

Using the Transtheoretical Model to Examine the Effects of Exergaming on Physical Activity Among Children

Zachary C. Pope, Beth A. Lewis, and Zan Gao

Background: The Transtheoretical Model (TTM) has been widely used to understand individuals' physical activity (PA) correlates and behavior. However, the theory's application among children in exergaming remains unknown. **Purpose:** Investigate the effects of an exergaming program on children's TTM-based PA correlates and PA levels. **Methods:** At pretest and posttest, 212 upper elementary children (mean age = 11.17 years) from the greater Mountain West Region were administered measures regarding stages of change (SOC) for PA behavior, decisional balance for PA behaviors, PA self-efficacy, and self-reported PA levels. Following the pretest, a weekly 30-minute, 18-week Dance Dance Revolution (DDR) program was implemented. Children were classified into 3 SOC groups: progressive children (ie, progressed to a higher SOC stage); stable children (ie, remained at the same SOC stage); and regressive children (ie, regressed to a lower SOC stage). **Results:** Progressive children had greater increased PA levels than regressive children ($P < .01$) from pretest to posttest. Similarly, progressive children had greater increased self-efficacy ($P < .05$) and decision balance ($P < .05$) than regressive children. **Conclusions:** The findings indicate that progressive children had more improvements on self-efficacy, decisional balance, and PA levels than regressive children over time. Implications of findings are discussed.

Keywords: behavior change, self-efficacy, decisional balance, active video games, stages of change

Recent data regarding obesity rates in the United States indicate that 8% of 2- to 5-year-olds and 17.7% of 6- to 11-year-olds are obese.¹ Overweight and obese children/adolescents have a significantly increased risk of premature mortality and cardiometabolic diseases, such as coronary heart disease, diabetes, stroke, and hypertension.² Physical activity (PA) has been shown to be an integral part of the treatment and prevention of childhood obesity and the promotion of healthier lifestyles.^{3,4} Exergaming, defined as video games which require the player to be physically active during gameplay [eg, Dance Dance Revolution (DDR), Wii boxing, Kinect Sports] has been seen as a viable method to increase children's PA participation and enjoyment.⁵⁻⁷

The Transtheoretical Model⁸ (TTM) has been widely used to understand individuals' PA correlates (eg, decisional balance, self-efficacy) and PA behavior. According to this theory, behavior change unfolds through 6 different stages: precontemplation, contemplation, preparation, action, maintenance, and termination.⁸ While progressing through the aforementioned stages, individuals use different behavior change processes as each stage has different needs and requires different intervention strategies (eg, stage-tailored interventions). Over time, changes in health behaviors can be observed through an individual's placement within this series of stages (see Figure 1). Researchers have used the TTM model to discern the correlates in PA behavior change in individuals with physical disabilities,⁹ individuals of varying ethnicity,¹⁰ and different child and adult populations.¹¹⁻¹³ For example, in a 12-month randomized control trial using both print- and phone-based TTM intervention strategies, statistically significant changes in the self-efficacy, decisional balance, and cognitive and behavior processes of change were evident after 6 months in both the print- and phone-based TTM interventions.¹³ Moreover, the magnitude of these changes increased during the 6- to 12-month intervention period in the group receiving print

materials.¹³ Indeed, reviews on the efficacy of the TTM stages of behavior change indicate this theoretical framework to be a practical method to observe correlates in PA behavior change interventions.¹²

The theory's application among children participating in exergaming is not known. Research evidence shows that exergaming has the potential to help children engage in greater PA as the

Six Stages of Behavior Change Model

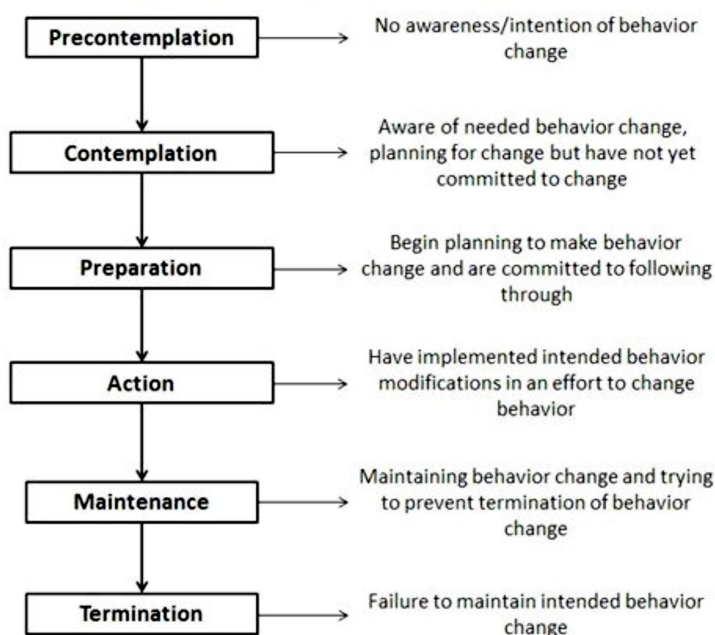


Figure 1 — Transtheoretical Model stages of behavior change. Note. Adapted from: Prochaska J, DiClemente C. Stages and processes of self-change of smoking: toward an integrative model of change. *J Consult Clin Psychol.* 1983;51(3):390-5.

