account. During the follow-up phase, each participant was required to wear a Fitbit Flex™ for 24 hrs per day across all days, until four weeks after the day she reached her terminal goal elapsed.

Debriefing. The researcher conducted a one-to-one debriefing session after each participant completed the follow-up phase, with the exception of Berta and Norma who completed their debriefing sessions after completion of their second treatment phase. During the debriefing session, the researcher reviewed graphical representations of step and sleep data across all phases of the study by vocally describing the pattern of data to the participant. Next, the researcher administered the *Social Validity Questionnaire* (see

Appendix B) to assess each participant's level of satisfaction with the goal, procedures and outcomes of the intervention. The participant was also given an open-ended questionnaire to gather information regarding potential confounding variables that may have influenced her engagement in walking during the study and to provide the opportunity to note any additional comments about their experience in the study that may not have been addressed in previous questions on the social validity or open-ended questionnaires. Specifically, the open-ended questionnaire items assessed whether participants utilized any strategies outside of those included in the study and if they encountered any challenges that interfered with their ability to achieve their daily step goal(s). Finally, the USDI (Khawaja & Bryden, 2006) was administered for the third time to assess each participant's depressive symptoms post-intervention.

Following completion of the questionnaires and the USDI, participants were given the opportunity to receive coaching on how to generalize their self-management strategies to a new self-selected goal. In addition, participants were provided with supplementary coaching in goal setting, arranging opportunities for feedback on engagement in the target behaviour(s), and selecting alternative self-monitoring strategies (without a Fitbit™ device). Debriefing sessions were held in a quiet, private space (i.e., *Brock Research and Innovation Centre*, library) in the participant's city of residence for her convenience.

Post-completion of the study, a registered psychotherapist blind to conditions, reviewed all total and subscale USDI scores for each participant (in addition to graphs of each participant's step and sleep data) and subsequently completed the CGI-S (Guy, 2000) for each participant, to provide an assessment of the clinical significance of any

change(s) observed in each participant's scores on the USDI (Khawaja & Bryden, 2006) across all phases of the study.

Results

Primary Outcome Variable: Steps per Day

Data analysis. Step data were collected from archived records on each participant's online Fitbit™ account and graphed on individual line graphs using GraphPad Prism© (version 7) graphing software. Visual analysis of trend, level, and stability were performed to analyze step data and determine if the treatment package (i.e., goal setting, self-monitoring, feedback) was efficacious in increasing the frequency of daily steps for each participant. A split-middle method of trend estimation (Wolery & Harris, 1982) was used to plot trend lines within each phase of each participant's graph. Analysis of trend variability within-conditions was conducted by applying a stability envelope of +/- 25% to the trend line within each phase (Kucskar, 2017; Lane & Gast, 2013). To determine the stability envelope (+/- 25%) for each participant, the baseline median was multiplied by 0.25 (Lane & Gast, 2014). The criterion of 80% of data points within 25% above or below the median value was used to determine whether the data were stable (Kratochwill et al., 2013; Kucskar, 2017; Lane & Gast, 2013, 2014).

The researcher performed both relative and absolute level change analyses for all participants. *Relative* level change *within* conditions identifies the change (if any) in the median value from the first half to the second half of the data set within a single phase. This provides information on the magnitude of the change in the target behaviour within a phase (Lane & Gast, 2014). Relative level change *between* conditions reflects the change in level from the data in the latter half of the baseline phase relative to the data

in the first half of the subsequent treatment phase (Lane & Gast, 2014). This type of level change provides information regarding the stability of the change (if any) in the target behaviour as a result of the change in conditions (e.g., introduction or removal or treatment) across phases. *Absolute* level change *within* conditions identifies the change in value from to first to the final datum in a single phase (Lane & Gast, 2014). The result of this calculation provides information regarding the trend within phases and whether it is improving or deteriorating. Absolute level change *between* conditions reflects the change in value from the last datum in baseline phase to the first datum in the treatment phase (Lane & Gast, 2014) which provides information regarding immediacy of any observed change in the target behaviour(s) as a result of a change in conditions (e.g., introduction or removal or treatment).

Due to the considerable variability in the daily step data across the majority of participants, the data are presented in several ways. First, the mean frequency of steps during baseline and follow-up and the mean frequency of steps within each subphase of the treatment phase, are presented for each participant across phases to provide a visual of the summarized pattern of results (Figures 1 and 2). Next, daily steps with unusual events (e.g., when a participant was ill or injured) and rest days removed for part of the treatment phase are presented (Figures 3 and 4). The detailed results of the trend and level analysis within- and between-conditions are presented in Tables 1 and 2.

Visual analysis of the summarized data. Figure 1 depicts summarized step frequencies (i.e., one data point represents the mean frequency of steps per sub-phase within the treatment phase) across phases for Dyad 1. Both Greta and Berta showed a moderate, yet immediate mean shift in steps from baseline to intervention and a gradual

increase in trend and level during the intervention phase. Greta maintained a relatively stable step count at one-month follow-up with a decreasing trend. Berta participated in a reversal phase and demonstrated an immediate and sizeable return to her baseline mean frequency of steps and level, and an immediate and sizeable return to her treatment mean frequency of steps and level upon reintroduction of the independent variable. Both participants demonstrated increasing trends in frequency of steps in the treatment phase(s). Berta's data are the clearest indication of a potential functional relation between the independent and dependent variable. Figure 2 depicts the same summarized step frequency for Dyad 2. Norma did not show an immediate or sizeable increase in frequency of steps from baseline to treatment. However, she engaged in very high frequency of steps in baseline relative to the other participants. During the reversal phase, Norma's data show an immediate and considerable increase in the mean frequency of steps compared the mean level in her final 3 weeks of the treatment phase. The data in her final treatment phase show a decrease in level (from the return to baseline mean) but a stable slightly increasing trend and mean frequency of steps above the mean frequencies observed in the final weeks of the initial treatment phase. Sheryl showed a moderate, yet immediate mean shift from baseline to treatment with a gradual increase in level.

Between-conditions analysis. An analysis of trend across conditions indicated that all but one participant (i.e., Norma) demonstrated a change in the primary dependent

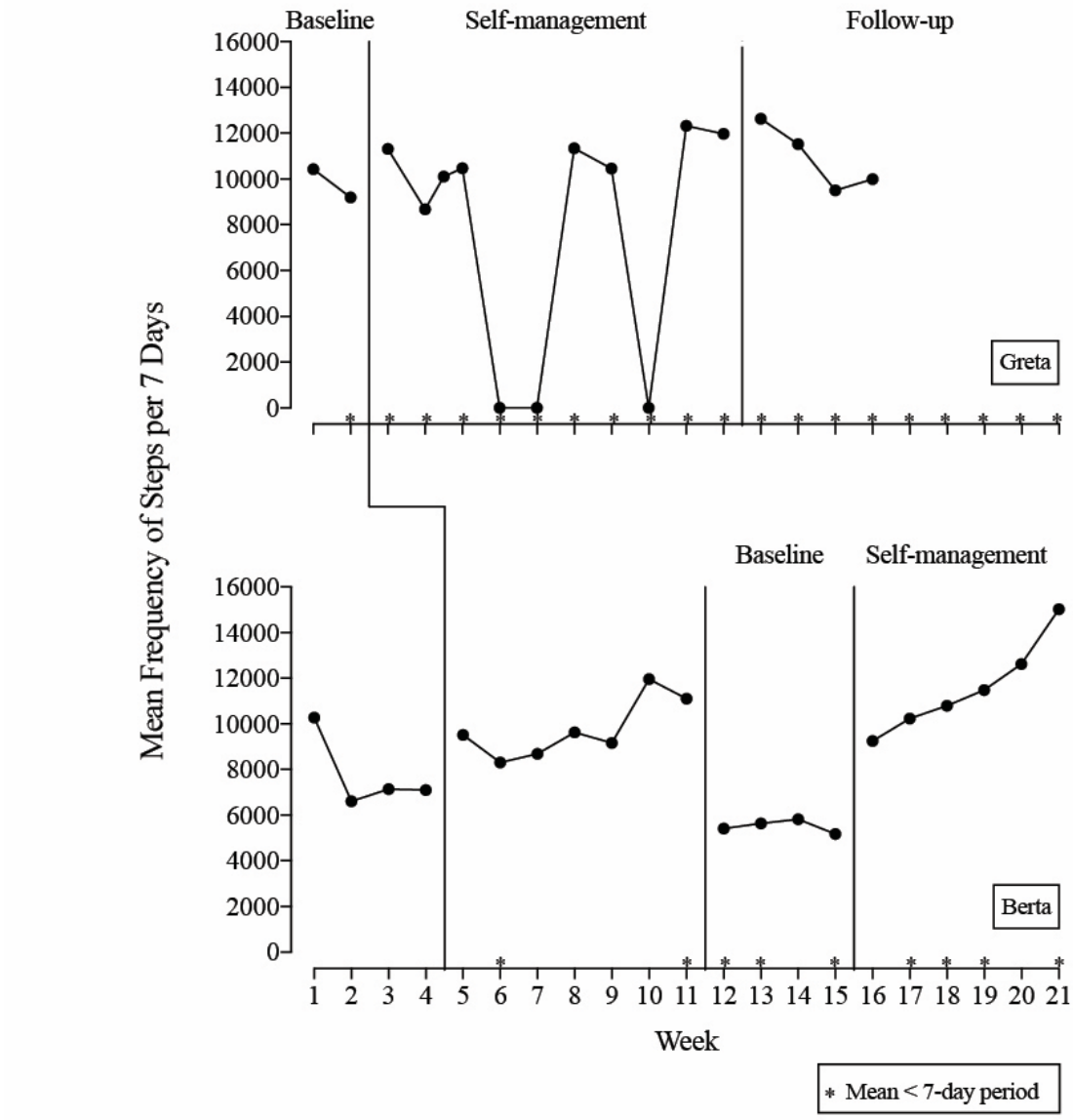

Figure 1. Mean frequency of steps per 7-day period, in chronological order across all phases for Dyad 1. Asterisks indicates a datum where the mean was calculated from a period of less than 7 days.

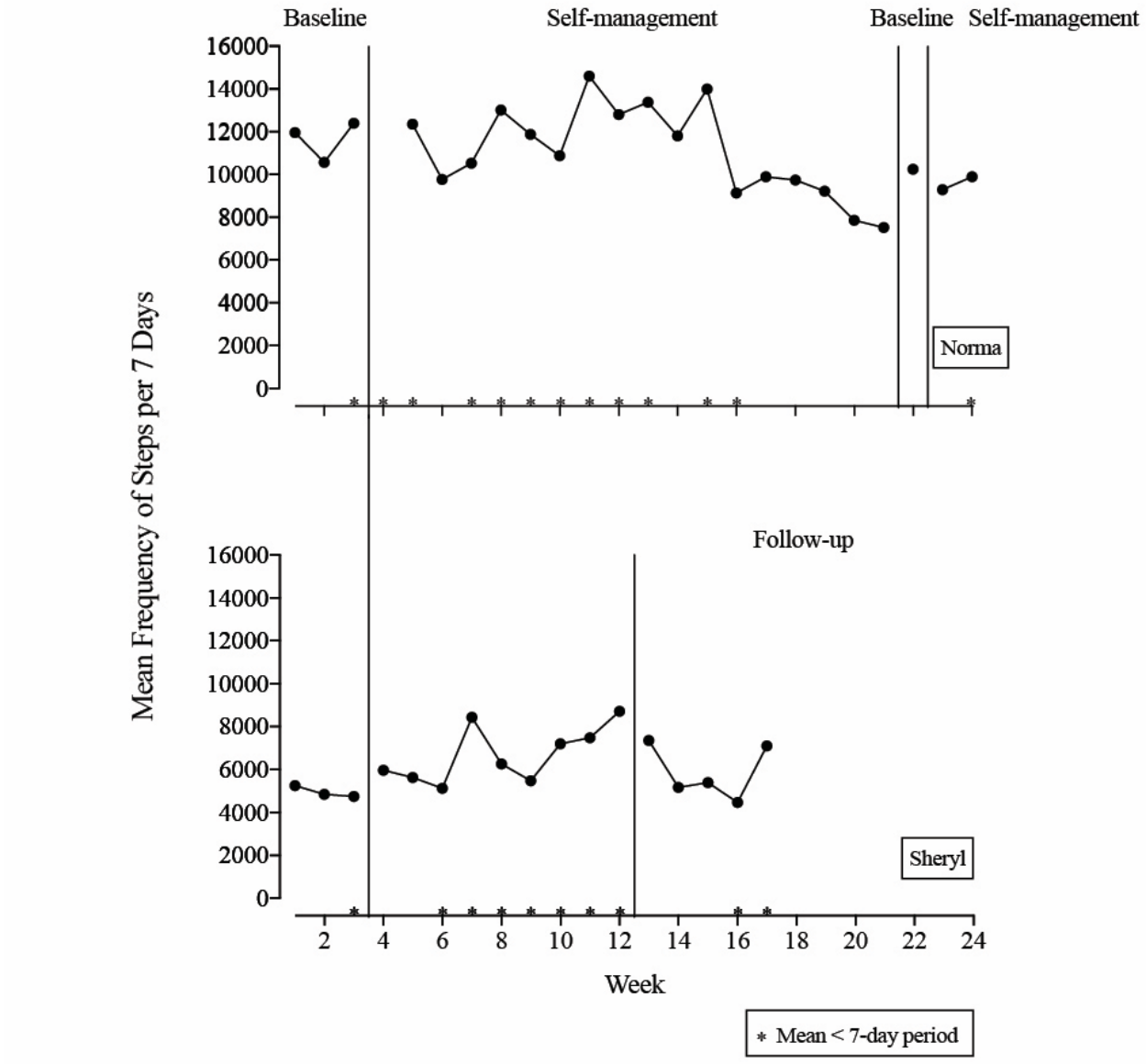

Figure 2. Mean frequency of steps per 7-day period, in chronological order across all phases for Dyad 2. Asterisks indicates a datum where the mean was calculated from a period of less than 7 days.

variable (steps) from a decelerating[1] trend in baseline to an accelerating[1] trend in intervention (Figures 3 and 4). This pattern was replicated in the reversal and reintroduction of the independent variable for Berta (Figure 3, bottom panel). Norma's data did not display a change in trend across the initial baseline and treatment phases; both baseline and intervention data were decelerating (Figure 4, top panel). During the reversal and reintroduction of the independent variable for Norma (Figure 4, top panel) an accelerating trend in a therapeutic direction is observed in both the reversal and treatment conditions. Analysis of change in trend direction from intervention to follow-up for Greta and Sheryl showed a change from an accelerating trend in a therapeutic direction during the intervention phase, to a decelerating trend during the follow-up phase for both participants. Visual analysis of trend stability from intervention to follow-up indicated a relative decrease in the variability of the data for Greta and an increase for Sheryl (Figures 3 and 4, top and bottom panels respectively).

