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Research Article

Active gaming and self-paced exercise: A self-determination perspective

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Abstract

Purpose: This study aimed to identify physical activity, enjoyment, and factors for future activity between an active video game (AVG) condition and self-paced exercise (SPE) among college-aged students.

Methods: Thirty college-aged volunteers (age=22±1.68 years) completed 4-45 minute physical activity sessions (2 AVG; 2 self-paced). A survey and a brief structured interview followed.

Results: Overall, participants expended more calories, accumulated more steps, and more physical activity during SPE; however, participants in the AVG condition met daily exercise recommendations. The majority of participants (81%) enjoyed playing the AVG. Autonomy and competence were found as common themes among those who preferred the SPE condition; whereas, lack of knowledge and exercise variety were emergent themes among those who preferred AVG.

Conclusions: This study provides evidence that college students could meet daily exercise recommendations by participating in AVG interventions; although AVGs that provided autonomy and allowed users to demonstrate competence would be preferable.

Introduction

Participation in regular physical activity is associated with a variety of health benefits, however, a large proportion of Americans are physically inactive and do not meet recommendations with over 50% of adults discontinuing an exercise program after 6 months [1]. Current physical activity recommendations suggest that adults should either participate in 30 minutes of moderate physical activity 5 days a week, 20 minutes of vigorous activity 3 days a week or a combination of the two [2]. According to the Spring 2016 National College Health Assessment, only 47.2 % of college-aged men and women met the physical activity recommendations, which is a 3% decrease from Spring 2014 [3]. Furthermore, transitions from secondary to postsecondary institutions show low levels of daily physical activity [4]. Given the difficulty of convincing adults to exercise along with the associated chronic diseases associated with inactivity, the United States Physical Activity Plan [5] specifically encourages post-secondary institutions to provide access to physical activity opportunities and promote physical activity.

Traditionally, video game play along with overall screen time promotes sedentary behavior; however, a new generation of video games, requiring human body movements for interaction is increasingly being used to promote physical activity and provide physical activity opportunities [6-10]. These active video games (AVGs) include products such as the Nintendo Wii, the Xbox Kinect, and Dance-Dance Revolution.

Initial AVG research investigated variables such as energy expenditure and physical activity within controlled laboratory settings to determine if AVGs provide sufficient amounts of physical activity [6,9]. Preliminary findings are mixed but participation in some AVGs have shown significant increases in heart rate, VO2, and energy expenditure comparable to conventional light-to-moderate physical activity [9] and some select games exhibit vigorous physical activity [12].

With sixty-five percent of college students reporting regular or occasional video game play [13], AVGs may provide a viable enjoyable solution to reduce sedentary gaming and physical inactivity in college students. However, little research exists on what type of game play in terms of physical activity and exercise would promote continued use of a game. Enjoyment of exercise has been found to mediate the effectiveness of exercise interventions [14] with intrinsic motives such as enjoyment being positively associated with exercise behavior [15]. Within a gaming context, it has been theorized that games that meet psychological needs of autonomy, competence and relatedness outlined with Self-determination theory would promote continued game play [16-18]. Self-determination theory examines the underlying psychological needs and how these needs contribute to motivation and behavior [18]. Self-determination theory proposes that decisions to engage in a behavior are based on needs for autonomy, competence, and relatedness, and that behavior is a result of an intrinsic motivation due to personal choices (autonomy) or extrinsic motivations due to external pressures [19,20] Research on inactive videogames has shown that perceived in-game competence and autonomy predict game enjoyment, game preferences, duration of game play, and post-game feelings of wellbeing [16]. This suggests that for individuals to adhere to AVGs they must be perceived as engaging and enjoyable, while providing a sense of autonomy and competence. Initial research suggests that participants prefer AVGs to laboratory prescribed exercise such as walking on a treadmill [11], however, both the AVGs and exercise conditions were controlled conditions where participants were unable to choose activities or display competence. To date there is insufficient evidence to determine if fitness based AVGs can elicit sufficient physical activity in an autonomous free play condition. Furthermore, motivational aspects for continued game play in active video games is unclear. Therefore, the purpose of this study was to identify differences in physical activity during autonomous self-paced exercise and autonomous active video game play. The secondary purpose was to identify enjoyment and factors related to continued game play among college-aged students. We hypothesize that 1) higher levels of moderate-to-vigorous physical activity will occur in the autonomous self-paced condition and 2) participants who enjoy AVG will experience autonomy and competence during game play.

