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Marathon training improves perceived stress, self-efficacy, and aerobic fitness in adolescents.

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Marathon training improves perceived stress, self-efficacy, and aerobic fitness in adolescents.

by

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Dedication

In dedication to my husband Sean, for always supporting me.

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Abstract

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Lack of physical activity among adolescents in the United States is leading to a concerning pattern of mental and physical health outcomes. Physical activity interventions, especially those that take place during school hours, have attempted to combat this trend but results have been inconsistent. The current study is a program evaluation of an existing physical activity intervention designed to train adolescents to complete a half or full marathon within five months. No previous studies have examined this mode of physical activity in the adolescent population, but anecdotal responses to this program justify a quantitative analysis. Results showed that participants who completed the program significantly increased their aerobic fitness. Participants also significantly reduced their perceived stress, and significantly increased their enjoyment and self-efficacy for exercise. The results are discussed in the broader context of adolescent physical and psychological health, and recommendations are made for future research.

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Introduction

HEALTH OUTCOMES RELATED TO PHYSICAL ACTIVITY

A lack of physical activity among adolescents represents a serious public health concern. The United States Centers for Disease Control recommends that children and teens accumulate 60 minutes of physical activity per day, and currently estimates that less than 30% of high school students in the U.S. are meeting this recommendation. Older adolescents (ages 16-19) engage in less moderate-to-vigorous physical activity (MVPA) than younger teens (12-15 years), and females engage less often than males. Among minority ethnic groups, only 29.8% of Hispanic adolescents report engaging in 5 or more bouts of MVPA per week. Within this group, just 19.5% of females report meeting this goal (Gordon- Larsen et al., 1999).

The impact of a lack of physical activity has been widely examined, and the research has revealed a grave pattern of effects. Inactivity or a sedentary lifestyle is associated with type II diabetes, obesity, and poor cardiorespiratory (aerobic) fitness. Poor aerobic fitness is a strong predictor of premature mortality, as strong a predictor as smoking, high cholesterol, and high blood pressure (Lakka et al., 2003). Unsurprisingly, the corollary to this relationship states that individuals who engage in physical activity have a reduced incidence of cardiovascular disease (CVD), type II diabetes, obesity and hypertension (Hallal et al., 2006; Autenrieth et al., 2011).

Warburton et al. (2006) provided a comprehensive meta-analytic overview of the relationship between physical activity and risk of cardiovascular-related death, diabetes, and cancer. This review established that physical activity is important not only for managing these disease conditions, but also for preventing them. Specifically, cardiovascular-related death relative risk decreased by 20-35% in individuals who

reported increased physical activity. A similar pattern was seen between physical activity and diabetes development and cancer diagnoses.

The relationship between physical activity and physical health outcomes is complemented by research on the relationship between physical activity and psychological outcomes. Mental health issues are of great concern in the adolescent population, and impact a large number of teens in the United States. Data obtained through the National Comorbidity Survey-Adolescent Supplement shows that 31.9% of adolescents suffer from anxiety disorders, 19.1% suffer from behavior disorders, and 14.3% suffer from mood disorders (such as depression) (Merikangas et al., 2010). Hispanic adolescents exhibit higher rates of mood disorders than non-Hispanic white adolescents.

A review of mental health outcomes and physical activity interventions by Biddle and Asare (2012) included interventions designed to address depression and anxiety, among others. The review revealed that physical activity interventions have small benefits for individuals experiencing depressive episodes, and/or anxiety, but that the evidence base is minimal. Interestingly, this review did not include articles about the relationship between physical activity and stress. In an earlier meta-analysis of correlates of physical activity among adolescents, Sallis et al. (2002) revealed that among the many factors associated with physical activity, stress was an understudied, but important issue. Only a single study included measures of adolescent stress, (Norris et al., 1992) and its results revealed that exercise participation is linked with lower stress levels, and lower rates of depression. Research on non-adolescent populations has revealed that moderate intensity and vigorous intensity exercisers were significantly less likely to identify themselves as "highly-stressed" (48% and 60% less likely, respectively), than low-intensity and non-exercising counterparts (Jonsdottir et al., 2010). Additional research

suggests that physical activity may serve as a buffer against negative life stress (Salmon, 2001).

SOURCES OF PHYSICAL ACTIVITY FOR ADOLESCENTS

Given physical activity's relationship with both physical and mental health, it is important that adolescents accumulate recommended levels of physical activity. Opportunities for physical activity in adolescence include school-based programs, such as physical education (PE) classes, school sports, and recess, as well as community based recreational sport and activity programs. However, access to these opportunities is not equal across the adolescent population.

In the United States, only six states currently have legislation that mandates that students participate in 150 minutes per week of physical education (Slater et al., 2012), and another 17 states merely "suggest" PE participation. According to the CDC, 52% of adolescents did not attend PE class at all in 2013 (CDC YRBS 2013). Unfortunately, even within states that do require PE, the actual activity rates among adolescent participants are not encouraging; students in PE class only averaged 19 minutes of MVPA per class session (Coe at al., 2006). Thus physical education must be supplemented by other interventions for children to achieve recommended levels of activity.

Youth sports have become increasingly popular in the United States, and many represent a source of appropriate physical activity volume for participants. Unfortunately, sport participation varies across socio-economic classes (SES). Children of high-SES families are more likely than their low-SES counterparts to participate in organized sports, and low-SES adolescents are more likely to spend time being sedentary (Fairclough, et al. 2009). The mechanism for the differential sport participation may be

the cost associated with organized sports; paying to play may not be a realistic option for low SES adolescents.