Examination of the median step value from the second half of days in baseline to the first half of days in treatment show an improvement in *relative* level change for all participants (Table 1). Assessment of the data in Berta's reversal and second treatment phases displayed an even greater increase in relative level change from the latter half of days during baseline to the initial half of days in treatment, however there is a deterioration in absolute level change (Table 1). Analysis of Norma's data across the reversal and second treatment phases indicated a deterioration in relative level change but

[1] The terms *acceleration* and *deceleration* are based on guidelines for visual analysis outlined by Lane and Gast (2014).

an immediate increase in absolute level upon reintroduction of the intervention (based on final datum in baseline and the first datum in intervention; Table 1).

Table 1

Absolute and Relative Level Change for All Participants Between Conditions (N = 4)

Participant	Baseline to Treatment 1		Treatment 1 to Reversal		Treatment 1 to Follow-up		Reversal to Treatment 2	
	Rel	Abs	Rel	Abs	Rel	Abs	Rel	Abs
Berta	+2984	+1130	-6106	-6804			+4487	-1083
Greta	+1059	+1547			+74	-1480		
Sheryl	+2000.5	+5624			+608	-1953		
Norma	+1253	+1926	+1240	+5748			-2752	+83

Note. Rel = relative level change, Abs = absolute level change.

Within-condition analysis. Inspection of the median step value from the first half of days in baseline to the second half show an improvement in *relative* level change for Berta but a deterioration for Greta, Norma, and Sheryl. Assessment of the data in Berta's second baseline phase displayed a deterioration in the median value of daily steps from the initial to the latter half of this phase (i.e., relative level change) but an improvement in frequency from the first to the last day in baseline (i.e., absolute level change; Figure 3, bottom panel; Table 2). Examination of the data in Norma's second baseline phase showed an improvement in the median value of daily steps from the initial to the latter half and a deterioration in absolute level from the first to the last value in this phase.

Berta, Greta, and Sheryl's overall mean frequency of steps per phase increased from baseline to treatment by 2631, 1875, 12981, and 1775 steps respectively (Figures 3

and 4). The greatest increase in overall mean frequency of steps was observed across Berta's return to baseline ($\overline{x} = 5895$) and second treatment ($\overline{x} = 10257$) phases (Figure 3, bottom panel). Norma's overall mean frequency of steps per phase progressively decreased across all phases from the initial baseline to the final treatment phase. Further inspection of Norma's data within the initial treatment phase indicated an accelerating trend in the initial half of this phase with her mean step performance peaking midway ($\overline{x}$ =15063; days 56-60) followed by a decelerating trend & deterioration in her mean frequency of steps ($\overline{x}$ = 6996). Additional examination of the data in Norma's final treatment phase demonstrated an accelerating trend and an increase in her mean frequency of steps from the first ($\overline{x}$ = 9299) to the last ($\overline{x}$ = 9319) half of this phase.

Table 2

Absolute and Relative Level Change for All Participants Within Conditions (N= 4)

Participant	**Baseline**		**Treatment 1**		**Reversal/ Follow-up**		**Treatment 2**	
	Rel	Abs	Rel	Abs	Rel	Abs	Rel	Abs
Berta	+2466.5	- 3756	+994	+5779	-1011.5	+1977	+3575	+7759
Greta	-246.5	+1488	+1112.5	+2499	-1516.5	-1335		
Sheryl	-1391.5	-2360	+1106	+435	-4424	-970		
Norma	-1410	-285	-2921	-5902	+1117	-1718	+1368	-2205

Note. Rel = relative level change, Abs = absolute level change.

Visual analysis of trend revealed unstable, contra-therapeutic trends in baseline data for Berta, Norma, and Sheryl with greater than 20% (46.4%, 31.6%, 45%, respectively) of data points falling outside of the stability envelope (Figures 3 and 4). Inspection of data in Berta's second baseline phase also showed an unstable, contra-

therapeutic trend with 55% of data points outside of the stability envelope (Figure 3, bottom panel). The data in Norma's second baseline phase displayed a stable, therapeutic trend with 85.7% of data points falling on or within the stability envelope (Figure 4, top panel). Greta's baseline data demonstrated a stable, contra-therapeutic trend in baseline with 84.6% of data points landing on or within the stability envelope (Figure 3, top panel).

Examination of treatment data revealed unstable, accelerating trends for Berta and Sheryl (Figure 3 and 4, top and bottom panels respectively), with 55.6% and 55% of data points landing outside of the stability envelope, respectively. Analysis of data in Berta's second treatment phase also demonstrated an unstable, accelerating trend with 55.6% of data points falling outside of the stability envelope. Greta's treatment data displayed a stable, accelerating trend with 89% of data points *on or within* the stability envelope. Norma's data during the initial intervention phase displayed an unstable, decelerating, trend with 46.4% of data points landing outside of the stability envelope, while the data in her second treatment phase showed an accelerating trend with considerably less variability (i.e., 21.4% of data points outside of the stability envelope).

Only two participants completed a follow-up phase (i.e., Greta and Sheryl). Since Berta and Norma completed a reversal, their final phases consisted of treatment. Analysis of absolute level change from the first to the last day in follow-up demonstrated a deterioration in daily steps for Greta and Sheryl (Table 2). A deterioration in the median level of steps was observed for both participants from the first half of days in follow-up relative to the last half (-1516.5, -4424, respectively). Greta's data in follow-up displayed a decelerating, stable trend with 100% of data points *on or within* the stability envelope

(Figure 3, top panel; Table 2). Sheryl's data showed a decelerating, unstable trend with 78.3% of her data landing *outside* of the stability envelope (Figure 4, bottom panel; Table 2).

Overall, the intervention increased walking behaviour above baseline levels for each participant with variable magnitude and stability across participants. The number of sub-goals each participant was variable and depended on their walking behaviour within the treatment phase. For example, higher frequency daily step counts within a sub-phase resulted in a higher sub-phase mean and a higher goal in the subsequent sub-phase. Berta met progression criteria for six of seven sub-phase goals in her initial treatment phase and seven of nine goals in her second treatment phase. Greta met progression criteria for six of eight goals during her treatment phase. Norma met progression criteria for nine of seventeen goals during her initial treatment phase and one of two goals in her second treatment phase, and Sheryl met progression criteria for seven of nine goals in her treatment phase. Intra-subject replication of this effect was demonstrated as each participant met the criteria for multiple walking goals (i.e., criterion levels) during the treatment phase. Further support for the likelihood of a functional relationship between engagement in self-management behaviours (i.e., goal setting, self-monitoring, feedback) and increased steps is demonstrated as inter-subject replication of this treatment effect was demonstrated across three participants (i.e., Berta, Greta, and Sheryl). It is also important to note that Norma's data do not indicate a functional relationship between the dependent and independent variable.

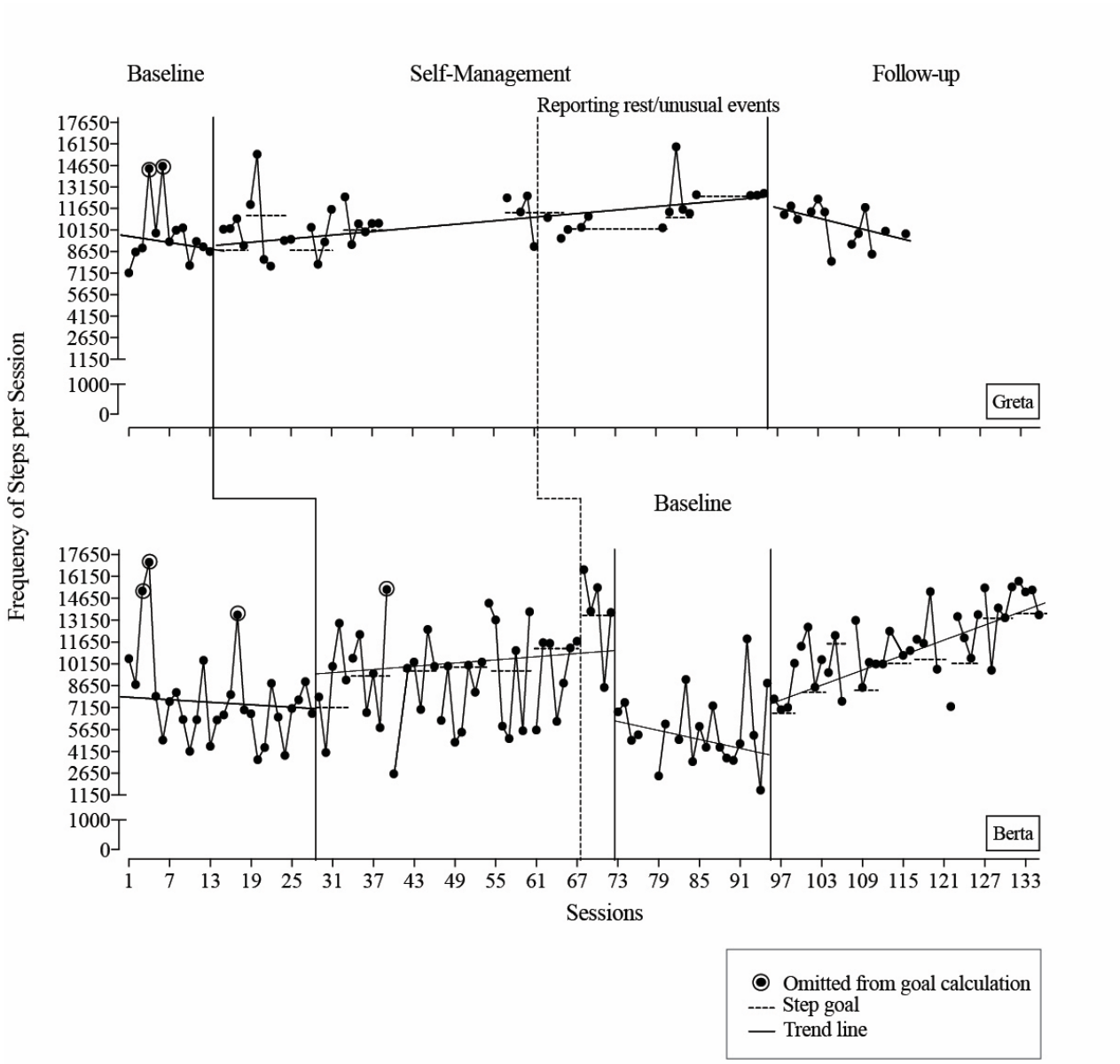

Figure 3. Daily frequency of steps across all phases (i.e., baseline, treatment, reversal or follow-up, treatment) for Dyad 1. Criterion levels (i.e., step goals) are depicted by horizontal dashed lines and trend lines are depicted by solid black lines. High frequency outliers (i.e., circled data points) were omitted from the calculation of the subsequent criterion level immediately following these data points. The dashed phase change line indicates when participants began tracking unusual events and rest days; Greta Day 63, Berta Day 68.