Methods

Participants

Thirty college-aged students (15 males and 15 females, mean age, 22.4±1.68 years) served as participants for the study. Prior to participation, each participant completed a written informed consent and the Physical Activity Readiness Questionnaire (PAR-Q) [22]. To be eligible, participants had to take part in a regular schedule of exercise (minimum of moderate or vigorous exercise three times per week) over the past month and answer "no" to all questions on the PAR-Q. We choose regular exercisers for two reasons 1) participants must be able to complete all four exercise sessions and 2) previous research has shown that for college students, experience with AVG is related to their current exercise participation [21]. Although all of the participants had played the Wii before, none of the participants had played this particular game prior to the familiarization session. The University's Human Subjects Institutional Review Board reviewed and approved this study in accordance with ethical standards.

Procedure

This study was a within subject design in which all subjects participated in five sessions: 1 familiarization session, 2 active video game sessions and 2 self-paced

exercise sessions. Demographic variables and a 15-minute introduction to the active video game were conducted during the familiarization session. The next four sessions (2 AVG and 2 self-paced conditions) were conducted over a two-week period and the conditions were counterbalanced. All sessions were 45-minutes in length. At the start of every session, a calibrated *Bodymedia* SenseWear Pro$_3$ armband was attached to the participants' right triceps. Participants were requested to press the timestamp button on the armband to indicate the start of exercise or game play. At the conclusion of the 5th condition the semi-structured interview was conducted. Figure 1 shows the flow of the study.

Demographic variables

Weight was measured on a balance beam scale before the exercise protocol. Participants wore T-shirt, exercise shorts or tights, and no shoes. Height was measured without shoes on a stadiometer. Body Mass Index (BMI) was calculated from weight and height measurements. Additional demographic variables were collected in order to calibrate the armband and included: birth date, sex, handedness (right or left), and smoking status (smoker or nonsmoker).

Rate of perceived exertion (RPE) was measured on the Borg Scale [23]. After each session the participants were shown a copy of the Borg scale and asked to rate how hard he/she believed the workout to be on a scale of 1 to 10. A rating of 1 represented very light activity and a rating of 10 represented maximum effort.

Physical activity/energy expenditure monitor

The SenseWear Pro$_3$ Armband utilizes five sensors (acceleration, heat flux, galvanic skin response, skin temperature, near-body ambient temperature) and demographic information to estimate energy expenditure [24]. The armband has companion software that uses physical parameters as part of the calculations to determine energy expenditure and time spent in physical activity in 1-minute intervals. Each participant's demographic data (birth date, height, weight, sex, handedness, and smoking status) was used to calibrate the armband. The armband was worn over the right triceps muscle at the midpoint between the acromion and olecranon processes. Calibrated armbands were placed on the participants' right arm for 10-minutes prior to data collection to allow for acclimation to skin temperature.

Active video game (AVG) condition

Participants played the Wii EA Sports Active 2 Personal Trainer twice for 45-minutes during the AVG condition. This game was chosen because it is available for Xbox Kinetic, Playstation as well as the Wii and game play is similar between

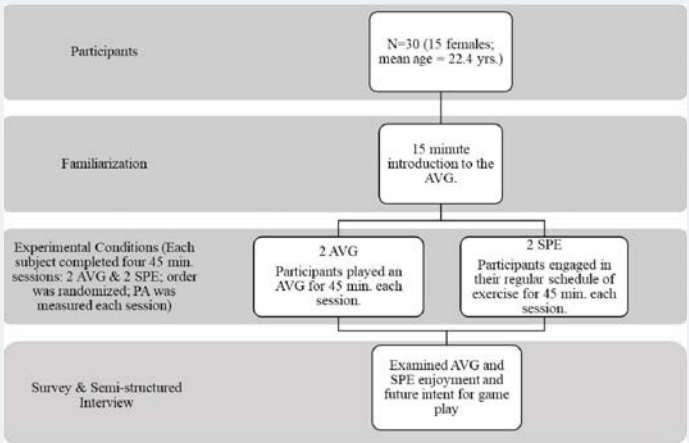

Figure 1: Study Flow Chart: AVG=Active Video Game; SPE=Self-Paced Exercise.

