ABSTRACT

THE EFFECTS OF HIGH INTENSITY INTERVAL TRAINING ON PERCEIVED STRESS AND CARDIORESPIRATORY FITNESS IN DOCTOR OF PHYSICAL THERAPY STUDENTS AT CALIFORNIA STATE UNIVERSITY, FRESNO: A PILOT STUDY

Stress-related mental health disorders are common amongst graduate students and can contribute to negative physiological and psychological outcomes including delayed academic success, sleep problems, and increased risk for cardiovascular disease. High intensity interval training (HIIT) is of particular interest to Doctor of Physical Therapy (DPT) students as a stress management strategy that fits into their busy academic schedules while also benefitting one's physical health. The purpose of this pilot study was to evaluate the effects of a HIIT program on perceived stress and cardiorespiratory fitness in DPT students at California State University, Fresno. Thirty-nine students self-selected into the intervention (n = 21) or control (n = 18) condition. The intervention group performed an 8-week HIIT program for a total of 16 sessions. Each session was 25 minutes in duration using a 45:15 second work:rest ratio. No statistical significance was found for perceived stress ($p = 0.105$) or cardiorespiratory fitness ($p = 0.547$). A trend toward significance was found such that a more significance decrease in perceived stress was found with increased participation in the HIIT sessions. The clinical implications of this pilot study indicate that HIIT can be an effective strategy to improve overall mental and physical health throughout the schooling process, but also as DPT students progress in their careers.

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May 2020

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by

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A project

submitted in partial

fulfillment of the requirements for the degree of

Doctor of Physical Therapy

in the Department of Physical Therapy

College of Health and Human Services

California State University, Fresno

May 2020

APPROVED

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ACKNOWLEDGMENTS

I would like to thank my parents for their love and support throughout my academic endeavors and for encouraging me to always follow my dreams. I would also like to thank my research partner, Alyssa Cabri, for sticking by my side throughout this entire research adventure. Finally, thank you to my research committee members, Dr. Jennifer Roos, PT, DPT, GCS, Dr. Jenna Sawdon-Bea, PT, PhD, and Dr. Amy Brogan, EdD for your support and for letting me share in your passion for overall wellness. Thank you for your guidance and for allowing me to enhance my knowledge through this journey. I appreciate all the time and effort you put into helping this research project come to fruition.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Page

BACKGROUND

Graduate Student Mental Health

Mental health disorders are a leading cause of disability and are increasing in prevalence across the world.[1] The mental health of graduate students in particular is a growing concern. Recent research indicates that the likelihood of graduate students experiencing depression and anxiety is greater than 6 times that of the general population.[2] A study by Evans et al. on mental health found that 39% of graduate students presented with moderate to severe depression compared to 6% of individuals in the general population.[2] Similarly, the 2014 UC Berkeley Report found that 43-46% of graduate students working towards bioscience degrees are depressed.[3]

The high prevalence of mental illnesses in graduate students poses significant economic and financial burdens. For instance, student dropout rates can create a financial burden for schools due to losses in fees and tuition.[4] Furthermore, mental illnesses contribute to increased health costs nationally and globally. In 2013, total health spending in the United States on mental illness was roughly $89 billion.[5] By the year 2030 mental health disorders are expected to cost the global economy $16 trillion.[6]

Stress and Mental Health in Graduate Students

Stress is a major contributing factor to mental health issues amongst graduate students.[7] According to the American Psychological Association, stress is defined as any experience of uncomfortable emotion that is accompanied by predictable biochemical, physiological and behavioral changes.[8] Studies report that stress contributes to 50% of all United States illnesses, and that stress-related illnesses account for two-thirds of visits to the doctor.[9] In a nationwide survey of

graduate students, 43% of respondents felt overstressed and claimed to be experiencing greater stress levels than they could handle.[10]

Stress can affect all graduate students equally, however the effects of stress on Doctor of Physical Therapy (DPT) students is of particular interest in this study. Students enrolled in DPT programs have an intensive academic curriculum and also participate in patient care which can contribute to increased stress levels.[11] Research suggests that heightened stress levels are commonly seen in students studying physical therapy.[11] In a study by Frank and Cassady, the authors found higher mean stress levels in DPT students compared to their peers in the working population.[12] Many factors contribute to increased stress levels amongst graduate students, and particularly DPT students, including clinical rotations, academic pressures to meet specific grade requirements, family expectations, time management struggles, and financial concerns.[11]

Psychological Effects of Stress

While a certain amount of stress can be beneficial, periods of intense or prolonged stress can detrimentally affect the psychosocial health of individuals. Research shows that high stress levels negatively impact students' academics, personal relationships, and quality of life.[12] In a study that detailed self-reported doctoral student challenges, the majority of students stated they believed stress directly delayed their academic progress.[13] The students reported that stress caused them to lose motivation, which led to disengagement and decreased productivity.[13] Stress was also noted to indirectly affect academic progress by negatively impacting students' mood and self-talk.

