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Motivation for Exergame Play Inventory: Construct Validity and Relationship to Game Play

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Abstract

The purpose of this study was to develop the Motivation for Exergame Play Inventory (MEPI) as a publicly available and validated measure of psychological and motivational constructs specific to increase the duration of exergame play. This study is an ancillary analysis of data from a randomized trial of sixty-one adolescents assigned to one of four exergames to play in their home for 4 weeks. Parents provided baseline demographic information. Adolescents completed the MEPI at the end of week 1 and completed game logs to record exergame play over the four weeks. Factor analysis with varimax rotation was used to determine the number of distinct composite factors within the MEPI. Cronbach's alpha assessed internal consistency of each resulting factor. Separate regression models were used to examine the association of each factor with total game play over 4 weeks. Twenty-two of 28 items were retained in the MEPI to measure five distinct constructs of motivation: sensory immersion/flow, user control, goals of the game, performance feedback, and challenge/difficulty. Sensory immersion/flow and user control were each significantly associated with total game play. Evidence of construct validity for the MEPI was demonstrated. The MEPI appears to be a promising tool to assess players' motivation for exergaming, an important contributor to sustained physically active game play.

Keywords: Physical activity; motivation; video games; self-report questionnaires

Introduction

Only 26% of U.S. adolescents report engaging in the recommended one hour of daily moderate-to-vigorous physical activity (MVPA) (Katzmarzyk et al., 2018), despite the documented benefits of MVPA on youths' cardiovascular health (Ekelund et al., 2012). Adolescents report a lack of competence and loss of interest as barriers to their physical activity (Slater & Tiggemann, 2010). Identifying innovative physical activity tools that motivate adolescents to engage in sustained MVPA remains a public health priority.

Exergames are video games that involve physical activity (Staiano & Calvert, 2011) and are highly popular among youth (O'Loughlin, Dugas, Sabiston, & O'Loughlin, 2012), including youth who are overweight or who report being excluded from competitive team sports (Biddiss & Irwin, 2010). Considering adolescents spend over 4.5 hours each day engaged with media (The Nielsen Company, 2017), exergames provide an opportunity to transform sedentary screen-time into active screen-time.

Literature Review

Exergames and duration of game play. Despite promising data that indicate playing exergames can result in greater levels of MVPA during acute bouts of game play (Barnett, Cerin, & Baranowski, 2011; Biddiss & Irwin, 2010; Peng, Crouse, & Lin, 2013), data are equivocal on the extent to which adolescents will play exergames over the long-term. Sustained gameplay is an important marker of motivation to play. In a study of children who received exergames to play in their homes over a 6-month period, body mass index and body fat were significantly reduced compared to a control group (Maddison et al., 2011). While Maddison et al. did not report change in game play duration across the 6-month intervention, children assigned to the exergaming group played 10 minutes/day more of exergames compared to the wait-list control group at 6 months. By contrast, other studies that also provided adolescents with exergames to play in their home with minimal support or supervision indicated that children and adolescents quickly lost interest in exergaming, experiencing a rapid decline in game play within the first few weeks of an exergaming intervention and no appreciable change in physical activity (Baranowski et al., 2012; Madsen, Yen, Wlasiuk, Newman, & Lustig, 2007).

While studies involving peer or coach support in a laboratory (Staiano et al., 2017) or school setting (Staiano, Abraham, & Calvert, 2013) indicated sustained engagement and attendance over a 3- to 6-month period, most exergame play occurs at home (Simons, de Vet, Brug, Seidell, & Chinapaw, 2014). A recent study observed sustained exergame play at home over 6 months (i.e. 94% adherence to 3 exergaming sessions/week) among children who also participated in regular video chats with a fitness coach (Staiano et al., 2018), but motivation was not measured to determine what specifically explained the sustained exergame play. If exergames are to be used as a physical activity tool at home, identifying the key motivators for sustained game play is critical so that players reap the cardiovascular benefits of physical activity.

