

Lessons learned during formative phase development of an asynchronous, active video game intervention: Making sedentary fantasy sports active

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ABSTRACT

Objectives: Active fantasy sports is a type of active video game (AVG) developed using principles from self-determination theory and the trans-contextual motivation model. The game leverages elements of a popular, previously sedentary game – traditional fantasy sports – but incorporates and encourages physical activity (PA) of participants ("fantasy team owners"). Early proof-of-concept stage research demonstrated potential for active fantasy sports to increase PA in adults (Moller et al., 2014). However, more formative research identifying factors that influence enjoyment of active fantasy sports and PA goal achievement could improve efficacy and inform the development of alternative AVGs.

Design: Three active fantasy sports leagues were organized and data from the three leagues were combined to examine intervention and social factors that predicted enjoyment and PA goal achievement.

Method: Participants ($N = 33$, 15.2% female, M -Age = 34.0 years) wore an accelerometer to track PA and completed self-report measures about their experience upon league conclusion (league duration ranged from 16 to 17 weeks).

Results: Findings revealed that average steps significantly increased during the first six weeks of the intervention and then significantly decreased during subsequent weeks. Frequency of checking the league website was associated with greater PA goal achievement. Greater frequency of checking the accelerometer website and the league website were also associated with greater league enjoyment.

Conclusions: Promoting greater frequency of using the league and accelerometer websites is important to achieving greater impact on PA and league enjoyment through active fantasy sports. Future studies of active fantasy sports leagues could use randomized controlled trial and multiphase optimization strategy designs to vary game components in order to test which components sustain intrinsic motivation and increase PA. Lessons may be further applied to the development of other AVGs, especially those that build on established and popular sedentary video games.

1. Introduction

Regular physical activity (PA) is associated with overall health and a reduced risk for chronic illnesses, such as cardiovascular disease, type 2 diabetes, metabolic syndrome, and certain types of cancer (Centers for Disease Control and Prevention [CDC], 2015). In order to attain these health benefits, the Office of Disease Prevention and Health Promotion (2018) suggests that adults should engage in at least 150 minutes of moderate intensity aerobic PA each week (Giroir & Wright, 2018; Office of Disease Prevention and Health Promotion, 2018). This lack of physical activity is linked to \$117 billion in annual health care costs (Giroir et al., 2018). Despite the well-publicized health benefits, only 26% of men, 19% of women, and 20% of adolescents in the United States

achieve the recommended amount of PA (Giroir et al., 2018).

1.1. Active video games

Active video games (AVGs) are a type of video game that require physical movement (Wiemeyer et al., 2015). Popular examples of AVGs include arcade games like Dance Dance Revolution, mobile phone-based games like Run Zombie Run, as well as games played on dedicated home consoles, such as the Nintendo Wii and Xbox 360 Kinect. Although these AVGs initially seemed promising for increasing population-level PA (Baranowski, Baranowski, Thompson, & Buday, 2011), so far, AVGs have been most effective for promoting PA in specific subpopulations (e.g., for older adults, individuals with disabilities, or

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those who are recovering from injuries). The results have been mixed for promoting PA in the general population. Baranowski, Baranowski, O'Connor, Lu, and Thompson (2012) concluded that AVGs evidenced minimal and temporary impacts on PA in adolescents. However, several systematic reviews suggest that AVGs are associated with increases in children's PA (Biddiss & Irwin, 2012; Norris, Hamer, & Stamatakis, 2016; Peng, Crouse, & Lin, 2011). Howe, Barr, Winner, Kimble, and White (2015) found that PA energy expenditure for adults (18–35-years-old) was significantly greater for AVGs than traditional seated video games. Additionally, a systematic review that explored the use of exergaming (playing AVGs) to promote PA behaviors in adults found that exergaming provided a novel method for increasing or substituting PA in the short term (Street, Lacey, & Langdon, 2017).

Asynchronous AVGs. One strategy for achieving greater generalizability of PA involves incorporating asynchronous PA into an AVG. Most AVGs involve synchronicity between players' physical movements and consequences in the game (i.e., synchronous AVGs). Asynchronous AVGs are games that involve accumulating credit for PA completed when not directly interacting with a game's screen-based interface. That is, rather than encouraging PA exclusively while playing and interacting with a digital screen (synchronously), AVGs can allow participants to earn and accumulate credit for engaging in ongoing PA (asynchronously). These asynchronous AVGs are also referred to as "accumulated activity games" (Mandryk, Gerling, & Standley, 2014). The AVG focal to the present study aimed to improve the efficacy of existing AVGs for the widest possible audience by incorporating asynchronous PA into an established sedentary video game, one that is already very popular with a general population audience (including adolescents, young and middle-aged adults), *fantasy sports*.

1.2. Fantasy sports

What are traditional fantasy sports? Traditional, season-long fantasy sports are a type of sedentary game played with small groups of friends or acquaintances (a "fantasy league" comprised of typically 8–16 people) over the course of a real professional sports season (typically lasting 12–24 weeks, depending on the type of sport). Participants ("fantasy team owners") draft and manage imaginary teams comprised of real professional athletes, and each fantasy team owners' performance is based on the performance of those real professional athletes from day-to-day or week-to-week. Thus, the game involves following data related to the real world performance of professional athletes and making predictions about their future performance.

What are active fantasy sports? Active fantasy sports make traditional fantasy sports active by integrating the PA of the fantasy team owner. In active fantasy sports, team owners' PA is objectively measured using an accelerometer, and their PA relative to other team owners impacts their fantasy team's performance.

1.3. Self-determination theory & the trans-contextual model of motivation

We endeavored to improve upon existing AVGs using a theory-guided approach, specifically by leveraging principles from self-determination theory (SDT; Ryan & Deci, 2017) and the related trans-contextual motivation model (TCMM; Barkoukis, Hagger, & Lambropoulos, 2010; Chan, Hagger, & Spray, 2011; Hagger & Chatzisarantis, 2012). SDT is an empirically derived macro-theory of human motivation (Deci & Ryan, 2011; Ryan & Deci, 2017), which has been useful in identifying factors that sustain individuals' motivation for PA (Teixeira, Carraça, Markland, Silva, & Ryan, 2012), within sedentary video games (Rigby & Ryan, 2011), and specifically within AVGs (Peng, Lin, Pfeiffer, & Winn, 2012).