PAST PHYSICAL ACTIVITY INTERVENTIONS

Based on the declining rate of physical activity and PE participation among adolescents, interventions were designed to target physical activity during the school day. This is a logical design, as children spend the majority of their waking hours in a school environment. Past interventions have included a variety of protocols designed to increase physical activity (primarily MVPA) during school hours. Metcalf et al. (2012) conducted a meta-analysis on the effectiveness of physical activity interventions among children and adolescents and determined that the effects these interventions were "small to negligible" on total physical activity volume. Dobbins et al. (2013) further supported these findings; at best, school-based PA interventions may have a small to moderate impact on the amount of MVPA accumulated.

The limited effectiveness of physical activity interventions may be caused by a number of factors. First, schools often identify competing interests as a barrier to physical activity (Slater et al., 2012). In the American education system, there is currently great pressure on schools and educators to provide as much curriculum time as possible to students to ensure adequate performance on standardized tests. Given this, it may make more sense to tailor physical activity interventions to after-school hours. Such interventions have been found to have a moderate effect size on physical activity volume and fitness (Heath et al., 2012, Beets et al., 2009).

The second limitation of many physical activity interventions is a practical one: resource intensive protocols limit their real-world applicability. For example, a large-scale school-based physical activity intervention (n = 2840) included a protocol that

supplied sports equipment such as jump ropes, Frisbees, balls, etc. to participating schools. In addition, students used computer software tailored toward increasing knowledge about healthy behaviors (Haerens et al., 2007). This is just one example among many interventions that employ similar designs. Unfortunately, without the funding and equipment provided by the researchers, physical activity behaviors would not have been impacted. It is simply not scalable to provide these resources to every school or student who could benefit from a physical activity intervention.

A third limitation of past interventions is that a lack of uptake among participants may be to blame for the minimal or non-existent effects (Dobbins et al., 2013). It is possible that the mechanism to explain the lack of uptake can be found in a brief examination of barriers to physical activity among adolescents. Barriers to physical activity include anything that prevents an individual from engaging in the behavior. Support for (and barriers to) physical activity can be categorized into two underlying mechanisms: tangible, and intangible (Beets et al., 2010). Tangible barriers to physical activity include lack of financial and operational support for physical activity, including transportation to practice, and paying for participation. Intangible barriers include lack of motivational support and encouragement. For those students who experience either tangible or intangible barriers, physical activity behavior is likely undermined.

Intangible support for physical activity behavior is key to the development of self-efficacy. Self-efficacy is the perception an individual has towards achievement of their goals, (Bandura, 1977). Specific to physical activity and exercise, *physical activity self-efficacy (PASE)* is the perception of an individual's ability to carry out a specific physical activity task such as running for a prescribed amount of time. An individual with a higher self-efficacy towards physical activity has been demonstrated to be more apt to participate in physical activity for both acute and chronic engagement (Hagger et al.,

2002). Self-efficacy is especially important in the adolescent population because these individuals are approaching a time in their lives where their behavioral control is increasing. Previously, parents and teachers managed behavior, but as children age, they begin to have more intentionality over their actions (Bandura, 2006). The choice to engage in a behavior, such as physical activity, is dependent (in part) on their feelings of efficacy about the specific task. Self-efficacy is the product of several sources, which include individual performance, vicarious experience, and persuasion, among others (Schunk and Meece, 2006). One of the shortcomings of past physical activity interventions has been a failure to target self-efficacy (Beets et al. 2009).

Past physical activity interventions have been limited by their setting (school), scalability, and by their failure to target self-efficacy development. In the present research, we examined an existing after-school program that requires very little operational support, and naturally targets self-efficacy through its program design. The program guides participants through the process of training and completing either a half or full marathon within five months. The Marathon High program presents physical activity in an environment primed to encourage self-efficacy among its participants. Specifically, coaches model desirable physical activity behaviors, from which participants learn about success. This represents the vicarious experiences factor discussed above. Students then go on to participate in a graded exercise protocol that demonstrates (through manageable short-term goals) how to be successful in sticking to an exercise program. Short-term goal achievement helps to build positive personal experiences, which encourages sustained participation. Increased self-efficacy aids in the completion of the program, as well as in the development of long-term healthy habits regarding exercise.

CURRENT INTERVENTION AND HYPOTHESES

Marathon training is a unique physical activity intervention because unlike school-based or game centered approaches running does not require special equipment, support, or skill. Participation in marathon training is open to individuals of all fitness levels, though this program primarily attracts individuals who do not participate in any other organized sport or physical activity. Support for a running protocol for use with adolescents has been supported in previous literature, and it was demonstrated that participating in a similar program yields positive life-long behavior patterns (Tammelin et al., 2003). It is important to note that among all the previous research on physical activity patterns in adolescents, and corresponding interventions, none to our knowledge has examined the unique physical activity mode of marathon training.

The research presented here directly examines the aerobic fitness effects and psychological impacts of marathon training in adolescents. We hypothesized that participants who completed the Marathon High program would exhibit significant improvements in aerobic fitness, as measured through timed-mile runs. Additionally, we hypothesized that participation would yield positive psychological impacts on perceived stress level, exercise self-efficacy, and enjoyment of exercise.