games require body movement while playing.⁶ Specifically, the fast growth of exergaming has led to the development of innovative PA programs in school settings.^{14–19} Despite the theory's lack of use during exergaming PA interventions, the TTM model has been used to analyze behavior change in children²⁰ and adolescents²¹ in other PA intervention programs. In a study of 8- to 12-year-old children, researchers found a PA intervention consisting of 45-minute classes 3 day/week for 12 weeks focused on increasing exercise self-efficacy (ie, Youth Fit for Life Program) advanced 14.3% of children 1 TTM stage.²⁰ Furthermore, not only did the aforementioned Youth Fit for Life Program promote behavior change but the program was also found to decrease BMI in children enrolled in the PA intervention.²² Despite other authors²³ striving to implement theories such as the Social-Cognitive Theory in populations of children to increase PA, the preceding research represents the extant literature on the TTM and children's PA interventions. Given the recognized importance of effective programs for children's PA behavioral changes, understanding the effects of exergaming programs on children's stage of change (SOC) and relevant psychosocial correlates is critical for initiation of intervention efforts aimed at health promotion among children.

Specifically, research on children's SOC in exergaming needs to examine the relationship between PA levels and changes in

self-efficacy (ie, situational self-confidence—situational confidence for PA engagement) *and* decisional balance (ie, the balance of pros and cons associated with engagement in a behavior—in this case, PA) resulting from exergaming. Given that more enjoyable experiences in PA are related to more decisional pros,¹⁰ children who participate regularly in an enjoyable exergaming intervention may develop a greater number of PA pros (ie, positive decisional balance) might be seen in this population. Further, since research has shown PA interventions with youth to increase self-efficacy and advance youth's SOC while also increasing PA levels,²⁰ an exergaming intervention wherein the children feel a sense of competence might have the ability to produce the same outcome. See Figure 2 for conceptual diagram.

As such, this study was designed to investigate the effects of an exergaming DDR (a dance video game requiring quick-step movement) program on children's TTM-based PA correlates (ie, self-efficacy, decisional balance) and PA levels. In this manner the study builds upon literature examining how self-efficacy can increase children's readiness for PA participation (ie, advancements in SOC) by also investigating how decisional balance plays a part in this process. Further, this examination will be completed using a novel PA intervention, exergaming. Based upon the literature review and previous studies, the following hypotheses were proposed. First,

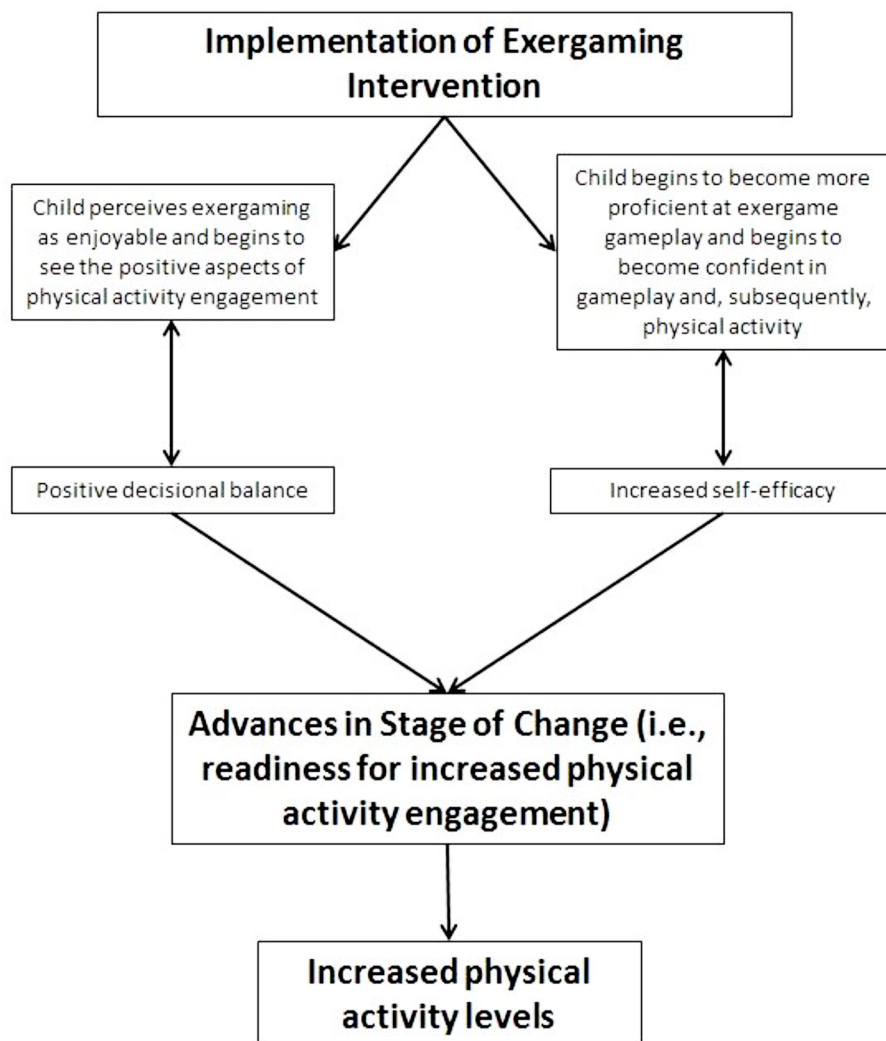


Figure 2 — Hypothesized effect of exergaming intervention on stages of change and physical activity levels.

it is hypothesized children will progress to a higher TTM stage from preintervention to postintervention. Second, it was hypothesized that children who progress to a higher TTM stage will have increased self-efficacy, decisional balance, and PA levels.