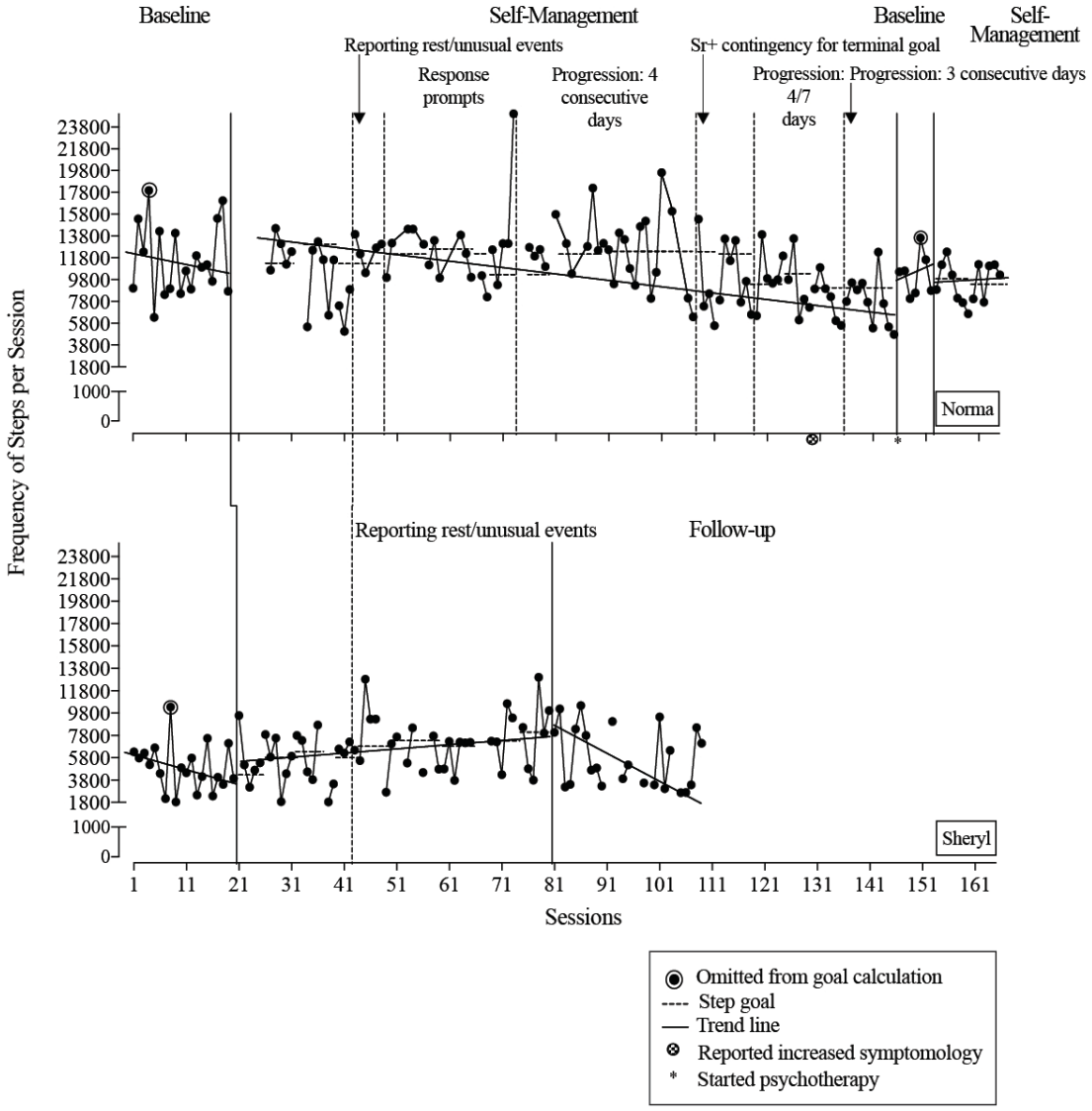

Figure 4. Frequency of steps data across all phases (i.e., baseline, treatment, and follow-up) for Dyad 2. Criterion level (i.e., step goals) are depicted by horizontal dashed lines and trend lines are depicted by solid black lines. High frequency outliers (i.e., circled data points) were omitted from the calculation used to determine the criterion immediately following these data points. The dashed phase change line indicates when participants began tracking unusual events and rest days. Norma and Sheryl began reporting rest days

and unusual events on day 43. Additional procedural changes for Norma are indicated with dashed phase change lines. The checkered circle on Norma's x-axis indicates when she began reporting increased depression symptomology and the asterisk denotes when she initiated bi-weekly psychotherapy sessions.

Secondary variables

Sleep duration and quality. Overall, the data on sleep duration and quality (i.e., frequency and duration of restless and waking periods) yielded mixed results. An increase in the mean duration of sleep per night from baseline to treatment was observed for Berta, Norma, and Sheryl (ranging from 0.5-40.7minutes; Figures 5-6). Similarly, an increase in the mean duration of sleep per night was observed for Norma from the reversal to the second treatment phase (i.e., 9.7 minutes; Figure 6). Sheryl's sleep data showed a slight decrease (i.e., - 4.2 minutes; Figure 6) in the mean duration of sleep per night from treatment to follow-up, while Berta's data displayed an increase from treatment to reversal (i.e., 18.5 minutes; Figure 5). Berta's data show a progressive increase in the mean duration of sleep per night across all phases with the largest increase in mean duration observed from baseline to the initial treatment phase (i.e., 40.7 minutes; Figure 7). Conversely, Greta's sleep data displayed a progressive decrease in the mean duration of sleep per night across all phases (i.e., 413, 407.7, 381.6 minutes; Figure 5).

The change in the mean duration of restless plus waking periods per night from baseline to treatment was mixed with half of the participants data displaying a mild increase (ranging from 3.6%-5.8%) and the other half showing a mild-to-moderate decrease (ranging from 2%-18.9%). Little change was observed in the mean frequency of restless periods per night from baseline to treatment with a slight decrease for Berta (i.e.,

0.2 periods) and a mild-to-moderate increase for Greta, Norma, and Sheryl (0.2, 0.4, 1.6 periods, respectively). Changes in the frequency of waking periods at night from baseline to treatment was similarly varied with Berta and Greta's data displaying a slight increase in frequency (0.3 and 0.8 periods, respectively) and Norma and Sheryl's data exhibiting a slight decrease (0.4, 0.5 periods, respectively). Greta and Sheryl's data show an increase in the mean duration of restless plus waking periods per night from treatment to follow-up (i.e., 3.5, 3.4 minutes, respectively). Berta's data display a decrease from the initial treatment to the reversal phase (i.e., 8.5 minutes) and a subsequent increase in the final treatment phase (3.9 minutes). Norma's data display an increase from the initial treatment to reversal phase (i.e., 3.9 minutes) and a subsequent decrease in the final treatment phase (9.5 minutes).

Sleep efficiency scores provided additional information on each participant's quality of sleep across all phases of the study. Overall, participants showed high mean scores in baseline and little variation in scores across phases. During baseline, all participant's mean *sleep efficiency* scores were between 93% to 96%. Greta's, Norma's, and Sheryl's mean *sleep efficiency* scores remained consistent from Baseline to treatment (93%, 93%, 97%, respectively). Berta's mean *sleep efficiency* score decreased slightly (i.e., 2%) from baseline to treatment (i.e., 96% to 94%, respectively). During the reversal phase, Berta's mean *sleep efficiency* score returned to her baseline level and remained at this level through the second treatment phase. During the reversal phase for Norma, her mean *sleep efficiency* score slightly decreased (i.e., 1%) then subsequently increased during the second treatment phase (i.e., 2%). Sheryl's mean *sleep efficiency* score remained consistent from treatment through follow-up phases and Greta's mean *sleep*

efficiency score showed a minor (i.e., 2%) decrease.

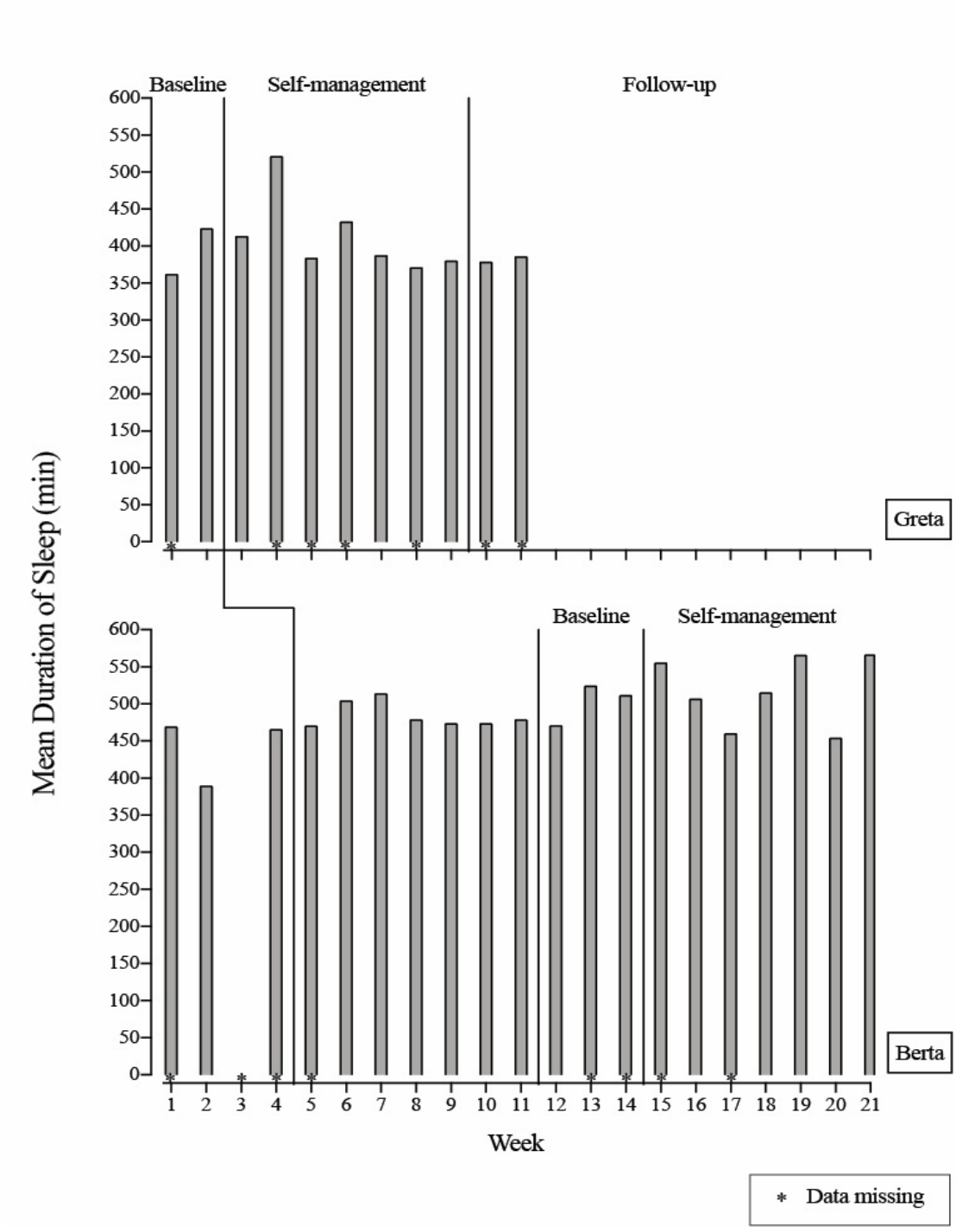

Figure 5. Mean duration of sleep (minutes) for *Dyad 1* across all phases of the study. Each bar represents a 7-day period in the study in chronological order along the x-axis.

Bars representing less than 7 days of data are identified with an asterisk along the x-axis. Missing data was due to technical malfunction with the Fitbit Flex™ data archive.

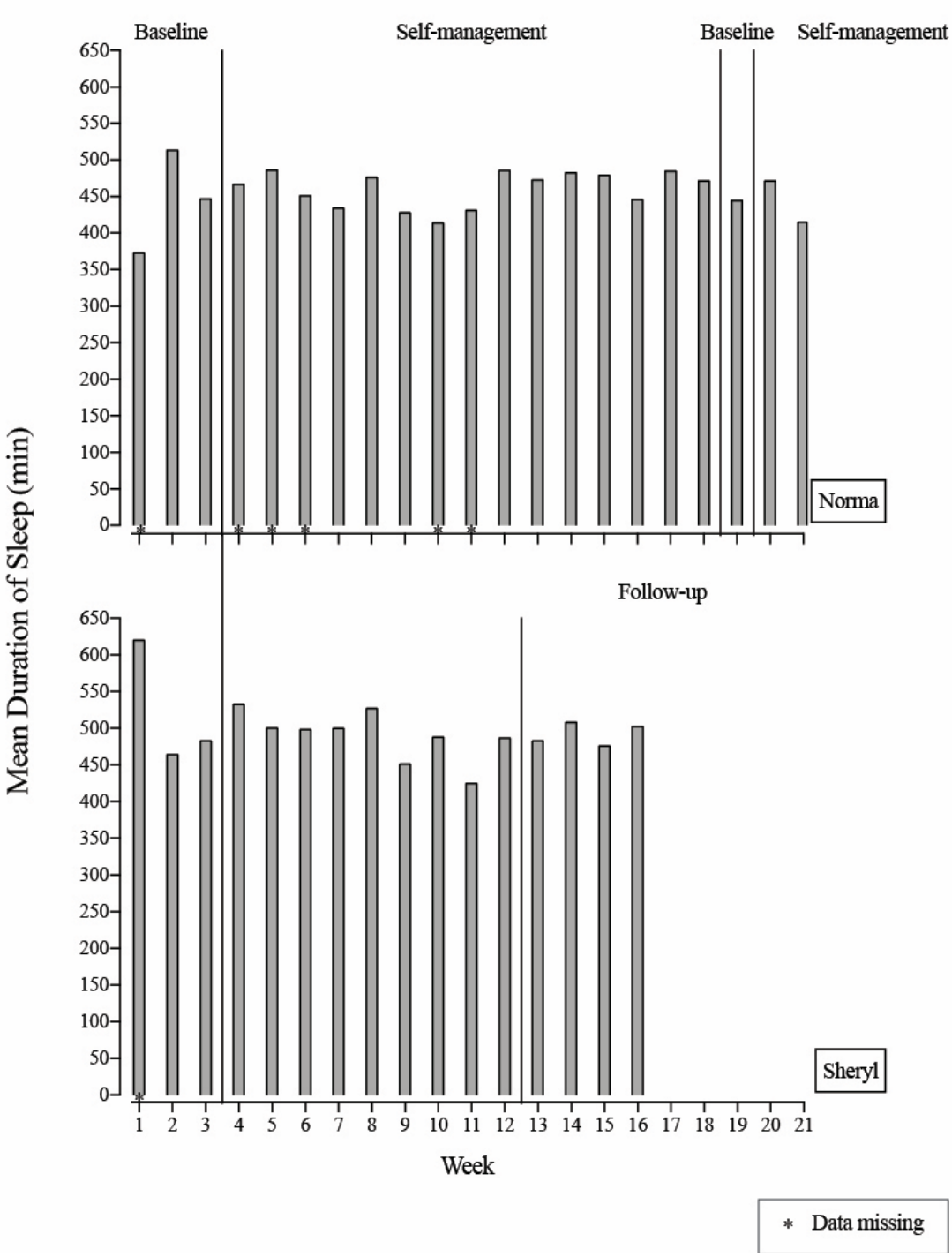

Figure 6. Mean duration of sleep (minutes) for *Dyad 2* across all phases of the study. Each bar represents a 7-day period in the study in chronological order along the x-axis. Bars representing less than 7 days of data are identified with an asterisk along the x-axis. Missing data was due to technical malfunction with the Fitbit Flex™ data archive.