Methods

PROGRAM

Marathon High is a free, afterschool exercise program directed at adolescents who would not otherwise engage in organized physical activity due to the barriers discussed previously. The organization is a not for profit entity, with private funding. Professional running coaches guide students through a five-month graded aerobic training protocol, with the ultimate goal of each student completing either a half or full marathon at the program's conclusion. At the outset of each program year (September), students are introduced to distance running through practices held three times per week. As the program progresses, the volume of exercise increases- up to 300 minutes of MVPA per week. In the first two years of the program, 67 students completed the half marathon, and 53 students finished the full marathon. The number of finishers shows that there is likely a fitness effect of participation, however such an effect has not previously been formally assessed.

Marathon High began as a way to teach children about healthy lifestyles and goal setting behavior through distance running. Over the initial two years of the program, the participants consistently communicated positive anecdotal experiences, but no objective measures were utilized to capture the program's impact. Thus, the current study was designed to quantify the fitness effects and psychological impacts of Marathon High.

Participants were recruited from five middle schools (two private, three public) and five high schools (one private, four public) in central Texas. The school districts included were 79.16% Hispanic, and 81.13% of students in those schools were economically disadvantaged. Because this research was an assessment of an existing

intervention, neither randomization of student nor school was possible. All ten participating schools had a Marathon High program, open to all students at their respective schools.

MEASURES

The Perceived Stress Scale was used to measure stress, and has a Cronbach's alpha reliability coefficient of .89 (Cohen et al., 1983, Roberti et al., 2006). The PSS is a ten-item measure that asks individuals to respond to statements using a five-point Likert-type scale anchored by 0 ("never") to 4 ("very often"). Items include statements such as "In the last month, how often have you felt nervous and stressed?" and "In the last month, how often have you been able to control irritations in your life?" among others. Reverse scoring is used on 4 of the ten items, and a summation score is calculated for each participant, ranging from 0 to 40, with a higher score indicating a greater degree of stress.

The Physical Activity Enjoyment Scale (PACES) was used to determine each individual's attitudes regarding physical activity (Cronbach's $\alpha = .906$) (Kendzierski and DeCarlo, 1991). Participants completed a series of 18-items in which they place ratings on a series of continuums of feelings about physical activity: e.g. "I like it", or "I hate it". The continuum is rated on a 7-point scale, 1 (I like it) to 7 (I hate it), with a 4 representing a neutral response between these anchors. This is repeated for the 17 remaining continuum anchors. This scale has been validated for use in an adolescent population (Dishman et al., 2005).

For the purposes of this study, we created the "Exercise Efficacy Scale" to attempt to understand the self-efficacy levels associated with different intervals of running. This ten-item scale asked participants to identify "How confident am I that I could run for *x* minutes?" where *x* represents a value from 10, 20, 30…100 minutes.

Responses ranged from 0-100%, in 10% increments. Scores were converted to a 1-10 scale, and an average efficacy score was computed for each subject, with a higher score indicating a higher degree of running self-efficacy. A reliability assessment indicated that this scale was highly reliable (Cronbach's α = .968).

The Youth-Life Orientation Test was used to measure each participant's optimism and pessimism about their life (Ey et al., 2005). This 19-item measure uses a four-point response scale with anchors ranging from 0 ("Not true for me") to 3 ("True for me"). This scale includes a global measure of optimism (Cronbach's α =.81) , as well as two subscales – optimism (Cronbach's α =.79) and pessimism (Cronbach's α = .78). Confirmatory factor analyses by Williams et al. (2010) indicated that this scale was appropriate across ages and ethnicities. This measure was included to assess whether or not Marathon High was meeting one of its espoused goals "[To] develop optimism both internally and externally".

To assess the aerobic fitness effects of participation in Marathon High, we utilized timed-mile data that was collected by coaches at each school. A pre-intervention mile time was collected at the earliest time point available. This varied between schools, though all were collected within the first four weeks of the program. Post-intervention mile times were recorded during the final two weeks of practice prior to the final race in February.

Attendance at practice was also recorded by coaches, and used to determine if any observed psychological or fitness effects were the result of attending practice sessions.

Cross-sectional comparisons on pre-program measures were conducted to determine if students who completed the program were different than those who dropped out.

PROCEDURES

Participants were administered the psychometric measures listed above in a pre-post format. Pre-testing occurred at the outset of the program (September), and again after the completion of program (March). Marathon High coaches recorded mile times at several points throughout the program, but for the purposes of this research, we utilized mile times from September/October (the beginning of the program) and February (the final week of practice before the half/full marathon). Coaches collected attendance data throughout the program and uploaded records to a central database for our use.

Results

DESCRIPTIVE STATISTICS

The final sample included 90 students, 55% of whom were female. The average age was 13.49 years (*SD = 1.64*). The number of valid cases for each measure varied, as some subjects did not complete all of the measures at both time points; *n*'s ranged between 29 and 54. Descriptive data are presented in table 1.1.

COMPARING PARTICIPANTS TO DROPOUTS

The collection of pre-test data allows for a comparison of those who completed the program to those who elected to drop out. Participants who dropped out rated their enjoyment of physical activity significantly higher than participants who completed the program (F=16.161, $p < .001$). Additionally, completers rated themselves as significantly more positive about their lives than those who dropped out (F=5.324, $p = .023$). Completers and dropouts did not differ in respect to their perceived stress levels, negative life orientation, or exercise efficacy.