Methods

Participants and Research Setting

The current study is part of a larger project designed to investigate children's beliefs and PA levels in exergaming. Details of eligibility criteria, sample, and exergaming intervention have been reported previously.⁷ However, the data presented in this study have not been published. A single group pre- and posttest design was employed in this study, whereby subjects' self-reported questionnaire data were collected before and after the DDR intervention. A total of 212 fourth- through sixth-grade urban school children (mean age = 11.17, SD = ± 1.10 , age range = 8–14; 104 boys, 108 girls) from the Mountain West region of the U.S. participated in this study. The participants consisted of 76 fourth-grade students, 68 fifth-grade students, and 68 sixth-grade students.

Participants engaged in 1 weekly 30-minute physical education class with a range of 24 to 30 students per class. A DDR program was introduced in spring 2010 by the principal investigator with the intention to promote children's PA participation at school and to investigate the effect of an additional dose of PA via exergaming. Before beginning the intervention, the principal investigator and the school physical education coordinator held several meetings to ensure the successful implementation of the program. As a result of the aforementioned meetings, a decision was made to offer the program every Thursday for 18 weeks as a supplement to the children's weekly 30-minute physical education class. That is, the participants had a total of 60 minutes structured PA at school every week. Students in grades 3 through 6 were eligible for participation in the DDR program. As a result of the DDR program's integration within the school's curriculum and the minimal risk of the intervention, all children and parents provided assent and consent, respectively, for this study. Consequently, the majority of the children targeted for participation in the study engaged in the intervention with the exception of those who became ill during the data collection period.

Exergaming Intervention

The exergaming intervention employed in this study has been detailed in a prior study.⁷ Briefly, 6 DDR stations in total were set up each with 2 master dance pads connected to a PlayStation Gaming System (Sony, New York, NY). Numerous other dummy dance pads (ie, dance pads not connected to the PlayStation) were available for individuals not dancing on the 2 master pads as each DDR station had 4 to 5 children present. Research assistants randomly assigned 2 children to the master dance pads at each station to direct the group during each game as the other children danced on the practicing pads (ie, dummy pads). Students playing on the master pads had autonomy to select the song and difficulty level of the DDR game. Thus, not all song choices or the level of difficulty of gameplay were identical. Following the cessation of the preceding dance leaders' gameplay, another 2 children rotated up to the master dance pads to serve as dance leaders meaning all children had a chance to be leaders during each intervention session. The principal investigator and research assistants introduced and demonstrated DDR gameplay on the first day of the intervention. Throughout the DDR program,

2 research assistants monitored the children in addition to providing the students encouragement (ie, way to go, great job, keep it up, and fantastic) to stay on task during DDR participation. This encouragement served to keep the children on task but also provided the possibility of increasing self-efficacy.

Each DDR game was composed of a series of 1 or more songs or several attempts at a single song. In short, DDR gameplay required a player to move his/her feet to a set stepping pattern governed by the rhythm/beat of a song as 4 stationary, transparent arrows present at the top of the screen were overlapped by arrows scrolling from the bottom to the top of the screen. As the scrolling arrow overlapped the stationary arrows at the top of the screen, the player was required to step on the arrow on the dance pad corresponding to the overlapping arrow(s). "Jump" steps required the player to simultaneously step on 2 arrows. Each step was also assigned a rating indicative of how closely the step matched the beat. Ratings of PERFECT, GREAT, GOOD, BOO, and MISS were provided for steps of the highest to lowest quality, respectively, while a "Dance Gauge" was filled in relation to the player's ability to hit the arrows in sync with the rhythm/beat of the music. Missing too many steps and depleting the Dance Gauge typically resulted in a student's failure of the song and, typically, a "game over" scenario. Otherwise, students who did not fail the song were taken to the Results Screen at which time the student's performance was rated from "A" to "E" in relation to the number of correct steps he or she completed as well as how well-timed each step was.

Measures

Stages of Change. In the current study, only the first 5 stages of the TTM were analyzed (ie, precontemplation, contemplation, preparation, action, and maintenance) given the duration of the intervention. As such, children's SOC were measured by an established questionnaire in young adolescents.²⁴ Specifically, 3 questions were grouped into 5 mutually exclusive groups representing the SOC (precontemplation-does not engage in PA and has no intention to change; contemplation-does not engage in PA but intends to change within the next 6 months; preparation-does not do PA but intends to change within the next month; action-engaged in 60 minutes of PA on most days of the week but not for longer than 6 months; maintenance-engaged in 60 minutes of PA most days of the week for more than 6 months). This scale has adequate psychometric properties for use in adolescents²⁴ and preadolescents.²⁵

Decisional Balance. To assess children's decisional balance, a 5-point Likert-type scale (1 = *not important*, 5 = *extremely important*) was adapted from the PA Pros and Cons scale for young adolescents.²⁴ Specifically, the stem of this scale was: "How important is each statement to you when deciding whether or not to do physical activity?" Samples of the 10 answers included "I would feel embarrassed if people saw me doing physical activity"; "Physical activity would help me stay fit"; "There is too much I would have to learn to do physical activity"; and "I do not like the way physical activity and exercise makes me feel." The mean of 5 PA pros items were used as children's PA pros, and the mean of the other 5 items were used as children's PA cons. This modified version of the scale has demonstrated acceptable validity,²⁵ and reliability for the PA Pro scale is between $r = .83$ and $r = .86$ while the reliability for the PA cons scale is between $r = .75$ and $r = .77$.²⁴