Exergames and external motivation. According to Adams et al. (2009), the motivation to play exergames are due in large part to their immersive digital experiences with a multitude of stimuli and behavioral contingencies (i.e., antecedent stimuli, rewards/feedback, and/or advancement are contingent on player's performance). Behavioral contingencies vary across games and occur concurrently and in real time to externally motivate a player's initial engagement. Studies that explore how these embedded behavioral contingencies in exergames affect existing motivational domains within individuals are lacking. In the parent of this ancillary study, adolescents assigned to exergames with a greater number of behavioral contingencies embedded within the games engaged in more accelerometry-measured MVPA compared to those assigned to games with fewer behavioral contingencies (Norman et al., 2013). The purpose of the present ancillary analysis was to develop a publicly available and validated measure of psychological and motivational constructs specific to increasing the duration of exergame play.

Exergames and internal motivation. Although measures such as the Player Experience of Need Satisfaction (PENS) and Intrinsic Motivation Inventory (IMI; McAuley, Duncan, & Tammen, 1989) have been used to assess internal motivation for playing exergames, these measures were developed for video game play in general (PENS) or for academic activities and competitive sports (IMI). Exergames may invoke different motivators for sustained play. Drawing from motivational theories and empirical studies, the Motivation for Exergame Play Inventory (MEPI) survey was developed by the current authors to evaluate the psychological domains of *user challenge, control, and immersion* within the previously mentioned trial testing four exergames that varied in the number of existing behavioral contingencies. Domains of motivation were drawn from Malone and Lepper's taxonomy of intrinsic motivation for learning (Malone & Lepper, 1987) and self-determination theory (Deci & Ryan, 1985). Malone and Lepper's (1987) taxonomy of intrinsic motivation proposes that a balance of challenge and sense of control are key to *maintaining motivation* during game play. Motivation is achieved by providing explicitly challenging goals with ongoing performance feedback that is clear, constructive, encouraging, and frequent. Video games can equip players with a sense of control over the game play strategy and a sense of challenge that is scaffolded to a player's abilities to support feelings of autonomy and competence (Ryan, Rigby, & Przybylski, 2006).

User challenge. In the Malone and Lepper taxonomy, the domain of 'challenge' includes concepts of goals and feedback. Goal setting is a highly utilized behavior change mechanism (Cullen, Baranowski, & Smith, 2001) and may provide a purpose for game play, but the role of goals in motivating exergame play remains unclear (Baranowski, Maddison, Maloney, Medina, & Simons, 2014). Goals within video games are operationalized

differently than typically seen in interventions that use goal setting as a behavior change mechanism. In general, goals in behavioral interventions may be personal or negotiated with others but typically are more ambiguous and longer term than goals in a video game. By contrast, exergame goals tend to be more precise, frequent, and require changes to specific dimensions of behavior (e.g., jump as quick as possible after the tone or hit 3 Aces in a row in a tennis exergame) to earn the desired reward associated with the goal.

Performance feedback on progress towards goals can be provided in various forms including points earned, auditory or visual verbal feedback, and biofeedback, all of which can be delivered throughout game play, at certain intervals, or at the end of play (Baranowski, Bower, Krebs, Lamoth, & Lyons, 2013). A review of studies on exergame play indicated that perceptions of performance feedback and experiencing a sense of challenge influence greater physical activity during exergaming (Lyons, 2015).

User control. In-game autonomy and competence are related to game enjoyment and preference to continue to play (Ryan et al., 2006). Peng , Lin, Pfeiffer, and Winn (2012) manipulated self-determination theory constructs within exergames: college-aged students who played exergames that provided a greater sense of autonomy/control and supported player competence experienced satisfaction of psychological needs and a higher enjoyment of exergame play. Further, a study of 62 college students observed that player achievement measured as longer play duration predicted feelings of autonomy, competence, enjoyment, and future intentions to play (Limperos & Schmierbach, 2016). Similarly, a sense of control and autonomy predicted increased physical activity among adolescents (Biddle, Whitehead, O'Donovan, & Nevill, 2005), but the extent to which autonomy/control motivates adolescents during exergame play is unclear.

User immersion. Malone and Lepper's (1987) taxonomy also included the concept of sensory curiosity, which they describe as the attention-attracting value of changes in sensory stimuli in an environment. This concept can be equated to the constructs of immersion posited by Ryan et al. (2006) and Yee (2006), as well as flow (Csikszentmihalyi, 2008). Flow is characterized by a loss of self-consciousness and transformation of time (Csikszentmihalyi, 2008) and has been noted to occur during sports (Jackson & Csikszentmihalyi, 1999).