Self-reported depressive symptoms. Each participant reported their depression symptoms by completing the USDI at three pre-determined time-points (i.e., pre-treatment, mid-treatment, post-treatment). The researcher calculated total and sub-scale scores for each USDI following the guidelines provided by the authors of the inventory. Higher scores (total and sub-scale) on the USDI indicate a greater occurrence of depressive symptoms (Romaniuk & Khawaja, 2013). Overall, the changes observed in the USDI data across the three assessment time points were mixed (Figure 9). Berta's and Greta's total USDI scores decreased considerably from pre-treatment to mid-treatment assessment (by 21 points [30%] and 18 points [19%] respectively; see Figure 9) and Norma and Sheryl's scores showed minor increases (by 4 points [4%] and 1 point [1%] respectively; see Figure 9). Similarly, Berta's and Greta's total USDI scores increased from mid-treatment to post-study assessment (by 5 points [10%] and 5 points [6%] respectively) and Norma and Sheryl's score decreased (by 19 points [17%] and 4 points [5%] respectively).

Analysis of the subscale scores from pre-treatment to mid-treatment assessment yielded a decrease in scores on all three subscales for Berta (ranging from 2-11; Table 3). Greta's scores on the *lethargy* and *cognitive-emotional motivation* scales decreased by 15 and 5 points, respectively while her score on the *academic motivation* scale increased by

2 points (Table 3). Norma's data displayed a decrease in scores on the *lethargy* and *academic motivation* scales (3 and 2 points, respectively) and an increase in her score on

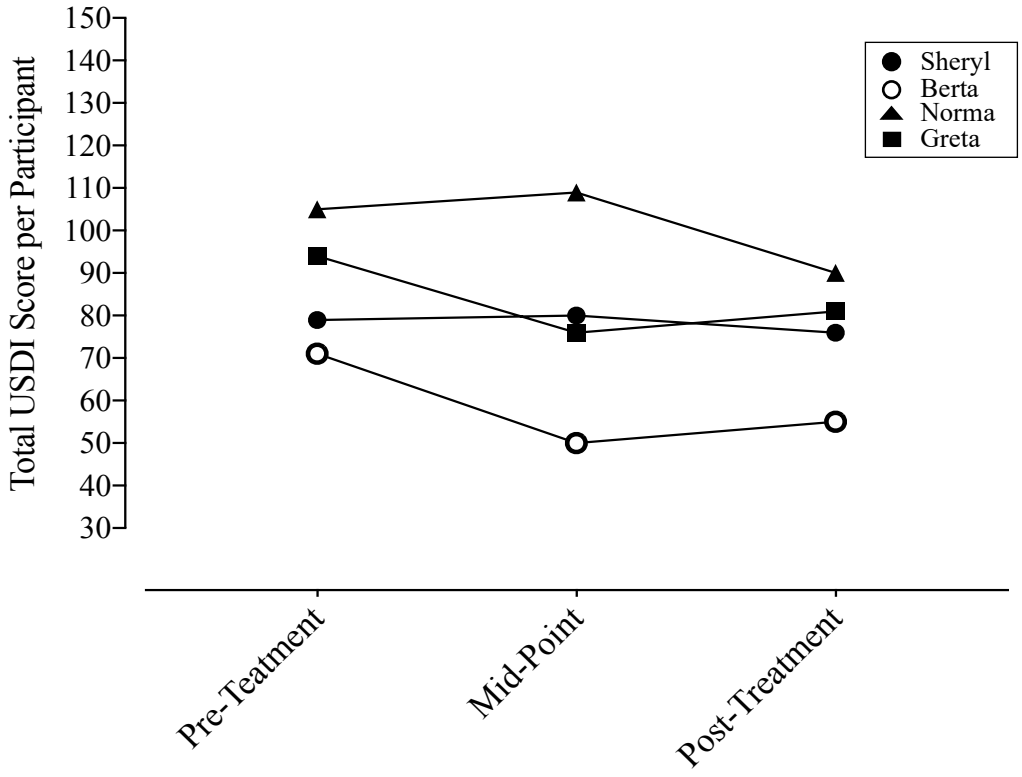

Figure 7. Each participant's total scores on the University Student Depression Inventory (USDI) are displayed across each of the three assessment time points (i.e., pre-treatment, mid-way through treatment, post-treatment).

the *cognitive-emotional motivation* scale (9 points; Table 3). Conversely, Sheryl's data displayed an increase in scores on the *lethargy* and *academic motivation* scales (3 and 2 points, respectively) and a decrease in her score on the *cognitive-emotional motivation* scale (4 points; Table 3). Analysis of data from mid-treatment to post-study showed that both Berta's and Greta's scores on the *lethargy* (2 and 6 points, respectively) and *cognitive-emotional motivation* scales increased (4 and 1 points, respectively) while their scores on the *academic-motivation* scale decreased (1 and 2 points, respectively; Table

3). Norma's scores decreased on all three subscales (ranging from 3-10; Table 3) with her change in score on the *academic motivation* scale demonstrating the greatest decrease in score (between two assessment time-points) across all participants. Sheryl's score increased on the *lethargy* scale (5 points) and decreased on the *cognitive-emotional motivation* (4 points) and *academic motivation* scales (5 points; Table 3).

Table 3

University Student Depression Inventory subscale scores for each participant (N = 4)

Participant	**Lethargy**			**Cognitive Emotional Motivation**			**Academic Motivation**		
	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
Berta	25	17*	19	34	23*	27	12	10*	9*
Greta	42	27*	33	38	33*	34	14	16	14*
Sheryl	26	29	34	36	32*	28*	17	19	14*
Norma	37	34*	31*	40	49	43*	28	26*	16*

Note. Pre = pre-treatment; Mid = mid-way through treatment; Post = post-treatment * = change in score (from the previous assessment) in a therapeutic direction.

The registered psychotherapist completed the CGI (Guy, 1976) to provide ratings of clinical significance of any change observed in self-reported depressive symptoms, steps, and sleep (Table 4). She completed the *Time 1* assessment based on each participant's pre-treatment USDI scores; thus, the *improvement rating scale* was not completed as there were no subsequent assessment scores to compare to the initial scores. The psychotherapist completed the *Time 2* assessment by comparing pre-treatment and mid-treatment USDI scores, and the *Time 3* assessment by assessing overall improvement based on all three USDI assessments (i.e., pre-, mid-, post-treatment). The CGI analysis indicated an improvement in depressive symptoms from pre- to mid-treatment for Berta,

Greta, and Sheryl, and no noteworthy change for Norma (Table 4). The psychotherapist's CGI data from the T*ime 3* assessment show an overall improvement in depressive symptoms of the same magnitude across all participants (Table 4). In summary, the results of the CGI analysis indicate a clinically significant change in depressive symptoms (i.e., from baseline levels) for all participants which maintained post-treatment for three of the four participants (i.e., Berta, Greta, & Sheryl). Norma's data do not demonstrate a significant change in self-reported symptoms mid-treatment (i.e., relative to baseline levels) but do show a clinically significant improvement in depressive symptoms post-treatment, relative to her mid-treatment levels (Table 4).

Table 4

Clinical Global Impression Scale ratings for each participant (N = 4)

Participant	**Time 1**		**Time 2**		**Time 3**	
	Sev	Imp	Sev	Imp	Sev	Imp
Berta	3		2	2	2	2
Greta	5		4	2	4	2
Sheryl	4		3	2	3	2
Norma	5		5	3	4	2

Note. Sev = severity rating; Imp = improvement rating. Higher severity rating scores indicate greater level of depressive symptomology. Lower improvement rating scores indicate greater improvement in symptomology, and an improvement rating score of 3 indicates "no change."

Social validity

Mid-treatment assessment. Overall, participants rated the study as highly effective (i.e., mean rating $\geq$ 4.6/5) in helping them to increase their daily steps (Table 4-5). Regarding secondary outcomes on the mid-point assessment, Berta and Greta

indicated that they experienced an improvement in their mood. Berta also noted an improvement in her quality of sleep (Table 4). Both Norma and Sheryl reported to be undecided (i.e., "neither agree or disagree" on the questionnaire) regarding possible improvements in mood or quality of sleep. Regarding treatment and training procedures, participants rated the program as a whole, as well as the self-monitoring procedure, and the progression of step goals as highly acceptable (i.e., rating $\geq$ 4.75/5; Table 4). Overall, participants indicated that they believed both the self-monitoring and feedback components contributed to the increase in their walking behaviour but rated the self-monitoring procedures as having a slightly higher influence. Individual differences in rating the efficacy of the components showed that both Berta and Greta believed self-monitoring and feedback to be equally effective, while Sheryl indicated self-monitoring had a stronger influence. On her mid-treatment assessment, Norma reported the monitoring of progress toward meeting progression criteria and receiving daily feedback equally but indicated indecision regarding the recording and reporting (to the researcher) of daily steps but indicated both were equally effective on her post-treatment assessment. Regarding maintaining engagement in walking for increased physical activity (post-study), both Norma and Sheryl indicated that they not only intend to maintain the frequency of steps per day achieved in the study but also to continue to try and increase their daily frequencies. Berta indicated that she plans to maintain the daily frequencies achieved in the study and Greta reported that she aims to continue to increase her steps (per day).

Post-treatment assessment. Overall ratings regarding treatment outcomes decreased post-study (range 0.25-0.5 decrease in rating; Table 5), with the greatest

decline on perceived improvement in quality of sleep. Participants' ratings regarding the efficacy of the feedback decreased (0.5) but increased for the self-monitoring procedures (0.25; Table 5). Overall ratings of the acceptability of treatment and training components were variable. Specifically, ratings regarding the overall ease of participating in the program decreased (0.25; Table 5), while ratings regarding the pre-treatment training sessions and the progression of step goals increased (0.75, 0.25, respectively; Table 5) and ratings regarding the ease of capturing the screenshot and sending it to the researcher remained the same. Finally, regarding maintaining engagement in the target behaviour, Sheryl indicated that she intended to continue to increase her daily frequencies, Greta and Norma reported their intention to maintain the frequency of steps per day achieved in the study, and Berta indicated indecision regarding her future engagement in walking.

Table 5

Mean Scores on the Social Validity Questionnaire for the Mid-treatment Assessment (N = 4)

Statement	Mean Score (out of 5)
Treatment Outcomes	
This program helped me to increase the number of steps I take on a regular basis	4.75
I noticed an improvement in my quality of sleep	3.25
I noticed an improvement in my mood	3.5
Acceptability of Treatment/Training Components	
This program was easy to follow	4.75
It was easy to capture the screenshot of my Fitbit Flex™ *Dashboard* and send that information to the researcher	5
The training sessions helped me learn how to use the Fitbit Flex™ and monitor my progress toward my goals	4.25

The progression of step goals moved at a comfortable pace for me	4.75
The feedback is/was a useful part of this program	4.25
Goodness of Fit between Participant and Treatment Goals	
Before beginning this program, I had difficulty engaging in exercise on a regular basis	3.75
Before beginning this program, I experienced sleeping difficulties	4.5
Efficacy of Treatment Components	
The feedback is/was supportive and helps me to stay on-track with my goals	4.5
The feedback is/was motivating to continue walking	4.5
I believe monitoring my progress towards my goal each day helped me to increase the number of steps I took each day	4.75
I believe recording and sending my daily step progress helped me to increase the number of steps I took each day	4.5
Likelihood of Maintaining Engagement in Targeted Behaviours	
I plan to continue to work on increasing the number of steps I take each day	4.25
I plan to maintain the number of steps I take each day	4
Likelihood of Generalizing Self-management Behaviours	
I will continue to use the techniques I learned in this program to achieve my future goals	4.75

Table 6

Mean Scores on the Social Validity Questionnaire for the Post-treatment Assessment (N = 4)

Statement	Mean Score (out of 5)
Treatment Outcomes	
This program helped me to increase the number of steps I take on a regular basis	4.5

I noticed an improvement in my quality of sleep	2.75
I noticed an improvement in my mood	3.25
Acceptability of Treatment/Training Components	
This program was easy to follow	4.5
It was easy to capture the screenshot of my Fitbit Flex™ *Dashboard* and send that information to the researcher	5
The training sessions helped me learn how to use the Fitbit Flex™ and monitor my progress toward my goals	5
The progression of step goals moved at a comfortable pace for me	4.75
The feedback is/was a useful part of this program	4
Goodness of Fit between Participant and Treatment Goals	
Before beginning this program, I had difficulty engaging in exercise on a regular basis	3.75
Before beginning this program, I experienced sleeping difficulties	3.75
Efficacy of Treatment Components	
The feedback is/was supportive and helps me to stay on-track with my goals	4
The feedback is/was motivating to continue walking	4
I believe monitoring my progress towards my goal each day helped me to increase the number of steps I took each day	4.75
I believe recording and sending my daily step progress helped me to increase the number of steps I took each day	4.75
Likelihood of Maintaining Engagement in Targeted Behaviours	
I plan to continue to work on increasing the number of steps I take each day	3.25
I plan to maintain the number of steps I take each day	3.25
Likelihood of Generalizing Self-management Behaviours	
I will continue to use the techniques I learned in this program to achieve my future goals	4

Open-ended questionnaire

Results of the open-ended questionnaire were variable across participants. All participants reported to have used additional strategies outside of the self-monitoring procedure included in the treatment package (i.e., observing the daily frequency of steps via the Fitbit™ application and reporting this information to the researcher). All additional strategies involved antecedent planning of when and, or where to complete walks. In addition, pre-planned walks involved known routes for which the participant was knowledgeable of the approximate number of steps she could accumulate for each particular route. All participants reported to synchronize to their Fitbit™ application periodically (range 1-8 synchronizations) throughout the day to monitor the exact number of steps accumulated. All participants also reported to have shared that they were attempting to increase their daily steps with others and Greta, Berta, and Norma noted that they told this individual(s) when they met progression criteria. Greta, Berta, and Norma also reported that this individual(s) would deliver praise for meeting progression criteria and encouragement (to walk more/longer) when the goal had not been met. Berta, Sheryl, and Norma reported to take at least one *rest day* per sub-phase, while Greta reported to only take a *rest day* if she was ill and when she was studying for an exam. Finally, Berta, Greta, and Sheryl reported that they believed the praise-based feedback from the researcher (i.e., praise statement regarding meeting the current goal) and the visual and tactile feedback from the device when they met their goal had less influence on their behaviour than their motivation to avoid meeting regression and receiving the associated encouragement-based feedback (i.e., text message notifying regression criteria was met and they should return to their most recently mastered goal).