Self-Efficacy. To assess children's self-efficacy, the 6-item Physical Activity Confidence Scale²⁴ was used. This scale has demonstrated validity and reliability among adolescents.²⁴ The stem employed

in the scale was: “Rate how sure you are that you can do PA in each situation.” Sample statements were a) “Do physical activity even when you feel sad or stressed”; b) “do physical activity even when your family or friends want you to do something else”; and c) “do physical activity even when you have a lot of schoolwork.” A 5-point Likert scale, ranging from 1 = *I am sure I can't* to 5 = *I am sure I can*, was used for all responses. The mean of these items were used as an indication of children's self-efficacy. This scale has demonstrated psychometric properties in preadolescents.²⁴

Physical Activity Levels. The Adolescent Physical Activity Measure²⁶ was used to assess children's overall PA engagement. The validity and reliability of this scale have been established among adolescents.²⁶ In particular, children self-reported how many days they were physically active for a total of at least 60 minutes per day in the past 7 days. They also reported how many days they were physically active for a total of at least 60 minutes per day over a typical or usual week. The responses ranged from 0 days to 7 days. The average score of these 2 items was used as an indicator of children's PA levels.

Procedures

The procedures were approved by the University Institutional Review Board, the school district, school principal and teachers. We also obtained written parental consent and child assent before the start of this study. At pretest, children's SOC, decisional balance, self-efficacy, and weekly PA levels were measured through a battery of questionnaires. Following the pretest, children participated in the 30-minute weekly DDR program for 18 weeks beyond their 30-minute weekly physical education class. Two research assistants were trained to assist with the data collection of the questionnaires. Specifically, the research assistants provided instructions for questionnaires on the first day of data collection. After the intervention, children completed the identical questionnaires to gauge progress.

Data Analyses

Data were analyzed in 4 steps. First, Cronbach's alpha coefficients were computed to ensure the internal consistency of the self-reported questionnaires over time. Second, children were classified into 3 SOC groups: progressive children (progressed to a higher SOC stage from pretest to posttest); stable children (no change in their SOC over time); and regressive children (regressed to a lower SOC stage over time). Next, a series of Repeated Measures ANOVAs

were conducted to determine the changes in children's self-efficacy, decision balance, and PA levels over time. The between-subject independent variable was SOC, and the within-subject independent variable was time. In addition, a crosstab test was performed to determine the number of children in different SOC at pretest and posttest. An alpha level of .05 was set for all statistical analyses.

Results

Demographic characteristics for 212 fourth- through sixth-grade urban school children revealed that participants came from a variety of cultural and ethnic backgrounds, and had the following self-report ethnic breakdown: White-American (n = 155), Hispanic American (n = 24), undeclared (n = 14), Asian American (n = 13), and African-American (n = 6). Participants' average height was 145 cm (SD = 8.77), and average weight was 41 kg (SD = 11.96). The Centers for Disease Control and Prevention growth charts²⁷ were used to classify all subjects by BMI into underweight (< 5% of age-predicted), normal weight (5% to 84.9% of age-predicted), overweight (85% to 94.9% of age-predicted), and obese (> 95% of age-predicted) categories. Of the current sample 9 children (4.2%) were underweight, 145 children (68.4%) were normal weight, 28 children (13.2%) were overweight, and 30 children (14.2%) were obese.

The self-reported questionnaires were tested for internal consistency. Cronbach's alpha coefficients were 0.84 and 0.85 at pretest and posttest for self-efficacy, 0.78 and 0.82 for PA pros, 0.81 and 0.80 for PA cons, and 0.79 and 0.81 for PA levels, respectively. The coefficients for the 4 scales exceeded the minimum recommended value of 0.70, suggesting that these measures were appropriate for the target population in this study. Table 1 presents the descriptive statistics by SOC groups and the whole sample across time. Results indicate the children in this study demonstrated moderately high levels of self-efficacy ($X = 3.46$ at pretest and 3.49 at posttest) and PA pros ($X = 3.88$ at pretest and 3.71 at posttest), as the mean scores of these variables were above the midpoint (ie, 3 for self-efficacy and PA pros) while the mean scores of PA cons were well below the same midpoint ($X = 1.56$ at pretest and 1.61 at posttest). The children also reported moderate levels of PA participation (see Table 1).

Based on the Repeated Measures ANOVAs, there was a significant time by SOC interaction effect for PA, $F(2, 202) = 18.93$, $P < .01$. More specifically, progressive children had significantly higher PA levels at posttest than pretest, whereas regressive children reported significantly decreased PA levels over time. Similarly, there was a significant interactive effect (time by SOC) for self-efficacy, $F(2, 199) = 4.05$, $P < .05$, and PA pros, $F(2, 202) = 4.52$,

Table 1 Descriptive Statistics for Study Variables over Time

		Self-efficacy		PA Pros		PA Cons		PA levels	
Stages of change		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pretest	Regressive (n = 63)	3.42	.93	3.95	.91	1.58	.70	4.62	1.84
	No change (n = 95)	3.54	.83	3.89	.85	1.50	.56	4.24	2.18
	Progressive (n = 47)	3.36	.99	3.75	1.07	1.66	.95	4.00	1.89
	Total	3.46	.90	3.88	.92	1.56	.71	4.30	2.02
Posttest	Regressive (n = 63)	3.26	1.00	3.54	.99	1.65	.70	3.71	1.93
	No change (n = 95)	3.55	.83	3.69	1.04	1.53	.58	4.64	2.08
	Progressive (n = 47)	3.67	.78	3.95	1.08	1.71	.84	5.32	1.58
	Total	3.49	.89	3.71	1.048	1.61	.69	4.51	2.01

Abbreviations: SD, standard deviation; PA, physical activity.

