Effectiveness of a Tailored Mind-body Physical Activity (Mbpa) Intervention on Stress and Well-being Among College Students During the Covid-19 Pandemic: a Pilot Study

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EFFECTIVENESS OF A TAILORED MIND-BODY PHYSICAL ACTIVITY (MBPA) INTERVENTION ON STRESS AND WELL-BEING AMONG COLLEGE STUDENTS DURING THE COVID-19 PANDEMIC: A PILOT STUDY

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Abstract

The purpose of this pilot study was to examine the preliminary effectiveness and feasibility of a tailored MBPA intervention on well-being, stress, interoceptive sensibility, and objective physical activity (PA) in a sample of college students during COVID-19. Participants were 21 university students (81% were female). The study was conducted within an Interrupted Time-Series Design framework. Self-report data, well-being (WHO-5), stress (PSS-4), and interoceptive sensibility were collected at six time points. Objective PA data were assessed using a wrist-worn ActiGraph GT9X accelerometer over three 7-day periods, at baseline, mid-and postintervention. Mixed design Analysis of Variance (ANOVA) tests with repeated measures showed that participants' time spent in light (LPA) and moderate-to-vigorous physical activity (MVPA) was significantly higher during and at the end of the intervention compared to baseline (LPA [F (2, 36) = 11.9, P = .003, partial eta-squared = 0.39]; MVPA [F (2, 36) = 11.2, P < .001, partial eta-squared = 0.38]). It was found that participants' subjective well-being main effect for time [F (5, 75) = 1.1, P = .363, partial eta-squared = 0.07], perceived stress [F (5, 75) = 1.2, P =

.281, partial eta-squared = 0.44], and interoceptive sensibility [F (1.4, 19.0) = 2.8, P = .097, partial eta-squared = 0.18] did not change significantly; however, the results indicated positive trends. In conclusion, results indicate conducting a more extensive study. The MBPA intervention's positive effects and trends promise to be a feasible intervention to increase PA among students in higher education.

1. Introduction

The SARS-CoV-2 Pandemic (COVID-19) shocked the world affected all sectors of society at the beginning of 2020; schools considered distance learning an effective strategy to mitigate the severe consequences (Fairlie & Loyalka, 2020; Paltiel et al., 2020). Students changed their daily movement behaviors, such as lowered physical activity (PA) and increased inactivity (Diamond et al., 2020; Goel et al., 2020). The disruption of life affected students' well-being as they experienced significant stress (Aristovnik et al., 2020). Regular PA and mind-body physical activities (MBPA) are associated with comprehensive health benefits across the lifespan, such as happy mood (Bai et al., 2022; Brusseau, 2020; Burns, Brusseau & Hannon, 2015; Powell et al., 2018). Therefore, young adults need to establish healthy lifestyle habits, move more, and reap the mental and physical health benefits; MBPA is a possible option in education (Grasdalsmoen et al., 2020; Miller & Street, 2019; Strehli et al., 2020).

In comparison, before and after the COVID-19 pandemic, students' level of stress, depressive symptoms, anxiety, worries about health, and sedentary behavior increased, and healthy behaviors such as PA decreased (Elmer et al., 2020; Sañudo et al., 2020). Regular PA is essential in enhancing well-being, and it positively correlates with stress management; many college students are inactive and have an increased risk of developing metabolic disorders (Grasdalsmoen et al., 2020; Miller & Street, 2019; Small et al., 2013). Although a physically active lifestyle is essential for healthy growth and to prevent chronic conditions as students age, PA levels decrease from high school through college years while they undergo a social, academic, physiological, and environmental transition (Bai et al., 2022; Brusseau et al., 2020).

Stress among students is exceedingly prevalent in higher education, and transition to adulthood is a sensitive period as the skeletal system and brain are still developing well into the thirties (Grasdalsmoen et al., 2020; Knapstad et al., 2019; Powell et al., 2018). The ability to sense and respond to stress-related bodily changes as a quality of experience is of paramount importance (Aldwin, 2007). More than 64% of college students reported personal health problems, 74.8% experienced difficulties related to their loved ones, and a significant association between life stress measures and mental disorders (Karyotaki et al., 2020). Increasing stress levels interferes with many aspects of health, such as mental health, that can be mitigated by a higher sense of well-being induced by regular PA (Bai et al., 2022; Grasdalsmoen et al., 2020; Powell et al., 2018).

The WHO characterizes mental health as "a state of well-being in which the individual realizes his or her abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2001a, p. 1). The ability to sense, detect, and respond to stress-related bodily changes when individuals learn that a brief MBPA may provide stress alleviating experience is vital. Interoceptive sensibility is a self-perceived dispositional tendency to be internally self-focused and sufficient awareness to detect internal bodily sensations (e.g., muscle tension, heartbeat) (Cabrera et al., 2018; Garfinkel et al., 2015). In other words, interoception is how an individual senses, interprets, integrates, and regulates signals originating from within itself. In this positive sense, well-being and interoceptive sensibility are essential for individuals, communities, and society. Existing life stress is associated with mental disorders among college students (Karyotaki et al., 2020). The pandemic impacted students' lives as they experienced increased frustration, anxiety, and worry about their future careers (Aristovnik et al., 2020).

Although many PA interventions and a typical yoga class have a duration of 60-minutes sessions, research revealed that even 10 minutes or less is associated with enhanced health outcomes (Jakicic et al., 2019). A single bout of 10 minutes of walking, meditating, or a combination of walking and meditating study can result in substantial anxiolytic benefits on state anxiety among healthy students when they meditate and combine meditation with walking vs. sitting (Edwards et al., 2018). One 30 minutes laughter yoga session decreased salivary cortisol compared to a reading group and protected the stress response when experiencing psychosocial stress among students (Fujisawa et al., 2018; Meier et al., 2020). Additionally, one 60 minutes yoga session revealed a significant decrease in stress among college women when exposed to power and stretch yoga (Sullivan et al., 2019). A 5-minute breathing exercise substantially reduced stress levels in the veterinary student while performing surgery on a live animal (Stevens et al., 2019). Researchers found that a single-session loving-kindness meditation was more effective in inducing positive emotions in college students who had no experience in meditative practices than compassion meditation and control conditions (Sirotina & Shchebetenko, 2020). The present MBPA intervention built on several core components of ancient eastern practices tailored to enhance well-being and reduce stress differs from existing programs in several fundamental ways; our approach is novel.

Ancient holistic MBPA practices, such as yoga, tai chi, and qi gong, are becoming powerful complementary lifestyle routines to manage physical and mental challenges, such as stress (Bhadane, 2018; Brems, 2020; Erdogan Yuce & Muz, 2020; Strehli et al., 2020). Yoga practitioners reported significantly lower perceived stress and higher well-being than the national population (Cartwright et al., 2020). Also, students in higher education perceive yoga as an ancient holistic MBPA, the most credible alternative medicine therapy to affect physiological processes within the body (Green et al., 2020). Therefore, brief bouts of light-intensity MBPA practices performed when students feel stressed may result in favorable physiological outcomes (Strehli et al., 2020).

Mind-body physical activity provides physical and mental health benefits; therefore, MBPA could be a possible solution to physical inactivity, reduce stress and cardiovascular risk, and prevent hypokinetic diseases (Bigliassi, 2020; Brusseau, 2020; Powell et al., 2018). However, there is limited research on brief MBPA interventions for students in higher education, examining the intervention's effects on PA, well-being, stress, interoceptive sensibility levels. This study contributes to the literature and may have the potential to provide strategies to institutions to enhance student PA, well-being, and stress levels, considering the paucity of research in this area. Therefore, the purpose of this study was to determine the effectiveness of a guided MBPA intervention for improving well-being, perceived stress, interoceptive sensibility, and PA in a sample of college students during COVID-19.

The following research questions were addressed.