the three systems. This fitness-based game provides a virtual personal trainer that provides step-by-step instructions for an exercise routine. Game players can choose from over 35 preset workouts or create an exercise routine of their choice. Written, verbal and visual instructions are available for each exercise. Participants have a wireless remote in their hand, a sensor on each forearm and a sensor on the right thigh. A sensor positioned on the TV/viewing monitor detects movement of the participant. For each session the participant attached the sensors, activated the Wii remote and proceeded to load the game for play. The 45-minute time interval was started when the game was loaded and ready for play. The introduction screen allows the user to utilize a pre-made exercise routine such as cardiovascular focus, resistance focus or a combination of cardiovascular and resistance; or the participant can develop their own exercise routine from a list of exercises. For example, the participant can choose 10-exercises that they would complete on a rotating circuit for a set length of time or they may choose exercises one at a time. Prior to the gaming condition participants were provided a15-minute familiarization session to the game. This included details about the basics of the game, how to use the remote and the sensors, how to create a personalized exercise routine, how to use the existing exercise routines and how to navigate through the game screens. The participants were asked to play the game for 45-minutes for two sessions. No other specifications for interactive play were given to allow for autonomous game play. Time for the condition was started when the participants were at the exercise selection screen. From this screen the participants could select a preset workout or make one of their own. Examples of preset workouts consisted of cardiovascular focus or specific body part focus such as arms, legs etc. The exercises were completed with only a light resistance style band for some resistance exercises. Each participant had the autonomy to choose which activities they wanted to complete. After each AVG session was complete predicted calories provided by the game was recorded along with each participants' rate of RPE.

Self-Pace Condition (SPE)

Participants were asked to engage in their regular schedule of exercise for 45-minutes. The purpose of this condition was to allow the participant to engage in their regular schedule of autonomous exercise; therefore, no specifications were given other than a 45-minute time interval. Time for the condition started upon entrance to the exercise facility and/or start of indoor/outdoor activity. After each SPE session the participant returned to the lab to report their RPE and complete an exercise log that specifically detailed their autonomous exercise.

Semi-structured interviews

At the conclusion of the fifth session each participant completed a semi-structured interview. An interview guide was used to structure the interviews and focused on prior experience with active video game play and specifically Wii EA Active Sports, factors associated with enjoyment and a lack of enjoyment during the active gaming condition, future intent to play active games and future intent to substitute active gaming for traditional forms of exercise. The flexible nature of the semi-structured interviews allowed for exploration of emerging themes and was aimed to facilitate participants' accounts of their experiences with the AVG. The interview guide was reviewed in a focus group by 1) 10 undergraduate students who had experience with active gaming and 2) 10 undergraduate students who did not have experience with active gaming. The interviews were revised based on feedback from both of these focus groups. Pilot interviews were conducted to improve the natural flow of the conversation and allow for more probing questions. As is in convention in qualitative methods, interview guides were adjusted throughout data collection to incorporate questions about emerging themes. All interviews were conducted by one individual who is trained in qualitative methodology. Each interview lasted 5-15 minutes, was tape recorded and then transcribed verbatim.

Statistical analysis

Descriptive statistics were generated to describe the sample (Table 1). Paired t-tests examined within subject differences between time spent in moderate-to-vigorous physical activity, accumulated steps, energy expenditure and differences between the energy expenditure predicted by the Wii gaming device and the energy expenditure calculated by the armband. All significance levels for the *t*-tests were adjusted to p=0.01 (0.05/4) using the Bonferonni correction factor. An ANOVA examined differences between sex and time spent in moderate-to-vigorous physical activity (MVPA) during the AVG condition. Alpha level was set at p=0.05.

The Framework Approach [25] provided a systematic thematic approach to analyzing the semi-structured interviews. This approach allows for a systematic approach to classification and organization of data in terms of emerging themes and patterns and is widely used in qualitative research. A period of familiarization with the dataset by the lead researcher was followed by a process of coding whereby apriori themes directed by the interview topic guide, unexpected emergent themes and recurring viewpoints were identified. The accuracy of the initial themes, derived from a subset of the data, was confirmed by other members of the research team, and then used to guide the indexing of the remaining transcripts. The coding process enabled the development of lower order themes to be charted and organized into salient higher order themes that manifest within the whole dataset. At the final stage of data analysis, the derived themes for both groups were compared to identify similarities and differences.