Doctoral students also reported that stress contributed to feelings of worry, sadness, and overwhelm.[13] Other research shows that feelings of loneliness and

nervousness may result from stress if it is not effectively managed.[14] Furthermore, excess stress can lead to increased feelings of depression and anxiety, both of which are associated with low life satisfaction.[15,16] With these stress induced mood changes, the quality of personal relationships may become compromised as individuals with high levels of stress become increasingly withdrawn and disengaged.[14]

Physiological Effects of Stress

In addition to having harmful psychological effects, stress can negatively influence physical health. Physiologically, stress activates several biological systems.[17] During perceived threats, including stress, the body undergoes a natural stress response. Acute or immediate stress induces activation of the sympathomedullary pathway.[17] Through this pathway, the brain signals the sympathetic nervous system to turn on, resulting in the secretion of the hormone adrenaline. The release of these hormones increases blood pressure and heart rate to allow for increased oxygen throughout the body's muscles, thus allowing for increased physical activity.[17] Once the stressor passes, the parasympathetic nervous system takes control and returns the body to a balanced state.

Another pathway that is activated during the stress response is the hypothalamic-pituitary-adrenocortical (HPA) axis. Long term stress heightens activation of the HPA axis which in turn results in the release of cortisol, the body's main stress hormone.[18] Cortisol helps fuel the body's 'fight or flight' instinct by increasing blood sugar levels which boosts energy and helps an individual cope with the stressor.[19] Once the perceived threat is over, the body senses the heightened cortisol levels and the system shuts down via a negative feedback loop, allowing the body's heart rate and blood pressure to return to

baseline levels.[18] Under constant stress, however, the body's fight or flight reaction is constantly turned on. Unmanaged stress leads to overexposure of the body's stress hormones and increases the risk for numerous health problems.[19] Studies indicate that stress can contribute to hypertension, digestive problems, headaches, heart disease, and obesity.[15,19] Moreover, intense or prolonged stress can contribute to poor sleeping and dietary habits, as well as lead individuals to engage in unhealthy behaviors including smoking.[15]

Stress Management

It is proposed that stress levels increase during the schooling process and continue throughout an individual's career.[20] Furthermore, research conducted by Williams et al. on first and second year DPT students found an increase in burnout and academic fatigue along with decreased coping strategies as students continued throughout their program.[21] Given this information as well as the large financial, economic, and health consequences of stress related mental health disorders, there is a need for effective and cost-friendly stress management strategies for graduate students. In a study where students described preferred methods for coping with stress, some students indicated that talking with friends, self-talk, journaling, and listening to music helped them deal with their feelings.[7] A variety of other techniques effective at reducing stress include progressive muscle relaxation, breathing exercises, guided imagery, cognitive behavior therapy, meditation, and exercise.[22]

Exercise Protects Against Stress-Related Symptoms

Exercise, defined as a type of physical activity which consists of structured and repetitive bodily movement performed to increase or maintain physical fitness, is a well-known and inexpensive method for stress management.[23-26]

Exercise helps to increase endorphins which are neurotransmitters in the brain that act as natural painkillers.[25] Exercise also stimulates the release of serotonin and dopamine, 2 neurotransmitters that are critical to many central nervous system functions such as regulating sleep and improving mood.[26] Moreover, studies have shown that exercise decreases the reactivity of the HPA axis during periods of repeated stress, thus indicating that exercise may reduce the adverse effects of increased cortisol levels secondary to stress.[26] Other reported benefits of exercise include improved concentration, decreased overall tension levels, reduced fatigue, increased self-esteem, and enhanced cognitive function.[25]

Furthermore, exercise increases the release of a protein in the brain called brain-derived neurotrophic factor (BDNF), which plays a critical role in the survival and growth of neurons and also contributes to neuronal plasticity.[26-28] When individuals experience stress, BDNF expression is reduced and this lack of neurotrophic support can lead to depression.[27] Exercise, however, is one of the best ways to increase BDNF production. The BDNF-promoting effect of exercise is essential for developing new brain connections and protecting brain cells. Keeping the brain healthy via high BDNF levels is not only crucial to fighting off neurological diseases, but it is also important for enhancing learning, retaining memories, and reducing the risk of stress related mental health disorders such as depression.[28]

In addition to having multiple psychological benefits, regular exercise also has extensive health benefits. Some of the positive effects of aerobic exercise include improved bone and muscle health, reduced susceptibility to chronic diseases, improved weight control, and decreased mortality.[29,30] Moreover, one of the main benefits of aerobic exercise is increased cardiorespiratory fitness. Cardiorespiratory fitness refers to the body's ability to supply oxygen to muscles

during periods of sustained physical activity.[29] One way to evaluate cardiorespiratory fitness is by estimating maximal oxygen uptake (VO_2 max). VO_2 max is defined as the maximum volume of oxygen that the body consumes during exercise and is the standard for measuring aerobic endurance and cardiorespiratory fitness.[30] Oxygen consumption is directly related to energy expenditure, thus, measuring oxygen consumption allows for an indirect measure of the body's maximal aerobic working capacity. Aerobic exercise aids in improved cardiorespiratory function by increasing the efficiency of oxygen transport within the body.[30] Consistent aerobic training helps the heart to pump more blood via increases in stroke volume, thus allowing individuals to exercise longer and harder without feeling fatigued.[31]

