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ORIGINAL RESEARCH

Process evaluation and proximal impact of an affect-based exercise intervention among adolescents

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ABSTRACT

The objective of this study was to evaluate the implementation and proximal impact of an intervention designed to enhance adolescents' affective experience during Physical Education (PE). Healthy adolescents (N=74) were randomly assigned to an affect-based or a traditional exercise prescription. Intervention logs, observations and interviews documented the implementation of the intervention. Participants completed a 30-min exercise task at an intensity that felt "good" to them before and after the intervention. Study procedures were implemented successfully and students enjoyed study participation. The intervention had no impact on exercise intensity during PE or during the "feels-good" exercise task. Among adolescents who manifested a negative affective response to moderate-intensity exercise at baseline, the selected intensity during the "feels-good" task increased over time. The intervention may have been too weak to impact behavior over and above a high-quality PE program. The results do suggest, however, that reluctant exercisers may choose to exercise at a higher intensity after experiencing a high-quality PE program in combination with heart rate monitoring.

KEYWORDS

Physical activity, Physical education, Pediatrics

Implications

Researchers: Effective methods for enhancing adolescents' affective associations with exercise should be developed.

Practitioners: Physical Education programs should encourage students to be active without over-emphasizing high-intensity activity, which may be aversive to those most at risk for a sedentary lifestyle.

Policymakers: School policy should reflect the knowledge that a higher return on investment is likely to be realized from adequately training and equipping PE instructors, rather than providing tailored heart rate prescriptions to students.

INTRODUCTION

By virtually all metrics (self-report, ambulatory monitoring, observation), most adolescents in the United States do not achieve levels of physical activity (PA) sufficient for optimal health and well-being [1–4]. The debilitating adverse health effects of long-term physical inactivity include chronic conditions such as obesity, type 2 diabetes, and cardiovascular disease [5, 6]. It is also worrisome that rates of PA participation have not increased any meaningful amount despite growing recognition of the problem and attempts to promote greater levels of activity [7]. New approaches are needed.

Recent theoretical and empirical work has diverged from a period of predominantly cognitive-based approaches to a more complex model of physical activity participation incorporating non-cognitive factors. After a considerable period of time during which most research in this area was restricted primarily to testing alternative social-cognitive models of exercise behavior, an appreciation for the role of affect has emerged. As thoroughly documented by Ekkekakis and Dafermos [8], this apparent shift in the field is actually a re-emergence of a theme present throughout philosophical and psychosocial writings for many hundreds of years, going back as far as the time of Plato, and including numerous well-known names such as Thomas Hobbes, Henry James, and Sigmund Freud. All of these historical figures affirmed the dominance of hedonism as a primary motivator of behavior. Stated most simply, individuals typically seek to repeat behaviors that bring about pleasant sensations and to avoid behaviors that bring about unpleasant sensations.

Applied to physical activity, a hedonistic understanding of behavior suggests that individuals who engage in bouts of exercise that they find enjoyable will be more likely to adopt and maintain an active lifestyle as compared to individuals who engage in bouts of exercise that they find aversive. Support for this hypothesis comes from studies correlating individuals' affective responses to exercise with their volitional activity levels. The affective response to a standardized exercise task has been found to be positively associated with adolescents' free-living PA [9], and with adults' change in PA in

response to an intervention [10]. In both of these studies, the assumption was that the affective response to a standardized exercise task would reflect some underlying predisposition toward enjoying PA. Those persons predisposed to enjoying activity would, therefore, choose to engage in greater amounts of activity and would respond more positively to a program designed to encourage increased activity.

Several studies do support the contention that individuals differ in their affective response to a standard exercise task [11–14]; yet, characteristics of the exercise task itself also partially determine the affective response. Most notable among the various characteristics of the task that may influence the affective response is the intensity of the exercise. Considerable evidence now exists demonstrating that high-intensity exercise (exercise that is of an intensity that threatens homeostasis and is difficult to maintain for any length of time) almost universally generates a negative affective response [11]. In contrast, exercise that is within the range of what is often called "moderate-intensity" appears to afford the opportunity for positive affective responses among some and negative affective responses among others [15, 16].

Several processes have been put forth as explanations for individual variability in the affective response to moderate-intensity activity. Some of this variability may be owing to varying levels of fitness among individuals. The same task may be experienced as considerably more challenging by a sedentary or obese person as compared to a regular exercise or person of normal weight [17]. An additional component of the variability in affective response may be the result of differing cognitive interpretations of the task; what one person interprets as an invigorating challenge another may perceive as a demoralizing test [18]. Research on the association of personality with exercise participation further suggests that some portion of the variability in the affective response to exercise may be a function of "affective style"[19, 20]; that is, persons with a more "approach-oriented" affective style may be more likely to perceive moderate-intensity exercise as pleasurable.