$P < .05$. In particular, progressive children had greater increased self-efficacy and PA pros over time, while regressive children reported significantly decreased PA pros and stable self-efficacy from pretest to posttest. However, there was no significant effect on PA cons over time. Finally, based upon a crosstab test (see Table 2 and Figure 3), more children progressed to higher SOC than regressed to a lower SOC at posttest ($\chi^2 = 71.30$, $P < .01$). Precisely, the stages of contemplation, preparation, and action gained 8, 6, and 10 students from pretest to posttest, respectively, while 13 less children were observed in the precontemplation stage at posttest. Interestingly, 11 fewer students were seen in the maintenance stage at posttest.

Discussion

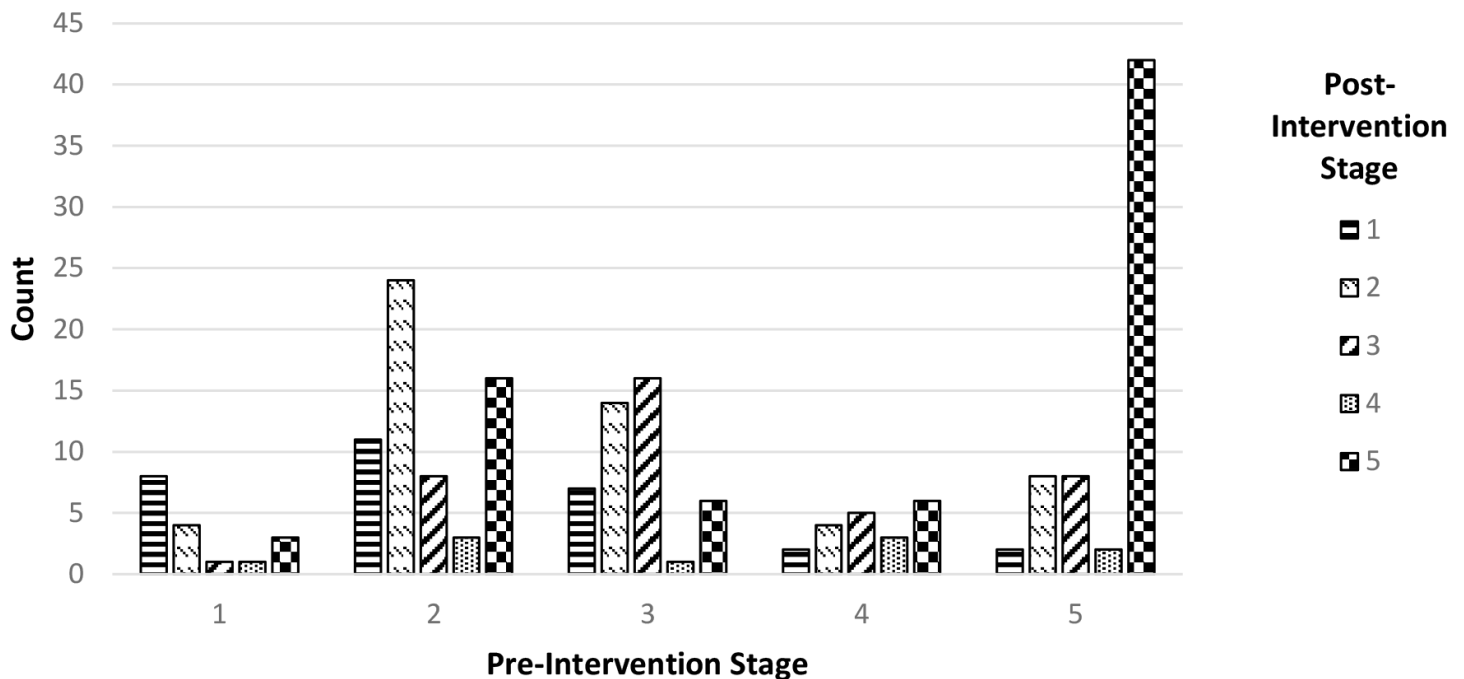
Two hypotheses were stated before the study. First, it was hypothesized children would progress to a higher TTM stage from preintervention to postintervention. The results of the study confirm this

hypothesis as a greater number of children progressed to a higher SOC than regressed to a lower SOC from pretest to posttest. Second, it was hypothesized improved self-efficacy, decisional balance, and PA levels would be seen in those who progressed to a higher TTM stage. Findings indicate this hypothesis was confirmed as progressive children experienced greater positive changes in self-efficacy, decisional balance, and PA levels from pretest to posttest than stable or regressive children. Furthermore, an associated finding was that the improvements in both self-efficacy and perception of PA pros was significantly greater from pre- to posttest in progressive children compared with regressive children.