A foundational principle in SDT concerns differentiating between intrinsic and extrinsic forms of motivation. Intrinsic motivation is characterized by positive emotions, like interest and enjoyment, and is

defined by rewards that are intrinsic to a task or activity itself. By contrast, extrinsic motivation tends to be characterized by more negative emotions, like anxiety, and is defined by rewards that are extrinsic to a task or activity. Decades of research on SDT suggests that, although people can be strongly motivated for either intrinsic or extrinsic reasons, intrinsic motivation for a behavior tends to result in greater consistency or maintenance of the behavior over time. This pattern exists in behavioral medicine, and specifically with regard to maintaining PA (e.g., Teixeira et al., 2012; Wasserkampf, Santos, Carraca, Meis, Kremers, & Teixeira, 2014). Given that AVGs are designed to promote intrinsic motivation, we used principles from SDT when designing our AVG.

Specifically, we designed the active fantasy sports intervention to support relatedness, one of the three basic needs relevant to intrinsic motivation. Many studies of PA interventions, including those based on SDT, have shown that supporting social interaction promotes relatedness, and sustained intrinsic motivation (e.g., Sylvester et al., 2014). More recently, AVGs specifically designed to emphasize social incentives effectively supported intrinsic motivation and increased PA (Patel et al., 2017). Within our active fantasy sports intervention, team owners were encouraged to interact socially via the league discussion board and were updated on the other team owners' PA progress to facilitate social comparisons. Initial evidence in college students suggests that encouraging opportunities for social comparison via online social networks increases PA more than providing support (Zhang et al., 2016).

Another foundational principle of SDT concerns the potential for extrinsic incentives, rewards or punishments, to undermine intrinsic motivation. All physically active games, including AVGs, include incentives for physical activity. Thus, it is critical to consider how extrinsic incentives are used. An SDT-guided meta-analysis of 128 experiments involving the effects of rewards on intrinsic motivation found that specific forms of incentive are more or less likely to undermine intrinsic motivation. Specifically, tangible rewards (i.e., physical incentives, as opposed to intangible or symbolic incentives) were found to have a more negative effect on intrinsic motivation. By contrast, positive feedback (considered an intangible incentive) was found to have a net positive effect on intrinsic motivation. SDT researchers have posited that extrinsic incentives tend to undermine intrinsic motivation to the extent that they are experienced as manipulative or controlling, as opposed to informational (e.g., see Moller & Deci, 2014; Ryan & Deci, 2017). As such, the extrinsic incentives incorporated into the Active Fantasy Sports AVG were designed to be modest, and/or intangible/symbolic.

The TCMM (Barkoukis, Hagger, Lambropoulos, & Tsorbatzoudis, 2010; Chan et al., 2011; Hagger & Chatzisarantis, 2012) extends SDT in several important ways. TCMM posits that the quality and quantity of motivation in one context or setting can often "spill-over" or transfer into another related context (e.g., from formal physical education into leisure time PA). Based on this principle, when designing our AVG, we opted to build upon an existing sedentary gaming platform (traditional fantasy sports) that had already been shown to promote and sustain intrinsic motivation over long periods of time, rather than create an entirely new game. The popularity of online fantasy sports has been steadily increasing for the last 30 years. The most recent estimates of audience size suggest that 59.3 million people were enrolled in online fantasy sports leagues in 2017 in the United States and Canada (Fantasy Sports Trade Association, 2017). Many participants in traditional fantasy sports leagues maintain their intrinsic motivation for years or even decades (Fantasy Sports Trade Association, 2017). For example, Howe and Campbell (2015) examined a fantasy sports league that remained relatively unchanged in terms of membership since the debut of the league in 1999 (over a decade). Our hypothesis, based on TCMM, was that intrinsic motivation for sedentary fantasy sports might transfer into intrinsic motivation for our AVG and PA.

A second and related application of TCMM involved the connection

of our AVG to the intrinsic motivation associated with being a spectator or fan of professional sports, in general. One explanation for fantasy team owners' sustained interest in fantasy sports involves strong identification with professional sports teams. Many people perceive their fandom or loyalty to a professional sports team as an important component of their identity (e.g., by wearing clothing that identifies them as fans; Rhodes, Kaushal, & Quinlan, 2016). We hypothesized that fans' strong identification with professional sports teams and intrinsic motivation for spectatorship might translate into more sustainable interest in our active fantasy sports AVG.

Consistent with this hypothesis, prior research suggests that associating an in-person PA or weight loss intervention to an individual's identification with a professional sports team has the potential to be a very powerful motivator (Hunt et al., 2014). European Fans in Training (EuroFIT) is a PA intervention trial under investigation in five countries that attempts to motivate individuals to increase PA via their emotional connectedness to a professional soccer club (Van Nassau et al., 2016). This work was inspired by an intervention delivered by Scottish Premier Football Clubs, which facilitated weight loss in male football (i.e., soccer) fans (Hunt et al., 2014). Other research on sedentary video games that thematically involve professional sports has demonstrated that playing professional sport themed video games predicted increased fitness and participation in real-life sport among children, adolescents, and young adults (7–25 years) over a 3-year period (Adachi & Willoughby, 2016; Bai et al., 2016). Furthermore, opportunities for identification with professional athletes and sports teams is another component of active fantasy sports that provides support for the psychological need for relatedness.

Learning from Pokémon GO. Pokémon GO represents (by many accounts) the most popular and successful AVG designed for a general population audience. Pokémon GO achieved staggering reach, acquiring an estimated 15 to 21 million daily users within two weeks of its launch (Wagner, 2016) and helped millions of people become more physically active (Althoff, White, & Horvitz, 2016). Given the success of the Pokémon GO AVG, we briefly consider how our Active Fantasy Sports AVG compares in terms of (i) the transfer of intrinsic motivation theorized in the TCMM, and (ii) the integration of synchronous versus asynchronous PA. The success of Pokémon GO may be related to the game leveraging strong established enthusiasm that many people had for Pokémon characters, sedentary card games and cartoons. In other words, a large audience was already intrinsically motivated to attend to the Pokémon franchise, and consistent with the TCMM, their intrinsic motivation transferred to Pokémon GO.