Research has also shown that high cardiorespiratory fitness levels help protect against the negative consequences of stress.[32] Gerber et al. examined how cardiorespiratory fitness and perceived stress are related to burnout and depression. The authors concluded that amongst individuals who reported high stress, those with high fitness levels reported lower levels of tension and less depressive symptoms compared to those with low fitness levels.[32]

Literature Supporting Exercise and Stress Management

Numerous studies have reported the effectiveness of exercise in helping to reduce perceived stress and improve mental health.[24,33-35] For instance, King et al. investigated the 12-month effect of exercise on perceived stress and anxiety in older adults. Results from the study show that exercisers had greater reductions in perceived stress compared to control subjects.[36] These results are consistent with the findings of Hassmen et al. who report that adults exercising greater than 2 times a week had significantly less stress compared to those exercising less

frequently or not all.[34] Likewise, a study by Norris et al. showed that individuals participating in high intensity aerobic training reported less stress than subjects in a flexibility training group or the control group.[33]

Even amongst students, the effects of exercise on stress have been investigated in multiple studies. Yorks et al. examined the relationship between exercise, stress, and quality of life in a medical student population.[35] The authors report a significant decrease in perceived stress levels and an increase in quality of life scores after students participated in a group fitness class for 12 weeks.[35] Similarly, Arazi et al. found a positive effect of aerobic exercise training on college students' stress, anxiety, and depression, while no changes on any of those measures were observed in the control group who did not partake in exercise classes.[24]

High Intensity Interval Training

It is well known that regular exercise has positive effects on an individual's physical health, quality of life, and ability to manage stress, however the effects of group exercise on DPT students is less well known. Furthermore, despite the benefits of exercise being well documented, research indicates that low levels of physical activity are a continual problem.[35] Standard guidelines for aerobic training recommend participating in at least 150 minutes of moderate intensity exercise per week, with 30-60 minute sessions and/or 75 minutes of vigorous intensity exercise per week with 20-60 minute sessions.[23] While these protocols are recommended for maximal effectiveness, they may not be realistic for time conscious graduate students. For doctoral students, the pressures associated with academics and social life make it difficult to maintain a regular fitness routine.[35] Due to the common complaint of time limitations, an increasing amount of

evidence supports the benefits of high intensity interval training (HIIT).[37] High intensity interval training consists of multiple rounds of a high intensity exercise period lasting 30 seconds to several minutes, followed by a rest period.[38] This type of training may be particularly appealing to DPT students because it can be completed in a short period of time (approximately 20 to 30 minutes), but also results in comparable physiological effects as traditional aerobic training.[38] For instance, studies show that HIIT significantly reduces subcutaneous fat, total body mass, total cholesterol, and improves VO_2 max.[38]

Purpose

An over-arching theme of research conducted at the Physical Therapy Department at California State University, Fresno over the past 4 years is that students enrolled in Fresno State's DPT program believe exercise will aid in stress reduction, but time and ease of availability is a common complaint about compliance with participation on a regular basis. This pilot study aims to determine if providing a free, convenient, timely, and group setting HIIT workout will have an effect on stress management for DPT students. Therefore, the purpose of this pilot study is to provide a group based HIIT exercise class for free to any student currently enrolled in the physical therapy program during the fall 2019 semester. The null hypothesis is that there will be no statistically significant difference amongst DPT students' perceived stress after participating in a group HIIT exercise class. The alternative hypothesis is that there will be a statistically significant difference amongst DPT students' perceived stress after participating in a group exercise class.

A secondary purpose of this study is to examine the effects of the HIIT exercise class on cardiorespiratory fitness. The null hypothesis is that there will be

no significant difference in VO_2 max between the control and experimental groups after the intervention program. The alternative hypothesis is that there will be a significant difference amongst DPT students' VO_2 max following participation in the HIIT class.

METHODS

Participants

This study was approved by the California State University, Fresno State Department of Physical Therapy Institutional Board Review Board prior to subject recruitment. Thirty-nine healthy young adults (28 females, 11 males) were recruited from California State University, Fresno's Department of Physical Therapy. All participants were Doctor of Physical Therapy (DPT) students enrolled in either the first, second, or third year cohort at Fresno State. Recruitment for participants included flyers, word of mouth, or email providing enrolled students information about the free exercise class opportunity. In addition, subjects were required to have no existing medical conditions or injuries preventing participation in physical activity. Participants reviewed and provided written informed consent prior to participation in the study.

Data Collection

Data collection occurred prior to and following an 8-week HIIT group exercise class intervention. Pre-testing occurred on 1 day and included intake survey, an aerobic fitness test, and a self-reported mental health questionnaire. Following completion of an 8-week intervention, participants completed pre-testing measures and an additional satisfaction survey. The pre intervention assessment took place 5 days prior to the intervention start date and the post assessment took place 5 days following completion of the intervention. The study took place during between September and November 2019, with the pre-assessment beginning 3 weeks into the term and post assessment occurring 5 weeks before the semester's end. This time frame allotted 8 weeks for the

students to be exposed to academic stressors with multiple assignments, practicals, and written exams.