Discussion

General Findings and Implications

A self-management treatment package involving goal setting (researcher- and participant-selected), self-monitoring, and planned feedback (researcher-delivered) was implemented for four adult, female university students with persistent depressive symptoms. The results of this evaluation provide further support for the use of a self-management treatment package (e.g., Normand, 2008; Donaldson & Normand, 2009; Van Camp & Hayes, 2012) to increase walking with a novel population (i.e., university students with depressive symptoms); albeit, the high variability in three of four participants' data require further consideration of the extent to which the independent variable contributed to the observed increase in walking. Each participant achieved average daily step frequencies above her baseline mean during the treatment phase (see Figure 1-2). Further support for a functional relationship between the use of the self-management treatment package and increasing daily walking was established as this relationship was replicated (i.e., during reversal & reimplementation of the treatment package) for one of participants (Berta), demonstrating generality of the findings (Barton et al., 2018). Not unlike previous self-management studies involving a return to baseline conditions, one participant's (Berta) highest walking performance was observed in the final treatment phase (De Luca & Holborn, 1992; Normand, 2008). In addition, the change in walking behaviour was more immediate and consistent with the second implementation of the treatment package for this participant suggesting that repeated practice of the use of self-monitoring may result in more rapid goal-attainment. Norma's data however do not confirm previous findings as her step data demonstrate a

decelerating trend during the initial treatment phase and accelerating trend during reversal, suggesting that this treatment package may not be efficacious for all university students with persistent depressive symptoms. It is important to consider this in relation to her very high baseline step data.

Despite the demonstration of variability in daily step frequencies across participants, the average number of days below the criterion decreased across the treatment phase for three of four participants. Specifically, Greta and Sheryl's average number of days below criterion per sub-phase decreased in the last three sub-phases, and Berta's overall days below criterion decreased from her initial to her final treatment phase (2.7, 1.4 days, respectively). This trend was not observed for Norma as her average days below criterion increased from the first to the second treatment phase from 2.8 to 3.5 steps, respectively.

Consistent with previous studies examining physical activity and its impact on sleep, the mean sleep duration per night from baseline to treatment increased for three of four participants suggesting increased walking may be associated with improvement in the amount of sleep per night (Pelletier et al., 2017; Wolff et al., 2011). However, this finding was not consistently demonstrated in these data; Berta's mean duration of sleep per night increased from the initial treatment to the reversal phase and Greta's data demonstrated a consistent decrease across all phases. Due to the highly variable results of the data on sleep quality measures (i.e., frequency & duration of restless and waking periods) the impact of increased walking on the quality of sleep per night cannot be concluded. The changes observed (i.e., increase or decrease) in the duration and frequency of restless and waking periods per night did not consistently occur with the

introduction and removal or termination of treatment package suggesting the observed changes may be influenced by an external factor(s) or potentially that the malfunctions[2] of the Fitbit Flex™ device may have considerably affected the data. While the Fitbit Flex™ has been shown to be valid and reliable device for recording sleep duration, previous studies have indicated limitations regarding the reliability of the sleep efficiency data (i.e., restless and waking periods once sleep mode is initiated; Mantua et al., 2016).

The findings from the researcher's analysis of the USDI data, contribute to the bulk of research demonstrating an inverse relationship between increased exercise and some symptoms of depression (e.g., Carek et al., 2011; Cooney et al., 2013; Mead, et al., 2009; Pelletier, et al., 2017; Wolff et al., 2011), suggesting that increased walking may be associated with a collateral decrease in some symptoms of depression (e.g., enjoyment of activities of interest, mood affecting one's ability to carry out tasks) from baseline levels for some participants. Similar to the outcomes of Vetrovsky et al. (2017), the mean increase in the frequency of steps per day from baseline to the end of the initial treatment phase for three of four participants (i.e., Berta, Greta, Sheryl) was 32% (compared to 33%; Vetrovsky et al., 2017). The decrease in self-reported depression symptoms for Berta and Greta was slightly lower than those reported in Vetrovsky et al., 2017 (24.5% compared to 33%, respectively). The mild increase in symptoms mid-treatment for Norma and Sheryl (4%, 1%, respectively) and subsequent decrease post-treatment (17%,

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[2] On multiple occasions, across participants, the Fitbit Flex™ recorded but did not store sleep data.

5%, respectively) may indicate that the reported changes in symptoms may have been the result of a natural fluctuation over time or perhaps in Norma's case, the addition of psychotherapy treatment.

It is important to note that it is impossible to determine whether the changes in depression symptoms can be attributed to the increase in daily steps as several other factors (e.g., engagement in self-monitoring, researcher feedback, natural fluctuation in symptoms over time) may have contributed or been wholly responsible. However, some useful information may be ascertained by interpreting these findings in the context of the previous literature demonstrating increased engagement in physical activity and collateral decreases in depression symptomology. Previous studies that showed statistically and/or clinically significant decreases in symptoms of depression typically employed an exercise program between 8 to 10 weeks (e.g., Doyne et al., 1987, Mather et al., 2002, Prathikanti et al., 2017) involving at least 1 type of physical activity (e.g., walking, running, yoga) that participants were expected to engage in at least 2 times per week. Similarly, the present study involved engagement in walking at frequencies above baseline levels at least 4 times per week for an average of 6.5 weeks (range 5.4-7.6 weeks). Given the modest outcomes in the current study (only 2 of 4 participant reported decreased symptomology mid-treatment), the duration of the treatment phase may not have been sufficient to reduce symptoms.

Limitations and Future Directions

While the results of the study provide some support for the use of the self-management treatment package to increase walking in adults with persistent depressive symptoms, the high variability in three of four participants' data require further

consideration of the extent to which the increase in walking can be attributed to the independent variable. Confidence with respect to the experimental control of the independent variable over the dependent variable is weakened by the considerable amount of variability in the data during the treatment phase(s) for Berta, Norma, and Sheryl. Both Berta's and Sheryl's data demonstrate an increase in level from baseline to treatment phase, however the actual frequencies varied considerably (i.e., frequency of steps $\geq$ +/- 1000 from the criterion) around criterion level during each sub-phase (range 1-7, $\overline{x}$ = 3.6), suggesting participants' daily frequencies during treatment were not consistently controlled by the specific criterion level.

Previous research examining the use of goal setting (in addition to other self-management techniques) to increase physical activity via a gradual increase in the dependent variable toward a terminal criteria, has shown that participant's engagement in the target behaviour frequently varies around the sub-phase criteria (i.e., above and below the criterion level; De Luca & Holborn, 1992; Donaldson & Normand, 2009; Normand, 2008; Zarate et al., 2019). It has been suggested that the frequent sub-criterion performance may be an indication that goal setting is not necessary to produce the desired behaviour change (e.g., Normand, 2008), however component analyses would be required to determine which self-management strategies are indeed necessary and sufficient for behaviour change in the target behaviour. The specific progression criteria (sub-phase and terminal goals) may be one variable that potentially influenced the variability in the participants' walking behaviour in the present study. Progression criteria required that participants meet or exceed the current criterion (i.e., specific frequency of steps per day) four times in a seven-day-period, thus permitting participants to progress to

a new goal despite some step frequencies exceeding or falling below the criterion level. Similar to previous findings, two of the three participants surveyed (i.e., Berta and Sheryl) reported (on the open-ended questionnaire) to take rest days during each sub-phase to attend to other tasks (e.g., academic assignments) or to simply take a break from engaging in planned walking (Normand, 2008).While the participants were required to report when they took rest days, these occurrences may have been underreported as the integrity data on participants' adherence to self-monitoring procedures showed inconsistent reporting of supplementary information (i.e., if they engaged in any physical activity other than walking). While variability in data during the intervention phase is typically attributed to decreased amount of control of the independent variable over the dependent variable, the relationship is not as clear when at least some of the variability may be due to the participant creating their own "rules" about when they would engage in the behaviour in order to achieve the criteria. In addition, walking and daily step frequencies measured across an entire day are highly susceptible to variability. The criterion allowed participants to engage in below-criterion performance (e.g., take rest days) for up to three days during each sub-phase and still attain the *progression criteria* which may have reinforced these rules. It is important to note that anecdotally, participants reported to appreciate the four out of seven-days at the criterion level *progression criteria* as it allowed some flexibility in arranging their week to accommodate not only their step goal but also academic and, or workplace demands. To combat high levels of variability across sub-phases and increase the likelihood of walking above baseline levels consistently, future researchers may choose to use a range-based

changing criterion design and set *progression criteria* to include achieving a daily frequency of steps within the specified range, across consecutive days.

Regarding data exceeding the sub-phase criteria, the environment in which participants accumulated their steps may have contributed to above-criterion frequencies. Specifically, all participants reported to accumulate their steps in unstructured, free-operant conditions (i.e., no discrete start and end or specific number of steps per walk or activity involving walking) and within the context of daily routines (e.g., walking the dog, running errands). As such, a participant may have achieved her step goal while walking in her neighbourhood or in the process of running errands but would need to keep walking to return home or complete her errands. When participants were asked (on the open-ended questionnaire) if they continued to try to accumulate steps after being notified that they reached their daily goal (i.e., by the device), all participants responded "no."

A second limitation worth further investigation involves the decreasing trend in Norma's daily steps during the second half of her initial treatment phase. The contra-therapeutic trend in Norma's treatment data may be the result of one or more of the following variables. Norma displayed a high frequency of steps in baseline (range 6343-17996 steps) which resulted in a high frequency initial step goal (i.e., 11212 steps) and subsequently higher early sub-phase goals (12063-12987 steps). Her baseline mean was already considerably higher than the commonly accepted criteria of 10,000 steps per day frequency for healthy adults (e.g., Tudor-Locke & Basset, 2004). Future researcher's may consider specifying a maximum daily (e.g., 10,000 steps) step frequency as part of their exclusion criteria. Despite Norma demonstrating the ability to achieve daily frequencies

considerably higher than the other participants, increasing her daily steps beyond a certain level may not have been achievable later in the study given the change in employment-related demands. Norma had a change in her employment during her 12th sub-phase and reported that many of the job-related activities at the new workplace were incompatible with walking. A marked decreasing trend in daily step frequencies is observed in the 11th sub-phase goal relative to the increasing trend observed in sub-phases 1-10. In addition, during this period of time in the study (i.e., sub-phases 11-17) Norma reported to be experiencing increased symptoms of depression (i.e., low mood, increased lethargy, and loss of motivation to engage in activities) and noted that she believed this was due to undesired changes in her personal life. The increase in depression symptomology is also reflected in an increase in her total score on the mid-treatment USDI assessment. Norma reported higher depression symptoms than the other three participants during baseline and mid-treatment assessments (post-study assessment is forthcoming) which may be an additional contributing factor to the decrease in daily steps across the treatment phase and a higher frequency of sub-criterion step frequencies within sub-phases (average of 3.4/sub-phase) than the other three participants (range 1.1-2.7/sub-phase). While it cannot be determined with the information gathered in the USDI, based on Norma's anecdotal reports it is reasonable to surmise that the increase in her depressive symptoms was most likely the result of undesired life events and not participation in the study.

No reliable dose-response rate for physical activity and depression has been established. The results of the present study suggest that the specific goal setting, self-monitoring, and feedback procedures utilized herein may be most appropriate for

individuals with *low* to *moderate* baseline levels of depression symptoms (as categorized by USDI cut-off scores; Romaniuk & Khawaja, 2013), as a treatment effect was not observed for the participant with the *high* symptomology. In addition, future studies targeting increased physical activity involving participants who are engaging in high frequencies of the target behaviour (e.g., walking) during baseline (even intermittently) may be more effective in helping these individual(s) achieve their physical activity goals by targeting a different topography (e.g., walking on an incline) or dimension of the behaviour (e.g., walking for longer durations in a single bout) or the consistency or intensity with which they walk. Targeting increased daily frequencies of a behaviour that is already occurring at high frequencies (i.e., in baseline) may result in setting goals that are unreasonably high and cannot be achieved in a single day. This may result in the participant meeting regression criteria as a result of inappropriate goals and receiving corrective feedback on their engagement in the target behaviour. The corrective feedback and, or stimuli associated with meeting the regression criteria may be aversive to some participants. Furthermore, when a goal is exceptionally high, the participant may be engaging in increased walking during all or most available opportunities (e.g., before & after work) but fail to meet the daily goal and, or progression criteria which could decrease future engagement in walking if the corrective feedback and, or stimuli associated with meeting the regression criteria are aversive.