Video games create a sense of immersion and flow for players when they incorporate aspects of discovery, customization, role-playing (Yee, 2006) and have intuitive game controls to provide the player with a sense of mastery and control over game play (Ryan et al., 2006). Ryan et al. conducted a series of experiments that supported these concepts in traditional video game play, including that feelings of competence, autonomy, and immersion into the game contributed to motivation to play video games (Ryan et al., 2006). Scientists have hypothesized that exergames can induce similar motivational factors (Baranowski et al., 2013; Baranowski et al., 2014; Lyons, 2015), but the evidence remains scant.

Study Aims

The data presented are an ancillary analysis of a parent study that sought to understand the role of game design principles in sustaining game play over a 4-week intervention period (Norman et al., 2013). However, all adolescents dramatically declined in game play between weeks 1 and 4. The aims of the present study was: 1) to describe the development of the Motivation for Exergame Play Inventory (MEPI) survey, 2) to evaluate the construct validity of the MEPI survey tool by examining its factor structure with factor analysis, and 3) to examine the relationship of this tool to total exergame play.

Methods

Participants

Adolescents (11 to 15 years of age) were recruited using community newspaper advertisements, internet advertisements (e.g., Craigslist), university staff listserv emails, and flyers posted in the community between July 2009 and April 2010. Eligibility and demographic information were collected via a telephone screening with potential participants and their parents. A total of 107 inquiries were screened out of approximately 120 inquiries made by telephone (13 inquiries could not be reached for screening). Sixty percent (63/107) of those screened completed the baseline visit. Of those screened, 28 were not eligible to participate, 7 declined to participate, and

9 did not complete the screening. The participant's parent/guardian completed a demographic survey at the baseline visit including the child's sex, date of birth, race/ethnicity, height, weight, and household income. The adolescent's body mass index (BMI) was calculated as kilograms/meters squared, and BMI percentile was calculated based on the CDC national norms (Kuczmarski et al., 2002).

All study procedures were approved by the university institutional review board. The ClinicalTrials.gov registration number of this study is NCT01171261.

Exergames

Four exergames manufactured by SSD/XaviX ® (Shiseido Co. of Japan) were used in this study: *XaviX Tennis*, *XaviX Bowling*, *XaviX Boxing*, and *Jackie Chan Studio Fitness* (*J-MAT*). Each video game was contained in a cartridge that was inserted into the XaviXPort game console platform and used infrared sensors to track a game controller's movement. The XaviXPort communicated the player's movements to display on the television. The tennis, bowling, and boxing games simulate the physical activity of each sport using wireless controllers shaped like a tennis racquet, bowling ball, or boxing gloves, respectively. The J-MAT game includes a four-panel floor mat that wirelessly communicates with the gaming console to track stepping, running, and jumping movements. Each exergame package includes the game cartridge, the XaviXPort platform, and game controllers (e.g., tennis racquets, boxing gloves, bowling ball, or floor mat).

Procedures

The procedures were previously described (Norman et al., 2013). In brief, an initial visit was conducted in the participant's home by two research assistants. The participant and parent/legal guardian provided informed assent and consent, respectively, then completed a baseline survey. Afterwards, research assistants installed the XaviXPort platform on the participant's television, randomly assigned one of the four exergames to the participant, and provided instructions on how to play the game. The selected exergames varied in the number of observed behavioral contingencies embedded (i.e. number of behavior—response consequences for a player's actions) as measured by direct observation (Norman et al., 2013). Participants were asked to play the exergame for as much as they like for the next four weeks.

During the four-week study, each participant was contacted three times (once per week) via telephone by study staff to complete a short survey on game play and attitudes about the exergame. At the end of week 4, research assistants visited the participant's home to collect the gaming package, to administer the final surveys, and to distribute participant compensation ($50 for completing all study procedures). All participants received the same compensation on the same schedule, effectively eliminating this variable as an explanation of the effects.