Intake Survey

Participants completed an intake survey which addressed current level of weekly physical activity including days per week and hours per day, the average workout intensity, age, and year in the DPT program. Refer to Appendix A for intake survey.

Mental Health

Participants completed the Perceived Stress Scale (PSS), a self-reported subjective outcome measure.[39] The PSS consists of a 10-item questionnaire which measures the degree to which situations in an individuals' life are appraised as stressful.[39] Participants rate each item on a 5-point Likert scale (0 = never to 4 = very often) indicating how they felt in the past month with different situations. The items are intended to assess how often respondents find their lives unpredictable, uncontrollable, and overloading.[40] A total score is calculated based on the sum of each item, with higher scores indicating more perceived stress. The PSS has been empirically validated with the college student population.[40] Refer to Appendix B for the PSS.

Aerobic Fitness

All subjects completed the Queen's College step test in order to assess cardiorespiratory fitness.[41,42] Participants completed step ups for a total duration of 3 minutes at a step height of 16.25 inches. Males stepped at the rate of 24 steps per minute (96 beats per minute) and females stepped at the rate of 22 steps per minute (88 beats per minute).[41,42] A metronome was used to determine beats per

minute. At the completion of 3 minutes, participants took their own heart rate at the carotid pulse site beginning 5 seconds after completion.[41,42] Heart rate was taken for 15 seconds and multiplied by 4. The test was completed in 2 different groups: 1 male and 1 female. Using the data obtained from the step test, the participants' VO_2 max was calculated to determine cardiorespiratory fitness with the following equations: For males: VO_2 max = 111.33 – [0.42 × pulse rate (beats/min)] [ml/Kg/min]; for females: VO_2 max = 65.81– [0.1847 × pulse rate (beats/min)] [ml/Kg/min].[41,42]

Exercise Intervention

The exercise group participated in an 8-week HIIT intervention, consisting of 2 different HIIT workouts per week. Sessions took place on Tuesday and Thursday afternoons in a lecture room located in the Department of Physical Therapy building. Days and times in which the exercise sessions took place were determined by the most available and convenient times for all 3 cohorts.

Each exercise session lasted a total of 25 minutes in duration. The workout began with a 2.5-minute dynamic warm-up and immediately transitioned into a 20-minute period of high intensity training with a work to rest ratio of 45 seconds on to 15 seconds off. The work intervals included various aerobic and strengthening exercises. Sessions ended with a 2.5-minute cool down period. See Appendix C for further details regarding the exercises performed each session.

To promote appropriate exercise intensity during the high intensity training, participants were encouraged to maintain a rate of perceived exertion (RPE) level of 7-8 on the modified Borg Scale.[43] The participants' average and peak RPE levels for each session were recorded following the completion of the workout. Participants exercised to a set music playlist throughout the entire duration of the

intervention. The sessions were supervised and instructed by 2 third-year physical therapy students.

Control Group

The control group participated in pre and post data collection at the same time as the intervention group. Control participants were asked to continue their normal activity throughout the duration of the 8-week study.

Post-Intervention Satisfaction Survey

Participants in the intervention group completed a satisfaction survey following the completion of the 8-week intervention. Refer to Appendix D for satisfaction survey.

Statistical Analysis

Statistical analysis was completed using Microsoft Excel's Data Analysis with alpha levels set to 0.05. A per protocol analysis was conducted using only participants who attended 70% or greater of the intervention sessions. Independent t-tests were used to assess between group differences at baseline. A single factor ANOVA was used to evaluate the effects of the 8-week exercise intervention in comparison to the control group. The primary outcome measure was perceived stress and the secondary outcome measure was cardiorespiratory fitness.

RESULTS

Thirty-three participants completed the study. The intervention group (n=15) consisted of 60% first year cohort, 7% second year cohort, and 33% third year cohort. The control group (n=18) consisted of 22% first year cohort, 22% second year cohort, and 56% third year cohort. The average age of the intervention group (mean = 26.9) was comparable to that of the control group (mean = 26.6). Tables 1 and 2 display all demographic information for both groups.

Independent t-tests revealed no significant difference on any dependent variable between the experimental and control groups. A one-way ANOVA was used to determine significance by comparing the mean change in scores between pre and post-testing for the experimental and control groups on the following variables: perceived stress and VO_2 max (see Table 3).

Mental Health

Table 3 displays the average change in pre and post intervention scores for the PSS scores. Perceived stress decreased following the HIIT interval training while scores for the control group increased, however the changes were not significantly different from each other ($p = 0.105$).

Aerobic Fitness

The Queen's College step test was used to assess cardiorespiratory fitness via estimated VO_2 max.[41] VO_2 max scores improved for both groups, however results indicate no significant difference between VO_2 max of the control and experimental groups ($p = 0.547$). See Table 3 for pre and post intervention VO_2 max scores.