Another unusual feature of Pokémon GO concerns its incorporation of asynchronous PA elements. Pokémon GO is a smartphone-based AVG that requires players to physically move through space (as opposed to physically move “in place”) in order to discover Pokémon in their real world (outdoors). When a Pokémon character is nearby, a vibration or sound notifies the player and very small synchronous movements (swiping a finger across the smartphone screen) allow players to capture it (Pokémon Go, 2016). Several studies have documented significant increases in physical activity associated with game play (Barkley, Lepp, & Glickman, 2017; LeBlanc & Chaput, 2017; Wagner-Greene et al., 2017). For example, a study by Wagner-Greene et al. (2017) assessed self-reported physical activity before and after downloading the Pokémon GO app. Before downloading the game, only 31% of the respondents met the recommended 150 min per week activity level, whereas 75% met this level after starting the game. Importantly, these increases in PA are best explained by asynchronous (walking), as opposed to synchronous (finger swiping) aspects of this AVG.

Thus, similarly to the Pokémon GO AVG, the Active Fantasy Sports AVG under development leverages: (1) established enthusiasm for an activity that was previously sedentary (enthusiasm for professional sports, in general, and more specifically for playing traditional fantasy sports), as well as (2) the incorporation of asynchronous PA.

Potential efficacy of active fantasy sports. A small, single proof-

of-concept study that included both sedentary and physically active adults ($N = 19$) provided some early evidence that participants who played in the active fantasy sports league either maintained (i.e., did not change during fall-to-winter months typically associated with reduced PA) or increased their PA (Moller et al., 2014). However, this small proof-of-concept study provided limited insight into generalizability of acceptability, mechanisms that might help to explain efficacy, or how activity fantasy sports could be improved.

1.4. The present investigation

In order to build toward more sophisticated tests of intervention efficacy (e.g., a randomized controlled trial), and shape future active fantasy sports intervention development, it is imperative to understand the intervention components that lead to changes in PA and to enjoyment of the active fantasy sports league. Prior research finds that positive affective responses during exercise are associated with future PA (Rhodes & Kates, 2015). As such, in the present investigation we examined participants' enjoyment of the active fantasy sports league as one of our main outcome variables.

We hypothesized that PA would increase over the duration of the active fantasy sports intervention (H1a), and that participants would enjoy the active fantasy sports intervention (H1b). Furthermore, we hypothesized that baseline PA, social factors, and use of intervention components would be associated with both PA change (H2a) and enjoyment (H2b). Social factors include the number of league members known at baseline, participants' perceived value of knowing other league members at baseline, and frequency of discussions with other league members. Intervention components include frequency of checking PA on an accelerometer, frequency of checking PA on the accelerometer website, and frequency of checking the active fantasy sports website.

2. Methods

2.1. Participants

Recruitment targeted faculty, staff, and students at two separate institutions: (blinded for review) and (blinded for review). Participants were recruited from flyers posted around the institutions, as well as emails sent to university-based email addresses. Participants were informed that this study aimed to examine the effect of an active fantasy sports league on PA.

Eligibility criteria required participants to be 18 years of age or older and affiliated with either (blinded for review) or (blinded for review) and were deemed safe to increase their PA as assessed via the PA Readiness Questionnaire (PAR-Q; Thomas, Reading, & Shephard, 1992). Participants were excluded if they were unable to provide informed consent, currently pregnant or planning pregnancy, or deemed not ready to increase his or her PA per a safety questionnaire. There were 51 individuals at (blinded for review) who initially inquired about the study. Of those 51 individuals, 20 (39.2%) met eligibility criteria and were enrolled. There were 20 individuals at (blinded for review) who initially inquired about the study. Of those 20 individuals, 16 (80%) met eligibility criteria and were enrolled. Between the two institutions, 36 participants were enrolled in one of three active fantasy sports leagues. Three participants (8.3%) dropped out of the study during the 16–17 week season; however, those participants did not differ significantly from completers in terms of PA during the intervention (Little's MCAR test: $\chi^2(29) = 31.78, p = 0.33$). Thus, the final sample included 33 participants.

2.2. Procedure

Interested individuals contacted the research team via email or phone call. A member of the research team conducted a telephone

screening and provided information about the study. Participants provided verbal consent and were screened to determine eligibility. Individuals who met eligibility criteria were scheduled for a 45-min in-person session where they provided written informed consent, completed baseline measures, and were oriented to one of three active fantasy sports leagues. Participants completed baseline measures in Qualtrics, a secure web-based application that has been designed for data collection for research studies or via paper copies of the questionnaire, which were then double entered into SPSS by research assistants. Following completion of these measures, participants received an accelerometer, (Fitbit Inc., 2014), which was used to assess baseline PA and establish each participant's weekly step goal. Participants also received handouts and verbal instruction on appropriate wear and use of the accelerometer, as well as the activity monitor website.

Participants enrolled in the active fantasy sports league created an account that allowed them to access the accelerometer website and a closed Yahoo online active fantasy sports league. Active fantasy sports leagues were limited to active study participants and were separated by institution and affiliation; there were three total active fantasy sports leagues. The fantasy sports league conducted at (blinded for review) was a National Football League (NFL) active fantasy sports league that ran for 16-weeks. There were two National Basketball Association (NBA) active fantasy sports leagues conducted at (blinded for review) (NBA#1) and (blinded for review) (NBA#2) that ran for 17-weeks. During the intervention phase, participants competed in an active fantasy sports league hosted by Yahoo.com. The principal investigators, serving as league commissioners, managed game-related consequences using the league commissioner tools provided by Yahoo once a week. Participants were updated on the other owner's PA goal progress once a week via messages posted to the league discussion board. Poll questions were also posted to the league discussion board once per week by the principal investigators in order to promote between-member communication. For example, participants were asked to respond to multiple-choice questions such as, "What aspect of health is hardest for you?" Additional features of the active fantasy sports intervention platform that encouraged peer-to-peer communication included opportunities for private messaging among participants and offering player trades. Participants were able to access their own PA data at any time via the accelerometer, or the accelerometer's website/dashboard or smartphone application. Participants could access the fantasy league anytime via both Yahoo's website and smartphone application.