Measures

The Motivation for Exergame Play Inventory (MEPI). The Motivation for Exergame Play Inventory (MEPI) was developed for the study (see Table A1 in Appendix). We developed an initial pool of items designed to be indicators of the latent constructs of Challenge, Sensory/Immersion, and Control. Following initial item construction, doctoral and graduate level researchers individually rated items taking into consideration face validity, singularity of concept, appropriate length, and reading level. Items ratings and feedback on specific items resulted in the set of 28 items. Twenty-four items were newly developed based on Malone and Lepper's Taxonomy of intrinsic motivations for learning (Malone & Lepper, 1987) and self-determination theory (Deci & Ryan, 1985). Four items were from Ryan's Player Experience of Need Satisfaction (PENS) measure (Ryan et al., 2006) (Questions 10, 13, 25, and 28 in Table 1). Constructs included 11 items to measure game challenge related to optimal difficulty, goals, and feedback; 8 items to measure sensory immersion/flow; and 9 items to measure control/choice. Response options ranged from 1 "strongly disagree" to 5 "strongly agree".

The MEPI was administered by a research assistant at Week 1 during the telephone call. The purpose of administering this survey at Week 1 was to capture the adolescent's motivation to play following an initial familiarization period of exergame play.

Game logs. Participants were asked to record information about game play on a paper log after each exergame play bout, including the date, start and end time, game mode (e.g. challenge games, tournament), and with whom they played. This information was queried during the weekly telephone survey, and logs were collected at the end the study to calculate total minutes of game play over 4 weeks.

Data Analysis

To assess internal validity of the MEPI inventory, factor analysis with varimax rotation was used to determine the number of composite item scales within the 28-item inventory. Varimax rotation maximizes the variance shared among items within each component, while decreasing correlations between other factors. An item was included in a composite scale if it had a factor loading of ≥ .40 on a single factor and loading less than .40 on the remaining factors.

Based on the factor analysis, composite item scales were computed as the unit weighted average of the items loading on a factor. Correlation coefficients determined the strength of associations among the resulting scale scores, and Cronbach's alpha assessed internal consistency of the items within each scale.

To assess external validity of the MEPI scales, separate regression models were specified for each scale with the scale as the independent variable and the total game play logged minutes over the four weeks as the dependent variable. Covariates (i.e. sex, age. Hispanic origin, family income, and BMI z-score) were included in the regression models due to observed group differences in exergame play and media use in prior studies (Biddiss & Irwin, 2010; O'Loughlin et al., 2012; The Nielsen Company, 2017).

Results

The study sample of 61 adolescents (M_{age} = 13.2, *SD* = 1.30, range 11-15 years old) was 38% female and 38% of Hispanic origin. BMI percentile classified 27% as overweight and 16% as obese. The number of weekly game log entries ranged from 0 to 20 and indicated that 98% played the game during the first week, 48% played during the second week, 56% played during the third week, and 38% played during the fourth week.

MEPI Construct Validity and Internal Consistency

The factor analysis with varimax rotation resulted in 22 items loading on five factors, which explained 58% of the variance. One item ("I was able to play the game well") did not load on any factor, and five items had loadings > .40 on more than one factor. A follow-up factor analysis on the 22 items resulted in five factors explaining 60.1% of the variance with the same pattern of loadings. Initial extraction resulted in eigenvalues ranging from 5.94 to 1.43 indicating that each factor contributed to variance explained by the five factors.

Table 1 reports the factor loadings for the remaining 22 items. The first factor included 8-items and represents sensory immersion and flow aspects of game play. The second factor consisted of 4 items related to user control of the game. The third factor had 3 items related to goals of the game. The fourth factor included 4 items about the game providing performance feedback. The fifth factor consisted of 3 items about the challenge and difficulty of the game.

Means, standard deviations, internal consistency assessed with Cronbach's alpha, and correlations among the scales are presented in Table 2. Alpha was lowest for challenge goals at .50 and highest for sensory at .87. The alpha coefficient for challenge/difficulty improved from .66 to .79 if item 11 was dropped from the scale, but because that left only two items remaining, the item was retained.

Correlations among the five scales were low to moderate, ranging from .03 between goals and difficulty to .43 between user control and sensory immersion/flow. The four correlations above .21 were statistically significant at the p <.05 level. The low to moderate correlations indicate that these five scales measured fairly distinct aspects of motivation.