DISCUSSION

The purpose of this pilot study was to examine the effects of HIIT on perceived stress and cardiorespiratory fitness amongst DPT students at California State University, Fresno. It was hypothesized there would be a significant difference in DPT students' perceived stress and VO_2 max following participation in a group HIIT exercise class. The results indicate there was no significant difference in perceived stress levels for individuals who participated in an 8-week HIIT program compared to the control group who continued with their usual exercise routines. In a secondary analysis, it was also found there was no significant difference in aerobic fitness, as measured via VO_2 max, between the intervention and control groups. Therefore, the alternative hypothesis was rejected, and the null hypothesis was accepted. This discussion will explore potential reasons for this study's results, identify limitations of the study, and consider the need for further research.

Perceived Stress Results

Limited research has investigated the effects of exercise on stress amongst graduate students, and more specifically DPT students; however, the results of this study can be compared to previous findings regarding students in general. Multiple existing studies have reported that participation in aerobic exercise can reduce perceived stress. For instance, Arazi et al. found that non-athlete female college students had a significant decrease in perceived stress after participation in a 10-week physical activity training program.[24] Similarly, Yorks et al. report a reduction in perceived stress levels amongst medical students following 12 weeks of group exercise classes.[35] Our pilot study, however, failed to replicate these findings.

In contrast to the aforementioned studies, the current study produced non-significant results. The average perceived stress score pre-intervention for the exercise group decreased from 16.00 to 12.93 after the intervention period, indicating that the average score dropped from a moderate stress rating to a low stress rating according to the PSS. The control group, on the other hand, saw an increase in average perceived stress score (15.22 to 15.67) from pre to post-testing. Despite these findings, the results were not significant.

The present findings are consistent with the results reported by Eather and colleagues.[37] Eather et al. examined the efficacy of HIIT training in a university setting and found no significant intervention effects in regard for psychological outcomes, including perceived stress and anxiety.[37] In a different study by Paolucci et al., the authors document an increase in perceived stress for university students following 6 weeks of HIIT.[44] They hypothesize that this surprising result may be due to exacerbating the physiological response to high-intensity exercise such that the body's ability to regulate its physiological response to psychological stressors is disrupted, thus increasing perceptions of stress.[44] While the majority of exercise-based studies have documented a positive effect of physical activity on stress, these findings show there are mixed results in the literature. It is possible that differences across the literature may be due to variations in the intervention protocols.[24,35,37,44] The documented interventions vary in the use of equipment, exercise session lengths, total invention length, mode of exercise, and exercise intensity.

One potential factor that may contribute to this study's insignificant results is the timeline of the assessments. Pre-intervention testing took place during week 3 of the fall semester before the majority, if any, exams were taken. At this point in the semester students may not have been exposed to large amounts of academic

stress. In contrast, post-intervention testing occurred in the middle of the semester when exams were plentiful and stress levels were likely elevated. Heightened stress levels as the semester progressed serves as a confounding variable that may appear to diminish the impact and effectiveness of the exercise intervention.

Another possibility for our findings is the dosage of exercise was not sufficient to affect stress levels. The amount of exercise per week and the total duration of the intervention program may need to be altered to produce significant results. Currently, there is no recorded standard for the minimum dosage of exercise required to promote stress reducing effects.[45] While the American College of Sports Medicine (ACSM) published general physical activity recommendations, these were largely determined in regard to improving physical health and reducing susceptibility to disease rather than for the promotion of psychological health.[23] Furthermore, existing studies report varying levels of dose-response effects of physical activity on mental health outcomes.[46] In a study by Hamer et al., the authors observed mental health benefits in individuals who participated in at least 20 minutes of physical activity per week[46], however this dosage may not be enough for graduate students who experience higher than average levels of stress. Future research is needed to carefully examine the most optimal exercise dosage required for graduate students to maximize the psychological benefits of physical activity.

Another major confounding variable that may have influenced the current study's results is the lack of a non-active control group. In the current study, the control group was not restricted in the amount and type of physical activity they were allowed to perform. Hence, individuals in the control group could have been exercising on their own even though they did not receive the intervention. In fact, in pre-intervention surveys all control participants reported that they exercise on

their own anywhere from 2 to 6 days a week for an average of 1.36 hours per workout session. If control participants continued to maintain their usual exercise routines throughout the semester, then the data is likely confounded. Failure to restrict the control groups physical activity participation weakens the results of the study and ultimately poses a threat to the study's interval validity.

VO_2 Max Results

The group HIIT exercise class also failed to find a significant intervention effect on cardiorespiratory fitness. This result is inconsistent with the findings of various other studies. In a meta-analysis of 28 studies that examined the effectiveness of HIIT and continuous endurance training on VO_2 max in young and healthy adults, Milanovic et al. found there was a large beneficial effect on VO_2 max for both modes of exercise when compared to non-exercise control groups.[47] Furthermore, the authors report greater gains in VO_2 max following HIIT compared to endurance training, which is consistent with the findings of Weston and colleagues.[47,48]

The lack of significant findings in the current study, with regard to VO_2 max, could be attributed to the intervention duration (8 weeks). Milanovic et al.'s meta-analysis analyzed interventions ranging from 3 weeks to 24 weeks and found that the greatest increases in VO_2 max were following interventions of longer duration.[47] Thus, the relatively short duration of the current exercise program may have influenced participants' potential for cardiorespiratory improvements.