PA goal settings. PA was measured throughout the intervention using the accelerometer and PA goals increased by ten-percent each week (unless the max goal of 10,000 steps was reached). For example, an individual who averaged 3219 steps per day during baseline was provided with a personalized PA goal of 3541 steps per day during the first week of the intervention. The rationale for increasing the goal by 10% each week was to avoid potential injury and try to make the goal challenging for less active participants. Tudor-Locke and Lutes (2009) suggest that the setting of any goal above baseline values for an individual to work towards may be sufficient to increase PA; suggestions include the method used in the present study (i.e., increment above individual baseline). PA goals were maxed at 10,000 steps per day; previous research suggests that individuals who accumulate 10,000 steps per day are likely to meet the current PA guidelines established by the Office of Disease Prevention and Health Promotion (Le-Masurier, Sidman, & Corbin, 2003; Office of Disease Prevention and Health Promotion, 2008). In the present study, 7 participants achieved an average of 10,000 steps per day during baseline; those participants maxed out their PA goal at 10,000 steps per day from the start of the intervention. These participants had a weekly PA goal equal to their baseline average throughout the duration of the intervention. By the end of the intervention, 90% ($N = 30$) of participants had maxed out their PA goal at 10,000 steps per day.

Each week, the percent of PA goal completed was connected to two game-related consequences. First, team owners who failed to meet their

PA goal had a player randomly selected for removal from their roster. The player was selected from their roster using a random number generator (i.e., selecting a number between 1 and 13), which was the number of players on every team's roster). Yahoo maintains and updates each week a list of the most valuable 100 NBA (or NFL) players for fantasy sports purposes (i.e., the Yahoo Can't Cut List); if the player randomly selected was on that list, the next player on the roster was dropped instead. Second, waiver wire priority was dependent on the average percent of PA goal completed during the prior week. Waiver wire priority is a feature of fantasy sports leagues that involves team owners' ability to add unclaimed players who are not currently on another team owners' roster at specified times (these unclaimed players are said to be on the "waiver wire"). Thus, earning higher waiver wire priority based on being more physically active provided team owners with an advantage. During a specified time each week, waiver wire claims are processed. If more than one team owner requests to add the same player, then the "waiver wire priority" determines which team owner will get to add that player. In traditional sedentary fantasy sports, the order of this waiver wire priority can be determined by various methods (e.g., the reverse of the original draft order); however, in the active fantasy sports leagues tested herein, waiver wire priority was reset each week and was contingent on team owners' PA (i.e., % of weekly activity goal completed; see [Appendix A](#) for illustrations). For example, each week the participant with the highest average percent of PA goal completed received the first opportunity to select a player to add to their team at the end of that week. Some participants received prizes for their active fantasy sports league placement at the conclusion of the study; prize amount ranged from \$7.69 to \$307.60. For the NBA leagues, a pre-determined amount was awarded for first, second, and third place; first place received a \$150 gift card, second place received a \$100 gift card, and third place received a \$50 gift card. For the NFL league, one dollar was added for every player who met his/her PA goal to the final pool of prize money each week. The top eight places earned a percentage of the final prize money; first place received 40% (\$307.60), second place received 25% (\$192.25), third place received 16% (\$123.04), fourth place received 8% (\$61.52), fifth place received 5% (\$38.45), sixth place received 3% (\$23.07), seventh place received 2% (\$15.38), and eighth place received 1% (\$7.69). There was no additional compensation available to participants.

Following completion of the active fantasy sports league, participants attended an in-person post-intervention session. Participants returned their accelerometer during the post-intervention session (unless they opted to purchase their accelerometer for \$20.00) and completed an online survey on the intervention. The Internal Review Boards of (blinded for review) (Docket #: 300.67PY) and (blinded for review) (Docket #: 2013–015) approved all procedures.

2.3. Measures

Demographics and eligibility screening. At baseline, participants self-reported age, gender, and race/ethnicity. Participants completed the PA Readiness Questionnaire (PAR-Q), which is a 7-item scale that assesses whether an individual can safely increase their PA (Thomas et al., 1992).

Physical activity. PA was measured using a Fitbit Zip, which is a low-cost (< \$50), triaxial accelerometer (Fitbit Inc., 2014). The accelerometer demonstrates adequate reliability and validity as a measure of PA (Tully, McBride, Heron, & Hunter, 2014).

Baseline PA. Baseline PA was obtained at the start of the study and was calculated by averaging at least 6 days of valid step data (i.e., greater than 1000 steps per day) prior to the start of the AVG intervention.

PA goal achievement. PA was measured during the intervention and was used to calculate: 1) weekly steps and 2) the average percent of the step goal met across the fantasy league. An average weekly step count was calculated for each week of the intervention; average PA was used

to establish the PA step goal for the subsequent week of the active fantasy sports intervention. If the PA step goal was met, the step goal increased by 10% for the following week. If the PA step goal was not met, the goal remained the same for the following week. Average percent of PA goal completed was determined by calculating the average of weekly percent PA goal completed over the 16-week or 17-week active fantasy sports intervention.

Enjoyment of the active fantasy sports intervention. Three questions from the Intrinsic Motivation Inventory (IMI; Deci & Ryan, 2003) were modified to assess enjoyment of the active fantasy sports league at the post-intervention assessment. Using a Likert-type scale (1 “not true at all,” 4 “somewhat true,” 7 “very true”), participants self-reported how much he/she enjoyed playing in the active fantasy sports league, whether the active fantasy sports league was a fun experience, and how much he/she enjoyed managing his/her team in the active fantasy sports league. The three questions were summed to create a single item of active fantasy sports league enjoyment (Cronbach's Alpha = 0.963).

Social factors. During the post-intervention assessment, participants completed a number of measures concerning their experience of relatedness, or the use of social features integrated into the active fantasy sports intervention. The number of league members known at baseline was assessed and evaluated as a social component and potential predictor of intervention success. Participants self-reported the number of people in the active fantasy sports league that they knew very well before the active fantasy sports league began. In order to assess the “frequency of discussions with peers (other active fantasy sports league members),” participants self-reported their frequency of discussing the active fantasy sport intervention with other members of the league off-line (e.g., conversations that happened in-person, by phone, or by email) using a 4-point Likert-type scale (0 “never,” 1 “very rarely/less than weekly,” 2 “almost every week,” 3 “almost everyday”).