Personality refers to an enduring and consistent pattern of thoughts, feelings, and actions. A meta-analysis of research examining the association between personality and physical activity [21] found that the dimension of personality most consistently associated with physical activity was extraversion (i.e., the tendency to be sociable, assertive, to seek excitement, and to experience positive affect). Carver et al. [22] posit that extraversion reflects the "approach" component of a dual model of personality that bisects motivation and behavior into two types of action tendencies: approach and avoidance (or withdrawal). Evidence from studies employing both self-report and brain activity (electroencephalography) data provide support for the existence of an affective style that shapes individuals' affective response to stimuli [23, 24]. Consistent with this theory, adolescents who scored higher on a scale assessing sensitivity to cues of reward responded to a moderate-intensity exercise task with enhanced positive affect [20]. This body of research suggests that affective style is a dimension of personality that should be taken into account in structuring an affect-based intervention to promote physical activity.

In an attempt to tap into individuals' abilities to find an intensity of exercise that is commensurate with their own physiological and psychological "comfort zones," a series of studies among adults allowed study participants to find an exercise intensity that felt "good" to them. Critically, these studies have demonstrated that when instructed to exercise at a level that feels "good" healthy adults, both sedentary and fit, will usually gravitate toward an intensity that is within the range that exercise physiologists consider beneficial for health [12, 25]. Specifically, women instructed to select their own work rate chose to exercise at an intensity that was approximately 64 % of estimated heart rate maximum (sedentary females; [26]) to 81 % of measured heart rate maximum (active females; [12]). Equally importantly, sedentary men and women who engaged in an intervention study for 8 weeks, during which they exercised regularly at a level that felt "good" to them, showed improvements in cardiorespiratory fitness, body mass index, and cholesterol as compared to a randomized control group [27]. However, a separate study of 20 sedentary females found that these women self-selected intensities that were of insufficient magnitude to bring about improvements in traditional measures of fitness across an 8-week intervention [25].

The difference in findings may be a function of a discrepancy in the instructions given to the study participants. Whereas in the study that found a significant impact of the intervention adults were instructed to calibrate their exercise to a Rating of Perceived Exertion of 13 ("somewhat hard" on the Borg scale), the study that found no impact was structured so that participants selected a level of exertion that felt "good." In both studies, participants reported that they did indeed feel "good" while exercising, but in the second study women worked on average at 50 % of their maximal heart rate, as compared to the men and women in the first study, who worked at over 60 % of maximal heart rate. Together, these studies suggest both that individuals may report feeling "good" when instructed to maintain a given intensity of exertion and also that sedentary adults instructed to be active at a level that feels "good" may not exert themselves sufficiently to improve fitness.

The rationale behind exploring the impact of interventions during which participants self-select the level of intensity is that by repeatedly exposing the individual to exercise experiences that feel

"good" motivation to continue exercising will be enhanced. Applying this rationale to work with children and adolescents is of critical importance, given the high potential for both short-term and long-term health benefits. If, by repeated exposure to exercise that feels good, today's youth were to remain active and transform into active adults, the impact on their future well-being and on public health could be enormous. The proposition that students who develop a positive affective association with PA within the physical education context will subsequently translate these experiences into an active lifestyle outside school has been repeatedly advanced [28] but inadequately tested [29].

On the basis of these theories and findings, it has been recommended that PA interventions should be tailored to promote a positive affective experience among participants [14], and that doing so would promote better adoption of and adherence to a physically active lifestyle [11]. Translating these recommendations to a school environment requires adapting to the usual modes of physical education instruction. Physical education programs commonly employ Target Heart Rate Zones to guide exercise intensity. The Target Heart Rate Zone (typically 60 % to 80 % of estimated maximal HR) is likely to be above the ventilatory threshold; the intensity threshold that typically corresponds to the point that exercise may become aversive among those sensitive to the negative sensations that accompany hard exercise[11]. This emphasis on working at an intensity that is expected to increase cardiovascular fitness fails to take into account the fundamental tenet that a moderately active lifestyle confers significant health benefits over a sedentary lifestyle [30]. If by pushing individuals to exercise at an intensity that is unpleasant for them we generate an aversion to PA, then we have failed in our mission to create a more active population. This paper reports on the implementation and proximal impact of an affect-based exercise intervention within a middle-school physical education setting.

To date, the body of research in which individuals have been encouraged to exercise at an intensity that "feels good" as a means of promoting increased physical activity and fitness has employed methods that can best be described as laboratory-based; using closely supervised exercise sessions among small samples of participants. To advance the knowledge thus gained toward being applied in a community setting, where population-level outcomes may be observed, it is necessary to move these interventions out of the laboratory. As described by Blumberg et al. [31], the later phases of the translational research continuum (T3/T4) represent the translation of new data acquired through controlled clinical studies into practice in the community. This study represents the translation of laboratory-based studies on the associations between exercise intensity, exercise-associated affect, and physical activity participation into an investigation of a community-based intervention with the potential to impact large numbers of adolescents.