1. Does the implementation of a guided 8-week online and asynchronous mind-body physical activity increase well-being during COVID-19?
2. Does the implementation of a guided 8-week online and asynchronous mind-body physical activity intervention improve (2a) perceived stress, (2b) interoceptive sensibility, and (2c) objective physical activity?

We hypothesized that (1) the primary outcome well-being will improve after the 8 weeks mind-body physical activity intervention; (2) the secondary outcomes of perceived stress, interoceptive sensibility, and objective physical activity will also improve after the 8-week intervention.

2. Methods

2.1. Study Design

This pilot study was conducted within an Interrupted Time Series Design (ITSD) quasi-experimental framework with the time-series disturbance being the intervention implemented after the third measurement time-point. ITSD designs have 2 phases: the pre-intervention phase (conducted in January and February 2021) and the intervention phase (ended in the first week of May 2021). The three pre-intervention phases were measurement time-points 1-3 (baseline), and the intervention phases were measurement time-points 4-6 during the 3rd, 5th, (midpoint) and 8th weeks (postintervention) of the intervention for all participants. Within ITSD designs, the stability (reliability) of the outcome variables can be assessed pre- and during intervention via the slope of the time coefficient, and the averaged change in the outcomes can be tested via the change in the intercept coefficients from the end of preintervention to the start of intervention. ITSD is a design that can provide strong internal validity evidence in the absence of group randomization and is an appropriate methodology when participants are analyzed within a single group (Bernal et al., 2017; Burns et al., 2015; Penfold & Zhang, 2013).

2.2. Participants

The present pilot study consisted of 21 participants. The non-probability convenience sample of 17 female and four male students enrolled in college classes for credits towards their graduation recruited from a southwestern university in the United States. Each student completed the six time-point measurement surveys; in addition, they were to wear an accelerometer for seven days at baseline, mid-point, and at the end of the MBPA intervention (see Supplementary files (Table 1 and Figure 1) illustrates the flow of compliance across the pilot study duration.

More than 50 students asked for further information and to email the consent form to them. Thirty students volunteered by sending the signed consent forms back to the researcher. Four participants asked the researcher to withdraw from the study after accepting the MBPA Canvas (Salt Lake City, UT, USA) an online course management system, class invitation. They participated in other research projects. Twenty-six participants completed the pre-intervention phase surveys and received the accelerometer. All measurements and surveys were taken using Canvas, and Zoom (San Jose, CA, USA), a communication video meeting platform, provided a remote real-time interaction as needed. Participants have received an identification number, which was used for all research documents. To protect privacy, all potential personal information shared during the study was de-identified to the furthest extent possible.

2.3. Demographic characteristics

Participants completed a short questionnaire covering questions about the following demographic characteristics: age, height and weight, gender, ethnicity/race, year in college, year planning to graduate, current relationship status, and annual household income. Body Mass Index (BMI) was calculated using the self-reported weight and height BMI ($kg \cdot m^{-2}$). At pre-intervention phase time-point one, the twenty-one participants (N = 21) had mean (SD) age = 21 (2.2) years, a BMI of 24.52 (4.5), and 81% were female. Sample demographics are presented in Table 1.

This project obtained approval from the University's Institutional Review Board. The IRB application included online informed consent procedures, assessment items, and study protocols. Written consent was obtained from all participants before they were enrolled to the MBPA Canvas class. All participants received a compensation of US $100 for their time and effort following the completion of the intervention and if they have successfully provided data at each time-point and returned the accelerometers to the researchers. Both quantitative and qualitative data were collected. Qualitative results are published elsewhere.

2.4. Instrumentation

2.4.1. PA assessment.

Physical activity was objectively monitored for 7 days using wrist-worn accelerometers. Accelerometers are valid and reliable noninvasive objective measures of PA and can track frequency, intensity, duration, and useful in laboratory and field settings (Puyau et al., 2002; Scott et al., 2018; Troiano et al., 2008). The ActiGraph GT9X accelerometer was used to assess PA. It was distributed in the PA research laboratory, where participants were verbally instructed and visually demonstrated the placement of the device. Additional instructions were posted on Canvas. Participants were asked to wear the accelerometer three times, during the pre-intervention and intervention phases on the non-dominant wrist for seven consecutive days for 24 hours/day, except when bathing, showering, swimming, and other water activities. In comparative research studies, both wrist and hip locations have high validity, and reliability and wrist-worn accelerometers have higher compliance rates (Ellis et al., 2014; Ozemek et al., 2014; Rowlands et al., 2018). The ActiGraph GT9X accelerometer captures the movement in 3 axes, and PA was assessed at a rate of counts/minute. The ActiLife 6 software was used to initialize the accelerometers; with a sample rate of 100 Hz, no data collection stop date, disabled idle sleep, wireless, and display mode to preserve battery life (ActigraphTM, Inc., Pensacola, FL).

To examine whether there is a difference between pre-mind-MBPA intervention and intervention data recordings were collected in 100 Hz and downloaded in 60-seconds epoch lengths (Matthew, 2005). Light PA values were conceptualized as 100 to 1951 counts/minute, and moderate-to-vigorous PA values were conceptualized as 1952 and higher counts/minute (Freedson, Melanson, & Sirard, 1998; Fuzeki, Engeroff & Banzer, 2017; Matthew, 2005). Participants wore the ActiGraph GT9X tri-axial accelerometer at the beginning of the intervention, to collect baseline data, at midpoint, and at the end for 24 hours/day for 7 consecutive days (see Table 3.2), beginning at wakeup the next morning they received it (Troiano et al., 2014; Welk et al., 2019).

<u>2.4.2. Subjective well-being.</u> The 5-item WHO Well-Being Index (WHO-5) was used to measure subjective well-being (WHO-5, World Health Organization 1998). The 6-point Likert response scale, "*all of the time*" *(=5)* to "*at no time*" *(=0)* of the five questions, refers to feelings over the last two weeks, such as cheerful, calm, vigorous, rested, and the higher score represents better well-being. The well-established WHO-5 is one of the most globally used well-being surveys and is a screening tool for depression with a specificity of 0.81 and a sensitivity of 0.86 (Topp et al., 2015). It has been demonstrated very high applicability across study fields, high clinimetric validity, and is a sensitive screening tool for depression (Topp et al., 2015).

<u>2.4.3. Perceived stress.</u> The 4-item Perceived Stress Scale (PSS-4) was used to measure perceived stress (Cohen et al., 1983; Warttig et al., 2013). The 5-point Likert response scale, "*never*" *(=0)* to "*very often (=4)*" of the four questions, refers to situations in a student's life in

the last month, which were perceived as stressful, such as "*ability to handle personal problems*" and "*ability to control the important things in life*". The lower score represents healthier stress levels. With the Cronbach's Alpha of 0.77, the psychometric properties of the PSS-4 are reliable and valid across cultures (Warttig et al., 2013).

2.4.4. Interoceptive sensibility. The Body Perception Questionnaire-Short Form (BPQ-SF) was used to measure interoceptive sensibility (Cabrera et al., 2018). A total score, using 18 items, was calculated on a 5-point Likert response scale, from "*never" (=1)* to "*always (=5)"* across all items (Kolacz, 2005). The identification of bodily sensations, such as "*how fast I am breathing*" and "*muscle tension in my arms and legs*," (see Appendix 3) was assessed according to the manual (Kolacz, 2005). The BPQ-SF has high retest reliability and a categorical omega coefficient between 0.68 and 0.97 (Cabrera et al., 2018).