Intervention components. At the post-intervention assessment, participants reported the number of times per week they checked 1) their PA on the accelerometer, 2) their PA on the accelerometer website/dashboard (via smartphone or computer) and 3) the active fantasy sports website (via smartphone or computer).

2.4. Analytic plan

A mixed model analysis was used to test whether there were significant changes in weekly steps over the duration of the active fantasy sports intervention (16- or 17-weeks). While we hypothesized that there would be a constant increase in PA over the duration of the intervention, since PA is influenced by seasonal changes (Tucker & Gilliland, 2007) and not all interventions report continual increases in PA (Marcus et al., 2000), we included linear and quadratic time trends in the model to examine whether weekly steps changed over the duration of the active fantasy sports league. For a significant quadratic trend, a graph of the quadratic regression analysis was used to identify the week during which the change in weekly steps occurred, followed by two linear regression analyses to confirm the change in weekly steps prior to the identified week and the change in steps after the identified week. A one-sample *t*-test was conducted to examine whether participants enjoyed participating in the active fantasy sports intervention.

Separate linear multiple regression analyses were used to identify whether baseline PA, social factors, and intervention components were significantly associated with average percent of PA goal achieved or active fantasy sports league enjoyment. Both analyses initially included all factors; non-significant factors were removed one by one based on beta-values to identify the most parsimonious model. Because three individual active fantasy sports leagues were combined for data analyses, league was dummy coded (e.g., NFL versus NBA#1, and NFL versus NBA #2) and controlled for, as well as the interactions between league and both the linear and quadratic time trends, in the data analyses examining average percent of PA goal achieved. Data analyses

were conducted using Statistical Package for the Social Sciences, Version 22.0.

Power analyses. We conducted a power analysis to ensure sufficient sample size to detect significant changes in PA over time, enjoyment of active fantasy sports intervention, as well as significant relationships between our individual factors and average PA goal achievement and enjoyment of the active fantasy sports intervention. In order to estimate the sample size needed, we conducted power analyses for small (Cohen's $f^2 = 0.02$) and medium (Cohen's $f^2 = 0.15$) effect sizes. Thus, we conducted six separate power analyses using G*Power 3. With an $\alpha = 0.05$, the present study requires 25 or 26 participants in order to detect a small effect size (Cohen's $f^2 = 0.02$) with 80% power in a mixed model analysis with 16 or 17 timepoints, respectively. With an $\alpha = 0.05$, the present study requires 49 participants in order to detect a small effect size (Cohen's $f^2 = 0.02$) with 80% power in a linear multiple regression analysis with seven predictors. With an $\alpha = 0.05$, the present study requires 65 or 66 participants in order to detect a medium effect size (Cohen's $f^2 = 0.15$) with 80% power in a mixed model analysis with 16 or 17 timepoints, respectively. With an $\alpha = 0.05$, the present study requires 103 participants in order to detect a medium effect size (Cohen's $f^2 = 0.15$) with 80% power in a linear multiple regression analysis with seven predictors. The present study had an adequate number of participants ($N = 33$) to detect a small effect size for changes in PA over time; the present study was initially powered to examine the longitudinal changes in PA. However, it is important to note that the present study does not have an adequate number of participants to detect a small or medium effect size for associations between our individual factors and average PA goal achievement, or individual predictors and enjoyment of the active fantasy sports intervention.

3. Results

3.1. Participants

Of the 36 participants enrolled, 33 (91.67%) had complete data on the study variables and constituted the study sample. Of the three participants that did not have complete data, two participants did not complete the intervention and one participant did not complete the follow-up measures. Participants were mostly non-Hispanic, white (75.8%), and between the ages of 19 and 78 years (M -age = 34.0 years, $SD = 13.7$; 15.1% female; Table 1). The sample was comprised of 15 (45.5%) participants enrolled in the NFL league, 10 (30.3%) participants enrolled in NBA#1 league, and 8 (24.2%) participants enrolled in NBA#2 league.

3.2. Preliminary data analyses

Preliminary descriptive analyses were conducted to screen for violation of assumptions. Review of the skewness and kurtosis standardized *z*-scores suggested that normality was a reasonable assumption for average percent of PA goal completed and enjoyment of the active fantasy sports league.

3.3. Primary data analyses

Did weekly steps significantly change over the duration of the active fantasy sports intervention (H1a)? The results of the time trend analysis revealed a significant quadratic time trend for weekly steps ($F(4,541) = 67.42$, $p < 0.01$, Cohen's $f^2 = 0.50$). Further observation of the quadratic regression analysis graph (Figure 1) suggested that weekly steps increased for the first six weeks of the intervention and significantly decreased beginning with the seventh week of the intervention. A linear regression analysis confirmed that average weekly steps significantly increased each week ($\beta = 0.17$, $t(30) = 2.99$, $p < 0.01$, Cohen's $f^2 = 0.70$) during the first six weeks of the

Table 1
Sample characteristics for the entire sample and split by league.

	Split by League							
	All Participants (N = 33)		NFL (N = 15)		NBA #1 (N = 8)		NBA #2 (N = 10)	
	M	SD	M	SD	M	SD	M	SD
Age	34.0	13.7	29.7	6.4	46.4	13.2	30.7	16.9
Body Mass Index	27.5	5.2	28.1	6.7	28.0	4.2	26.2	3.3
	N	%	N	%	N	%	N	%
Sex								
Male	28	84.8	14	93.3	5	62.5	9	90.0
Female	5	15.1	1	6.7	3	37.5	1	10.0
Hispanic/Latino Ethnicity								
Yes	3	9.1	1	6.7	1	12.5	1	10.0
No	30	90.9	14	93.3	7	87.5	9	90.0
Race Category								
White	26	78.8	13	86.7	7	87.5	6	60.0
Asian	5	15.2	2	13.3	0	0.0	3	30.0
Black	1	3.0	0	0.0	0	0.0	1	10.0
Multiracial	1	3.0	0	0.0	1	12.5	0	0.0
Education								
High School Degree	1	3.0	0	0.0	1	12.5	0	0.0
Some College	3	9.1	2	13.3	1	12.5	0	0.0
Associates Degree	2	6.1	2	13.3	0	0.0	0	0.0
Bachelor's Degree	15	45.4	7	46.7	1	12.5	7	70.0
Master's Degree	9	27.3	3	20.0	4	50.0	2	20.0
Doctoral or Professional Degree	3	9.1	1	6.7	1	12.5	1	10.0