It is also possible that the nonsignificant findings are due to the intensity of the exercise sessions. Swain and Franklin analyzed 15 studies and found strong support that training at higher intensities of exercise results in greater improvements in VO_2 max compared to training at lower exercise intensities.[49]

High intensity interval training is proven to be a highly effective way to improve VO_2 max. As the name suggest, HIIT involves training at a high intensity level which can range anywhere from near maximal to supramaximal work rates.[50] In the current study, the average rate of perceived exertion across all sessions was 6.44 on the modified Borg Scale.[43] This indicates that subjects were exercising, on average, at a moderate rather than a maximal or high intensity level.[31] Although moderate intensity exercise has been shown to also increase VO2 max[51], it is possible that this lower than intended exercise intensity in combination with short session durations was not sufficient to make significant physiological changes within this active group of students.

Another explanation for the current findings is the participants already had high baseline fitness levels, thus making it more difficult to achieve a significant change in cardiorespiratory fitness. Swain and Franklin, as well as Milanovic et al., report that greater improvements in VO_2 max are seen in individuals with lower initial fitness levels.[47,49] The average VO_2 max values for this study's participants at baseline were either average or above average for the target gender and age range. Hence, because the students in this study were relatively fit prior to the study's start, a significant change in cardiorespiratory fitness after 8 weeks is less likely.

Finally, as with the perceived stress results, a likely possibility for the results is the lack of restrictions placed on the control group with respect to their participation in physical activity. If the experimental and control groups were exercising at similar levels in regard to amount and intensity as our pre-treatment surveys indicate, then the data is confounded and the chances of finding a significant effect are diminished.

Other Trends and Considerations

Although the intervention effects from the current study are nonsignificant, the findings are consistent with those of previous studies in regard to heightened stress levels amongst graduate students. In the present study, 61% of DPT students scored within the moderate stress range or higher on the PSS prior to the start of the intervention. Furthermore, 58% of students perceived stress scores were higher than the average norms for peers in a similar age range at pre-intervention testing.[39] These results parallel the findings of previous studies and show DPT students have increased stress levels compared to same aged individuals in the general population.[11,12]

Another notable point of discussion is the results show a trend towards significance with increased participation. Sub-analysis on perceived stress scores found a significant decrease in perceived stress when limiting the analysis to participants who attended 75% or greater of the offered workouts ($p = 0.039$). On the other hand, when including all participants in the analysis, regardless of attendance rate, the p-value increased ($p = 0.184$) compared to the original p-value using a cut-off of 70% or greater attendance rate ($p = 0.105$). Thus, in this study a trend exists between attendance rate and perceived stress level such that an increase in attendance rate is correlated with a decrease in perceived stress.

Furthermore, post-intervention surveys indicate the program was well received by all of the participants. On a 5-point Likert scale ranging from 1 = not at all, to 5 = a great deal, 100% of participants reported the extent to which they were satisfied with the class as either very much or higher, with 86% reporting that they were satisfied a great deal. When asked how likely participants would be to enroll in the program if offered again, 86% indicated that they were very

interested in participating a second time. Furthermore, all participants reported that they were highly likely to refer other students to the exercise program.

Even though the majority of students indicated a great liking of the program, an overarching issue throughout the course of the intervention was attendance, as only 71% of participants attended 70% or more of the sessions offered. Students reported illness, doctors' appointments, being out of town, and feeling too stressed as main reasons for missing sessions. To increase compliance, future studies can provide more variation in the exercises to maintain participants' interest in the program. Moreover, adherence to the intervention program may improve if the exercise classes are scheduled at a convenient time for all students (either directly before or after classes).

Limitations

There are several limitations to the present study. First, a convenience sample that included DPT students from 1 university was used. Second, the sample size in the present study was small and included an uneven number of male and female participants. Both the small sample size and the imbalance between male and female participants limit the generalizability of the results. The population used is not a sufficient representation of all DPT programs, thus threatening the external validity of the study.

In addition to compromised external validity, lack of randomization and lack of blinding threaten the study's internal validity. Participants were aware of their group assignment (either control group or exercise group) during both pre and post-testing assessments. As a result of knowing their group assignment, participants may have reported untruthful responses on their perceived stress questionnaires in an attempt to support their interpretation of the experiment's

purpose. Response bias may have also influenced how participants rated their perceived exertion levels during each exercise session, thus leading to an inaccurate representation of the intensity level at which they were exercising. Moreover, this pilot study had a large difference in cohort representation between the intervention and control groups. The intervention group consisted of mainly first year students, while the control group consisted of mainly third year students. This difference in representation between the 2 groups also limits the study's interval validity.