2.5. Intervention

The tailored MBPA intervention sessions for the study use core components of (1) traditional deep, diaphragm mindful breathing activities, (2) yoga poses (asanas), breathing activities (pranayama), qigong movements, and (3) loving-kindness walking meditation with present moment awareness to achieve fidelity and the maximum benefits. The researcher created the online class based on best practices, delivered using the asynchronous model, where intervention participants had access to the pre-designed MBPA activities at any time and completed the activities at their own pace following the outlined four modules (Healy et al., 2017). The intervention was organized in 4 modules, conducted asynchronously online for 8 weeks with 3 approximately 10-minutes sessions per week via Canvas. This MBPA intervention duration is in line with the literature of general PA interventions. As examples, self-reported PA increased following four weeks of brief interventions (Lamming et al., 2017). To responding and learning to manage the signs of chronic stress, such as difficulty concentrating, sleeping, and how hard the heart is beating, engaging in stress alleviating practices that promote a healthy 24-h cortisol pattern is a paramount lifestyle behavior (Jakicic et al., 2019; Smyth, Rossi & Wood 2020). Therefore, the 10-minute MBPA intervention delivered 8 weeks three times weekly is an agreeable protocol that has the potential to protect the stress response and have substantial, sustainable effects in healthy young adults.

The researcher provided pre-recorded videos and voice audio of the MBPA intervention protocol, and participants were asked to practice it any time during the week. The brief, 10-minutes practice should take place in an environment where students feel comfortable or when they sense that the MBPA intervention may provide a stress alleviating experience. As examples, during the morning hours, or around lunchtime, or in the afternoon in an environment where they feel comfortable. It has been proposed that the tailored 10-minutes multicomponent (traditional diaphragmatic breathing, asanas, pranayama, qigong movements, loving-kindness walking meditation) and multilevel MBPA intervention could positively influence the well-being of college students and establish sustainable stress ameliorating physically active behaviors. The researcher is a certified instructor with over 35 years of teaching experience.

All MBPA sessions have included a reminder from the researcher that the critical components of the MBPA practice have been the connection to the breath and awareness of the body. There has been an encouragement for modifying the postures and environment if desired and attentively practice whenever needed to make the experience more diverse.

2.6. Data Collection

All measurements were taken using Canvas. The chronological summary of the MBPA intervention quantitative procedures is represented in (Supplementary files Table 1).

2.7. Statistical Analyses

The data were screened for outliers using z-scores (using a +/- 3.0 *z* cut-point) and checked for normality using histograms and homogeneity of variance using the Levene's test of equality of variance. Descriptive statistics for both minutes and % of wear-time in, light, moderate-to-vigorous PA, in addition to well-being, perceived stress, and interoceptive sensibility at each of the timepoints were reported. Specifically, descriptive statistics were reported as means and standard deviations for continuous data and as counts and %'s for categorical data.

The primary analyses consisted of a series of mixed design analysis of variance (ANOVA) tests with repeated measures to examine the associations between sex and time on PA, subjective well-being, perceived stress, and interoceptive sensibility. Sex was between-subject factors and time (preintervention, intervention timepoints) the within-subject factor.

Preintervention time points were weeks 1-3 and intervention time points were implemented weeks 3, 5, and 8 of the 11 weeks procedure (3 weeks preintervention data collection and 8 weeks intervention). Both main effects and the sex x time interactions were inspected within each ANOVA model. To assess the assumption of sphericity, (meaning that variances of mean differences between time-points are approximately equal) Mauchly's test was employed with a Greenhouse-Geisser correction factor applied to the degrees of freedom if the assumption was violated. Effect sizes for main effects were examined using partial eta-squared and pairwise comparison effect sizes were examined using Cohen's delta (d). Pair-wise effect sizes were considered small if d = 0.20, medium if d = 0.50, and large if d= 0.80 (Cohen, 1992).

Alpha level was set at $p \leq 0.05$ but adjusted using the Bonferroni correction because of multiple comparisons. All analyses were conducted using IBM SPSS Statistics Version 27 (IBM, Armonk, New York, USA).

3. Results

3.1. Descriptive Statistics

Based on z-scores (+3.0z) the initial screening of the data did not show potential outliers and the test of homogeneity of variance resulted in non-significance ($p \geq 0.05$), confirming equal variances for all analyses. The results for the demographic data presented in Table 1.

Descriptive statistics results are provided for each dependent variable within each timepoint are presented in tables two and three.

3.2. Analysis of Variance Results

3.2.1. Physical activity. Mixed design ANOVA with repeated measures showed that for objectively measured minutes/week LPA there was a statistically significant main effect for time [F (2, 36) = 11.9, P = .003, partial eta-squared = 0.39]; displaying greater LPA values at postintervention (timepoint 6) than at baseline. Figure 1 (and supplementary files figures 2 and 3) are the visual representation of the distribution of objectively measured time spent in LPA.

Additionally, mixed design ANOVA with repeated measures showed that for minutes/week MVPA there was a statistically significant main effect for time [F (2, 36) = 11.2, P < .001, partial eta-squared = 0.38]; displaying greater MVPA at postintervention (timepoint 6) than at baseline (timepoint 1). Figure 2 (and supplementary files figures 5 and 6) are the visual representation of the distribution of objectively measured time spent in MVPA.

3.2.2. Well-being. Mixed design ANOVA with repeated measures showed that in subjective well-being there was no statistically significant main effect for time [F (5, 75) = 1.1, P = .363, partial eta-squared = 0.07]; the positive trend is displaying greater values at postintervention (timepoint 6) than at preintervention (timepoint 1). Figure 3 visually shows the distribution of the estimated marginal means of raw scores of subjective well-being across time.

3.2.3. Perceived stress. Mixed design ANOVA with repeated measures showed that in perceived stress there was no statistically significant main effect for time [F (5, 75) = 1.2, P = .281, partial eta-squared = 0.44]; the negative trend is displaying better values at postintervention (timepoint 6) than at preintervention (timepoint 1). Figure 4 visually shows the distribution of the estimated marginal means of raw scores of perceived stress values across time.

3.2.4. Interoceptive sensibility. Mixed design ANOVA with repeated measures showed that in interoceptive sensibility there was no statistically significant main effect for time [F (1.4, 19.0) = 2.8, P = .097, partial eta-squared = 0.18]; the trend is displaying better values at postintervention (timepoint 6) than at preintervention (timepoint 1). Figure 5 visually shows the distribution of the estimated marginal means of raw scores of interoceptive sensibility across time.

4. Discussion

The purpose of this pilot study was to examine the effects of the MBPA intervention on self-reported well-being and objectively measured PA, perceived stress, and interoceptive sensibility among college students during the COVID-19 crisis. The principal findings indicate statistically significant main effects for time spent in light and moderate-to-vigorous PA, displaying greater postintervention values than at baseline among MBPA intervention participants. The results demonstrated no statistically significant main effects for self-reported well-being, perceived stress, and interoceptive sensibility. Overall, as we investigate the effects of the 10 minutes MBPA intervention by observing all timepoints, the results suggest encouraging trends with no gender by the time significant interactions were found. Therefore, the substantial effects of the MBPA intervention show encouraging trends and tend to be strongest in PA during and after the 8-week MBPA intervention period than before; this indicates further investigation in a more extensive study. Our findings may contribute meaningful evidence on the effectiveness of the MBPA intervention and the impacts of COVID-19 on young adults' health. Further discussions presented by our outcome variables are below.