Table 1. *Rotated Factor Loadings from the 5-Factor Extraction for Items in the Motivation for Exergame Play Inventory.*

	1	2	3	4	5
Sensory Immersion / Flow					
6. I liked the game's sound effects.	.74				
7. I felt like I was really part of what was happening in the game.	.73				
8. The game is addictive.	.72				
9. I lost track of time playing this game.	.72				
10. The game provides me with interesting options and choices.	.65				
21. I liked the game's graphics.	.67				
22. I discovered new things about the game the more I played it.	.54				
24. Given the chance I would play this game in my free time.	.73				
User Control					
12. I felt like I could control what was happening in the game.		.66			
13. Learning the game controls was easy.		.84			
14. I felt like my movements were controlling the game.		.64			
27. The game controllers (e.g., tennis racquet, bowling ball) tracked my movements well.		.63			
Goals of the Game					
3. The purpose of the game was easy to understand (i.e. winning or scoring high point totals).			.65		
18. I knew what I had to do to win the game.			.75		
28. When I wanted to do something in the game, it was easy to remember the correct control.			.56		
Performance Feedback					
4. There were tips in the game that helped me play better.				.71	
5. The game gave me feedback on how to improve my play.				.60	
19. The game gave me feedback on how I was doing.				.67	
20. I was able to practice skills in the game that helped me play better.				.71	
Game Challenge and Difficulty					
2. The game got harder as it went along.					.81
11. I tried to figure out new ways to play the game.					.44
15. The game was challenging for me.					.87
Did Not Load on any Factors					
1. I was able to play the game well.					
Loaded on Multiple Factors					
16. The game kept me on my toes but did not overwhelm me.					
17. The game included challenges within each level.					
23. I found myself getting totally absorbed in the game.					
25. The game lets you do interesting things.					
26. I was able to play the game the way I wanted to play it.					

In multivariable regression models adjusted for demographic variables, total game play minutes over four weeks were regressed onto each of the five MEPI scales and covariates of sex, age, Hispanic origin, family income, and BMI z-score. Table 3 shows the standardized beta coefficients and 95% confidence intervals for the MEPI scales. MEPI scales for sensory/flow and user control were statistically associated with game play minutes. Table 3 also shows the range of standardized beta coefficients and range of p-values for the covariates across the five regression models.

Table 2. *Means, Standard Deviations, Internal Consistency Coefficients, and Correlations Among the Five Motivation for Exergame Play Inventory Scales.*

	1. Sensory Immersion / Flow	2. User Control	3. Goals of the Game	4. Performance Feedback	5. Game Challenge and Difficulty
1.	**.87**	.43 *	.17	.39 *	.41 *
2.		**.73**	.27 *	.18	.11
3.			**.50**	.08	.03
4.				**.66**	.21
5.					**.66**
***M*[a]**	3.54	4.03	4.60	3.69	3.44
SD	.81	.80	.47	.80	.89

Note. Internal consistency alpha coefficients displayed on the diagonal. $N = 61$.
a. Mean is the average of items for that scale with scale scores ranging from 1 to 5.
* Correlation coefficients greater than .21 are statistically significant at $p < .05$.

Table 3. *Estimated Standardized Betas from Multiple Regression Models of Motivation for Exergame Play Inventory Scales Predicting Total Game Play Minutes over Four Weeks.*

	Standardized Beta	95% CI	*p*-value	R^2
MEPI Scales				
Sensory Immersion / Flow	.39	[.12, .68]	.005	.20
User Control	.27	[.01, .43]	.043	.14
Goals of the Game	.16	[-.11, .43]	.241	.10
Performance Feedback	.03	[-.25, .30]	.831	.08
Game Challenge and Difficulty	.13	[-.17, .43]	.393	.09
Covariates				
Child's sex	-.12 to -.08[a]	-	.336 to .581[b]	-
Child's age	-.14 to -.07[a]	-	.259 to .844[b]	-
Hispanic origin	-.03 to .16[a]	-	.302 to .588[b]	-
Family income	-.10 to .04[a]	-	.472 to .888[b]	-
BMI z-score	.09 to .14[a]	-	.325 to .528[b]	-

Note. Each scale was the independent variables in a separate regression model adjusting for covariates: child's sex, age, Hispanic origin, family income, and BMI z-score ($N = 61$).
a. range of standardized betas across five regression models.
b. range of *p*-values for standard betas across five regression models.