As stated previously, the findings of the current study indicate improvements in progressive children's self-efficacy, decisional balance, and PA levels from pretest to posttest when compared with regressive children. Numerous studies have demonstrated that increased self-efficacy and decisional balance helps advance adult populations to a higher SOC which helped these individuals increase PA levels.^{10,28,29} Moreover, the literature to date concerning

Table 2 Crosstabulation Totals by Stage of Change

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Prestage	Count	30	54	38	10	73
	%	14.6	26.3	18.5	4.9	35.6
Poststage	Count	17	62	44	20	62
	%	8.3	30.2	21.5	9.8	30.2



Note: 1 = Precontemplation; 2 = Contemplation; 3 = Preparation; 4 = Action; 5 = Maintenance

Figure 3 — Stages of change crosstabulation chart.

the use of TTM interventions in youth populations seems to render the same relationship. For example, in a series of studies, researchers applied an intervention, the Youth Fit for Life program, to the enhancement of self-efficacy in the hopes of increasing PA levels in preadolescents.^{20,22} The researchers found that enhancements in self-efficacy for PA resulting from the Youth Fit for Life program increased voluntary PA levels^{20,22} and facilitated the advancement of preadolescents to higher TTM stages.²⁰ In the current study, as some of the children began to improve the skills needed to play DDR and received the real-time positive feedback on the television screen (ie, PERFECT, GREAT, GOOD), these children experienced increased situational confidence (ie, self-efficacy). As a result of the increased self-efficacy for DDR and the fact the game required a large amount of movement on the part of the player, some children were able to progress to a stage of greater readiness for change in regards to PA.

This study also found progressive children had enhanced decisional balance compared to regressive children from pretest to posttest. Specifically, progressive children perceived a greater amount of PA pros than cons. As such, one theory may hold that the perception of more PA pros led to greater PA levels among the progressive children. However, studies assessing decisional balance in populations of children are limited. A study evaluating the TTM model in a population of middle school children revealed no differences in decisional balance in relation to higher SOC despite the fact that significantly higher self-efficacy scores and performance on the FITNESSGRAM³⁰ was seen in those students in the maintenance stage compared with those in the action, preparation, contemplation, and precontemplation stages.²⁵ However, it should be noted that the preceding study was only cross-sectional in design, only assessing the children at 1 time point. As for the current study, increases in decisional balance might be attributed to the intervention design employed. Other research on exergaming interventions using DDR have displayed significantly increased levels of PA enjoyment from preintervention to postintervention.³¹ Therefore, as the children experienced greater enjoyment for participating in the PA related to the DDR intervention in the current study, it is likely these children began to perceive greater PA pros than cons. The increased PA pros from pretest to posttest contributed to the significant increase in decisional balance among the progressive children in the study.

As a result of the aforementioned increases in self-efficacy and decisional balance, progressive children also had more improvements on PA levels than regressive children from pretest to posttest. Indeed, research reviewed previously has shown higher TTM stages, resultant from increases in self-efficacy and/or decisional balance, were related to increased PA levels in children and adolescent populations.^{3,20–22} Thus, the significance of this finding within the current study cannot be understated as, currently, U.S. children have high rates of overweight and obesity,¹ which has trended upward since the turn of the century.³² Research provides evidence as to the increased risk overweight/obese children harbor regarding risk of premature mortality and diseases such as stroke, coronary heart disease, diabetes, and hypertension.² Thus, the findings of this study point to a potential manner by which health professionals can get children to not only engage in and adopt physically active behaviors but also enhance children's health. Although, it is important to note that the current study did not strive to produce reductions in overweight or obesity status among the children nor was the study long enough in duration to produce this type of change in weight status. Future studies with the aim of reducing overweight and obesity status in children should consider interventions longer in duration to

accomplish this objective (eg, 6 to 9 months). Further, these future studies should look to provide 60 minutes of structured moderate-to-vigorous physical activity (MVPA) per day as the children in the current study only had 60 minutes of structured MVPA per week.

Finally, more children at posttest progressed to higher SOC than seen at pretest. These changes may be due to the DDR program and, thus, in future studies stage-tailored, exergaming-based strategies for increased PA levels are warranted. The development of stage-tailored exergaming-based strategies is important as research has demonstrated that higher SOC levels were correlated with increased PA.^{10,21} For instance, in a comparison of a stage-tailored versus a standard care intervention strategy to increase PA levels in adults, researchers found the stage-tailored intervention to result in higher PA levels and significantly greater self-efficacy than the standard care intervention.³³ Another study found greater increases in the fruit and vegetable consumption of young men and women 18 to 24 years of age when a stage-tailored intervention was employed versus a control group receiving nontailored nutritional information.³⁴ Despite the positive results regarding behavior change seen in various adult populations, little research has been conducted wherein a stage-tailored intervention for behavior change has been employed with a sample of children. The scarcity of this literature has led researchers to advocate for more research utilizing a stage-tailored design in this population.²¹ In the current study, 57.5% ($122/212 \times 100 = 57.5$) of the sample resided in the precontemplation, contemplation, and preparation stages at the onset of the study. Thus, in future studies with populations of young children, perhaps tailoring the intervention to the first 3 SOC (ie, the preaction stages) might be desirable. These future studies would focus on children in preaction stages by decreasing children's perceived barriers for PA engagement, increasing self-efficacy for PA, and providing education on the benefits of PA behavior.³⁴