4.1. Physical activity

Prior research has found significant negative associations in increased PA with mental health problems with the most robust effect sizes of frequency of activity (Grasdalsmoen et al., 2020). Previous research on healthy behaviors among students in higher education has revealed PA levels significantly decreased while sedentary and sitting time increased during the COVID-19 pandemic worldwide (Bertrand et al., 2021; Lopez-Valenciano et al., 2020; Sañudo, Fennell & Sanchez-Oliver, 2020). Conversely, our results suggest that participation in the online MBPA intervention is associated with higher PA, both in light and moderate levels, during the Spring semester of 2021. Previous research investigated MBPA interventions within their framework as they were developed in ancient cultures, such as yoga, qigong, tai chi, mindfulness walking activities; we integrated these movements as all generally considered light and moderate-intensity PA (Kee et al., 2019; Powell et al., 2018; Strehli et al., 2020). Besides ancient movements, such as yoga, qigong, and tai chi, walking activities were some of the core elements of our MBPA intervention. An early systematic review of the PA levels conducted in 8 countries observed PA levels substantially decreased, such as objective reduction in 67.7% fewer daily steps, during COVID-19 (Lopez-Valenciano et al., 2020; Sañudo et al., 2020). Specifically, young adults spent increased time using smartphones, sleeping and sitting while decreased time in PA (Sañudo et al., 2020). From the total of systematically reviewed 10 studies, a significant reduction of PA levels was found in 9 investigations; in one study, students spent significantly more time both sitting and in PA (Lopez-Valenciano et al., 2020). Given that regular PA is a complex behavior to capture, using objective instruments to assess using accelerometers presents its challenges and values (Brusseau et al., 2020; Powell et al., 2018). Furthermore, the majority of researchers applied self-administered questionnaires, while in one study, accelerometers were used to capture PA behavior during COVID-19 among 20 university students and found no significant increase in PA levels (Lopez-Valenciano et al., 2020). Although local confinements have altered and affected health behaviors and most studies reported a significant decrease in PA levels globally, one study found a substantial increase in MVPA and the total number of minutes per week self-reported by health sciences students (Lopez-Valenciano et al., 2020; Romero-Blanco et al., 2020).

Students perceive that frequent light and moderate PA could help maintain well-being (Wasil et al., 2021). Similarly, in the present study, participants were physically active three times weekly for 10 minutes while practicing the MBPA intervention. Concurrently, researchers found significant negative associations in PA intensity, duration, and frequency with mental health problems, with the most robust effect size for frequency, among 50,054 college students (Grasdalsmoen et al., 2020). Also, researchers indicate that PA levels decrease from freshman to seniors and do not meet guideline recommendations (Miller & Street, 2019). Encouraging and providing the opportunity to frequently engage in brief MBPA could be an effective way to increase PA and cope with academic and interpersonal stress, thus enhancing overall well-being.

Our findings are encouraging because they indicate that the MBPA intervention has the potential to increase PA and may have positive effects on physical and mental health while alleviating stress. Similarly, a meta-analytical review found statistically significant and large pooled effects for MBPA intervention's effectiveness for lowering health-related physiological health markers, such as cortisol and heart rate (Strehli et al., 2020).

4.2. Well-being, stress, interoceptive sensibility

Our findings revealed no statistically significant main effects for self-reported well-being, perceived stress, and interoceptive sensibility; however, results demonstrated a constant trend during the intervention. This trend could be attributed to the enjoyment of the MBPA activities and learning new skills. From the PA perspective, enjoyment and neural changes (i.e., neuroplasticity) occur when learning new skills, which are present across the lifespan (Brusseau et al., 2020; Davidson & McEwen, 2012; Powell et al., 2018; Shaffer, 2016). The common goal of the MBPA intervention is to integrate mind, body, and spirit (i.e., vitality, lifeforce, energy) while being physically active and aware of the breath, thus improving physical and mental health well-being by stress alleviation, as one package (Kabat-Zinn, 2005; Powell et al., 2018; Smyth et al., 2020; Strehli et al., 2020). Light and moderate (i.e., walking) PA combined with purposeful attention to the breath, asanas, and loving-kindness in a safe environment may create a positive physiological and psychological state; may influence stress-related health markers (i.e., cortisol, heart rate, and blood pressure) and neurological processes in favorable ways as a beneficial experience in young adults (Fredrickson et al., 2017; Kora et al., 2021; Strehli et al., 2020; van Loon et al., 2021). Additionally, researchers found significant negative associations in PA intensity, duration, and frequency with mental health problems, with the most robust effect size for frequency (Grasdalsmoen et al., 2020). Therefore, our findings could be attributed to the fact that the intervention was not frequent enough to result in significant effects. In other words, increasing the frequency of the MBPA intervention from three to five times weekly and using the synchronous format may result in larger/increased effect sizes since social isolation is a significant predictor of well-being during COVID-19 (Liu et al., 2021).

Although mindfulness activities often are effective core elements of ancient practices and interventions, researchers have not reported the potential adverse effects (Farias et al., 2020; Kabat-Zinn, 2005; Reangsing et al., 2022). Indeed, researchers found mindfulness interventions as a mediator in MBPA (Pascoe et al., 2017). As practicing the MBPA intervention three times 10 minutes weekly in a safe environment, participants learned breathing activities, ancient movement, and loving-kindness walking activities while focusing on the breath. Since well-being, perceived stress, and interoceptive sensibility show parallel enhanced trends, these observations encourage that the MBPA intervention could reduce stress-related bodily sensations, such as muscle tension and heartbeat. As well as students may become more aware of the systemic health benefits of MBPA, such as lowering cortisol and heart rate (Strehli et al., 2020). Also, loving-kindness meditation has a significant short-term effect on anxiety in university students; decreased values in treatment while the matched control group had increased values (Totzeck et al., 2020). Similarly, the context of longitudinal research among college students on loving-kindness and PA revealed a significant decrease of depression, stress, anxiety, and higher PA levels indicated better mood at the same and following days (Bai et al., 2022; Totzeck et al., 2020). Further, in healthy young adults, interoceptive training significantly reduced state anxiety, bodily symptoms, and higher BMI is associated with deficits in interoception in adults (Robinson et al., 2021; Sugawara et al., 2020).

Instrument sensitivity may have a potential impact on our findings. For example, the WHO-5 is a diagnostical tool for depression, and raw scores of 13 or lover indicate further evaluation (Topp et al., 2015). The PSS-4 is generally used as a brief measure of perceived stress, and scores of six or higher indicate high stress; however, it is not a diagnostic instrument (Warttig et al., 2013). Therefore, using the PSS-10 or PSS-14 may affect the results of the present study. Transition to higher education is a sensitive, stressful period and different experience for each student; academic expectations are changing every semester and are generally clearly outlined. However, structured, regular opportunities, such as PA, to maintain overall well-being diminish while the brain is still developing (Grasdalsmoen et al., 2020; Miller & Street, 2019; Powell et al., 2018). Therefore, learning strategies to maintain physical and mental well-being, manage life stressors, and productively contribute to personal and professional growth is necessary as part of formal higher education. First-year college students experience environmental, psychological, physiological, and academic changes; thus, it is vital to increase PA levels as an individual and institutional responsibility (Grasdalsmoen et al., 2020; Powell et al., 2018). Consequently, regular programs need to be incorporated to overcome the inevitable encounters of life and maintain overall well-being. Given the overall results and practical implications, we can discuss that MBPA applied in higher education is an essential lifestyle behavior to meet the needs of students and institutions in the COVID-19 era and beyond. Therefore, a brief, multilevel and multicomponent 10-minutes MBPA is a viable, feasible, and effective solution for optimal well-being as we discuss further.

The MBPA program can be introduced to all incoming students and create evenly distributed practice environments around campus and online, to structure MBPA learning opportunities. To protect and promote students' well-being, understanding their experience both on the intra- and interpersonal level should be acknowledged and relate to personal and academic success.

4.3. Strengths and Limitations

This study should be perceived within the context of notable strengths and limitations. To the best of the author's knowledge, this is the first pilot study to examine the effects of the brief, multicomponent MBPA intervention and is comprehensive in the variety of data captured. The strength of our research includes objective PA measurement as wrist-worn accelerometers to capture light and moderate PA. It is imperative to consider that this study's primary limitation is the small sample size, and there was no active control group to compare the MBPA intervention. To address the lack of true experimental design, where clustered randomization is implemented, a valid ITSD design was used. Therefore, casual interference was established as we captured data at six timepoints across the intervention. It must also be acknowledged that participants were college students, and the results are not generalizable. Also, bias, such as response to self-report instruments, may have been present in this sample. Further, limitations to this study are the lack of examination of mediating variables, and using self-report data for measuring well-being, perceived stress, and interoceptive sensibility, as potential biases can exist. The MBPA needs further investigation because, as a multicomponent intervention, without component analyses, we can't tell to what degree the online (synchronous vs. asynchronous) delivery or distribution of ancient movements specifically influenced the outcome.