Discussion

The purpose of this study was to develop a publicly available and validated measure of psychological and motivational constructs specific to increasing the duration of exergame play. To accomplish this purpose, we completed the following aims: 1) we developed the MEPI, 2) we determined the construct validity of the MEPI tool, and 3) we examined the relationship of this tool with duration of exergame play. Given the insufficient levels of physical activity engaged by modern adolescents (Katzmarzyk et al., 2018), developing and validating a tool to measure motivation may identify opportunities to elicit more physical activity during adolescents' daily lives. With screen-time technologies like exergames transforming sedentary screen-time into physical activity, identifying motivators to sustain physically active game play may support players' healthy habits and thereby promote cardiovascular health.

To complete the first aim, we identified an initial list of items for inclusion in the tool related to Challenge, Sensory/Immersion, and Control, which were chosen based on the theoretical frameworks of intrinsic motivation for learning and self-determination theory. To complete the second aim, the full MEPI instrument was then tested

within a randomized trial of sixty-one adolescents who had been assigned to play exergames in their home. From their responses, we used exploratory factor analysis to derive five distinct factors of exergaming motivation: sensory immersion/flow, user control, goals, performance feedback, and difficulty/challenge. Finally, to complete the third aim, we examined relationships of the tool with duration of the adolescents' exergame play and determined that sensory immersion/flow and user control were each associated with total game play minutes over 4 weeks.

Sensory immersion and flow was the strongest factor related to higher amounts of total game play. Seven of the eight items developed to measure immersion loaded on this factor. This is one of the first reports to support a prior literature search that indicated that exergame play allows a player to experience flow (Lyons, 2015) and that flow is an important predictor for accumulated minutes of exergaming. Immersion into a game is assisted by experiencing graphics, sounds, progression, and other stimuli.

Control was the second strongest factor contributing to total game play. Four of the nine control items loaded uniquely on this factor. Importantly, the exergames played in the present study involved game controller peripherals that mimicked authentic sports, such as a tennis racquet, bowling ball, and boxing gloves, which may have aided with senses of both immersion and control. Control over game play in the present study was related to total game play, which aligns with prior evidence that control and autonomy are predictors for increased adolescent physical activity (Biddle et al., 2005), as well as studies that indicate college students experienced greater enjoyment and satisfaction of psychological needs when playing exergames that provided a sense of autonomy/control (Peng et al., 2012) and player achievement (Limperos & Schmierbach, 2016).

The eleven originally developed challenge items did not load onto a single factor representing challenge, but rather, 10 of the 11 items divided into three separate factors: goal setting, performance feedback, and challenge/difficulty. While these were distinct constructs, the challenge constructs were not related to total game play. The present results did not support prior findings from a literature search that perceptions of performance feedback and a sense of challenge influence higher physical activity (Lyons, 2015).

This finding of non-significance may not generalize to other exergames that evoke more variation in feedback and challenge. It also may be the case that the MEPI scales need further refinement. Adding additional items to the 'performance feedback' and 'game challenge and difficulty' scales would likely improve scale reliability and capture more of these constructs' content domains. The sense of challenge/difficulty is related to working towards behaviors that are both personally meaningful and that require sustained effort, which may make capturing these complex perceptions difficult. Challenging and rewarding games are perceived as highly motivating for players (Baranowski, Buday, Thompson, & Baranowski, 2008), whereas playing an exergame that lacks optimal challenge has been noted as a detractor of motivation during exergaming (Osorio, Moffat, & Sykes, 2012).

The present investigation of motivation while exergaming can be compared to motivation while engaging in other types of video games. Survey results of 3000 players of massively-multiplayer online role-playing games (MMORPGs) indicated three factors for motivation: achievement, social interaction, and immersion (Yee, 2006). The achievement component included advancement (the desire to gain power, progress rapidly, and accumulate in-game status symbols) and competition (the desire to challenge and compete with others). These constructs align with the MEPI components of performance feedback and of game challenge and difficulty, neither of which were significantly related to game play in the present study.