METHODS

Procedures

This study was conducted during the 2011–2012 and 2012–213 school years within a public middle school in an ethnically diverse community in Southern California. Recruitment and assessments took place on campus. An empty classroom was provided to the study to use as a clinical laboratory, and study staff maintained a daily presence at the school. Students were released from Physical Education (PE) classes to complete the assessments. The protocol was reviewed and approved both by the Institutional Review Board of the University of California, Irvine and by the Research Review Committee of the school district. Study participants provided written assent for participation, and a parent or guardian provided written consent.

Recruitment–Flyers were sent home to families of all 6th-grade students, and announcements were made in PE classes. Participants had to meet the following criteria: (a) able to participate in regular physical activity without restriction; (b) not currently participating in a team or individual competitive sport; (c) not left handed; (d) not depressed; and (e) free from a history of head trauma. The last three criteria were related to the inclusion in the study protocol of a resting electroencephalogram (EEG) assessment, which was conducted as part of a study aim not addressed in this report.

Assessment schedule–Each participant visited the classroom/lab for four separate visits in the fall, separated by at least 1 week: (1) cardiorespiratory fitness test to determine peak oxygen consumption (peak VO_2); (2) resting EEG and behavioral questionnaires; (3) moderate-intensity exercise task; and (4) exercise task at an intensity that was self-selected to feel "good." The feels-good task was also repeated after the intervention had been completed. Each participant also wore an Actigraph activity monitor (model GT3X, ActiGraph, Pensacola, Florida) for 7 days in between visits (1) and (2). A $25 gift card was provided to the participant upon the successful completion of each assessment. As only the exercise tasks are relevant to the present report, details of the procedures for the EEG are not presented below.

Cardiorespiratory fitness–Participants performed a ramp-type progressive cycle-ergometer exercise test [32]. Breath-to-breath measurement of gas exchange (ventilation, oxygen uptake, and carbon dioxide output) was viewed online and analyzed using a Sensor Medics® metabolic system (Yorba Linda, CA) to determine peak VO_2. Participants were verbally encouraged to exercise until their limit of tolerance was reached, and the test was concluded when the participant voluntarily stopped pedaling the stationary cycle.

Moderate-intensity exercise task–Using the results of the cardiorespiratory fitness test, each participant completed a 30-min exercise session on a stationary cycle at a work rate equivalent to the work rate at 50 % of the work rate achieved at the end of the fitness test. Participants were instructed to maintain a cadence of between 60 and 70 RPM throughout the task. If the participant exhibited signs of fatigue, either by reducing RPM below 60 for at least 1 min or by having an elevated heart rate (above 170 beats per minute) for at least 1 min, then work rate was reduced by 10 W. Every 3 min, a research assistant recorded heart rate (using the Polar heart rate monitor) and elicited self-ratings of perceived exertion (RPE) and affect (Feeling Scale; FS) from the participant. Using the FS data from this task, participants were classified into one of two affective style categories: reluctant exercisers were those who evidenced a pattern of declining affect throughout the task; latent exerciser were those who demonstrated a pattern of improving affect throughout the task. This procedure replicated that used in earlier research yielding evidence that adolescent latent exercisers engaged in greater amounts of free-living physical activity as compared to reluctant exercisers [9] and scored higher on a pencil-and-paper assessment of approach-oriented motivation (i.e., Behavioral Activation) [16].

"Feels-good" exercise task–To determine an exercise-intensity range associated with positive affect, students completed a 30-min exercise task on a stationary cycle, during which they were given an opportunity to adjust the resistance (i.e., work rate in Watts) every 3 min in increments of 10 W. The initial work rate was calibrated to 20 % of the participant's VO_2peak. Throughout the 30-min exercise task, heart rate and self-reported ratings of perceived exertion (RPE) and affect (FS) were recorded every 3 min.

Prior to commencing, participants were given the following instructions[1]:

> "Today you are going to be asked to pedal the bike for 30 min at 60–80 RPM. Every 3 min we are going to show you a scale, and ask you to tell us how hard you think you are working. Right after that we are going to show you another scale, and ask you to tell us how you are feeling at that moment. Then we will ask you if you want to keep the resistance where it is or if you want to change it by increasing it or decreasing it. We will ask you these questions every 3 min until your 30 min are over.
> The goal of this task is for you to exercise at a level that feels good to you. We want you to find a level that feels good to you, so if you need to increase or decrease the resistance to stay feeling good just let us know, okay? We want to know how you are really feeling, so please be honest and tell us the number that truly reflects how you feel. Do you have any questions?"

Randomization–Using a computer program that assigns subjects to stratified groups, students were randomly assigned to one of two interventions after all baseline assessments had been completed. Assignment was stratified by gender, body composition (body mass index above or below the 85th percentile), and affective style (latent versus reluctant exercisers).