The strengths of this study allude to some practical implications. Of note is this study successfully increased self-efficacy and decisional balance in a population of children through an exergaming PA intervention. As a result of improved confidence regarding PA participation (ie, self-efficacy) and greater perceptions of PA pros as opposed to PA cons (ie, decisional balance), a number of children progressed to a higher TTM stage while increasing PA levels. In addition, the study was 18 weeks in length which allowed time for the preceding changes to be observed. Finally, this study also provided evidence as to the reliability of the various questionnaires used to assess changes in self-efficacy, decisional balance, and PA in populations of children. Practically, the aforementioned outcomes can be applied in the following manner. First, since research has shown that exergaming leads to greater enjoyment of PA in children,³¹ setting up after-school programs which use exergaming to increase PA levels in children could be a manner by which health professionals can attenuate physical inactivity among children. Furthermore, as a result of this increased enjoyment of PA through exergaming, children can improve self-efficacy and decisional balance while progressing to higher TTM stages—as seen in the current study. The preceding progression is needed to sustain PA in the long-term. Increasing long-term PA participation in children will help mitigate the future poor health outcomes related to inactivity during childhood.²

Despite the strengths, the current study is not without limitations. First, although the length of the intervention was long at 18 weeks in duration, only pretest and posttest measures for self-efficacy, decisional balance, and PA levels were conducted. Due to the fact long-term behavior change is a desired outcome of an intervention of this type, lack of a third follow-up assessment of the

abovementioned variables 3 to 6 months postintervention might be seen as a limitation. Therefore, future studies might look to implement a follow-up assessment to discern the longevity of changes to PA behavior made by the children. In addition, the current study did not tailor the intervention to the child's current TTM stage. As discussed previously, researchers have advocated for TTM interventions tailored to the subject's current stage of behavior change^{10,21} as studies have shown stage-tailored interventions produce more beneficial results.^{33,34} While positive results were seen in the current study from pretest to posttest in self-efficacy, decisional balance, PA levels, and TTM stage progression, future studies should look to tailor the exergaming intervention to the child's stage of behavior change to yield even more favorable outcomes. Further, the study employed a self-report measure to assess PA engagement of which could be seen as a major limitation. However, moderate to vigorous physical activity was assessed via accelerometry during the exergaming sessions within the larger study associated with this manuscript.⁷ Finally, due to the fact the current study is correlational in nature, future studies employing a stage-matched TTM intervention may wish to conduct a randomized control trial to infer which cognitive and behavioral processes contribute the greatest to a child's SOC progression. The aforementioned cognitive and behavioral processes were not assessed in the current study due to the complexity of the items needed to assess these processes and the fact some children may not be able to interpret these items in the correct manner.

The results of the current study provide evidence as to the viability of an exergaming intervention to increase self-efficacy, decisional balance, and PA levels among children in addition to progressing children to a higher TTM stage. Given the high rates of overweight/obesity seen in U.S. children, interventions which look to stimulate increased PA via methods children find relatable (eg, video game play) are vital. Exergaming appears to be a promising prospect toward achieving this goal.

Acknowledgments

The authors would like to thank Dr. Maria Kosma for her input at the onset of this study. The suggestions made by Dr. Kosma contributed greatly to the quality of this work.