All participants reported a decrease (from pre-treatment levels) in some depressive symptoms on the mid-treatment assessment USDI that was reflected in a lower total *and, or* subscale(s) score suggesting increased walking may be associated with a decrease in some depressive symptoms. Specifically, Berta and Greta reported

changes in symptomology that resulted in lower total and subscale scores, Norma's reported decrease was reflected in lower scores on the lethargy and academic motivation subscales, and Sheryl's reported decrease resulted in a lower score on the cognitive-emotional motivation sub-scale. In addition, all participants reported less frequent occurrence of symptoms associated with items on the academic motivation scale (e.g., poor attendance to lectures, difficulty initiating assignments & completing study tasks; Romaniuk, & Khawaja, 2013). Further, decreased daily walking and termination of the self-management treatment package (i.e., follow-up and reversal phases) were associated with increased total scores for two of three participants and increased scores on at least one USDI subscale all three participants. These findings are consistent with previous research in this area, suggesting that engaging in increased physical activity, relative to one's individual baseline, is associated with a collateral decrease in depressive symptoms (e.g., Cooney et al., 2013; Mather et al., 2002, Pelletier, et al., 2017; Wolff et al., 2011).

Consistent with previous literature examining the relationship between increased engagement in physical activity and depressive symptoms, three of four participant's sleep data showed an increase in mean sleep duration from baseline to treatment. In addition, two of these three participant's sleep data also displayed an increase in sleep quality (i.e., a decrease in the duration of restless and/or awake periods per night) in the treatment phase (e.g., Pelletier et al., 2017; Wolff et al., 2011). Berta's mean duration of sleep continued to increase across reversal and the second treatment phase suggesting the collateral effects of increased physical activity associated with improved sleep duration may maintain during a brief (i.e., 20 days) pause in physical activity. Conversely, her mean duration of restless and, or awake per night increased from baseline to treatment

and subsequently decreased during return to baseline and increased slightly in the final treatment phase. Similarly, Sheryl's mean duration of restless and, or awake periods per night increased from treatment to follow-up. Interpretation of the sleep data was considerably limited due to multiple days of missing data (particularly during baseline) due to technical malfunction of the Fitbit Flex™ device. Further research is needed to determine if increased engagement (relative to individual baseline level) in walking is sufficient to produce improvements in sleep duration and quality.

In conclusion, the findings of the present study indicated that combined goal setting, self-monitoring, and feedback can effectively produce an increase in daily walking frequencies of adults with persistent depressive symptoms. In addition, increased walking (relative to baseline levels) may be sufficient to produce a decrease in some symptoms of depression. Together these findings suggest that the treatment package provides a low-cost intervention to increase engagement in walking for adults with depressive symptoms. Furthermore, the intervention can be implemented remotely and participant behaviours (i.e., walking, self-monitoring) can be conducted in environments convenient for the individual, reducing response effort. An interesting area for future research could include pre-treatment training of researcher-directed components (i.e., goal setting & feedback) and subsequent fading of these components once terminal goals are achieved. Furthermore, researchers should collect data on self-monitoring behaviour across phases to determine if engagement in self-management behaviours will be maintained beyond the treatment phase in the absence of feedback. To increase the likelihood of maintenance of the target behaviours, researchers may also consider fading the use of the tracking device and substituting it for an alternative tracking method if

participants will not be using the device post-study. Finally, future studies could also investigate the use of other tracking devices with increased reliability with respect to sleep data to further examine the relationship between low-intensity physical activity and sleep disturbance.

References

American College Health Association. (2016). *American College Health Association-National College Health Assessment II*. Retrieved from https://www.acha.org/documents/ncha/NCHA-II_Spring_2016_Reference_Group_Executive_Summary.pdf

American College Health Association. (2018). *American College Health Association-National College Health Assessment II*. Retrieved from https://www.acha.org/documents/ncha/NCHA-II_Spring_2018_Reference_Group_Executive_Summary.pdf

American Psychological Association. (2013). *Diagnostic and Statistical manual of Mental Disorders* (5th ed.). Arlington, VA: American Psychiatric Association.

Barton. Lloyd, Spriggs, and Gast, (2018). In J. R. Ledford, & D. L. Gast. (Ed.). Single case research methodology (pp. 157-178). New York: NY. Retrieved from https://www-taylorfrancis-com.proxy.library.brocku.ca/books/e/9781315150666

Blumenthal, J. A., Smith, P. J., & Benson. B. M. (2012). Opinion and evidence: Is exercise a viable treatment for depression. *American College of Sports Medicine's Health & Fitness Journal, 16,* 14-21.

Brobst, B., & Ward, P. (2002). Effects of public posting, goal setting, and oral feedback on the skills of female soccer players. *Journal of Applied Behavior Analysis, 35,* 247-257.

Buchanan, J. L. (2012). Prevention of depression in the college student population: A review of the literature. *Archives of Psychiatric Nursing, 26,* 21–42. doi: 10.1016/j.apnu.2011.03.003.

Buman, M. P., Hekler, E. B., Bliwise, D. L., & King, A. C. (2011). Moderators and mediators of exercise-induced objective sleep improvements in midlife and older adults with sleep complaints. *Health Psychology, 30*, 579-587.

Carlbring, P, Linder, P., Martell, C., Hassmen, P., Fossberg, L., Strom, L., Andersson, G. (2013). The effects of depression on internet-administered behavioral activation and physical exercise with treatment rationale and relapse prevention: Study protocol for a randomized control trial. *Trials, 14,* 2-8. Retrieved from http://www.trialsjournal.com/content/14/1/35

Carek, P. J., Laibstain, S. E., & Carek, S. M. (2011). Exercise for the treatment of depression and anxiety. *International Journal of Psychiatry in Medicine, 41,* 15-28.

Cooney, G. M., Dawn, K., Grieg, C. A., Lawlor, D. A., Rimer, J., Waugh, F. R., McMurdo, M., & Mead, G. E. (2013). *Exercise for depression*. Retrieved from. Cochrane Database of Systematic Reviews. (CD004366)

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied Behavior Analysis (2nd ed.).* Upper Saddle River, NJ: Pearson Education Inc.

De Luca, R. V., Holborn, S. H. (1992). Effects of variable ratio reinforcement schedule with changing criteria on exercise in obese and non-obese boys. *Journal of Applied Behavior Analysis, 25,* 671-679.

Diaz, K. M., Krupka, D. J. Chang, M. J. Peacock, J. Ma, Y. Goldsmith, J., Schwartz, J. E., & Davidson, K. W. (2015). Fitbit: An accurate and reliable device for wireless physical activity tracking. *International Journal of Cardiology, 185,* 138-140.

Doyne, E. J., Ossip-Klein, D. J. Bowman, E. D., Osborne, K. M., Mc Dougal-Wilson, I. B., & Neimeyer, R. A. (1987). Running versus weightlifting in the treatment of depression. *Journal of Consulting and Clinical Psychology, 55,* 748-754.

Driller, M. W., Dixon, Z. T., & Clark, M. I. (2017). Accelerometer-based sleep behavior and activity levels in student athletes in comparison to student non-athletes. *Sport Sciences for Health, 13,* 411-418. doi: 10.1007/s11332-017-0373-6

Dunn, A. L., Trivedi, M. H., & O'Neil, H. A. (2001). Physical activity dose-response effects on outcomes of depression and anxiety. *Medicine & Science in Sports & Exercise, 33,* 587-597. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/11427783

Furlonger, B. E., Oey, A., Moore, D. W., Busacca, M., & Scott, D. (2017). Improving a mature rock-climbing performance using a changing criterion design within a self-management program. *The Sports Journal.* Retrieved from https://www.researchgate.net/publication/317379349

Gast, D. L. (2010). *Single-subject Research Methodology in Behavioral Sciences.* New York, NY: Routledge. Retrieved from https://doi-org.proxy.library.brocku.ca/10.1177/1088357610391087

Geiger, G, Todd, D. D., Clark, H. B., Miller, R. P., & Kori, S. H. (1992). The effects of feedback and contingent and reinforcement on the exercise behavior of chronic pain patients. *Pain, 49*, 179-185.

Habibi, M., Khawaja, N. G., Moradi, S., Dehghani, M., & Fadaei, Z. (2014). University student depression inventory: Measurement model and psychometric properties. *Australian Journal of Psychology, 66,* 149-157. doi: 10.1111/ajpy.12037

Hustyi, K. M., Normand, M. P., & Larson, T. A. (2011). Behavioral assessment of physical activity in obese preschool children. *Journal of Applied Behavior Analysis, 44,* 635-639. doi: 10.1901/jaba.2011.44-635

Ibrahim, A. K., Kelly, S. J., Adams, C. E., & Glazebrook, C. (2013). A systematic review of studies of depression prevalence in university students. *Journal of Psychiatric Research, 47,* 391-400.

Jansen, N., Huibers, M. J. H., Lucassen, P, Vosshar, R. O., Marwijk, H., Bosmans, J, Pijnapples, M, Spijker, J., Hendriks, D-J. (2017). Behavioral activation by mental health nurses for late-life depression in primary care: A randomized control trial. *BMC Psychiatry, 17,* 2-11. doi: 10.1186/s12888-017-1388-x

Knapen, J., Vancampfort, D., Morien, Y., Marchal, Y. (2015). Exercise therapy improves both mental and physical health in patents with major depression. *Disability and Rehabilitation, 16,* 1490-1495. doi: 10.3109/09638288.2014.972579

Kooiman, J. M., Dontje, M. L., Sprenger, S. R., Krijnen, W. P., van der Schans, C. P., & de Groot, M. (2015). Reliability and validity of 10 consumer activity trackers. *BMC Sports Science, Medicine and Rehabilitation,* 7, 24-35. doi: 10.1186/s13102-015-0018-5.

Kratochwill, T. R., Hitchcock, J. H., Horner, R. H. Levin, J. R., Odom, S. L., Rindskopf, D. M., Shadish, W. R. (). Single-case intervention research design standards. *Remedial and Special Education, 34,* 26-38. doi: 10.1177/0741932512452794

KucsKar, M. (). *A comparison of the effects of video modeling other and peer-implemented pivotal response training to video modeling on other positive social interactions of young children with developmental disabilities* (Unpublished doctoral dissertation). University of Nevada, Las Vegas.

Kvam, S., Kleppe, C. L., Nordhus, I. H., Hovland, A. (2016). Exercise as a treatment for depression: A meta-analysis. *Journal of Affective Disorders, 202,* 67-86. doi: 10.1016

Lane, J. D., & & Gast, D. L. (2014). Visual analysis ins single case experimental design studies: Brief review and guidelines. *Neuropsychological Rehabilitation, 24,* 445-463. Retrieved from: https://doi.org/10.1080/09602011.2013.815636

Larson, T. A., Normand, M. P., & Hustyi, K. M. (2011). Preliminary evaluation of an observation system for recording physical activity in children. *Behavior Interventions, 26*, 193-203.

List Randomizer [Computer software]. Dublin, Ireland: Randomness and Integrity Services Ltd.

Ma, H. H. (2006). An alternative method for quantitative synthesis of single-subject researches: Percentage of data points exceeding the median. *Behavior Modification, 30,* 598-617. doi: 10.1177/0145445504272974

Mantua, J., Gravel, N., & Spencer, R. M. C. (2016). Reliability of sleep measures from four personal health monitoring devices compared to research-based actigraphy and polysomnography. *Sensors, 16,* 646-657. doi:10.3390/s16050646

Mather, A. S., Rodriguez, C., Guthrie, M. F., McHarg, A. M., Reid, I. C., McMurdo, M. E. T. (2002). Effects of exercise on depressive symptoms in older adults with poorly responsive depressive disorder. *British Journal of Psychiatry, 180,* 411-415.

Mayer, G. R., Sulzer-Azaroff, B., & Wallace, M. (2012). *Behavior Analysis for Lasting Change (2nd ed).* NY: Sloan Publishing.

McDaniel, S. C., Bruhn, A. L. (2016). Using a changing criterion design to evaluate the effects of check-in/ check-out with goal modification. *Journal of Positive Behavior Interventions, 18*, 197-208.

Mead, G. E., Morley, W., Campbell, P., Grieg, C. A., McMurdo, E. T. & Lawlor, D. A. (2009). Exercise for depression. *Mental Health and Physical Activity, 2,* 95-96.

Mellalieu, S. D., Hanton, S., & O'Brien, M. (2006). The effects of goal setting on rugby performance. *Journal of Applied Behavior Analysis, 39,* 257-261. doi: 10.1901/jaba.2006.36-05

Miltenberger, R. G. (2016). *Behavior modification: Principles and procedures.* Boston, MA: Cengage Learning.

Montano, O. M., Montenegro, M. A., & Munoz-Martinez, A. M. (2018). Functional analytic psychotherapy enhanced behavioral activation for depression: A concurrent and non-concurrent between participants design. *The Psychological Record, 68,* 27-37. doi: 10.1007/s40732-018-0263-6

National Institute of Mental Health. (2003). *Depression and College Students*. Retrieved from https://www.nimh.nih.gov/health/publications/depression-and-college-students/index.shtml

National Institute for Health and Care Excellence. (2013). *Depression in Adults: Recognition and Management*. Retrieved from https://www.nice.org.uk/guidance/cg90

Normand, M. P. (2008). Increasing physical activity through self-monitoring, goal setting, and feedback. *Behavioral Interventions, 23*, 227-236.