Determination of target heart rate zone–Participants were randomly assigned to receive a prescribed heart rate zone that was computed either using the traditional approach (based on maximum heart rate reached at VO_2peak) or an alternative approach (using the data obtained through the feels-good exercise task; affect-based). The upper boundary of the target heart rate range for the affect-based prescription was equivalent to the maximum heart rate achieved during the feels-good exercise task plus ten beats per minute.[2] The upper boundary of the traditional prescription was set at 80 % of the maximum heart rate achieved during the cardiorespiratory fitness test. In both conditions, the lower boundary was 20 beats per minute below the upper boundary.

Intervention–The translation of an affect-based approach to PA to the middle school environment must take into account the characteristics of the setting. Unlike a clinical research setting, in which study participants may be individually monitored within a structured environment to ensure that they are actively engaged in the intervention, implementing an affect-based intervention in the public school PE setting requires a modified approach. In this setting, the student participants are not the only stakeholders; PE teachers also must endorse the intervention for it to have any chance of success. Work within the school setting and discussions with PE teachers clearly indicated that instructing students to exercise in PE at a level that felt "good" offered far too little structure for the teachers to support the intervention. Moreover, PE teachers are accustomed to employing heart rate as a measure of how hard students are working, and so are naturally predisposed to endorse using heart rate as a

[1] Originally, we intended to use a procedure analogous to that used by Rose and Parfitt [26], who instructed adults to exercise at an intensity equivalent to a "3" on the Feeling Scale. Pilot testing revealed that if we used this instruction then adolescents would consistently report a Feeling Scale rating of "3" during the task without variation. We therefore modified the instructions to ask adolescents to exercise at a level that felt "good".

[2] We added the buffer of 10 beats above the maximum achieved during the feels-good task because early experience with the intervention revealed that some students were exceeding their maximum simply by walking from the changing room to the field.

measure of exertion. Accordingly, the approach taken in this study was to use an exercise task completed in a clinic setting to determine the heart rate range that felt "good" to each study participant. The results of this procedure were then used to assign a target heart rate zone that encompassed this range.

The intervention was implemented during the winter semester. Each student received a SmartHealth heart rate monitor/watch (model 22023, Salutron, Fremont, California) that was pre-programmed according to the target heart rate determined for that student. The SmartHealth watch has been validated against the Polar Heart Rate monitor and ECG, and found to correlate very highly with both ($r \geq .95$) [33]. The watch displays heart rate and a prompt indicating whether the wearer is "in," "hi," or "lo" relative to their personal target heart rate zone. Watches were handed out daily to students at the beginning of the PE period, and returned at the end of each period. Students were instructed to check their heart rate at will, and were encouraged to stay within their assigned heart rate zone. PE teachers were asked to remind students to check their heart rate twice during each class and to encourage students to adjust their exercise intensity level if needed to remain within their zone.

It should be noted that the intervention was overlaid on a state-of-the-art PE program, taught by certified PE instructors who used a combination of innovative strategies to motivate students to be active during class time. Moreover, to maximize the likelihood that all of the PE teachers collaborating with the study would provide a class experience that was similar, teachers were provided with training in effective class management and strategies for keeping students active. Training consisted of one 4-h workshop at the beginning of the school year followed by 2–3 observations and personalized feedback. The workshops and feedback were provided by a Master PE teacher with over 30 years of experience in middle school PE teaching and training. Finally, the PE department was provided with a $3,000 budget each study year to purchase equipment in support of the PE activities, thus minimizing the common barrier of inadequate equipment to support all students being active simultaneously.

Process evaluation–Four sources of data contributed to the process evaluation, which documented facets of the intervention.

1) A daily log of intervention participation.
2) Polar Heart Rate monitors (Polar Electro, Inc., Lake Success, NY) assessed students' heart rates three times each, with each monitoring session separated by approximately 2 weeks. Data were analyzed using Polar E Series Software (version 4.9.0.17) to provide the percent of wear time that each student was above and below their personalized target heart rate zone.
3) PE classes were observed by teams of two trained observers to document that intervention procedures were being followed and that students were receiving similar quality of instruction across classes. Intervention students were integrated into the regular PE program, and so were distributed across different teacher/period combinations. Each teacher/period combination was observed twice separated by at least 2 weeks, thus yielding 22 class observations.
4) Semi-structured interviews were conducted with half of the adolescents participating in the study to elicit their opinions about the study as well as their self-report of any behavior change. Interviews were conducted by the Lead Researcher on the school grounds during the PE period, and took 5–10 min.

Measures

Body mass index (BMI) percentile–Students were weighed using a calibrated digital scale (Seca 869, Chino, CA) and height was measured using a stadiometer (PE-AIM-101, Perspective Enterprises, Portage, MI). BMI percentile was computed according to the normative values provided by the Centers for Disease Control and Prevention [34].