4.4. Conclusions

In conclusion, the MBPA intervention increased LPA and MVPA during the COVID-19 crisis as students progressed through the semester. Our results suggest that participation in the online MBPA intervention is associated with higher PA during the Spring semester of 2021. These results are encouraging because they indicate that the MBPA intervention has the potential to increase PA and may have positive effects on physical and mental health while alleviating stress. Data on participants' self-reported well-being, perceived stress, and interoceptive sensibility suggested a constant trend through the Spring of 2021 semester. Therefore, results indicate positive effects; thus, MBPA shows promise to be a viable intervention to increase PA and overall well-being among students in higher education. Future research needs to further examine the MBPA intervention using objective measures, such as stress-related physiological health markers or salivary markers of inflammation, to establish the sustainability of MBPA in higher education. Interventions such as MBPA demonstrated a meaningful capacity to improve youth and young adults' physical and mental health by increasing PA, well-being, proprioceptive sensibility, and improving stress.

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Table 1. Demographic data for the MBPA Intervention.

	(N=21)
Age (years, mean (SD))	21 (2.236)
Height (meter, mean (SD))	1.7 (0.1)
Weight (kg, mean (SD))	69.95 (17.593)

BMI ($kg \cdot m^{-2}$) [1] (mean (SD))	24.5 (4.5)
Gender (%) Female	81%
Male (4)	19%
Female (17)	81%
Other	0
Did not respond	0
Ethnicity (%)	
White (17)	81%
Hispanic or Latino (2)	9%
Black or African American (1)	5%
Native American or American Indian	0
Asian/Pacific Islander (1)	5%
Other	0
Did not respond	0
Year (%)	
Freshman (5)	24%
Sophomore (4)	19%
Junior (6)	28%
Senior (5)	24%
Graduate/Professional Student (1)	5%
Year participants were planning to graduate:	2021 - 2026
Did not respond	0
Current Relationship Status (%)	
Single (12)	57%
Single but cohabiting with a friend or significant other (6)	29%
Married (3)	14%
In a domestic partnership	0
Other	0
Did not respond	0
Annual Household Income (%)	
Below $10k (3)	14%
$10k - $25k (8)	38%
$25k - $50k (6)	29%
Over $50k (4)	19%
Did not respond	0

[1] BMI stands for Body Mass Index

Table 2. Descriptive statistics for physical activity at each time-point

Variable	Preintervention* (M±SD) N = 20	Midpoint (M±SD) N = 21	Postintervention (M±SD) N = 21
Time in LPA	256.68±201.61	426.58±176.78	446.15±160.49
Percent in LPA	2.55±1.99	4.23±1.75	4.42±1.59
Time in MVPA	75.49±67.84	134.55±67.08	122.43±62.49
Percent in MVPA	0.75±0.67	1.33±0.66	1.21±0.61

Note. M = mean score; SD = standard deviation; n = number of participants; Preintervention* = baseline separated by breakpoint after week 3 when intervention implemented; LPA stands for light physical activity; MVPA stands for moderate-to-vigorous physical activity.

Table 3. Descriptive statistics for subjective well-being, perceived stress, and interoceptive sensibility at each time-point

Variable	Timepoint 1 (M±SD) N = 18	Timepoint 2 (M±SD) N = 21	Timepoint 3* (M±SD) N = 21	Timepoint 4 (M±SD) N = 21	Timepoint 5 (M±SD) N = 21	Timepoint 6 (M±SD) N = 20
WHO-5**	14.05±3.79	14.23±3.76	13.95±4.11	15.57±3.82	15.66±4.84	14.10±5.69
PSS-4***	6.55±2.61	6.71±2.36	6.81±2.67	5.81±2.29	5.76±3.17	6.00±3.22
Interoceptive sensibility	26.83±10.98	25.04±10.44	24.09±12.14	21.52±7.81	16.50±8.28	20.44±10.47

Note. M = mean score; SD = standard deviation; n = number of participants; Timepoint 3* = separated by breakpoint after week 3 when intervention implemented; WHO-5 ** = the 5-item World Health Organization Well-Being Index raw score ranging from 0 representing the worst imaginable well-being to 25 representing the best imaginable well-being; PSS-4*** = the 4 item Perceived Stress Scale higher values indicate more stress.

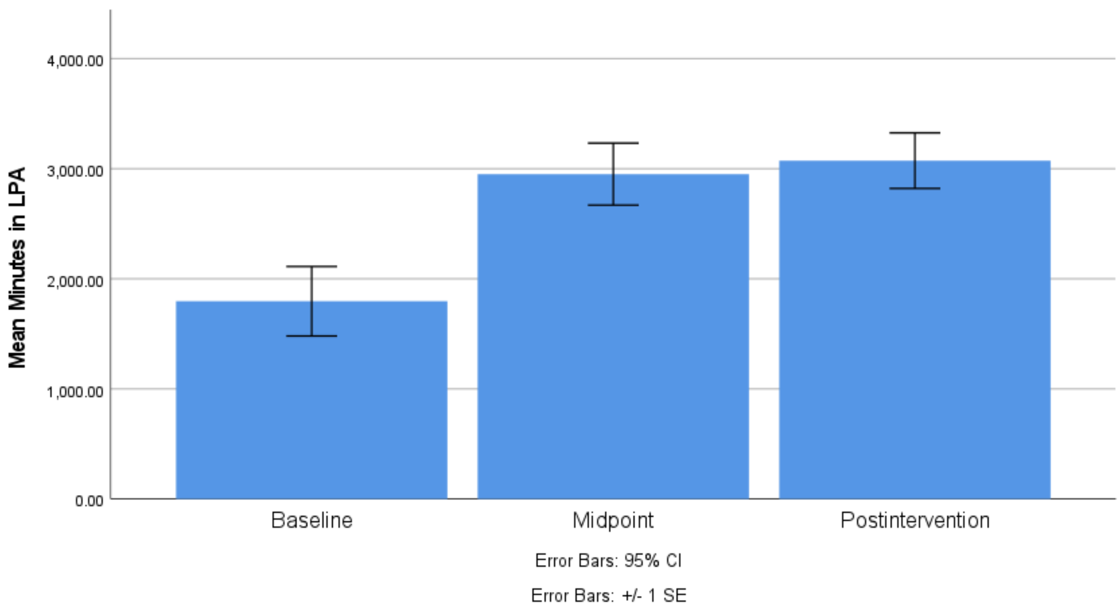

Figure 1. Time spent in light physical activity changes.

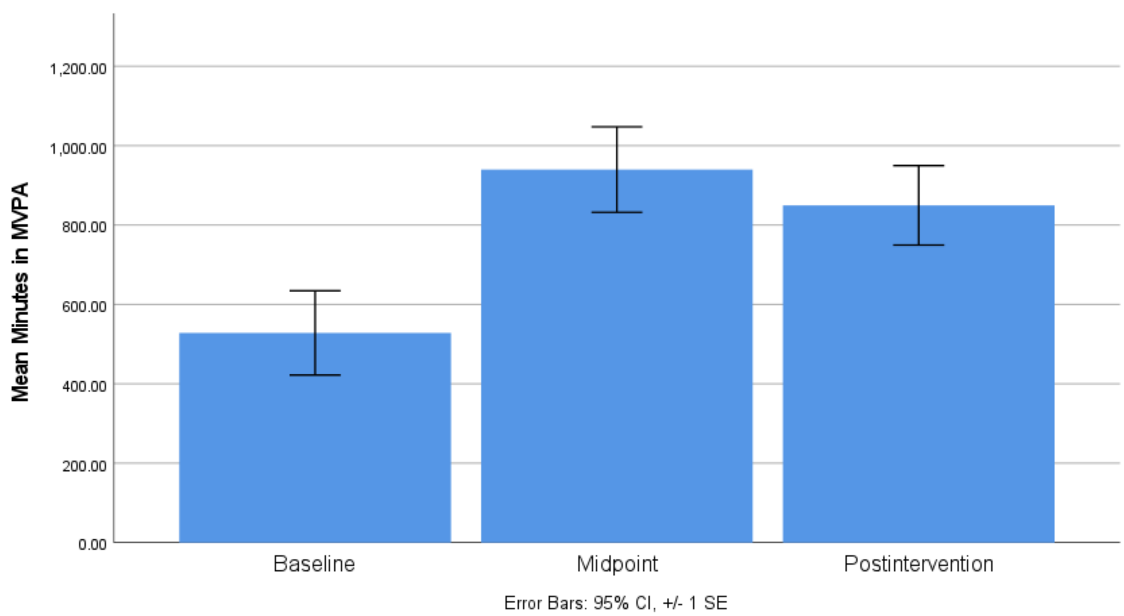

Figure 2. Time in moderate-to-vigorous physical activity changes.