PRE-POST COMPARISONS

Repeated-measures general linear models were used to calculate the pre-post differences for all outcome variables, both psychological and physical. Among the psychological variables examined, perceived stress level significantly decreased (n = 29, F= 6.779, $p = .015$, partial eta squared = .195) physical activity enjoyment significantly increased (n = 31, F = 39.383, p<. 001, partial eta squared .568), and exercise self-efficacy significantly increased, (n = 31, F=35.914, p < .001, partial eta squared .545), (Table 2).

No significant effect was found on participant optimism (n=34, F=2.377, p=. 13) or pessimism, (n=34, F= .067, p = .798).

Significant fitness effects were also found (n = 61, F =46.449, $p < .001$, partial eta squared = .436). 94% of participants experienced some degree of positive change in their demonstrated fitness, and on average participants experienced a 17% (SD = 16.71%) gain in aerobic fitness.

FACTORS ASSOCIATED WITH THE CHANGE IN FITNESS

Change in fitness was a significant predictor of post self-efficacy ($R^2 = .243$, p<. 001). When controlling for pre-self-efficacy scores, fitness change was nearly a significant predictor (p=. 061).

Discussion

CROSS-SECTIONAL ANALYSIS

It is clear that this study achieved its goal of reaching those students who are most at-risk for sedentary behavior. The Marathon High program was able to retain participants who rated themselves as having low-enjoyment of physical activity at the outset. Common logic suggests that if an individual does not enjoy an activity, they are likely to stop participating; however, that was not the case in our program. Dropouts rated their enjoyment of physical activity more highly than completers. It is possible that the individuals who dropped out did so to participate in another sport or physical activity opportunity, at the expense of Marathon High participation. Follow-ups were not possible with the population of dropouts, and therefore this requires further assessment.

A second minor difference between completers and dropouts was found in their ratings of optimism. Completers rated themselves as significantly more optimistic than their dropout counterparts. Research suggests that optimism in the face of difficult tasks is beneficial for persistence, and this difference in optimism may explain their continued participation (Graham and Williams, 2009). Regardless, these are relatively minor differences between groups.

FITNESS

Past physical activity intervention protocols have employed a variety of techniques to increase physical activity in hopes of impacting aerobic fitness (Ben Ounis, et al., 2010, Kaufmann et al, 2007, Lee et al. 2010). Among these, none to our knowledge examined the impacts of long-distance running on this outcome. In the current research, participants completed a graded-aerobic training protocol across five months, and we demonstrated a significant positive change in aerobic fitness as measured through timed-

mile data. This observed effect is especially important in the context of physical health. While even small doses of regular physical activity are enough to improve health (Haskell, et a., 2007) the positive health outcomes are maximized by an improvement in physical fitness (Millard-Stafford et al., 2013). Millard-Stafford's systematic review included 28 randomized control studies on physical activity interventions that included a measure of aerobic fitness as an outcome variable. Aerobic fitness was inversely related to triglyceride levels (indicative of CVD), insulin sensitivity (related to diabetes), and waist circumference. Increasing physical activity does not guarantee this change in fitness. A systematic review of children and teen physical activity interventions found that only 57% of interventions lead to a change in fitness (Kriemler, 2011).

Fitness norms for the adolescent population are available in the form of VO^2 max values from the National Health and Nutrition Examination Survey (NHANES) (Eisenmann, et al. 2011). By utilizing the timed-mile conversion formula created by Boiarskaia et al. (2011), we converted the mile times for 7 subjects, and compared their VO^2 estimations to the population norms. (Only seven subjects had all of the variables needed to calculate an estimation of VO^2 max). Marathon High participants began the program at around the 60^{th} percentile for VO^2 max, and upon completion of the program were reclassified into the 80^{th} to 90^{th} percentile. This demonstrates that our program targeted participants with an average level of fitness, not those who were already fit or very fit.

The large effect size found in the current study may be explained by the amount of physical activity amassed during the Marathon High practices. The program offers participants the opportunity to engage in physical activity amounts well beyond the recommended weekly value (150 minutes). Across the course of the program, the average time spent running is 150 minutes, with weekly values ranging from barely 20

minutes at the outset, to 300 minutes two weeks prior to the final race. On average, students attended 52% of practices (SD = 23%), however our attendance data does not account for the length of each practice, an important variable as one practice per week was significantly longer than the other two. Future iterations of this research should include a stronger objective measure of physical activity volume, such as accelerometry.

PSYCHOLOGICAL OUTCOMES

Stress

In line with past research (Sallis et al., 2002), physical activity participation was associated with a significant reduction in perceived stress levels. These results suggest that the stress-relieving benefits of physical activity need not be associated with great financial cost, if the mode of exercise is marathon training. This program, which requires very few resources, represents an activity that can be engaged in by any member of the adolescent population (barring physical or mental handicap). Interestingly, percentage of practice attended did not predict the change in PSS score. Given this, it is possible that the benefits of participating in group-exercise may not be directly related to the amount of physical activity amassed, as much as it is to social support provided by the group. No measures in the current study attempted to assess social support, but this is an interesting question for future research.

The ability to reduce perceived stress is an important feature of the current program because stress is linked to a variety of negative physical and mental health outcomes. Casement et al., (2013) demonstrated that stressful life events during adolescence are linked to early adulthood problematic use of alcohol, and animal models suggest that exposure to unpredictable life stress during adolescence is associated with increased anxiety. The relationship between adolescent stress and long-term health

outcomes suggests that the impact of Marathon High in this domain is especially important. The reduction in perceived stress may be related to the program's impact on self-efficacy.