Affective response to exercise–The Feeling Scale (FS) is a single-item 11-point bipolar measure of pleasure-displeasure used to assess affective valence [35]. The scale ranges from −5 (very bad) through 0 (neutral) to +5 (very good). It is only moderately related to ratings of perceived exertion (RPE), suggesting that the two constructs are distinct, is sensitive to alterations in exercise intensity among adolescents [36] and is positively related to enjoyment of acute exercise [37].

Affective style–Students were categorized as either "latent" or "reluctant" exercisers on the basis of their affective response to the moderate-intensity exercise task. Those who responded to the task with an upward trend in affect were classified as "latent" exercisers; they responded to the task with enhanced positive affect. Participants who responded to the task with a downward trend in affect were classified as "reluctant" exercisers; they responded to the task with deterioration in positive affect.

Rating of perceived exertion–Borg's RPE scale [38] served to document participants' self-perceptions of their level of exertion during the preferred intensity exercise task. This scale ranges from 6 (no exertion at all) to 20 (maximal exertion).

Heart rate during feels-good exercise tasks–Study participants wore a Polar Heart Rate monitor during the feels-good exercise task. A research assistant manually recorded the heart rate every 3 min at the same time that the study participant reported FS and RPE ratings.

Baseline physical activity participation–Participants were instructed to wear the Actigraph® accelerometer on the left hip for seven consecutive days, except while sleeping, swimming, or bathing. Data from the Actigraph® were analyzed using the Actilife software with the Freedson cutoff [39] to yield the average number of minutes daily that participants engaged in moderate-to-vigorous physical activity (MVPA). For a

day to be included in the computation, a minimum of 8 valid hours must have been recorded. A minimum of 4 valid days (including at least 1 weekend day) of data was required.

PE class observations–Observations focused on the amount of class time during which students were active, the number of times the instructor prompted the students to check their heart rate, and whether students responded to instructor prompts by checking their heart rate.

Intensity of exercise during physical education classes–Data from the Polar Heart Rate monitors deployed during PE classes (described under process evaluation, above) were analyzed to provide a mean average heart rate for each participant.

Intensity of exercise during the "feels-good" exercise task–Both work rate and heart rate during the feels-good task were employed as indices of exercise intensity. In both cases, the area under the curve was estimated using the formula recommended by Pruessner et al. [40] to yield an overall summary value that represented the cumulative work rate and/or heart rate over time during the task. For heart rate, absolute values obtained at each 3-min assessment were divided by maximum heart rate during the cardiorespiratory fitness test, to provide values representing percent of maximal heart rate.

Data analyses

Baseline assessments were completed for 74 students; 4 failed to complete the intervention (1 dropped out, 2 sustained injuries that prevented PE participation for at least 10 days, and 1 had excessive school absences). Data analyses related to baseline assessments, therefore, were conducted on all 74 consented students, but process data are presented only for the 70 who completed the intervention. Comparability between the two intervention groups on key participant characteristics was examined using t-tests, as was comparability between latent and reluctant exercisers. Descriptive data are presented for the two 30-min exercise tasks. Data from the feels-good task were examined for reluctant and latent exercisers separately and t-tests compared the two groups at each time period. To examine the proximal impact of the intervention, mean average heart rates during PE were compared by intervention group (*t* test), affective style (*t* test), and the interaction between group and affective style (ANOVA), and the change over time (i.e., from pre- to post-intervention) in exercise intensity during the feels-good task was compared by intervention group (paired *t* test) affective style (paired *t* tests) and the interaction between group and affective style (hierarchical linear regression).

RESULTS

Participant characteristics

A total of 74 6th-grade students consented to participate (49 % male; 36 Latinos, 9 African-American, 13 non-Hispanic White, 7 Asian/Pacific Islander, and 9 Multiracial/Other). Table 1 provides baseline characteristics. There were no significant differences between the participants assigned to the two intervention groups; nor were there any significant differences in baseline characteristics between latent and reluctant exercisers.

Moderate-intensity exercise task

Heart rates recorded during the moderate-intensity task indicated that on average adolescents were working at approximately 83 % of maximal heart rate. The pattern of affective ratings obtained during the task revealed that 52.7 % (N=39) of adolescents were reluctant exercisers; their affect declined over the course of the task. In contrast, 47.3 % (N=35) were latent exercisers; their affect increased over the course of the task.

Feels-good exercise task

Adolescents were able to follow instructions during the feels-good exercise task and maintained an affect level that corresponded to feeling "good" throughout the task. Although scores on the Feeling Scale were consistently at or above a 3 ("good") on the scale, latent exercisers felt better compared to the reluctant exercisers at 18, 21, 24, and 27 min into the task (p's$<$.05; see Fig. 1). Heart rates recorded during the feels-good exercise task at baseline indicated that on average adolescents were working at approximately 71 % of maximal heart rate (see Fig. 1). Latent exercisers chose to work at a higher percent of peak heart rate at 15, 18, 21, 24, and 27 min (p's$<$.05). Ratings of perceived exertion rose steadily throughout the task from about 9 to about