Confounding variables such as examinations and other environmental factors (i.e. diet, finances, social relationships, etc.) may have influenced students' levels of stress, and hence serve as another threat to interval validity. On the other hand, individuals may have been utilizing other forms of stress management, such as mindfulness techniques or other forms of exercise, in conjunction with the group exercise class. Since other possible causes of potential stress reduction cannot be ruled out, this study cannot accurately demonstrate cause. Furthermore, failure to use a nonactive control group poses a significant threat to the study's ability to draw causal conclusions.

Future Research

Future research should be directed towards the development of high-quality studies that analyze the efficacy and feasibility of a group HIIT class in the graduate education setting for the purposes of stress reduction and improved physical health. Studies can improve upon the research design of this existing study by using a larger sample size and a nonactive control group. Additionally, providing heart rate monitors to participants would allow for a more accurate measure of exercise intensity level. If subjects are exposed to a live reading of

their heart rate, it may also motivate participants to maintain a higher level of work throughout the course of the intervention, thus improving compliance with exercise intensity. Moreover, scheduling sessions directly before or after classes, providing more workout sessions per week, including a greater variety of exercises, and incorporating music requests from participants may all help to improve overall attendance rates.

In addition to improving the current research design, future studies should explore different types and amounts of physical activity as well as varying work to rest ratios for HIIT programs. A comprehensive analysis of the dose-response relationship between exercise and stress management amongst graduate students is needed in order to provide guidelines regarding the optimal amount of physical activity recommended to achieve both mental and physical health benefits in a population that is prone to stressors. Finally, it would be of interest for future studies to investigate the combined effects of an exercise program in conjunction with at-home mindfulness techniques to promote maximal stress benefits in graduate students.

Clinical Implications

This study adds to limited literature analyzing stress reduction in graduate students. More specifically, the data collected in this study highlights the importance of stress management in DPT students. Time constraints are a commonly reported reason for high levels of stress amongst health care students.[11] Providing a convenient and quick workout in the form of HIIT is beneficial as it can be incorporated into students' schedules without taking a large amount of time away from their studies. Furthermore, the benefits of exercise allow students to better manage their stress and contributes many physiological benefits such as

weight loss, increased energy levels, improved cardiorespiratory fitness, and reduced risk of chronic disease.[35,38] Given the HIIT program was highly liked by participants and required little resources, the potential of incorporating a program into a variety of education settings could be of benefit in order to increase academic outcomes as well as improve overall mental and physical health.

Furthermore, a high satisfaction rating from participants following an exercise program can be used to influence one's own personal workout routine as individuals enter the workforce. Managing stress is not only important while in school but is also critical as people begin and progress in their careers. The workplace is one of the most prominent causes of stress in many individuals' lives.[52] Physical therapists generally have a positive view regarding their work; however, statistics show that job strain does occur.[53] Stress in the workplace can lead to absenteeism, poor productivity, poor time keeping, missed deadlines, and burnout.[52,54] Given these negative consequences, finding a method to effectively manage stress early on is important. Providing DPT students with a technique to manage stress not only in school, but in their future careers can help contribute to their quality of work life, thus, allowing them to better provide quality care for their patients.

Conclusion

The results of this study were nonsignificant but show a trend towards reduced perceived stress with increased participation in HIIT training. Many graduate programs, and especially health science programs, subject students to demanding, fast-paced, and stressful academic environments.[11] Stress can have a powerful impact on many aspects of life including one's mood, relationships, energy level, academic performance, and physiological health.[12] Furthermore, the

stress DPT students experience during their schooling may continue throughout their careers.[53] This can ultimately increase the risk for poor quality patient care as well as burnout.[54] It is important for DPT programs to acknowledge students stress and implement stress reducing techniques to help students learn how to cope with and manage stress in school and throughout their careers. Incorporating HIIT into DPT programs may serve as an effective and time efficient way for students to deal with daily stressors and improve physical health, thus helping to increase academic performance and overall well-being. In all, by finding a time-friendly and successful stress management technique as a student and future clinician, the negative physiological and psychological effects of stress will be diminished.

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TABLES

Table 1. Demographic Information of Intervention and Control Groups Including Age and Average Current Physical Activity (PA) Level

Variable	Intervention Group (n = 15)		Control Group (n = 18)	
	M	SD	M	SD
Age	26.93	5.97	26.60	1.52
Hours of PA/day	1.40	0.46	1.36	0.50
Days/week of PA	3.80	1.17	4.67	0.88
Exercise intensity	5.40	1.09	5.78	0.85

Table 2. Demographic Information of Intervention and Control Groups Including Gender and Cohort

Variable	Intervention Group (n = 15)	Control Group (n = 18)
Gender		
Male	2 (13.3%)	7 (38.9%)
Female	13 (86.7%)	11 (61.1%)
Cohort		
1st Year	9 (60.0%)	4 (22.2%)
2nd Year	1 (6.7%)	4 (22.2%)
3rd Year	5 (33.3%)	10 (55.6%)