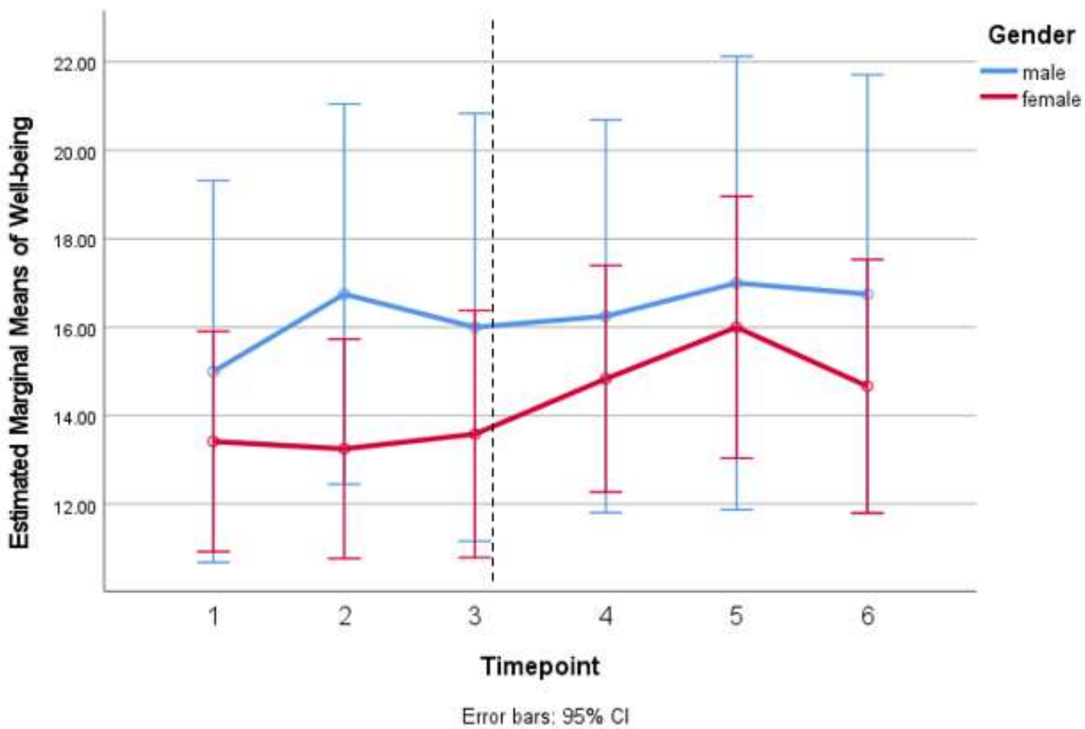

Figure 3. Means of subjective well-being levels at six timepoints separated by breakpoint (Mean ± Standard Deviation).

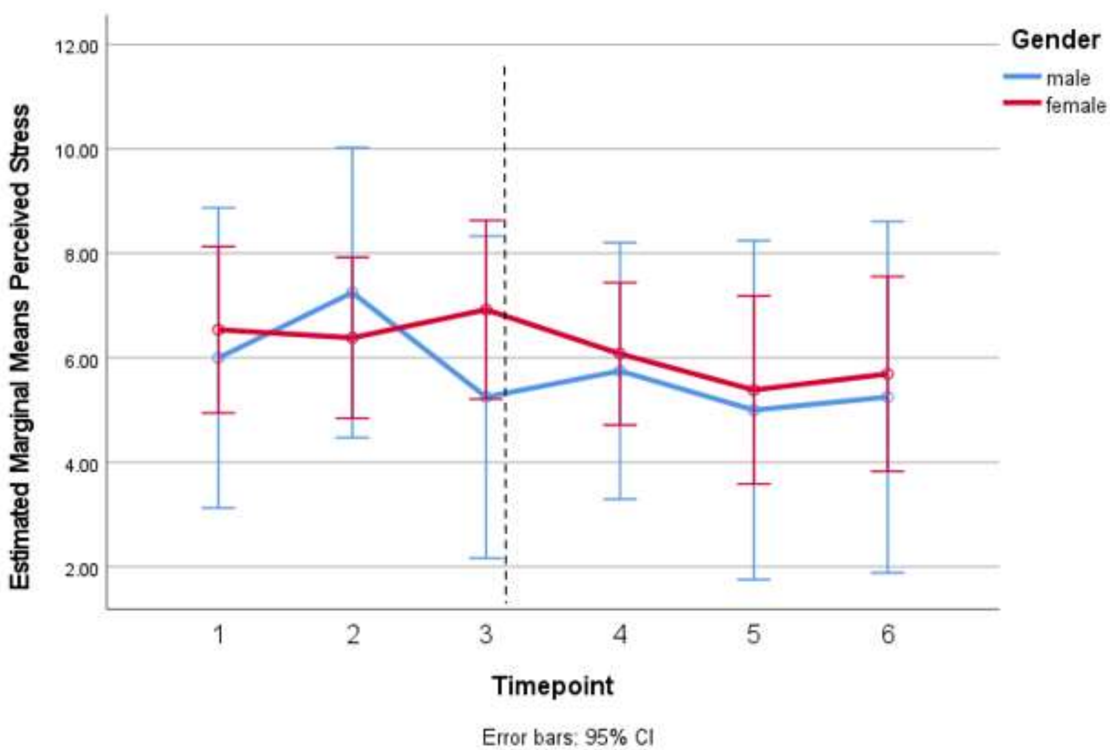

Figure 4. Means of perceived stress levels at six timepoints separated by breakpoint (Mean ± Standard Deviation).