Self-Efficacy

Marathon High participation leads to a significantly greater degree of exercise-related self-efficacy. The positive relationship between self-efficacy and physical activity has been previously identified (Shields et al. 2009, Sallis et al. 2000), and these results add to a growing body of literature on the topic. Adolescent self-efficacy for exercise predicts behavior for both acute and chronic bouts (Hagger et al., 2002), indicating that increasing self-efficacy can impact health throughout and beyond adolescence. Self-efficacy development in adolescence is not only important for health outcomes, but also for social functioning. Research on coping mechanisms and stress suggest that self-efficacy is an important resource for dealing with stressors in adolescence (Cicognani, 2011). High self-efficacy is related to the development of effective problem solving strategies, and setting higher goals (Locke and Latham, 2002). Effective problem solving skills are especially important to develop during adolescence, and increasing self-efficacy is one way to promote such behavior.

In 2013, 16,230 marathon finishers were under the age of 20 (RunningUSA Annual Marathon Report, 2014). This represents just .038% of the total US population ages 10 to 19 (U.S. Census Bureau, 2013). Clearly, the vast majority does not have personal experience with marathon running, and as such cannot rely on their past behaviors to build self-efficacy. An intervention must then target the other malleable sources of self-efficacy: vicarious experience, and persuasion. Dishman et al. (2009) demonstrated that the success of a physical activity intervention is partially mediated by

perceptions of self-efficacy. The authors argue that self-efficacy enhancement should be targeted through several different channels, and recommended "using approaches that [favor] small groups and cooperative and successful learning experiences." Furthermore, that the interventions should facilitate mastery experiences in a noncompetitive environment, with appropriate models for behavior. Marathon High meets both of these recommendations.

As this result demonstrates, self-efficacy is a factor that is modifiable, a concept that was previously reported in a paper by Sallis and colleagues (2000). Past research has found that self-efficacy partially mediates the success of physical activity interventions (Dishman et al., 2009, Lewis et al., 2002), and is therefore an important variable to include in physical activity intervention designs. Due to the limited sample, a mediation analysis was not possible, however self-efficacy may be a mediator for both reduced stress, and sustained physical activity behavior in the current intervention.

Enjoyment

Physical activity enjoyment was also significantly impacted across the course of the Marathon High program. Enjoyment of physical activity is important for sustained behavior; self-rated enjoyment of physical activity is a significant predictor of engaging in various types of physical activity (Salmon et al., 2003). The positive effect on physical activity enjoyment is unsurprising in the context of past research. Dishman et al. (2005) concluded that physical activity enjoyment was a partial mediator to the positive effects of an intervention on physical activity behaviors. Though a mediation analysis was not possible using the current data, the pattern of observed effects is consistent with existing literature.

THE MARATHON HIGH PROGRAM IN CONTEXT

The importance of these results may lay in the novelty of the exercise program. Physical activity interventions with the adolescent population have been plentiful, however their effects have been far from consistent. Many past interventions are founded on the recommendations catalogued in the CDC's "Guide to strategies to increase physical activity in the community (2011)". The school-based strategy suggests understanding competing interests within schools, and notes the common need for additional resources such as age-appropriate sporting equipment, teachers, and money. School-based interventions run the risk of interrupting valuable instruction time in the classroom, which may limit their impact on physical activity behavior. Additionally, physical activity interventions have traditionally been cumbersome to implement and sustain. The requirement of specialized staff and equipment is a limiting factor to adoption of long-term interventions for physical activity behavior change. Therein lies the importance of the Marathon High program. This intervention does not compete for instructional time, and does not require special equipment, or a particular physical environment (such as a field or court). Running groups can be supported with minimal resources and effort, and yet as the results demonstrate, may still have a profound impact physically and psychologically.

The Marathon High program is consequential not only because it can exist with minimal assistance, but also because the mode of physical activity can be reasonably sustained throughout adolescence and into adulthood. Physical activity modality and volume are not consistent across the lifespan. Children and teens tend to engage in more team sport-related activities, whereas adults accumulate physical activity through individual fitness activities such as weightlifting and running (Sports and Fitness Industry Association report, 2013). Unlike physical activity interventions that focus on sport-

specific skill development, or games, running is a physical activity that is more "adult-like".

This shift in exercise modality is an indicator of a transitional life period. Research exists on the impacts of life changes and transition periods on physical activity behavior, however, it is limited. These life changes have been operationalized as a job or school change, change in marital status, having children, and entering retirement (Hirvensalo and Lintunen, 2011), For the purposes of the current research, we have chosen to operationalize adolescence as a period of transition, as it is a period associated with a great number of physical, psychological and emotional changes. The reduction in physical activity associated with entering and progressing through adolescence may have significant lasting physical and psychological impacts, as it has been demonstrated that physical activity in adolescence is predictive of adult physical activity (Hirvensalo and Lintunen, 2011, Hallal et al., 2006). Consequently, the effects of decreased physical activity behavior during adolescence are two-fold. Firstly, individuals who do not meet the recommendations for physical activity during adolescence are not obtaining the positive health outcomes and risk-mitigating effects of physical activity during those years. Secondly, if behavior in adolescence is predictive of adult physical activity patterns, individuals who do not develop healthy physical activity habits in adolescence are not likely to reap the long-term benefits.