Results

Physical activity

Descriptive results for calories, steps, and time spent in MVPA are located in Figure 2. Overall, participants accumulated an average of 267.24 calories, 3205 steps, and 38 minutes of MVPA during the self-paced condition and 222.66 calories, 2024 steps, and 32.29 minutes of MVPA during the interactive gaming condition. Paired sample *t*-tests revealed that participants accumulated significantly more steps, expended more calories and engaged in more MVPA in the self-paced condition versus the interactive gaming condition ($p<0.001$). However, a 45-minute session of the interactive gaming condition was effective in meeting the daily recommendation for physical activity. The calories burned provided to the participant at the workout summary on the AVG (192.4) underestimated energy expenditure ($p=.003$) compared to the armband (222.66; Figure 2). There were no sex differences for time spent in MVPA during the AVG condition ($p=0.88$).

The most common exercise reported for SPE was running and lifting weights. During the first AVG session participants played 1-2 preset games and for the second AVG session participants typically (92%) developed their own workout. The mean RPE reported for the SPE condition was 6.8 and the mean RPE reported for the AVG condition was 5.8.

Semi-structured interview

The higher order themes within the data included factors related to enjoyment within the AVG and SPE conditions, explanations for preference of AVG or SPE and future intent to use active gaming (Figure 3).

Table 1: Participants Mean Values and Standard Deviations for Age, Weight and BMI.

	n	Age (years)	Weight (lb)	BMI (kg/m^2)
Males	15	21.71±1.68	84.85±13.92	26.10±3.82
Females	15	21.25±1.95	69.07±8.66	22.62±2.68
Total	30	21.47±1.81	73.45±15.93	24.30±3.68

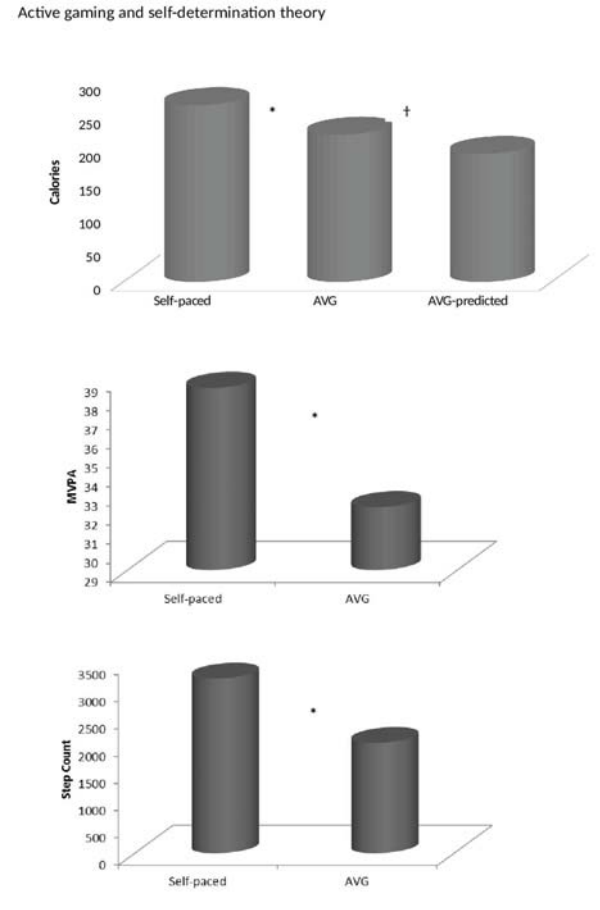

Figure 2: Energy Expenditure, Step Count and MVPA during Self-paced exercise and the AVG conditions. Note* denotes significance at p<0.001; † denotes significance at p=0.003