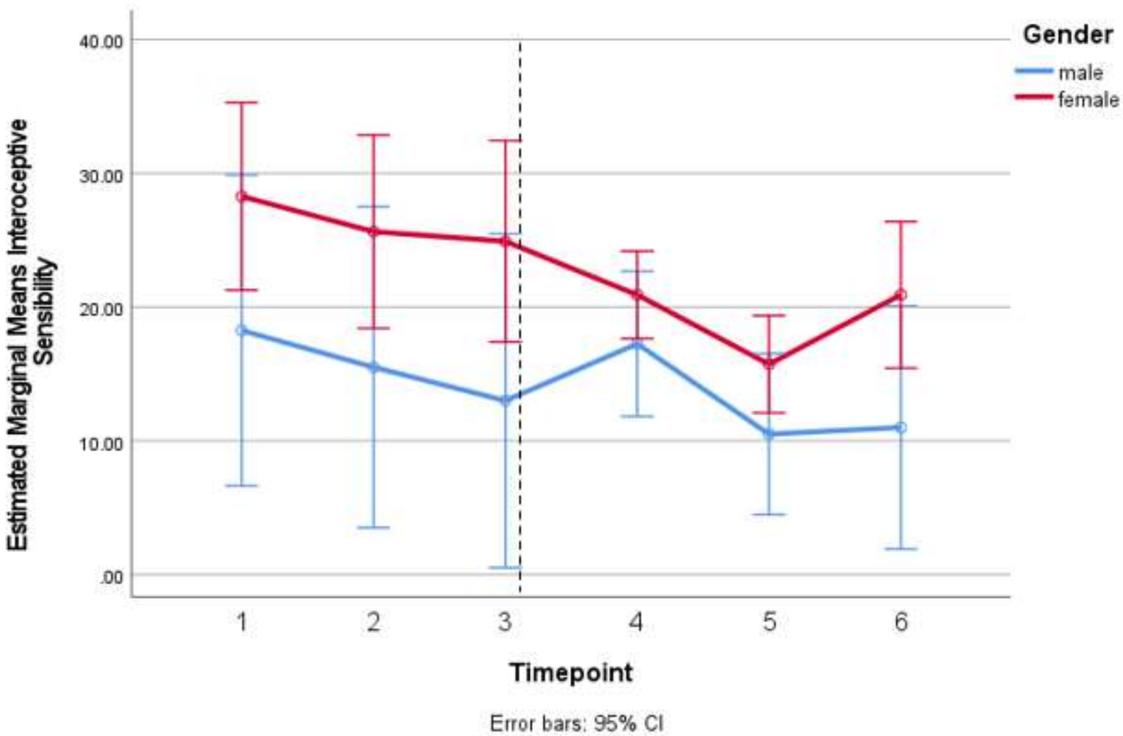

Figure 5. Means of interoceptive sensibility levels at six timepoints separated by breakpoint (Mean ± Standard Deviation).

Supplementary Files

Table 1. The chronological summary of the MBPA intervention procedures

MODULE 1	**WEEK 1**	1st 10-minute Session: Breathing Activity: Deep Breathing	2nd 10-minute Session: Breathing Activity: Deep Breathing	3rd 10-minute Session: Breathing Activity: Ocean Breath	**DATA COLLECTION** **Before starting week one** breathing activities, participants will complete the **Pre-Intervention Phase surveys at time-point 1, 2, and 3** (WHO-5, PSS-4, Interoception). The pre-intervention-phase lasts for approximately 3 weeks. Schedule to pick up your accelerometer and wear it for 7 days (baseline data).
	WEEK 2	4th 10-minute Session: Breathing Activity: Ocean Breath	5th 10-minute Session: Breathing Activity: 4-7-8	6th 10-minute Session: Breathing Activity: 4-7-8	
MODULE 2	**WEEK 3**	7th 10-minute Session: Ancient Movement Activities	8th 10-minute Session: Ancient Movement Activities	9th 10-minute Session: Ancient Movement Activities	**TIME-POINT 4** Complete the 1st Intervention Phase surveys (WHO-5, PSS-4, Interoception). Schedule to drop off your accelerometer at your earliest convenience. Optional: 1-hour Zoom meeting

	WEEK 4	10th 10-minute Session: Ancient Movement Activities	11th 10-minute Session: Ancient Movement Activities	12th 10-minute Session: Ancient Movement Activities	

Table 1. Continued

MODULE 3	**WEEK 5**	13th 10-minute Session: Walking Activities	14th 10-minute Session: Walking Activities	15th 10-minute Session: Walking Activities	**TIME-POINT 5** Complete the 2nd Intervention Phase surveys (WHO-5, PSS-4, Interoception). Schedule to pick up your accelerometer and wear it for 7 days (midpoint data). Optional: 1-hour Zoom meeting
	WEEK 6	16th 10-minute Session: Walking Activities	17th 10-minute Session: Walking Activities	18th 10-minute Session: Walking Activities	Schedule to drop off your accelerometer at your earliest convenience.
MODULE 4	**WEEK 7**	19th 10-minute Session: Loving-Kindness Activities	20th 10-minute Session: Loving-Kindness Activities	21st 10-minute Session: Loving-Kindness Activities	**TIME-POINT 6** Complete the 3rd Intervention Phase surveys (WHO-5, PSS-4, Interoception). Optional: 1-hour Zoom meeting
	WEEK 8	22nd 10-minute Session: Loving-Kindness Activities	23rd 10-minute Session: Loving-Kindness Activities	24th 10-minute Session: Loving-Kindness Activities	Schedule to pick up your **accelerometer and wear it for 7 days** (postintervention data). Schedule to drop off your accelerometer at your earliest convenience.

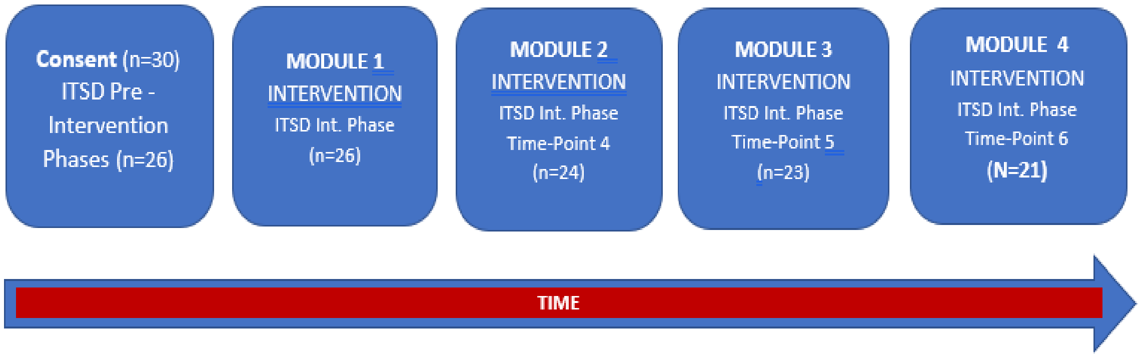

Figure 1. Flow diagram of compliance across the pilot study duration

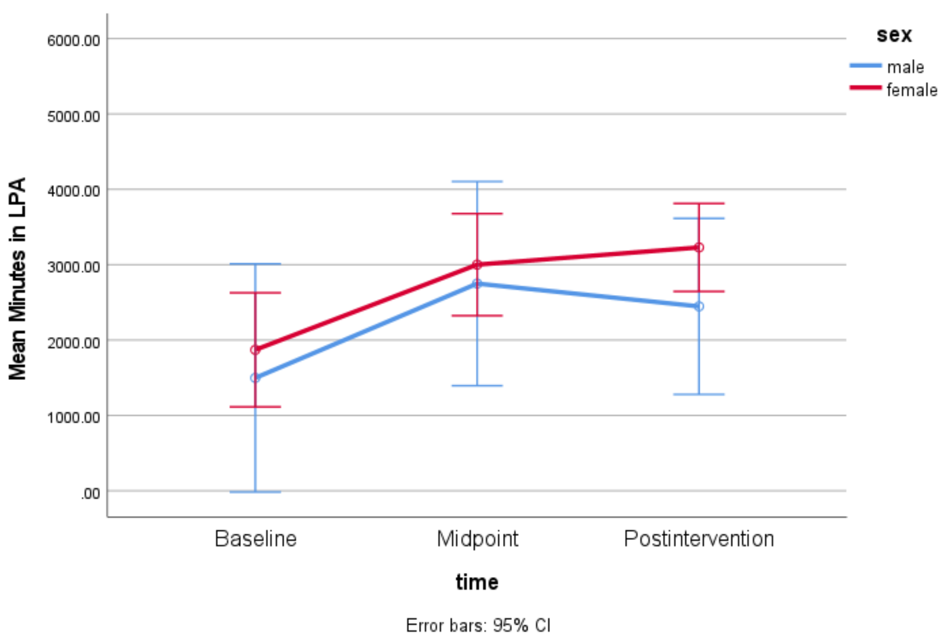

Figure 2. Mean minutes spent in light physical activity changes (Mean ± Standard Deviation).