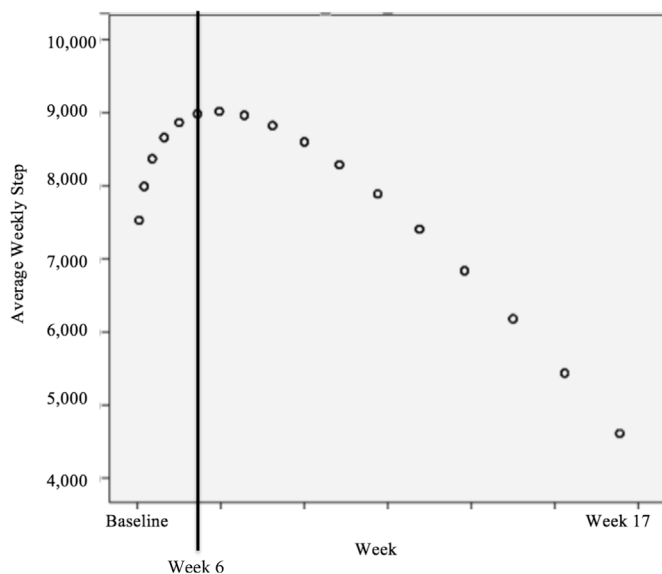


Figure 1. Quadratic time trend of weekly participant steps during the Active Fantasy Sports intervention.

intervention and a linear regression analysis confirmed that average weekly steps significantly decreased each week thereafter ($\beta = -399.75$, $t(30) = -6.68$, $p < 0.01$, Cohen's $f^2 = 0.48$). The dummy coded league variables were significant, with NFL league participants demonstrating greater baseline PA than participants in the NBA #1 league ($t(30) = 2.36$, $p = 0.02$) and lower baseline PA than participants in the NBA #2 league ($t(30) = -11.84$, $p < 0.01$).

Did participants enjoy playing the active fantasy sports intervention (H1b)? Enjoyment scores on the 3-item IMI ranged from 1 to 7 (1 “not true at all,” 4 “somewhat true,” 7 “very true”). A one-sample t -test was used to assess whether the average participant rated the active fantasy sports intervention as more (or less enjoyable) than the neutral midpoint score (4.0). The one-sample t -test indicated that enjoyment of

the active fantasy sports intervention was significantly higher than this neutral midpoint, $t(32) = 10.29$, $p < 0.05$).

Were baseline PA, social factors, and intervention component use associated with average PA goal achievement (H2a)? The most parsimonious model indicated that frequency of checking the active fantasy sports website was the only variable positively associated with PA goal achievement ($\beta = 0.506$, $t(5) = 3.69$, $p < 0.01$, Cohen's $f^2 = 0.92$). The leagues did not significantly differ on average percent of PA goal achieved ($p > 0.05$).

Were baseline PA, social factors, and intervention component use associated with enjoyment of the active fantasy sports intervention (H2b)? The most parsimonious model indicated that frequency of checking PA on the accelerometer dashboard, frequency of checking the active fantasy sports website, and frequency of discussions with fellow active fantasy sports league members were positively associated with active fantasy sports league enjoyment ($F(5,26) = 6.89$, $p < 0.01$, Cohen's $f^2 = 1.33$). Greater frequency of checking PA on the accelerometer ($t = 2.87$, $p = 0.01$), checking the active fantasy sports website ($t = 2.28$, $p = 0.03$), and discussions with fellow active fantasy sports league members ($t = 2.11$, $p = 0.04$) were associated with greater enjoyment of the active fantasy sports intervention. The relationship between league association and enjoyment of the active fantasy sports intervention differed between participants enrolled in the NFL league and NBA #1 league ($t = -2.40$, $p = 0.02$) and participants enrolled in the NFL league and NBA #2 league ($t = -2.44$, $p = 0.02$), such that participants in the NFL league enjoyed the intervention more than participants enrolled in the two NBA leagues.

Post hoc exploratory analyses. We conducted post-hoc analyses to better understand the observed results and further guide the development of the active fantasy sports intervention. A series of questions asked participants to imagine future versions of active fantasy sports and rate how much better or worse these hypothetical versions would be. Descriptive analyses were conducted on items that were oriented to future active fantasy sports interventions and administered during the post-intervention assessment (Table 2). Familiarity of fellow league members seemed to play an important role in the intervention given that 84.9% of participants reported that the active fantasy sports

intervention would be somewhat better, better, or much better if they knew everyone in the league well, before starting the season. Active fantasy sports game consequences tied to PA goals seemed to impact participants given that 78.8% reported that potentially losing a player for failure to meet a PA goal very much motivated them to be more physically active. 72.7% of participants reported that the active fantasy sports intervention would be at least somewhat better if there were cash prizes tied directly to PA. On the contrary, 69.7% of participants reported that concern about what league members might think of them provided no motivation for PA.

4. Discussion

Participants in our active fantasy sports intervention increased their weekly steps during the first six weeks of the intervention, but gradually decreased their weekly steps during the remaining weeks of the intervention. This result differs from that reported by Moller et al. (2014) who reported that participants maintained or increased their PA using a simpler pre-post design that did not assess changes in activity within the intervention phase.

Several key differences between the present investigation and the Moller et al. (2014) study may highlight features of the active fantasy sports intervention that influenced PA initiation and maintenance. First, the Moller et al. (2014) study employed a 12-week active fantasy sports intervention in conjunction with Major League Baseball (MLB), whereas the present study employed a 16- or 17-week active fantasy sports intervention in conjunction with either the NBA or the NFL. The MLB league occurred during the summer, while the NBA and NFL leagues began in fall and ended in winter (all studies were run in Chicago, IL). Since PA tends to seasonally decline from fall to winter in northern states (Tucker et al., 2007), colder weather could have negatively influenced participants' PA in the present study, while warmer summer temperatures may have supported, or minimally not hindered, PA in the Moller et al. (2014) earlier study. Moreover, in the MLB league, the average participant reported knowing 4.22 out of 9 (46.9%) participants in the league at baseline (approximately half of the league); by contrast, in the present investigation the average participant reported knowing 1.79 out of 15 (11.9%), 1.79 out of 10 (17.9%), and 1.79 out of 8 (22.4%) participants of the league at baseline. In traditional fantasy sports, it is highly unusual to play with strangers and league members tend to know a high percentage of the other league members (Howie & Campbell, 2015).