Nystrom, M. B. T., Neely, G., Hassmen, P., & Carlbring, P. (2015). Treating major depression with physical activity: A systematic overview with recommendations. *Cognitive Behavior Therapy, 44,* 341-352. doi: 10.1080/16506073.2015.1015440

Parsons, M. B., Rollyson, J. H., & Reid D. H. (2012). Evidence-based staff training: A guide for practitioners. *Behavior Analysis and Practice, 5,* 2-11.

Pelletier, L., Shanmugasegaram, S., Patten, S. B., & Demers, A. (2017). Self-management of mood and/or anxiety disorders through physical activity/exercise, *Research, Policy, and Practice, 37,* 149-159. Retrieved from https://doi.org/10.24095/hpcdp.37.5.03

Prathikanti, S., Rivera, R., Cochran, A., Tungol, J. G., Fayazmanesh, M., & Winemann, E. (2017). Treating major depression with yoga: A prospective, randomized, controlled, pilot trial. *PLos One 12*. Retrieved from https://doi.org/10.1371/journal.pone.0173869

Reid, D. H., Rotholz, D. A., Parsons, M. B., Morris, L., Braswell, B. A., Green, C. W., & Schell, R. M. (2003). Training human service supervisors in aspects of PBS:

Evaluation of a statewide performance-based program. *Journal of Positive Behavioral Interventions, 5,* 35-46.

Romaniuk, M., & Khawaja, N. G. (2013). University student depression inventory (USDI): Confirmatory factor analysis and a review of psychometric properties. *Journal of Affective Disorders, 150*, 766–775.

Salazar, I. N. M. (2015). Behavior analysis program to improve habits of physical activity, eating, and sleeping (Doctoral dissertation). Retrieved from Scholar works at western Michigan university. (743).

Sarokoff, R. A. & Sturmey, P. (2004). The effects of behavioral skills training on staff implementation of discrete-trial teaching. *Journal of Applied Behavior Analysis, 37*, 535-538.

Schneider, K. L., Panza, E., Handschin, B., Ma, Y., Busch, A. M., Waring, M. E…Pagoto, S. L. (2016). Feasibility of paring behavioral activation with exercise for women with type 2 diabetes and depression: The get it study pilot randomized control trial. *Behavior Therapy, 47,* 198-212.

Scruggs, T. E., Mastropeiri, M. A., & Casto, G. (1987). The quantitative synthesis of single-subject research: Methodology and validation. *Remedial and Special Education, 8,* 24-33.

Sharpe, P. A., Wilcox, S., Schoffmann, D. E. & Baruth, M. (2017). Participation, satisfaction, perceived benefits, and maintenance of behavioral self-management strategies in a self-directed exercise program for adults with arthritis. *Evaluation and Program Planning, 60,* 143-150.

Tudor-Locke, C., & Basset, Dr. Jr. (2004). How many steps/day are enough? Preliminary pedometer indices for public health. *Sports Medicine, 40,* 537-543.

Van Camp, C. M., & Hayes, L. B. (2012). Assessing and increasing physical activity. *Journal of Applied Behavior Analysis, 45,* 871-875.

Van Wormer, J. J. (2004). Pedometers and brief e-counselling: Increasing physical activity for overweight adults. *Journal of Applied Behavior Analysis, 37*, 421-425.

Vetrovsky, T., Cupka, J., Dudek, M., Kuthanova, B., Vetrovska, K., Capec, V., & Bunc, V. (2017). Mental health and quality of life benefits of a pedometer-based walking intervention delivered in a primary care setting. *Acta Gymnica, 47,* 138-143. doi: 10.5507/ag.2017.017

Wack, S. R., Crosland, K. A., & Miltenberger, R. G. (2014). Using goal setting and feedback to increase weekly running distance. *Journal of Applied Behavior Analysis, 47,* 181-185. doi: 10.1002/jaba.108

Ward, P., & Carnes, M. (2002). Effects of posting self-set goals on colligate football players' skill execution during practice and games. *Journal of Applied Behavior Analysis, 35,* 1-12.

Wolery, M. & Harris, S. R. (1982). Interpreting results of single-subject research designs. *Physical Therapy, 62,* 445-452. doi:10.1093/ptj/62.4.445

Wolff, E., Gaudlitz, K., Lindenberger, B.-L. Plag, J. Heinz, A., & Strohle, A. (2011). Exercise and physical activity in mental disorders. *European Archives of Psychiatry and Clinical Neuroscience, 261,* 186-191. DOI 10.1007/s00406-011-0254-y

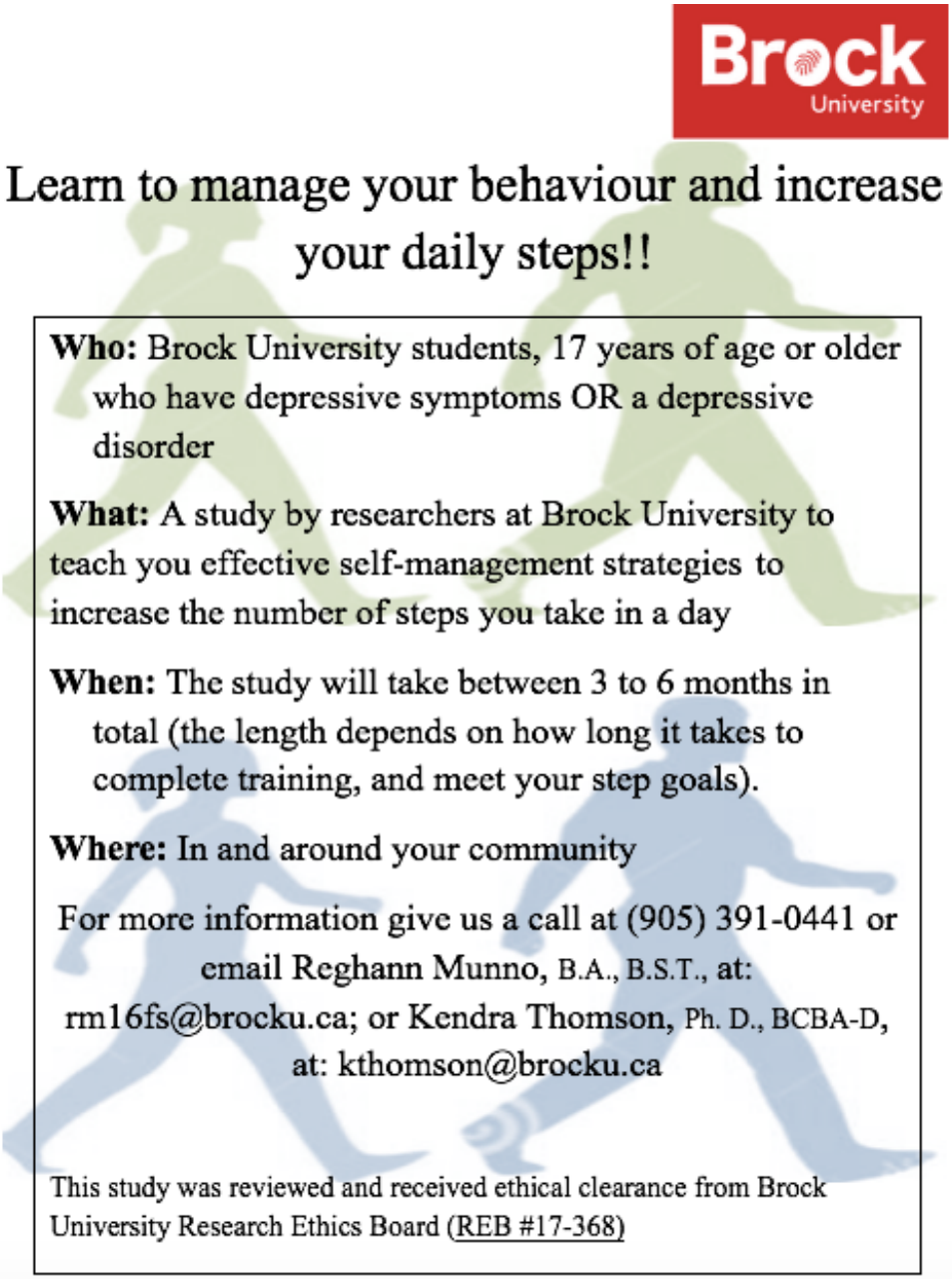
World Health Organization, Mental health. (2012). *Physical Activity.* Retrieved from http://www. who.int/mental_health/mhgap/evidence/depression/q6/en/index.html

World Health Organization, Mental health. (2012). *Mental Health Gap Action Programme (mhGAP).* Retrieved from https://www.who.int/mental_health/mhgap/en/

Zarate, M., Miltenberger, R., Valbuena D. (2019). Evaluating the effectiveness of goal setting and textual feedback for increasing moderate intensity physical activity in adults. *Behavioral Interventions, 34,* 553-563. https://doi.org/10.1002/bin.1679

Appendix A

Recruitment Poster



Recruitment Email Announcement

Hello fellow Brock students,

My name is Reghann Munno, I am a student in the masters of arts in applied disabilities studies program, with a specialization in applied behaviour analysis, and I am completing my thesis under the supervision of Dr. Kendra Thomson. I am currently recruiting university students who are experiencing symptoms of depression to participate in my thesis research. This study will examine the potential effects of engaging in increased physical activity (i.e., walking), on depressive symptoms and sleep disturbance associated with depression. Through participation in this study it is expected that, participants will learn valuable strategies (i.e., self-monitoring, goal-setting) to manage their own fitness behaviour, which has the potential to improve other areas of their lives (e.g., healthy eating, improved study habits). We also expect that participants will achieve an increase in the number of steps they take on a daily basis, which may have short- and long-term health benefits, such as: lower risk of heart disease and stroke, reduced stress levels, increased energy, and improved digestion. Some other possible benefits may include a decrease in depressive symptoms and improvement in sleep disturbance.

If you are interested in learning more about this study please email me for further information at rm16fs@brocku.ca.

Kind regards,

Reghann Munno
BA hons., BST, M.ADS candidate

Appendix B

Social Validity Questionnaire

Social Validity Participant: Midway/Post-Intervention

1. This program helped me to increase the number of steps I take on a regular basis

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

2. This program was easy to follow

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

3. I noticed an improvement in my quality of sleep

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

4. I noticed an improvement in my mood

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

5. Before beginning this program, I had difficulty engaging in exercise on a regular basis

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

6. Before beginning this program, I experienced sleeping difficulties

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

7. The training sessions helped me learn how to use the Fitbit Flex™ and monitor my progress toward my goals

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

8. I believe monitoring my progress towards my goal each day helped me to increase the number of steps I took each day

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

9. I believe recording and sending my daily step progress helped me to increase the number of steps I took each day

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

10. It was easy to capture the screenshot of my Fitbit Flex™ *Dashboard* and send that information to the researcher

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

11. The progression of step goals moved at a comfortable pace for me

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

12. The feedback is a useful part of this program

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

13. The feedback is supportive and helps me to stay on-track with my goals

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

14. The feedback is motivating to continue walking

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

15. I will continue to use the techniques I learned in this program to achieve my future goals

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

16. I plan to continue to work on increasing the number of steps I take each day

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

17. I plan to maintain the number of steps I take each day

Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree

Appendix C

Open-Ended Questionnaire

Individual Qualitative Questionnaire

1. Did you use any strategies (in addition to the strategies from the research) to help you achieve your daily step goal (e.g., tracking the approximate number of steps you took during specific walking routes & repeating them, tracking the approximate number of steps you could accumulate in a specific time period [10 min walk = 5000 steps])? **Yes/No**

   If yes, did you find this helpful? **Yes/No**
   Why or why not? _____
   _____

   If yes, did you use these strategies prior to the treatment phase of this study? **Yes/No**

2. Did you synch to your Fitbit to check the number of steps you accumulated? **Yes/No**

   If yes, approximately how many times per day? _____

   If yes, did you find this helpful? **Yes/No**
   Why or why not? _____
   _____

3. Did you allow yourself to take "rest days" where you did not attempt to achieve your goal? **Yes/No**

   If yes, please proceed to Question 4, if "no" please proceed to Question 5.

4. Approximately how many rest days did you take in each sub-goal phase? _____
   Did you find this helpful? **Yes/No**
   Why or why not? _____
   _____

5. Were there any significant changes in your schedule (e.g., started a new job/hobby/class) during the treatment phase? **Yes/No**

   If yes, what did they include? _____
   _____

6. Did you tell anyone you were trying to increase your steps (e.g., friends, family)? **Yes/No**

   If yes, please proceed to Question 7, if "no" please proceed to Question 8

7. How many people did you share this information with? _____
   Did you find this helpful? **Yes/No**

   Why or why not? _____
   _____

8. Did you share your daily step progress/or when you met your daily or sub-goal with anyone throughout the day (i.e., at any point from the time you woke up until the time you submitted your screenshot before going to bed)? **Yes/No**

   If yes, approximately how many times did you share your progress in a single day? _____

   If yes, did you find this helpful? **Yes/No**
   Why or why not? _____
   _____

9. Did you share when you met progression (received a new, higher goal) or regression criteria (returned to a previously mastered goal)? **Yes/No**

   If yes, please specify which one(s) you shared & how often? _____
   _____

   If yes, did you find this helpful? **Yes/No**
   Why or why not? _____
   _____

10. When the Fitbit notified you that you met you daily goal (i.e., all 5 lights flashing + vibrations) did you continue trying to accumulate steps or rest? **Yes/No**

    If yes, did you find this helpful? **Yes/No**
    Why or why not? _____
    _____

Any other comments you would like to share?