Table 1 | Baseline participant characteristics

	All *M* (SD); *N*=74	Affective-based prescription *M* (SD); *N*=39	Traditional prescription *M* (SD); *N*=35
Gender (% male)	49 %	53 %	47 %
Age (yrs)	11.09 (0.40)	11.18 (0.50)	11.18 (0.39)
VO2peak (ml/kg/min)	37.30 (7.41)	37.58 (7.64)	36.98 (7.24)
BMI	48.05 (11.89)	48.03 (10.07)	49.69 (12.93)
BMI %ile	71.66 (28.29)	69.11 (29.19)	81.11 (21.55)
MVPA (min)	42.98 (15.80)	40.54 (14.29)	45.42 (17.27)

MVPA derived from Actigraph assessment using Freedson cutoff of 1952 counts/minute for MVPA

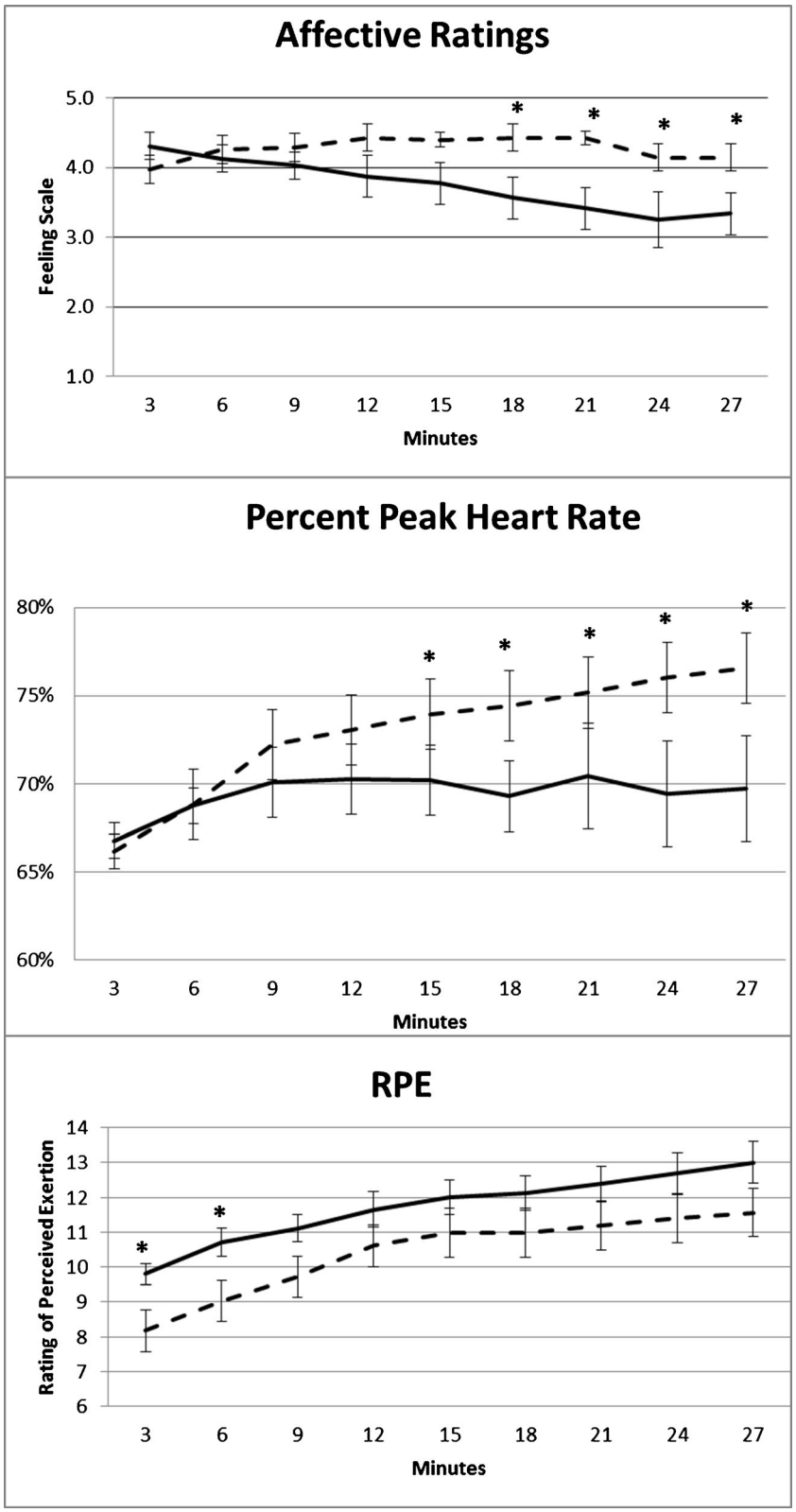

Fig 1 | Affective ratings, percent peak heart rate, and ratings of perceived exertion during the baseline feels-good task (*N*=74). *Solid lines* **depict reluctant exercisers;** *dashed lines* **depict latent exercisers. Feeling scale (FS) is scored from −5 (very bad) to +5 (very good). Ratings of perceived exertion (RPE) are scored from 6 (no exertion) to 20 (maximal exertion). *p<.05**

11; a range that reflects moderate exertion (see Fig. 1). Although there was a trend for reluctant exercisers to report that they were working harder than latent exercisers, this difference was only significant in the early part of the task (i.e., 3 and 6 min; p's<.05).