Timing of the intervention is key. Adolescence represents a transitional period where both short-term and long-term health outcomes may be impacted, and therefore interventions that target this population are extremely important. Mental health in adolescence and throughout adulthood tends to be relatively stable (Schulenburg and Zarrett, 2006), which implies that individuals who are experiencing difficulties in adolescence are likely to continue those throughout adulthood. Interventions that can

address mental health outcomes, such as stress levels and self-efficacy have the potential to impact participants across their lifespan.

LIMITATIONS AND FUTURE DIRECTIONS

The results presented here demonstrate that further analysis of this program is warranted. The sample size limited the scope of this assessment. Specifically, a larger sample would be valuable to understand the role of mediators, such as self-efficacy, on program success, as well as the impact of potential covariates such as age, past participation, and gender.

The current research is an analysis of an existing physical activity program, and therefore is limited by a lack of randomization. This could mean that the individuals who chose to participate in Marathon High are fundamentally different from individuals who may have chosen a different after-school activity, such as a team sport or an academic club. We were unable to access an appropriate control group, thus future assessments should include a non-Marathon High group, to understand the true magnitude of effects. There are three suggested comparison groups – first, students who are enrolled in a school-based physical activity program, secondly, students who participate in school-sponsored athletics, and finally, a group enrolled in an after school activity that is not physical activity focused.

Future research on the Marathon High participants, (and appropriate comparison groups), should also include an objective measure of physical activity volume. Although we can infer from the positive fitness effects we observed, we cannot unequivocally state that the Marathon High participants amassed the recommended amount of physical activity per practice. This is a clear limitation, and should be addressed in the future.

A longitudinal research model would be helpful in assessing the program's impact beyond the 5-month intervention period. Of particular interest would be participants running and physical activity behaviors, and whether or not those were impacted by Marathon High participation. Furthermore, it would be interesting to examine if stress and self-efficacy gains were sustained beyond the program's period.

There are several variables of interest that were not included in the current study. The relationship between physical activity and academic performance is an area that holds great potential for future research. Also not addressed were measures of cognitive function. Past research on both academic performance and cognitive function in relation to physical activity has shown that there may be measureable positive impacts of adolescent exercise participation on cognition (Chaddock, 2012). An assessment of Marathon High's ability to impact these constructs is warranted.

In popular media, (e.g., Runner's World Magazine, The Atlantic) there has been some discussion about the appropriateness of distance running for children and adolescents, however the issue has not been empirically examined. While there were few reported injuries during the Marathon High program, we did not conduct a formal assessment of this topic. Future research on marathon training for adolescents should assess physiological changes associated with this protocol, to ensure injuries are not sustained.

Despite these limitations, there are clear strengths. The program's exercise volume and modality are unique. To our knowledge, no past interventions have examined marathon training as a mode of exercise for adolescents nor has any past intervention provided the volume of physical activity equivalent to Marathon High. Marathon training represents a novel physical activity intervention with significant impacts on aerobic fitness and psychological factors. The magnitude of the effect sizes, despite the

limited sample, shows that Marathon High is a valid physical activity program with substantial impacts on adolescent physical and mental health.

Conclusion

The Marathon High program represents a viable physical activity intervention model that requires few resources, yet has significant impacts on participant stress levels, physical activity enjoyment, self-efficacy and aerobic fitness. The encouraging results presented here justify further research on physical activity programs that focus on marathon training. Future analysis of this program should involve randomization and comparison groups, as well as an objective measure of physical activity volume.

Table 1: Sample descriptive statistics

Age	**Female**	**Male**	**Total**
Unknown	6	4	10
9	0	1	1
11	8	5	13
12	11	7	18
13	12	15	27
14	6	4	10
15	2	0	2
16	1	3	4
17	4	1	5
Total	**50**	**40**	**90**

Table 2: Repeated measures statistics

Measure	**Pre Value**	Pre SD	**Post Value**	Post SD	**p-value**
Timed-Mile	11.012	2.142	8.202	3.391	$p < .001$
Perceived Stress Score	19.655	5.115	17.31	6.059	$p = .015$
Physical Activity Enjoyment Scale	69.581	34.385	108.097	14.693	$p < .001$
Exercise Self-Efficacy	4.675	2.458	7.565	2.25	$p < .001$

References

Autenrieth, C. S., Baumert, J., Baumeister, S. E., Fischer, B., Peters, A., Döring, A., & Thorand, B. (2011). Association between domains of physical activity and all-cause, cardiovascular and cancer mortality. *European journal of epidemiology*, *26*(2), 91-99.

Avenevoli, S., Swendsen, J., He, J. P., Burstein, M., & Merikangas, K. R. (2015). Major Depression in the National Comorbidity Survey–Adolescent Supplement: Prevalence, Correlates, and Treatment. *Journal of the American Academy of Child & Adolescent Psychiatry*, *54*(1), 37-44.

Bandura, A. (2006). Adolescent development from an agentic perspective. *Self-efficacy beliefs of adolescents*, *5*(1-43).

Beets, M. W., Beighle, A., Erwin, H. E., & Huberty, J. L. (2009). After-school program impact on physical activity and fitness: a meta-analysis. *American journal of preventive medicine*, *36*(6), 527-537.

Beets, M. W., Cardinal, B. J., & Alderman, B. L. (2010). Parental social support and the physical activity–related behaviors of youth: a review. *Health Education & Behavior*.

Ben Ounis, O., Elloumi, M., Makni, E., Zouhal, H., Amri, M., Tabka, Z., & Lac, G. (2010). Exercise improves the ApoB/ ApoA-I ratio, a marker of the metabolic syndrome in obese children. *Acta Paediatrica (Oslo, Norway), 99,* 1679–1685.