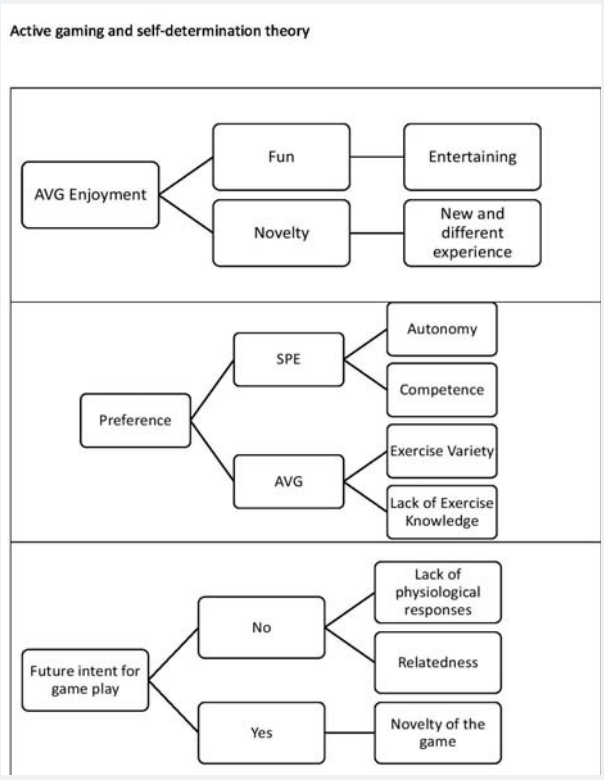

Figure 3: Framework for Semi-structured interview.

Factors related to AVG enjoyment

Eighty-one percent of the participants enjoyed playing the AVG. Participants who enjoyed the AVG stated the game was *"fun, entertaining, and different than their normal routine".* Sub-ordinate themes that emerged for AVG enjoyment were a sense of fun and novelty. For example, *"I enjoyed playing the game because it was new and different"*; "*it was entertaining, I didn't realize I was working out"; "it was fun and different than what I normally do".* Enjoyment was tempered with ease of use of the game and being able to customize the workout. For example, *"once I figured out how everything worked it was fun"; I enjoyed being able to customize my own workouts, but I did not like the preset workouts."* Those who did not find enjoyment discussed their inability to display competence at a task. For example, "*the game was boring, not intense enough, and frustrating in terms of the rudimentary game play*"; "*the game did not challenge me physically"; "the game did not require much effort."*

Exercise preference

Seventy-two percent of the participants would prefer their own workout to the AVG. Autonomy and competence were subordinate themes for preferring SPE. In terms of autonomy, the participants preferred SPE because they were able to choose their own workout and immediately change the intensity and time of their exercise program based on their physiological feelings such as fatigue. Furthermore, they stated that "*I didn't like the exercises I had to choose from during the game*" and "*it was too controlled for me, I like to be able to switch things up as I feel the vibe*". For those who preferred the AVG, knowledge and exercise variety were emergent themes. Participants who preferred the AVG displayed a lack of knowledge to program their own exercise. For example, "*I don't really know what to do on my own for exercise; "the workouts are already there, I don't have to try to come up with my own."* In terms of exercise variety participants stated that the "*The game provided new workout options; I tend to do the same thing all the time in my own workouts. This game had so many new options for me.*" The majority of the participants (63%) would not substitute AVG for their exercise unless weather and/or access to self-paced condition were impaired. For example: "*I like being outside when I exercise; and I enjoy being outside when I exercise, but if I couldn't be outside I might try the game*."

Future intent for AVG play

A majority (95%) of the participants did not intend to play the AVG in the future for exercise due to a lack of physiological responses and a lack of relatedness. Although, many participants were surprised that the AVG could provide physiological responses (i.e. sweating) a lack of physiological responses (e.g. "*I didn't sweat enough*"; "*it was entertaining but I never felt a good burn like I get from my own workout*"; "*I didn't get tired*") emerged as the subordinate theme to not play the game in the future. Participants also expressed a lack of relatedness as a reason to not play the game in the future. Participants discussed that they enjoyed exercising in a group setting or with partners. For example, *"I have a running partner and we motivate each other, I didn't not get that from the game even though the trainer was talking to me"; "I like working out with others".* Finally, the participants discussed they wanted different types of exercise than the game offered. Essentially, the participants wanted more traditional forms of weight lifting versus more body weight exercises. Novelty emerged as the theme for participants who expressed intent to play the AVG in the future. The participants expressed the novelty of the game motivated them throughout game play and provided enjoyment. For example, *"Usually I run by myself, but this was something new and different*."