Table 3. Descriptive Statistics of Perceived Stress and VO_2 Max in Intervention and Control Groups

Index	Intervention Group (n = 15)		Control Group (n = 18)	
	M	SD	M	SD
Perceived Stress				
Pre-test	16.00	6.19	15.22	5.48
Post-test	12.93	5.83	15.67.	4.90
VO_2 Max				
Pre-test	39.69	6.34	41.07	7.12
Post-test	41.20.	7.02	43.45.	8.50

APPENDICES

APPENDIX A: INTAKE SURVEY

Student Information:

1. Student ID: _____
2. Age: _____
3. Height _____
4. Weight: _____lbs
5. Gender: _____
6. Year in DPT program: _____
7. Current hours of physical activity per day: _____
    1. Number of days per week:
8. How would you rate the intensity of your physical activity (circle below):

APPENDIX B: PERCEIVED STRESS SCALE

INSTRUCTIONS:

For each question choose from the following alternatives:

0 – never 1 - almost never 2 - sometimes 3 - fairly often 4 - very often

1. **In the last month, how often have you been upset because of something that happened unexpectedly?**
2. **In the last month, how often have you felt that you were unable to control the important things in your life?**
3. **In the last month, how often have you felt nervous and stressed?**
4. **In the last month, how often have you felt confident about your ability to handle your personal problems?**
5. **In the last month, how often have you felt that things were going your way?**
6. **In the last month, how often have you found that you could not cope with all the things that you had to do?**
7. **In the last month, how often have you been able to control irritations in your life?**
8. **In the last month, how often have you felt that you were on top of things?**
9. **In the last month, how often have you been angered because of things that happened that were outside of your control?**
10. **In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?**

APPENDIX C: EXERCISE INTERVENTION

	MONDAY	WEDNESDAY
Warm-Up	Dynamic warm up (2:30 minutes - 30 seconds each) 1. Knee to chest 2. Piriformis 3. Quad stretch 4. Side lunge 5. Mummy walks	
Intervention 45 sec on/15 sec off = 20 minutes total	1. Butt Kicks 2. Forward lunges - legs (alt) 3. Jumping jacks - total body 4. Sumo squats - legs 5. Up downs - total body 6. SL RDL - legs (switch halfway) 7. High knees - total body 8. Tricep dips - tricep 9. SL glute bridge - legs (switch half way) 10. Leg lowers - abs 11. Front plank - abs 12. Russian twists - abs 13. Fake Jump Rope 14. Side lying leg lifts - leg/glut (switch) 15. Jumping lunges - legs 16. Fire hydrants - legs/glutes 17. Mountain climbers - total body 18. BW squats - legs 19. Standing lateral crunches - abs 20. Tuck jumps - total body	1. Forward/back skaters- legs 2. Reverse lunges - legs 3. Burpees - total body 4. Straight leg kicks (glut med) - leg/glute 5. Toe touch jumps 6. Flutter kicks - abs 7. Push ups 8. Stars - total body 9. Side plank alt - abs 10. Criss cross jacks 11. Alt toe taps - abs 12. Static squat with reach 13. Star plank 14. Quick forward straight leg kicks 15. Lunge in place- switch legs at 20 sec - legs 16. Spiderman mountain climbers - total body 17. Calf raises - legs 18. Skater hops lateral - total body 19. Standing oblique crunches - abs 20. Jump squats - total body

Cool-Down 2:30 minutes	1. Walk in place for 30 seconds 2. Static quad - 30 sec both sides 3. Hamstring - 30 sec both sides
	Warm up = 2:30 mins HIIT workout = 20 minutes Cool down = 2:30 minutes **Total workout = 25 minutes**

APPENDIX D: SATISFACTION SURVEY

Please check the box that apply	Not at all	A little	Somewhat	Very much	A great deal
How satisfied with the selection/variety of exercises?					
How satisfied are you with the variety and appropriateness of music?					
How satisfied were you with the energy and enthusiasm in the room?					
How satisfied were you with the location/convenience of the class?					
How satisfied were you with the duration of the classes? (30 mins)					
How satisfied were you with the length of the program? (8 weeks)					
How satisfied were you with the frequency of the program? (2x/week)					
How satisfied were you with the organization of the class?					
How satisfied were you with the overall program?					
Did the program meet your expectations?					
How likely are you to enroll in this program again if it were to be offered?					
How much do you think this program relieved your stress?					
How likely are you to refer this program to other students?					

Why did you choose to attend the program? (Circle all that apply)

- ☐ Free
- ☐ Brief time
- ☐ Easily accessible on campus
- ☐ Form a connection with peers in the program
- ☐ Stress reduction
- ☐ Learn something new
- ☐ Enjoy exercise
- ☐ Health benefits

What was the top reason you chose to participate in the program?

Did you miss a class? If so, why? (check all that apply)

- ☐ Did not miss any classes
- ☐ Too stressed
- ☐ Ill/sickness
- ☐ Simply did not feel like it
- ☐ Other commitments
- ☐ If other and would like to explain, please tell us why

_____

Do you have any other recommendations or comments regarding the program?