Biddle, S. J., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British journal of sports medicine*, bjsports90185.

Casement, M. D., Shaw, D. S., Sitnick, S. L., Musselman, S. C., & Forbes, E. E. (2014). Life stress in adolescence predicts early adult reward-related brain function and alcohol dependence. *Social cognitive and affective neuroscience*, nsu061.

Centers for Disease Control and Prevention (CDC). (2011). Strategies to prevent obesity and other chronic diseases: The CDC guide to strategies to increase physical activity in the community. *Atlanta: US Department of Health and Human Services*.

Centers for Disease Control and Prevention (CDC). (2014). Adolescent and School Health: Childhood obesity facts. Retrieved from http://www.cdc.gov/healthyyouth/obesity/facts.htm.

Centers for Disease Control and Prevention (CDC). (2014). Adolescent and school health: Physical activity facts. Retrieved from http://www.cdc.gov/healthyyouth/physicalactivity/facts.htm

Chaddock, L., Hillman, C. H., Pontifex, M. B., Johnson, C. R., Raine, L. B., & Kramer, A. F. (2012). Childhood aerobic fitness predicts cognitive performance one year later. *Journal of Sports Sciences*, *30*(5), 421-430.

Cicognani, E. (2011). Coping strategies with minor stressors in adolescence: relationships with social support, self-efficacy, and psychological well-being. *Journal of Applied Social Psychology*, *41*(3), 559-578.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. Journal of health and social behavior, 385-396.

Coe, D. P., Pivarnik, J. M., Womack, C. J., Reeves, M. J., & Malina, R. M. (2006). Effect of physical education and activity levels on academic achievement in children. *Medicine and science in sports and exercise*, *38*(8), 1515.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., & Pate, R. R. (2005). Enjoyment mediates effects of a school-based physical-activity intervention. *Medicine and science in sports and exercise*, *37*(3), 478-487.

Dishman, R. K., Saunders, R. P., Motl, R. W., Dowda, M., & Pate, R. R. (2009). Self-efficacy moderates the relation between declines in physical activity and perceived social support in high school girls. *Journal of Pediatric Psychology*, *34*(4), 441-451.

Dobbins, M., DeCorby, K., Robeson, P., Husson, H., & Tirilis, D. (2009). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. *The Cochrane Library*.

Duda, J. L., Ehrnwald, P. M., & Tappe, M. K. (1989). Perceived barriers to exercise among adolescents. Journal of School Health, 59(4), 153

Ey, S., Hadley, W., Allen, D. N., Palmer, S., Klosky, J., Deptula, D., ... & Cohen, R. (2005). A new measure of children's optimism and pessimism: The youth life orientation test. Journal of Child Psychology and Psychiatry, 46(5), 548-558.

Fairclough, S. J., Boddy, L. M., Hackett, A. F., & Stratton, G. (2009). Associations between children's socioeconomic status, weight status, and sex, with screen-based sedentary behaviours and sport participation. International journal of pediatric obesity, 4(4), 299-305.

Fitzgibbon, M. L., Stolley, M. R., Schiffer, L., Horn, L., KauferChristoffel, K., & Dyer, A. (2006). HipHop to Health Jr. for Latino Preschool Children. *Obesity*, *14*(9), 1616-1625.

Graham, S., & Williams, C. (2009). An attributional approach to motivation in school. *Handbook of motivation at school*, 11-34.

Gordon-Larsen, P., McMurray, R. G., & Popkin, B. M. (1999). Adolescent physical activity and inactivity vary by ethnicity: The National Longitudinal Study of Adolescent Health. *The Journal of pediatrics*, *135*(3), 301-306.

Haerens, L., De Bourdeaudhuij, I., Maes, L., Cardon, G., & Deforche, B. (2007). School-based randomized controlled trial of a physical activity intervention among adolescents. *Journal of Adolescent Health*, *40*(3), 258-265.

Hagger, M. S., Chatzisarantis, N. L., & Biddle, S. J. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity:

Predictive validity and the contribution of additional variables. Journal of sport & exercise psychology.

Hallal, P. C., Victora, C. G., Azevedo, M. R., & Wells, J. C. (2006). Adolescent physical activity and health. *Sports Medicine*, *36*(12), 1019-1030.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., ... & Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*, *116*(9), 1081.

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., ... & Lancet Physical Activity Series Working Group. (2012). Evidence-based intervention in physical activity: lessons from around the world. *The lancet*, *380*(9838), 272-281.

Hirvensalo, M., & Lintunen, T. (2011). Life-course perspective for physical activity and sports participation. *European Review of Aging and Physical Activity*, *8*(1), 13-22.

Jago, R., Baranowski, T., Baranowski, J. C., Thompson, D., Cullen, K. W., Watson, K., & Liu, Y. (2006). Fit for Life Boy Scout badge: outcome evaluation of a troop and Internet intervention. *Preventive medicine*, *42*(3), 181-187.

Janz, N. K., & Becker, M. H. (1984). The health belief model: A decade later. *Health Education & Behavior*, *11*(1), 1-47.

Jonsdottir, I. H., Rödjer, L., Hadzibajramovic, E., Börjesson, M., & Ahlborg, G. (2010). A prospective study of leisure-time physical activity and mental health in Swedish health care workers and social insurance officers. *Preventive medicine*, *51*(5), 373-377.