_____
_____
_____
_____
_____

Appendix D

Procedural Integrity: Participant Behaviour

Participant Self-Management Checklist			
Procedural Steps	Date completed/ Participant initials	Correct	Incorrect
Sent a screenshot of her step data *correct date* to the researcher via text message within 15mins. of her *personal* deadline			
Captured the date and daily step count in the screenshot			
Participant included a sentence noting whether she engaged in any physical activity other than walking, if so, specified the type of activity			

Appendix E

Participant Consent Form

Research Consent for Participants

Project Title: The Effects of a Self-Management Treatment Package on Physical Activity in University Students with Depressive Symptoms

Principal Investigator (PI):
Dr. Kendra Thomson, BCBA-D, Associate Professor, Department of Applied Disability Studies; Ph: (905) 688-5550 x 6710 (office); Email: kthomson@brocku.ca

Principal Student Investigator (PSI):
Reghann Munno, BA, BST, MA student, Department of Applied Disability Studies; Ph: (905) 688-5550 x 6710 (lab); Email: rm16fs@brocku.ca

INVITATION

You are invited to participate in a research project that is evaluating the effects of a self-management treatment package on increasing physical activity in university students who report experiencing depression. The self-management package will involve the use of goal setting, self-monitoring, and feedback to increase the number of steps you take each day.

WHAT'S INVOLVED

Self-management techniques have been shown to be effective for increasing various forms of physical activity (e.g., walking, flexibility, weight training) in a wide variety of individuals. In addition, engaging in physical activity has been found to be an effective treatment for decreasing symptoms of depression and improving some sleep disturbances associated with depression. The specific type of physical activity targeted in this study will be the number of steps taken per day, which will be tracked using the Fitbit Flex™.

As a participant, I (Reghann Munno) ask that you attend two separate training sessions. The training sessions will be approximately one hour in length and will occur once per week. If necessary, to master the skills from these sessions, I will ask you to complete additional training approximately 30 minutes in duration. All training sessions will take place in a private location on the Brock University campus. I will conduct all training sessions on a one-to-one basis. I will provide you with a Fitbit Flex™ during the first training session that you will use for the duration of the study. You *must* return the Fitbit Flex™ once the study is complete. During the first training session you will learn how to charge the Fitbit Flex™. During the second training session you will learn how to

download the Fitbit™ cell phone application, access your step data on the Fitbit™ application *Dashboard*, take a screenshot of your *Dashboard* with your cell phone, send the screenshot via text message, and set your step goals. I will teach these skills using verbal instructions and live demonstration. You will then be given the opportunity to practice, with verbal feedback provided to assist you if necessary. All of these skills will be practiced until you are able to perform them correctly without assistance. At this time, you will also be asked to report if you are currently receiving treatment for depression. If you are currently receiving treatment, you will also be asked to indicate the type of treatment and how long you have been receiving this treatment.
Once the study begins, you will be required to wear the Fitbit Flex™ 24 hours a day throughout the study, so that we can measure the number of steps you take per day, the duration of minutes spent sleeping once you are in bed for the night, and the number of times you wake up throughout the night (if any). I will arrange a one-to-one meeting with you to discuss how to determine your first step goal and subsequent step goals. Together, we will write an individualized behaviour contract that will outline, your overall goal for the study, your initial goal, and the criteria for meeting this goal and subsequent goals, as well as when and where you will likely accumulate your steps and how you will monitor your behaviour. I will provide you with daily feedback via cell phone text message about progress towards your step goals. We will set the text messages to have read receipts to gauge whether there are any issues in receiving the messages. Finally, I will send you a reminder via text message to charge your Fitbit Flex™ about every four days. I will graph this information daily and analyze these data using visual inspection methods and statistical analysis.

You may be asked to discuss preferred items or activities that could be used as rewards for reaching your step goals in the project. If you are asked to choose a reward(s), you will also be required to select or purchase the reward of your choice as well as designating an individual close to you (or the researcher) to administer the reward when you meet your goal.

You will be asked to complete a social validity questionnaire once mid-way through the study and once after the study is complete. The social validity questionnaire will involve a series of questions that address your satisfaction with the procedures involved in the study, the Fitbit Flex™, and the likelihood that you will continue to use the self-management techniques outside of this research project. You will also be asked to complete the University Student Depression Inventory© once during the first training session, once mid-way through the study, and once after the study is complete. The University Student Depression Inventory© will provide information on any depressive symptoms you may be experiencing. Once all three administrations of the University Student Depression Inventory© are completed, a clinical psychologist will review the scores for each and the associated graph, in order to complete the *Clinical Global Impression Scale*©. This is done to provide an assessment of the clinical significance of any change observed in your data across the three administrations. Prior to the clinical psychologist reviewing your data, all identifying information will be removed from the inventory and associated graph (i.e., name). The clinical psychologist will be blind to the purpose of the study and no further information or data will be provided.

As a participant, you may also be given the opportunity to receive a re-introduction of the treatment package once you have achieved your terminal goal and we have removed the treatment package (i.e., self-monitoring, goal-setting, and feedback) for some time to see if your step goal maintains. If your terminal goal is not maintained, the treatment package would be reinstated. This procedure is used to further assess if the treatment package is efficacious and necessary for you to continue to increase or maintain your daily frequency of steps at the level of your terminal goal.

Once the study is complete, I will hold a debriefing session to give you the opportunity to receive additional training in alternative self-monitoring strategies (without a Fitbit™ device) to help you to continue to increase your daily steps. During this time, I will ask you to complete your final social validity questionnaire. You will also be given the opportunity to complete a questionnaire regarding factors that may have influenced your walking behaviour during the study. Specifically, these questions are used determine if you utilized any strategies outside of those included in the study, if there were any challenges you encountered that interfered with your ability to achieve your daily step goal(s), and anything you would change about the program.

You will be asked to report if you are currently in crisis or in need of acute care. For example, we would ask if you are unable to complete necessary daily tasks such as eating or getting out of bed. If so, we will provide appropriate resources for counselling services. You will also be asked to report if you have suicidal ideation or engaged in any suicide attempts in the month preceding the study. Finally, you will be asked to indicate any changes in your medication including, introduction of new medication(s), discontinuation of medication(s), and or change in dosage of any medication(s) in the last month. No further detail is needed, just an indication of whether any of the above three changes occurred. If you agree to provide this information you may check the appropriate boxes provided at the bottom of the form. You may decline to share this information at any point during the study. Not disclosing this information will not affect your participation in this study.

POTENTIAL BENEFITS AND RISKS

Participation or withdrawal will not affect your current or future standing at Brock University. It is expected that, as a participant, you will learn valuable strategies (i.e., self-monitoring, goal-setting) to manage your own fitness behaviour, which has the potential to improve other areas of your life (e.g., eating healthy, taking your medication, following physician/psychologist recommendations) after the study is complete.

We also expect that you will achieve an increase in the number of steps you take on a daily basis, which may have short- and long-term health benefits, such as: lower risk of heart disease and stroke, reduced stress levels, increased energy, and improved digestion. Some other possible benefits may include a decrease in depression and improvement in sleep disturbances.

As a participant, you may feel some level of distress while working towards your personal physical activity goals, and potentially, not meeting your goal(s). However, to reduce the likelihood of experiencing this distress, we will base the initial goal on your current level

of physical activity. We will encourage you to increase subsequent goals gradually, only after you have demonstrated the ability to consistently maintain the lower-level step goal. I will also provide encouragement and constructive feedback to help you stick to your goals and overcome barriers; you will never experience any aversive consequences for not meeting a goal.

CONFIDENTIALITY

The data collected by the Fitbit Flex™ will be kept confidential, only the principle investigators will be permitted access. I will store the data collected during this study, as well as, any identifying information (i.e. name, phone number, email address) in a locked cabinet in Dr. Thomson's locked lab space. Your name will not appear on any data sheets or study materials; instead, a numeric code will be randomly assigned to all of your data. The numeric code will ensure the confidentiality of your data. Because the research team will be able to link your data to you, these data are not considered anonymous; however, we will not share this information with anyone outside of our research team. Electronic data will be kept on the principle student investigator's password-protected laptop and only the principle investigators will have access to it. Data will be kept for 2 years, after which time all information will be deleted or shredded.

If at any point throughout the study you indicate that you are in actual immediate or pending danger to yourself or others, I will contact the police immediately by phone as required by law.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time and may do so without any penalty or loss of benefits to which you are entitled to. Should you choose to withdraw from the study, you can choose whether your data can be used or if you prefer we destroy it immediately.

PUBLICATION OF RESULTS

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available within three months after the study is completed. You can contact the principle student investigator (Reghann Munno) or Dr. Kendra Thomson using the contact information provided above. Feedback can be provided via e-mail or postal mail depending on your preference.

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please contact Reghann Munno or Dr. Kendra Thomson using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (File #:17-368). If you have any comments or concerns about

your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca.

Thank you for your assistance in this project. Please keep a copy of this form for your records.

CONSENT

I agree to participate in this study described above. I have made this decision based on the information I have read in the Research Consent for Participants Letter. I have had the opportunity to receive any additional details I want about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

☐ I have read and understood the consent form and agree to participate in this study.
☐ I would like to receive a summary of the results of the study.
☐ I am willing to provide information regarding my belief on whether I am experiencing a crisis and if I can complete necessary daily tasks.
☐ I am willing to provide information on introduction of new medication(s), discontinuation of medication(s), and or change in dosage of any medication(s).

Name: _____

Email/Postal Address (to receive results): - _____

Signature : _____ Date: _____

Appendix F

Pre-Treatment Training Components

Components of Participant Pre-treatment Training Sessions

Session One

1. How to charge the Fitbit Flex™

Session Two

1. Download the FitBit™ cell phone application
2. Access their step data via the Fitbit™ application *Dashboard*
3. Take screenshots of their *Dashboard* with their cell phones
4. Send the screenshot via text message
5. Set initial goal using the visual prompt
6. Change the daily step goal on the Fitbit™ application

Appendix G

Procedural Integrity: Researcher Behaviour

Charging the Fitbit™					
	Deliver Instruction	**Model Step**	**Initiate Rehearsal**	**Deliver Contingent Feedback**	**Total score per Step**
Task Steps					
1.Remove "pebble" from Fitbit	+ / -	+ / -	+ / -	+ / -	/4
2.Put pebble in charging port	+ / -	+ / -	+ / -	+ / -	/4
3.Plug charging port into USB port on computer/charger	+ / -	+ / -	+ / -	+ / -	/4
4.Remove pebble from charging port	+ / -	+ / -	+ / -	+ / -	/4
5. Return pebble to Fitbit	+ / -	+ / -	+ / -	+ / -	/4

Appendix H

Procedural Integrity: Researcher Behaviour

Accessing Fitbit™ Data & Taking a Screenshot					
	Deliver Instruction	**Model Step**	**Initiate Rehearsal**	**Deliver Contingent Feedback**	**Total score per Step**
Task Steps					
1.Select Fitbit app on phone	+ / -	+ / -	+ / -	+ / -	/4
2. Ensure you are looking at the correct date	+ / -	+ / -	+ / -	+ / -	/4
3. To find correct date press left arrow key (<) to scroll back & right (>) to scroll forward	+ / -	+ / -	+ / -	+ / -	/4
4. Simultaneously press & hold home & sleep/wake buttons (iPhone) OR Simultaneously press & hold home & power buttons (Android)	+ / -	+ / -	+ / -	+ / -	/4

Sending a Screenshot of the Step Data					
	Deliver Instruction	**Model Step**	**Initiate Rehearsal**	**Deliver Contingent Feedback**	**Total score per Step**
Task Steps					
1.Select text message icon on phone	+ / -	+ / -	+ / -	+ / -	/4
2. Select icon to begin new message	+ / -	+ / -	+ / -	+ / -	/4

3. Select photo icon	+ / -	+ / -	+ / -	+ / -	/4
4. Select screenshots folder	+ / -	+ / -	+ / -	+ / -	/4
5. Select screen shot for the correct date	+ / -	+ / -	+ / -	+ / -	/4
6. Confirm selection (e.g., press “choose”)	+ / -	+ / -	+ / -	+ / -	/4
7. Write sentence in the same message noting did/did not engage alternative physical activity & note the type (if applicable)	+ / -	+ / -	+ / -	+ / -	/4
8.Press send button	+ / -	+ / -	+ / -	+ / -	/4

Training Goal-setting Using Textual Prompt					
	Deliver Instruction/ Discuss	**Model Step**	**Initiate Role-Play**	**Deliver Contingent Feedback**	**Continue to rehearse w/ feedback until mastered**
Task Steps					
1.Review graphical baseline data a. describe trend b. identify step mean	+ / -	N/A	N/A	N/A	N/A
2. Encourage participant to set initial goal at BSL mean	+ / -	N/A	N/A	N/A	N/A

a. provide rationale					
3.Calculate initial goal using textual prompt	+ / -	+ / -	+ / -	+ / -	+ / -
4.Discuss criteria for setting subsequent goals (5-15% mean previous phase)	+ / -	N/A	N/A	N/A	N/A
5.Have participant determine terminal goal	+ / -	N/A	N/A	N/A	N/A

Training use of the Fitbit™ Cellphone Application					
	Deliver Instruction/ Discuss	**Model Step**	**Initiate Role-Play**	**Deliver Contingent Feedback**	**Continue to rehearse w/ feedback until mastered**
Task Steps					
1.Open Fitbit app	+ / -	+ / -	+ / -	+ / -	+ / -
2.Select *account* icon	+ / -	+ / -	+ / -	+ / -	+ / -
3.Under goals tab, select activity	+ / -	+ / -	+ / -	+ / -	+ / -
4.select *Daily Activity* select steps	+ / -	+ / -	+ / -	+ / -	+ / -

5.Type in step goal	+ / -	+ / -	+ / -	+ / -	+ / -
6.Select back tab 2 times to return to *Dashboard*	+ / -	+ / -	+ / -	+ / -	+ / -