Based on previous research, and consistent with SDT, factors addressing relatedness in active fantasy sports may have the greatest impact on changes in PA. Several studies have revealed that “competing with friends,” “be[ing] in a league with friends,” “bonding with family/friends,” and “social interaction with other participants” are the most commonly reported motivations for playing traditional fantasy sports (Fantasy Sports Trade Association, 2009; Howie et al., 2015; Lee, Seo, & Green, 2013). In traditional fantasy sports, leagues are constructed of individuals who know each other fairly well prior to the start of the season; it is very unusual to play traditional fantasy sports with strangers. While the league in the Moller et al., 2014 active fantasy sports study consisted of individuals who knew several others in the league, the present active fantasy sports study leagues mostly consisted of individuals who were unfamiliar with the other league members. This difference likely led to varying degrees of social engagement, which may have impacted enjoyment in the active fantasy sports intervention via the frequency of discussion with other league members. The findings of the present study contrasted with the findings of the Moller et al. (2014) study suggest that social components may be equally as important in active fantasy sports as they are in traditional fantasy sports.

Several intervention components relevant to extrinsic motivation influenced PA and intervention enjoyment. Greater frequency of checking the active fantasy sports website was associated with greater PA goal completion and greater enjoyment of the active fantasy sports

intervention. Identifying factors that contribute to greater league performance may lead to greater use of the league and accelerometer websites, which may in turn impact PA and enjoyment of the active fantasy sports intervention. Additionally, the game feature of losing a player when not meeting a PA goal impacted steps during the first six weeks of the intervention such that participants who lost a player, increased their steps. Greater examination of the impact of this feature is warranted since we are unable to distinguish the impact of the feature from any regression to the mean that could explain increases in PA. Given that these game features appear to increase PA goal completion and league enjoyment, future active fantasy sports interventions may consider phasing in new game features throughout the duration of the league's season (e.g., each week introduce a new feature or change how team owners' PA influences the game). Several research studies suggest that novelty and/or variety positively impact intrinsic motivation (González-Cutre, Sicilia, Sierra, Ferriz, & Hagger, 2016; Sylvester et al., 2014; Sylvester et al., 2016). Thus, new game features may increase intrinsic motivation, which may lead to greater use of the intervention components, greater enjoyment of the intervention, and increases in PA.

Moreover, based on the TCMM, we hypothesized that factors relevant to intrinsic motivation would be associated with PA goal achievement and enjoyment of the active fantasy sports intervention. Future active fantasy sports interventions may also consider implementing more timely feedback and consequences to participants regarding their performance. As a result, participants may recognize a stronger association between his/her PA and league performance.

The results of the present study highlight the potential efficacy of combining traditional online fantasy sports and asynchronous PA as a platform for a PA intervention. Individuals who are invested in their active fantasy sports league performance are likely to monitor their league performance by checking the active fantasy sports intervention website; in turn, these individuals are likely to achieve their PA goal due to the fact that their league performance relies on their PA. A similar strategy (e.g., encouraging use of monitoring PA via fitness tracker or smartphone application) is being used by the Women's National Basketball Association (WNBA) Watch Me Work challenge to increase PA (WNBA, 2016). Individuals are encouraged to log 20 workouts in 30 days using the NBAFIT smartphone application to be entered for a chance to win WNBA game admission and autographed merchandise. Future research should examine whether using websites or smartphone applications to track PA, as well as the frequency of checking those applications serves as a mediator between interest in one's performance in the active fantasy sports league and achievement of a weekly PA goal.

Frequency of checking the active fantasy sports website, as well as the frequency of checking the accelerometer website, were associated with greater league enjoyment. Research suggests a relationship between self-efficacy and enjoyment of PA, such that the higher an individual's self-efficacy for exercise, the greater his or her enjoyment of PA (Hu, Motl, McAuley, & Konopack, 2007). Thus, participants who checked the active fantasy sports website may have experienced increased self-efficacy for the active fantasy sports intervention, which may have led to greater enjoyment of the active fantasy sports intervention. Additionally, participants who checked the accelerometer website may have independently enjoyed using the fitness tracker, which may have led to greater enjoyment of the active fantasy sports intervention.

4.1. Strengths

This is the first study to examine which components of the active fantasy sports intervention influence PA and league enjoyment. Strengths of the study include the combination of three separate active fantasy sport leagues at two different institutions and the use of an objective measure of PA. Similar to Pokémon GO, active fantasy sports

are built on a sedentary game infrastructure that evolved and attracted a very large audience over several decades.

4.2. Limitations

Several limitations relate to the quality of measures used. The use of self-report for participant height and weight is likely biased and the commercially available accelerometer used could have overestimated PA (Tully et al., 2014). Use of the intervention components relied on retroactive participant self-report, which could be problematic due to recall bias (Coughlin, 1990). Previous research examining recall bias for mobile phone use found that individuals often underestimate the number of calls made (Vrijheid et al., 2009). Thus, participants could have underestimated their use of the accelerometer website and active fantasy sports website. More accurate and objective measures of height, weight, PA and tracking of website use would address these limitations.

The study's measures were also limited with respect to assessing the full range of psychological mechanisms identified by self-determination theory; specifically with regard to basic psychological need satisfaction and frustration (e.g., Chen et al., 2015), and different forms of extrinsic motivation (e.g., using a Self-Regulation Questionnaire; Levesque et al., 2007) for sports fandom/spectatorship, AVG participation, and PA in general.

The lack of a control condition hinders our ability to conclude whether changes in PA were due to the intervention. Moreover, the present study had limited statistical power. While the present study had an adequate number of participants to detect a small effect size for changes in PA over time, the present study did not have an adequate number of participants to detect a small or medium effect size for significant relationships between our individual predictors and average PA goal achievement and enjoyment of the active fantasy sports intervention. Replication of study findings with a larger sample is warranted. Participants in the study were mostly non-Hispanic white, and male, which limits the generalizability of the results.