Kaufman, C., Kelly, A.S., Kaiser, D.R., Steinberger, J., & Dengel, D.R. (2007). Aerobic-exercise training improves ventilatory efficiency in overweight children. *Pediatric Exercise Science, 19,* 82–92.

Kendzierski, D., & DeCarlo, K. J. (1991). Physical Activity Enjoyment Scale: Two validation studies. *Journal of Sport & Exercise Psychology*.

Koplan, J. P., & Dietz, W. H. (1999). Caloric imbalance and public health policy. *Jama*, *282*(16), 1579-1581.

Kriemler, S., Meyer, U., Martin, E., Van Sluijs, E. M. F., Andersen, L. B., & Martin, B. W. (2011). Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *British journal of sports medicine*, *45*(11), 923-930.

Lakka, T. A., Laaksonen, D. E., Lakka, H. M., Männikkö, N., Niskanen, L. K., Rauramaa, R., & Salonen, J. T. (2003). Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. *Medicine & Science in Sports & Exercise*, (35), 1279-86.

Lee, K., Shin, Y., Jun, T., & Song, W. (2010). Aerobic exercise training-induced decrease in plasma visfatin and insulin resistance in obese female adolescents. *International Journal of Sport Nutrition and Exercise Metabolism, 20,* 275–281.

Lewis, B. A., Marcus, B. H., Pate, R. R., & Dunn, A. L. (2002). Psychosocial mediators of physical activity behavior among adults and children. *American journal of preventive medicine*, *23*(2), 26-35.

Lupien, S. J., Fiocco, A., Wan, N., Maheu, F., Lord, C., Schramek, T., & Tu, M. T. (2005). Stress hormones and human memory function across the lifespan. *Psychoneuroendocrinology*, *30*(3), 225-242.

Metcalf, B., Henley, W., & Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *BMJ: British Medical Journal*, *345*.

Merikangas, K. R., He, J. P., Burstein, M., Swanson, S. A., Avenevoli, S., Cui, L., ... & Swendsen, J. (2010). Lifetime prevalence of mental disorders in US adolescents: results from the National Comorbidity Survey Replication–Adolescent

Supplement (NCS-A). *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*(10), 980-989.

Millard-Stafford, M., Becasen, J. S., Beets, M. W., Nihiser, A. J., Lee, S. M., & Fulton, J. E. (2013). Is Physical Fitness Associated With Health in Overweight and Obese Youth? A Systematic Review. *Kines Rev*, *2*, 233-247.

Netz, Y., Wu, M. J., Becker, B. J., & Tenenbaum, G. (2005). Physical activity and psychological well-being in advanced age: a meta-analysis of intervention studies. *Psychology and aging*, *20*(2), 272.

Norris, R., Carroll, D., & Cochrane, R. (1992). The effects of physical activity and exercise training on psychological stress and well-being in an adolescent population. *Journal of psychosomatic research*, *36*(1), 55-65.

Roberti, J. W., Harrington, L. N., & Storch, E. A. (2006). Further psychometric support for the 10-item version of the perceived stress scale. *Journal of College Counseling*, *9*(2), 135-147.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and science in sports and exercise*, *32*(5), 963-975.

Salmon, P. (2001). Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. *Clinical psychology review*, *21*(1), 33-61.

Salmon, J., Owen, N., Crawford, D., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behavior: a population-based study of barriers, enjoyment, and preference. *Health psychology*, *22*(2), 178.

Schunk, D. H., & Meece, J. L. (2006). Self-efficacy development in adolescence. *Self-efficacy beliefs of adolescents*, *5*, 71-96.

Shields, C., Spink, K., Chad, K., Muhajarine, N., Humbert, L., & Odnokon, P. (2009). Examining self-efficacy as a mediator of the relationships between family social influence and physical activity. *J Health Psychol*, *13*, 121-30.

Schulenberg, J. E., & Zarrett, N. R. (2006). Mental Health During Emerging Adulthood: Continuity and Discontinuity in Courses, Causes, and Functions.

Slater, S. J., Nicholson, L., Chriqui, J., Turner, L., & Chaloupka, F. (2012). The impact of state laws and district policies on physical education and recess practices in a nationally representative sample of US public elementary schools. *Archives of pediatrics & adolescent medicine*, *166*(4), 311-316.

Sports and Fitness Industry Association. *2013 Sports, Fitness and Leisure Activities Topline Participation Report*. Accessed from : https://www.sfia.org/reports/all/

Tammelin, T., Näyhä, S., Hills, A. P., & Järvelin, M. R. (2003). Adolescent participation in sports and adult physical activity. *American journal of preventive medicine*, *24*(1), 22-28.

Toftager, M., Christiansen, L. B., Ersbøll, A. K., Kristensen, P. L., Due, P., & Troelsen, J. (2014). Intervention Effects on Adolescent Physical Activity in the Multicomponent SPACE Study: A Cluster Randomized Controlled Trial. *PloS one*, *9*(6), e99369.

United States Census Bureau. *Population Estimates: Vintage 2013*. Accessed from: http://www.census.gov/popest/data/national/asrh/2013/index.html

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: the evidence. *Canadian medical association journal*, *174*(6), 801-809.

Williams, N. A., Davis, G., Hancock, M., & Phipps, S. (2010). Optimism and pessimism in children with cancer and healthy children: confirmatory factor analysis of the youth life orientation test and relations with health-related quality of life. *Journal of pediatric psychology*, *35*(6), 672-682.