References

- Ogden C, Carroll M, Kit B, Flegal K. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA*. 2014;311(8):806–814. [PubMed doi:10.1001/jama.2014.732](#)
- Reilly J, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *Int J Obes (Lond)*. 2011;35:891–898. [PubMed doi:10.1038/ijo.2010.222](#)
- Nemet D, Barkan S, Epstein Y, Friedland O, Kowen G, Eliakim A. Short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention for the treatment of childhood obesity. *Pediatrics*. 2005;115(4):e443–e449. [PubMed doi:10.1542/peds.2004-2172](#)
- Simon C, Wagner A, DiVita C, et al. Intervention centered on adolescents' physical activity and sedentary behaviour (ICAPS): concept and 6-month results. *Int J Obes*. 2004;28:S96–S103. [PubMed doi:10.1038/sj.ijo.0802812](#)
- Lyons E, Tate D, Ward D, Bowling J, Ribisl K, Kalyararaman S. Energy expenditure and enjoyment during video game play: differences by game type. *Med Sci Sports Exerc*. 2011;43(10):1987–1993. [PubMed doi:10.1038/sj.ijo.0802812](#)
- Graf D, Pratt L, Hester C, Short K. Playing active video games increases energy expenditure in children. *Pediatrics*. 2009;124:534–540. [PubMed doi:10.1542/peds.2008-2851](#)
- Gao G, Podlog L, Huang C. Associations among children's situational motivation, physical activity participation, and enjoyment in an active dance video game. *J Sport Health Sci*. 2013;2:122–128. [doi:10.1016/j.jshs.2012.07.001](#)
- Prochaska J, DiClemente C. Stages and processes of self-change of smoking: toward an integrative model of change. *J Consult Clin Psychol*. 1983;51(3):390–395. [PubMed doi:10.1037/0022-006X.51.3.390](#)
- Kosma M, Gardner R, Cardinal B, Bauer J, McCubbin J. Psychosocial determinants of stages of change and physical activity among adults with physical disabilities. *Adap Phys Act Qu*. 2006;23:49–64.
- Kim Y, Cardinal B. Effects of a transtheoretical model-based stage-matched intervention to promote physical activity among Korean adults. *Int J Clin Hlth Psych*. 2009;9(2):259–273.
- Levy S, Cardinal B. Factors associated with the transitional shifts is college students' physical activity behavior. *Res Q Exerc Sport*. 2006;77(4):476–485. [PubMed doi:10.1080/02701367.2006.10599382](#)
- Lewis B, Marcus B, Pate R, Dunn A. Psychosocial mediators of physical activity behavior among adults and children. *Am J Prev Med*. 2002;23(Suppl 2):26–35. [PubMed doi:10.1016/S0749-3797\(02\)00471-3](#)
- Papandonatos G, Williams D, Jennings E, et al. Mediators of physical activity behavior change: findings from a 12-month randomized controlled trial. *Health Psychol*. 2012;31(4):512–520. [PubMed doi:10.1037/a0026667](#)
- Zhu W. Promoting physical activity using technology. *Research Digest*. 2008;9(3):1–8.
- Gao Z, Liang T, Huang C. Promoting children's exercise motivation and physical activity through interactive games. *Res Q Exerc Sport*. 2010;81(1):A-22.
- Hansen L, Sanders S. Fifth grade students' experiences participating in active gaming in physical education: the persistence to game. *Inter Counc Phys Educ Recre Sport Dance J Res*. 2010;5(2):33–40.
- Epstein L, Beecher M, Graf J, Roemmich J. Choice of interactive dance and bicycle games in overweight and nonoverweight youth. *Ann Behav Med*. 2007;33(2):124–131. [PubMed doi:10.1007/BF02879893](#)
- Murphy E, Carson L, Neal W, Baylis C, Donley D, Yeater R. Effects of an exercise intervention using Dance Dance Revolution on endothelial function and other risk factors in overweight children. *Int J Pediatr Obes*. 2009;4(4):205–214. [PubMed doi:10.3109/17477160902846187](#)
- Trout J, Zamora K. Using Dance Dance Revolution in physical education. *Teaching Elementary Physical Education*. 2005;16(5):22–25.
- Annesi J, Faigenbaum A, Westcott W. Relations of transtheoretical model stage, self-efficacy, and voluntary physical activity in African American preadolescents. *Res Q Exerc Sport*. 2010;81(2):239–244. [PubMed doi:10.1080/02701367.2010.10599671](#)
- Sanaeinasab H, Saffari M, Nazeri M, Zarchi A, Cardinal B. Descriptive analysis of Iranian adolescents' stages of change for physical activity behavior. *Nurs Health Sci*. 2013;15:280–285. [PubMed doi:10.1111/nhs.12020](#)
- Annesi J. Relations of physical self-concept and self-efficacy with frequency of voluntary physical activity in preadolescents: implications for after-school care programming. *J Psychosom Res*. 2006;61:515–520. [PubMed doi:10.1016/j.jpsychores.2006.04.009](#)
- Goran M, Reynolds K. Interactive multimedia for promoting physical activity (IMPACT) in children. *Obes Res*. 2005;13(4):762–771. [PubMed doi:10.1038/oby.2005.86](#)
- Norman G, Sallis J, Gaskins R. Comparability and reliability of paper- and computer-based measures of psychosocial constructs for adolescent physical activity and sedentary behaviors. *Res Q Exerc Sport*. 2005;76(3):315–323. [PubMed doi:10.1080/02701367.2005.10599302](#)
- Hausenblas H, Nigg C, Downs D, Fleming D, Connaughton D. Perceptions of exercise stages, barrier self-efficacy, and decisional balance for middle-level school students. *J Early Adolesc*. 2002;22(4):436–454. [doi:10.1177/027243102237191](#)
- Prochaska J, Sallis J, Long B. A physical activity screening measure for use with adolescents in primary care. *Arch Pediatr Adolesc Med*. 2001;155(5):554–559. [PubMed doi:10.1001/archpedi.155.5.554](#)

27. Kuczmarski R, Ogden C, Guo S. *2000 CDC growth charts for the United States: methods and development*. Atlanta, GA: National Center for Health Statistics; 2002.
28. Kim Y, Cardinal B, Lee J. Understanding exercise behavior among Korean adults: a test of the transtheoretical model. *Int J Behav Med*. 2006;13(4):295–303. [PubMed doi:10.1207/s15327558ijbm1304_4](#)
29. Griffin-Blake C, DeJoy D. Evaluation of social-cognitive versus stage-matched, self-help physical activity interventions at the workplace. *Am J Health Promot*. 2006;20(3):200–209. [PubMed doi:10.4278/0890-1171-20.3.200](#)
30. Research ClfA. *Prudential Fitnessgram test administration manual*. Dallas, TX: Author; 1992.
31. Gao Z, Zhang T, Stodden D. Children's physical activity levels and psychological correlates in interactive versus aerobic dance. *J Sport Health Sci*. 2013;2(3):146–151. [doi:10.1016/j.jshs.2013.01.005](#)
32. Ogden C, Carroll M, Kit B, Flegal K. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999–2010. *JAMA-J Am Med Assoc*. 2010;307(5):483–490. [PubMed doi:10.1001/jama.2012.40](#)
33. Lewis B, Forsyth L, Pinto B, Bock B, Roberts M, Marcus B. Psychosocial mediators to physical activity in a randomized controlled intervention trial. *J Sport Exer Psychol*. 2006;28:193–204.
34. Park A, Nitske S, Kritsch K, et al. Internet-based interventions have the potential to affect short-term mediators and indicators of dietary behavior of young adults. *J Nutr Educ Behav*. 2008;40(5):288–297. [PubMed doi:10.1016/j.jneb.2008.02.001](#)

Copyright of Journal of Physical Activity & Health is the property of Human Kinetics Publishers, Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.