4.3. Future directions

The results of the present study highlighted several future directions for active fantasy sports intervention. One future direction involves greater consideration for maximizing the satisfaction of all three basic psychological needs identified by SDT. For example, relatedness need satisfaction might be supported more by posting more frequent, real-time updates to the league message board regarding all team owner's PA, rather than weekly updates. This might increase use of the league discussion boards, which could encourage discussion and interaction among league members. Autonomy and competence need satisfaction was considered in the design of the intervention, but was not measured in the current study, a limitation that should be addressed in future studies. For example, autonomy need satisfaction was supported by providing participants with a range of options for customizing their fantasy team (e.g., selecting a team name and avatar, and professional athletes to place on their rosters). Credit for PA could be earned in a wide range of ways and on the participants' individually selected schedule. That is, participation in the league did not require that everyone exercise at the same time or in the same way; credit was earned asynchronously throughout the week. As such, asynchronous AVGs provide greater support for individual choice about when and where to exercise. The hypothesis that participants experience asynchronous integration of PA into AVG as more autonomy supportive than synchronous integration, however, could not be tested in the current study. Competence need satisfaction was also supported, most directly by individually calibrating weekly PA goals in order to be optimally challenging and stretch each participant's ability. However, in this formative phase version of the intervention, individual PA goal calibration was relatively simplistic, and it was only possible to link PA to features of the active fantasy sports game on a weekly basis. The relative

infrequency of reinforcement may not be optimal for the active fantasy sports intervention since it is ideal to pair reinforcement as soon as possible with the desired behavior to strengthen a conditioned response (e.g., PA). Third, there was a significant imbalance of male versus female participants in the present study. The limited participation of females in the present study is to be expected since significantly more males play traditional fantasy sports. The Fantasy Sports Trade Association reported that only 29% of the 59.3 million people who participated in traditional fantasy sports in 2017 were female (Fantasy Sports Trade Association, 2017). Strategies such as female only leagues or creating leagues where members know one another, could increase female participation in active fantasy sports. Fourth, a number of PA intervention studies have demonstrated that increasing *variety* can promote intrinsic motivation and maintenance (Sylvester et al., 2014, 2016), and a systematic review of digital health interventions, in general, recently found that *novelty* (generated by regular content updates) is positively related to engagement (Perski, Blandford, West, & Michie, 2016). Consistent with these empirical findings, the Pokémon GO AVG has rolled out a series of updates adding novel game features over time (Webster, 2016). As such, future versions of active fantasy sports might increase variety by changing which game privileges or incentives are contingent on meeting PA goals from week-to-week, or even day-to-day. Fifth, conducting a randomized controlled trial (RCT) that includes a control group is an important next step to verify the possible benefits of the intervention and address the possible seasonal weather effects of PA. Although very challenging, future active fantasy sports interventions should aim to recruit and enroll groups of participants who know each other well at the start of the study (e.g., see Edney et al., 2017). We anticipate that these are the optimal circumstances for maximizing social support, intrinsic motivation, and maintenance. Sixth, future studies should assess PA barriers to understand the extent to which weather or other factors impact PA during the intervention. Understanding PA barriers in the context of the Fantasy Sports intervention could enable the creation of in-game strategies to address PA barriers (e.g., seasonally adjusting weekly or daily PA goals). Broadly, it is our hope that the formative phase research described here can help justify the significant investment required to develop an active fantasy sports AVG that addresses these future directions described, in particular, using RCT and even multifactorial optimization designs (e.g., using a Multiphase Optimization Strategy; Collins, 2018). RCT and MOST designs require large numbers of participants to be adequately powered, even more so when groups of existing friends are cluster randomized to conditions. The current version of the active fantasy sports AVG requires significant manual effort from human research assistants to reconcile the Fitbit and Fantasy Sports interfaces; a single web or mobile application would reduce manual effort, enable the ability to easily alter game components and assess their impact, and make these more sophisticated research designs possible. It is estimated that it took the developers of Pokémon Go over 20 years with millions of dollars invested before the launch of that AVG (Severson, 2016). Thus, we believe conducting and reporting this formative research, for the benefit of others and for the purpose of inviting public comment, represents an important and worthwhile early phase of a long-term, multiphase project.

Finally, lessons learned from both the Pokémon GO and active fantasy sports AVGs may be applied to identifying and “activating” other established sedentary video games with large and loyal audiences (e.g., *League of Legends*, *World of Warcraft*, *Dota 2*, *Minecraft*). These established sedentary video game platforms, in particular Massively Multiplayer Online Role Playing Games with sophisticated social components, present behavioral health interventionists with incredible opportunities for increasing the reach and public health impact of their work. This may be accomplished by making privileges or advantages within these games contingent on participants' asynchronous PA, emphasizing opportunities for social support, and regularly adjusting such contingencies (novelty) in order to sustain intrinsic motivation. For

another recent example of how asynchronous PA can be incorporated into a previously sedentary video game see Tan and colleagues work with the popular PC game, *Skyrim* (Tan, Kumar, & Ralph, 2016).

Conclusion. While there was a significant decrease in PA during the latter portion of the active fantasy sport intervention, there were several intervention components that were positively associated with average percent of weekly PA goal achieved. Understanding the factors associated with average percent of PA goal achieved shines light on future directions for active fantasy sports and other AVG interventions. Results also highlight the value of examining linear and quadratic time trends to assess PA interventions, as interventions of this kind are often characterized by initial increases in PA followed by decreases. The present study demonstrates the feasibility and acceptability of an active fantasy sports PA intervention with high potential reach. However, participants' failure to maintain initial increases in PA over 17-weeks suggest that more formative and optimization design work is needed before disseminating this AVG on a larger scale.

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Disclosures

The last author of this manuscript (Moller) is also the sole inventor of an issued by the US Patent and Trademark Office (filed on December 3rd, 2013), titled: "Incorporating objective assessments of fantasy-team-owners' physical activity into fantasy sport platforms" (Serial No. 14/088,632). Ownership of the referenced intellectual property is vested in Illinois Institute of Technology. For the other authors of this manuscript, no competing financial interests exist.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.psychsport.2018.12.003>.

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