Process evaluation

Intervention dose–Among the 70 students who completed the intervention, students wore the heart rate watch for a mean of 47 days (SD=2). No student wore the watch fewer than 40 days out of the 52 days of school available during winter semester.

PE class observations–According to the observations, an average of 27.89 min (SD=5.58) per class was spent in activity, which translates to 51 % of the class period. On average, teachers spent 2 min (SD=1.15) taking roll, and .64 min (SD=.95) giving instructions. Observations also showed that during 91 % (20 out of 22) of observations, PE teachers prompted students to check their heart rate at least once during the class period, and students checked their heart rate when prompted during 91 % of observations. One-way ANOVAs indicated that there was no difference across PE classes in terms of the percent of the class spent in activity or in the frequency with which students were prompted to check their heart rate.

Compliance with heart rate prescriptions.–The average duration of the PE heart rate monitoring sessions was 45 min (SD=4.76). Across all of the monitoring sessions (N=3 sessions X 70 students=210 sessions), the students spent an average of 66 % (M=66.25, SD=18.96) of the class period above the minimum heart rate assigned by their target heart rate zone. There were no significant differences across intervention groups, affective style, or the interaction between the two in terms of the amount of time spent exercising at an intensity that was above the minimum prescribed heart rate.

Interviews–All of the students interviewed (n=29) were happy to be participating in the project ("You get to wear these watches and exercise more. You get to see how fast or slow you are; I like it"). They particularly liked engaging in the assessments ("It's fun because I got to exercise and I don't have to stay in PE class. I liked doing the tests"), and several mentioned that wearing the watch had made them much more self-aware ("I check my heart rate more now. Even after I take the watch off, I still think about my heart rate"; "It has made me think more about my health"; "I know how hard to work and how to keep in my heart rate zone for which activities"). Many of the students reported that they did try to adjust their activity level to stay within their assigned zone ("I slow down and start walking during the mile run"; "I am more likely to be below. I tell myself to work harder"; "If I am too high, I tell my teacher, and she lets me slow down"; "I know not to go too fast when I am running. I know that if my heart rate is too low I can exercise to get it up.")

Exercise intensity–The average mean heart rate during PE classes was 135 bpm (SD=−10.03). There were no significant differences across intervention groups, affective style, or the interaction between the two in terms of mean average heart rate. In comparing the change from pre- to post-intervention in the self-selected intensity of exercise during the feels-good task, paired t-tests revealed a significant impact of affective style on both work rate and heart rate. Among reluctant exercisers, the area under the curve for work rate increased from baseline to post-intervention (t=−4.50, p<.05), whereas there was no significant change in area under the curve for work rate among latent exercisers (p>.05). In contrast, reluctant exercisers manifested no change in area under the curve for heart rate during the feels-good task (p>.05), whereas latent exercisers showed a decrease in area under the curve for heart rate over time (t=2.35, p<.05). This pattern suggests that reluctant exercisers exerted themselves more at the post-intervention assessment, yet exhibited a stable heart rate response (i.e., no change over time).

DISCUSSION

The intent of this study was to examine the implementation and proximal impact of an affect-based exercise prescription in a school-based intervention study targeting adolescents. The results suggest that the approach is feasible in that study participants understood the instructions for the exercise tasks, enjoyed monitoring their heart rates during PE across approximately 40 days of school, and attempted, by self-report, to modify their activity level to remain within their target heart rate zone. Despite these positive indications, the intervention had no impact on the intensity of exercise selected by study participants either during PE or during the feels-good exercise task. It is possible that the quality of the basic PE program at this school was so high that the heart-rate intervention was insufficiently potent to bring about additional gains in exercise-related affect. This particular PE program employs certified PE instructors who work as a team to implement a state-of-the-art curriculum that maximizes class management while encouraging engagement in activity from all students all the time. The affect-based intervention, which targets individual behavior more than the classroom environment, might be more effective in a more typical PE program.

Of particular interest and note is the finding that, at baseline, adolescents who manifested enhanced affect during a moderate-intensity exercise task (identified as "latent" exercisers) also chose to work at a higher intensity when instructed to find a level of exertion that felt "good" and maintained a higher intensity of activity for much of the feels-good task as indicated by heart rate. The consistency across these tasks supports the hypothesis that some adolescents are predisposed to enjoy exercise and to engage in higher-intensity exercise spontaneously whereas others may be predisposed to dislike exercising and to choose to reduce their level of exertion during exercise when given the option to do so.