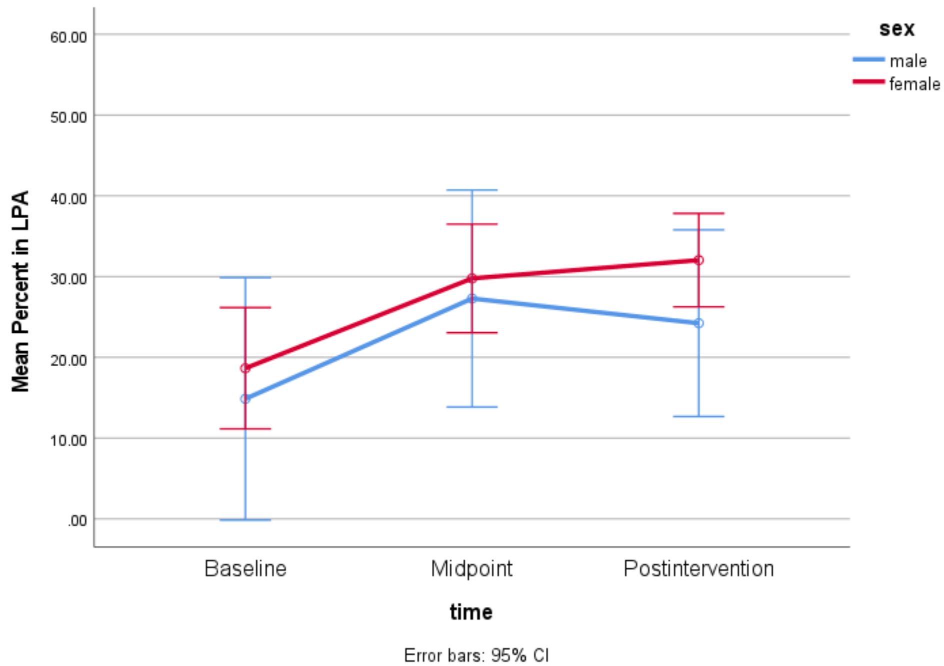

Figure 3. Mean percent of light physical activity changes (Mean ± Standard Deviation).

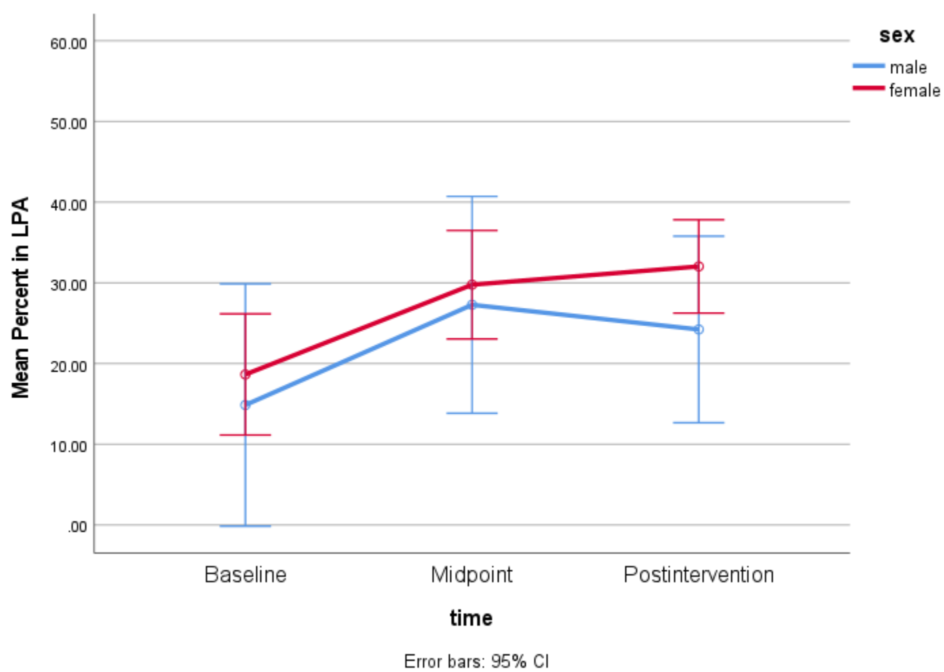

Figure 4. Mean percent of light physical activity changes (Mean ± Standard Deviation).

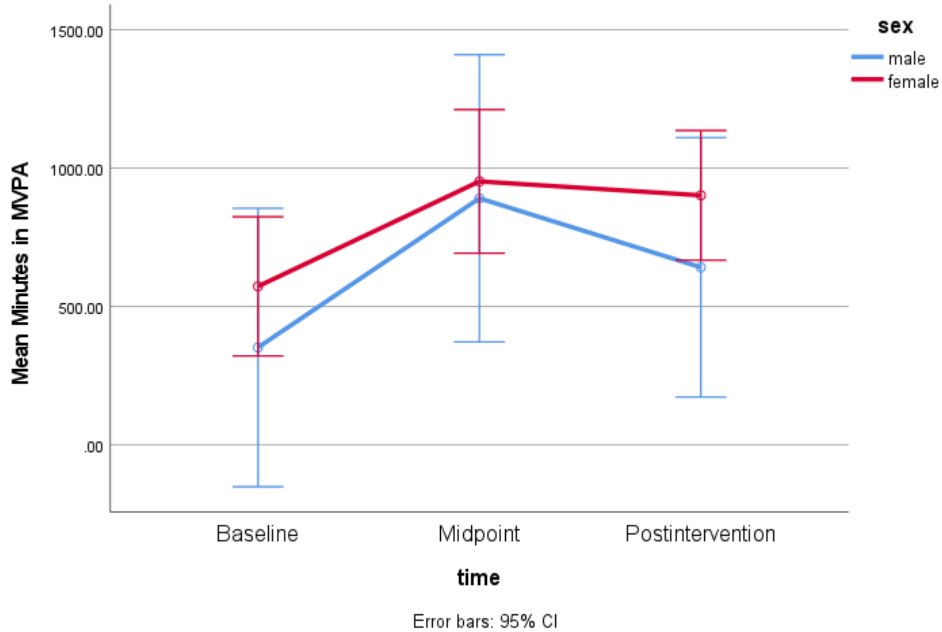

Figure 5. Mean minutes spent in moderate-to-vigorous physical activity changes (Mean ± Standard Deviation).

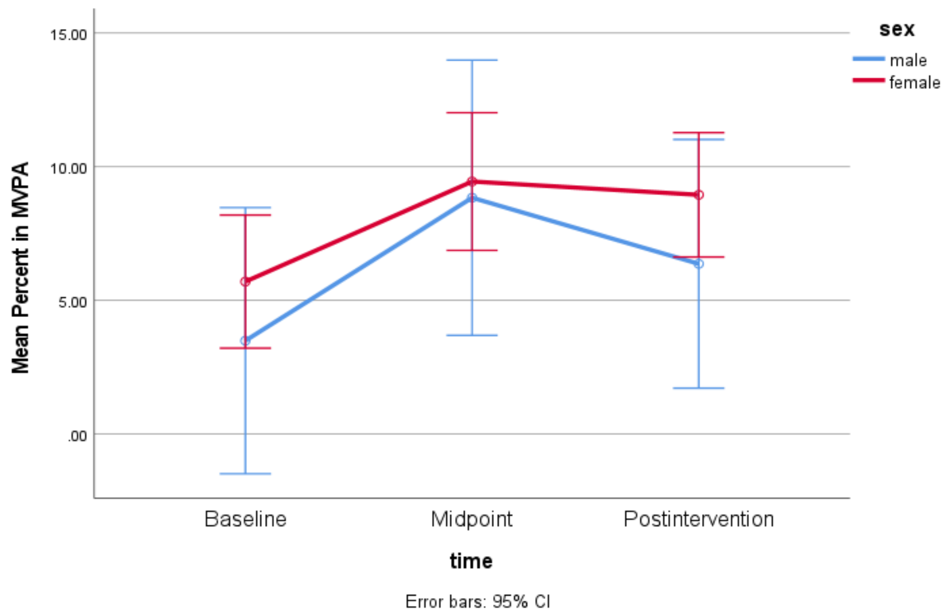

Figure 6. Mean percent of wear time in moderate-to-vigorous physical activity changes (Mean ± Standard Deviation).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- STROBEchecklistMBPAPilot.pdf