Discussion

We investigated whether participating in a fitness based AVG game would elicit enough physical activity to sustain health benefits, and the participants' perspective

about participating in AVG. Our results show that while participants can meet daily exercise recommendations by participating in AVG, self-paced conditions were more enjoyable and preferable. The results from this study show that a 45-minute session playing this AVG elicited high enough levels of physical activity to meet minimum daily recommendation levels for adults. Participants spent approximately 32 minutes out of 45 minutes or 71% in MVPA during game play. This is higher than previous studies that have investigated Wii FitPlus and Wii Sports for adults [26] and children [12] which showed that AVG promotes higher physical activity levels than traditional video games, but fall short of meeting recommendations. It appears that the fitness-based games elicit higher levels of MVPA compared to the sport based systems and could be used as a method to meet daily physical activity guidelines.

Although participants completed similar exercises in both conditions such as running, jogging, resistance training, abdomen exercises, and flexibility, the AVG condition elicited lower levels of physical activity compared to self-paced exercise. These results are similar to studies that examined sport based video games compared to playing the sport itself [12,27]. There have been reported differences in the motivation between males and females to play video games [28]. These differences lead to the question of gender-based tailoring for video games. The results of this study did not find differences between males and females for time spent in MVPA. The AVG allows the user to tailor the image on the screen by visual characteristics such as sex, hair color etc. It is possible that allowing participants to create an image of "themselves" is enough to promote engagement in physical activity for both sexes.

With a majority of adults not meeting exercise recommendations and 50% dropping out of a self-initiated exercise program, the question is whether AVG will motivate participants to persist and adhere to an exercise program. From a self-determination perspective, for continued game play to occur players' psychological needs of competence, relatedness, and autonomy must be met [19,20]. Research on inactive videogames has shown that perceived in-game competence and autonomy predict game enjoyment, game preferences, duration of game play, and post-game feelings of wellbeing [16]. Participation in AVG and exercise is nearly always voluntary for adults, so at the onset both activities would have equal autonomy and participants' willingness for continued participation in an activity would vary as a function of personnel appeal, activity content and from a gaming perspective game design. This sense of autonomy would directly reflect enjoyment while playing the game [20].The game utilized for this study allowed participants to determine different aspects of frequency, intensity, type, and timing of the exercises or participate in a pre-set workout. The virtual personal trainer provided specific feedback on execution of the exercise (e.g. extend the arm further for a triceps extension) and general feedback upon the completion of an exercise and/or session (e.g. good job). Based on the responses from the interviews a majority enjoyed playing the AVG (81%), but would prefer their own exercise regimen (72%). Enjoyment subordinate themes reflect the three psychological needs of autonomy, competence, relatedness. Specifically, participants preferred to have the freedom to "*push myself; go at own pace; structure my own workout*; and *adjust intensity*" during their self-paced workout versus the AVG. Although the AVG would allow them to structure their own workout, multiple participants stated that this process took time away from exercise. In fact, a lack of autonomy was given as the preference for the AVG and described as "*I like that they (virtual trainer) tell me what to do; it (pre-set workouts) was already made up, I just follow along*". Relatedness, defined as the connection with others, not typically associated with single-level game play such as that utilized in this game, emerged as a subordinate theme as to why participants would not substitute the AVG for a workout. "*I like to work out around other people; I would not push myself if I didn't have my workout partner*" are examples of this theme. Lastly, 52% participants expressed the desire to be outside for exercise and

that enjoyment of exercise was affected by inside game play. These responses provide further insight into the AVG experience and should be considered when utilize AVG for exercise promotion interventions.

It is important to note that these participants were participating in regular exercise at least one month before the intervention and these results might be different for non-exercisers. The utility of the AVG as an intervention tool cannot be identified from this study, though findings suggest that for an intervention to be effective the needs of autonomy, competence, relatedness, and preference for indoor and/or outdoor activity would need to be addressed. This study utilized a within subjects design that may be affected by carryover or practice effects. This was minimized by randomizing the order of the experimental conditions and allowing for a 48 hour period before participating in a subsequent condition. Future research should examine the use among sedentary individuals and evaluate the possibility of long-term interventions.

Conclusions

This study provides initial evidence that college students could meet daily exercise recommendations by participating in AVG interventions. AVG solutions may provide a practical and effective solution to sedentary behavior in a technology-driven society; however, from a self-determination perspective game design should address psychological needs to encourage continued game play. Based on this study AVGs that provide autonomy and allow users to demonstrate competence would be preferable.

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