The immersion factor identified in the Yee (2006) study included components of discovery and escapism, constructs that align with the MEPI factor of sensory immersion/flow. One key difference is that the MEPI instrument used in the present study did not measure social factors. Whereas MMORPG by nature involves playing with or against others, the adolescents in the present study had a choice whether to play alone or with a partner. Given the success of adult coaching (Staiano et al., 2018; Staiano et al., 2017), parent and family game play (Staiano et al., 2018), and cooperative game play with peers (Staiano et al., 2013) to achieve sustained adherence in exergaming trials, the role of social support on sustained exergame play warrants further investigation.

Strengths and Limitations

A strength of this study was the sample of adolescents who were diverse in terms of ethnicity and weight status, nearly half of whom were classified as overweight or having obesity. Limitations include the relatively brief period of observation (4 weeks) and self-reported game play minutes. The relatively small sample size limited the statistical power to detect smaller effects sizes found for the Goals of the Game and Game Challenge/Difficulty scales. The data were collected several years ago, and in the interim period exergames have become increasingly responsive to user control and more immersive (e.g. virtual reality games). Nevertheless, the motivational domains included in the MEPI are fundamental behavioral constructs and should still apply to players' experiences with the newer generation exergames.

Future Directions for Research

The MEPI survey should be validated in other populations and with other exergaming platforms such as ones that sense the whole body or use virtual reality, which will be a significant next step. Secondly, the MEPI survey should be examined for its utility to monitor longer-term exergame play beyond 4 weeks. Different motivational constructs may drive a longer-term commitment to sustained exergaming, such as the extent to which game play is tailored to the individual characteristics and personality of the player (Macvean, 2012). For instance, players may choose to continue playing games over the course of several weeks or months due to different motivations: achievement regarding mastery over the game, socialization to interact with other players, or immersion in order to escape into the game (Yee, 2006). The optimal thematic content and style of play may vary based on the player's unique psychological needs and may evolve over time.

Conclusions

The MEPI tool is a promising instrument used to assess players' motivation for playing exergames. Five distinct constructs emerged: sensory immersion/flow, user control, goals of the game, performance feedback, and challenge/difficulty. Sensory immersion/flow and user control were each, in turn, related to total game play. There are opportunities to improve the MEPI, such as adding a social scale component to capture social interaction during exergame play and adding additional items to the performance feedback and the game challenge/difficulty scale to more comprehensively capture these domains. If exergaming is to be used to offer alternative ways to meet MVPA guidelines, identifying factors that motivate sustained exergaming is critical to promote players' cardiovascular health.

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Appendix

Table A1. *Motivation for Exergame Play Inventory.*

For each statement please circle which response is most true for you about playing the exergame.					
	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1. The game got harder as it went along.	1	2	3	4	5
2. The purpose of the game was easy to understand (i.e. winning or scoring high point totals).	1	2	3	4	5
3. There were tips in the game that helped me play better.	1	2	3	4	5
4. The game gave me feedback on how to improve my play.	1	2	3	4	5
5. I liked the game's sound effects.	1	2	3	4	5
6. I felt like I was really part of what was happening in the game.	1	2	3	4	5
7. The game is addictive.	1	2	3	4	5
8. I lost track of time playing this game.	1	2	3	4	5
9. The game provides me with interesting options and choices.	1	2	3	4	5
10. I tried to figure out new ways to play the game.	1	2	3	4	5
11. I felt like I could control what was happening in the game.	1	2	3	4	5
12. Learning the game controls was easy.	1	2	3	4	5
13. I felt like my movements were controlling the game.	1	2	3	4	5
14. The game was challenging for me.	1	2	3	4	5
15. I knew what I had to do to win the game.	1	2	3	4	5
16. The game gave me feedback on how I was doing.	1	2	3	4	5
17. I was able to practice skills in the game that helped me play better.	1	2	3	4	5
18. I liked the game's graphics.	1	2	3	4	5
19. I discovered new things about the game the more I played it.	1	2	3	4	5
20. Given the chance I would play this game in my free time.	1	2	3	4	5
21. The game controllers (e.g., tennis racquet, bowling ball) tracked my movements well.	1	2	3	4	5
22. When I wanted to do something in the game, it was easy to remember the correct control.	1	2	3	4	5

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