The finding that reluctant exercisers increased their exercise intensity during the feels-good exercise task at the end of the school year, as compared to the beginning of the school year, suggests that a high-quality PE program combined with heart rate monitoring has the potential to shift the exercise-associated affective experience of these youth. This change was not observed in latent exercisers, which is consistent with the hypothesis that those individuals who are predisposed to enjoying exercise will be less affected by interventions targeting exercise enjoyment; a dynamic observed in earlier research among sedentary adolescents[41]. The absence of an interaction between affective style and the heart rate intervention in this study may well indicate that the social and environmental influences relevant to the affective response to exercise were more salient to these adolescents than the physiological cues they received during physical activity. In terms of the judicious application of resources toward promoting adolescent physical activity through the school, the results of this study suggest that a higher return on investment is likely to be realized from adequately training and equipping PE instructors, rather than providing tailored heart rate prescriptions to students.

Although this study failed to find evidence for the effectiveness of the intervention for encouraging students to modify their exercise behavior, it should be noted that the outcome variables examined were short-term and quite proximal to the intervention. Most school-based interventions examine the impact on longer-term and/or more distal outcome measures, including fitness and physical activity participation rates. It should not be assumed that because the intervention had no impact on self-selected exercise intensity it will have no impact on fitness and physical activity. In fact, we will be able to examine these impacts in the future, with the addition of subsequent study cohorts that will provide an adequate sample size and statistical power to examine these variables.

This study reflected a translational approach in that it was designed to be compatible with existing middle-school PE practices and norms and required relatively little accommodation from the school staff. A rigorous process evaluation ensured that each study participant was exposed to a similar PE experience. The results of this process evaluation confirmed that all intervention participants were exposed to a similar quality of PE instruction, as evidenced by the observed time spent active. Across all the classes included in the study, classes spent an average of 51 % of the class time engaged in activity. This proportion meets the public health recommendations issued by the U.S. Department of Health and Human Services and compares favorably to other school-based studies of time spent active in PE [42, 43].

A growing body of scientific evidence suggests that choices related to physical activity are shaped at least in part by individuals' affective associations with being active. Meta-analyses with adults [44] and youth [45] suggest that there is a medium-sized correlation between what the authors call "affective judgment" (the overall pleasure/displeasure, enjoyment, and feeling states expected from enacting an activity or from reflection on past activity) and physical activity. What is needed now is some guidance regarding how to cultivate positive affective judgments. Qualitative research among low-active youth [14] offers evidence that exercise that challenges the physiological abilities of the adolescent generates negative affect. The present protocol allows youth to self-identify an exercise intensity that feels "good" (i.e., not pegging it to a fitness parameter) and then uses that self-identified intensity to prescribe a level of activity. Theoretically, individuals who are repeatedly exposed to exercise sessions that feel good will form positive affective judgments and therefore be more likely to engage in physical activity.

Much of the research into the relationship between affect and exercise refers at least tangentially to Self-Determination Theory (SDT) [46]. This theory of behavioral motivation places intrinsic motivation (doing something for the simple pleasure of it) at the center of a model that posits three basic psychological needs which, when satisfied, generate intrinsic motivation. These three needs are competence (a feeling of mastery when engaged in an activity), autonomy (having control over the activity) and relatedness (feeling related to others during the activity). Studies using this model to predict exercise and/or exercise-associated affect have consistently found that competence is the strongest and most consistent correlate of both exercise and exercise-associated affect [47, 48]. It could be argued that the mechanism through which the intervention in this study operates is competence, since students are afforded the opportunity to choose an exercise intensity that feels good to them; a level that may reflect their perceptions of their own competence. One potential explanation for the apparent lack of an effect of the intervention in this sample might be that within this age group (middle school) relatedness may play a greater role in the affective response to exercise than competence. Since all students in this study experienced a similar social environment in PE, one that is specifically designed to build that sense of relatedness, the incremental gains in competence that may have been brought about by the intervention may have been insubstantial in comparison.

A recent report suggests that fewer than 15 % of U.S. adolescents meet the aerobic guidelines set forth in the Healthy People 2010 report [49]. Effective PE programs have long been promoted as a promising avenue for increasing activity levels among school-aged youth, and the present study provides one illustration of an effective PE program that gets students moving for approximately 30 min per day. Since the current recommendation is for

adolescents to engage in 60 min per day of MVPA, it is equally important that youth be encouraged to engage in activity outside of school. Thus, an effective PE program should be judged not just on the amount of time in class that students are active, but also how much activity students seek out on their own time. A program that forces students to exert themselves at a level that is physically uncomfortable may backfire by cultivating disaffection for physical activity. The present study takes a first step toward determining whether a PE program can be tailored to individuals' level of enjoyment of physical exertion with the long-term goal of promoting lifetime activity. Initial results suggest that the approach can be implemented in the PE setting; future work must determine whether the approach is an effective means of promoting long-term PA.

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