# Using Games to Increase Exercise Motivation

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## ABSTRACT
In recent years, there has been significant work in integrating physical activity into video games. One goal of this work has been to help motivate sedentary people to be more physically active. Konami's Dance Dance Revolution and Nintendo's Wii Sports have shown that exercise games can be both fun and commercially successful.

To date, however, there has been little attempt to investigate what properties of exercise games will help motivate sedentary people to start and continue exercise programs. This paper reviews the literature on exercise motivation and derives from it requirements for computer-aided exercise games. The paper then introduces the new Life is a Village exercise game, and uses it to illustrate how these requirements can be met.

## Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – evaluation/methodology, input devices and strategies, user-centered design.

## General Terms
Human Factors.

## Keywords
Computer-aided exercise, exertion interfaces, video game design, computer-supported cooperative work.

## 1. INTRODUCTION
Recent years have seen the development of numerous games that require players to engage in physical activity such as cycling, dancing or swinging a virtual tennis racket. Some of these games were created for purely entertainment purposes, using physical actions as a novel form of interaction. Other games are intended to help motivate people with sedentary lifestyles to become physically active.


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As evidenced by the commercial success of games such as Dance Dance Revolution (Konami Corporation) and Wii Sports [16], it is possible to create fun games that contain an exercise component. However, there has been as yet little attempt to understand the link between what motivates people to perform exercise and the design of exercise games. This raises the question of how to move towards a deeper understanding of what game features will contribute to or detract from players' motivation to perform exercise.

In the sports psychology field, there has been extensive work attempting to understand how to motivate people to start and maintain exercise programs. In this paper, we draw requirements from this exercise motivation literature, and show how these requirements can help in the design of exercise games. Key findings from this literature include the linkage of low compliance to exercise programs to poor self-efficacy, poor exercise self-image, and lack of peers to exercise with. Features from traditional games can help address these barriers to exercise, although naïve design can exacerbate these problems. In order to illustrate these requirements and the tradeoffs inherent in applying them, we introduce our *Life is a Village* computer-aided exercise game. Life is a Village contains several novel features, including an innovative approach to cooperative game play.

The paper is structured as follows. We first survey existing exercise games in order to show the broad range of game styles that have been produced to date, both in the commercial and academic fields. We then present requirements for exercise games, drawn from the exercise motivation literature. Finally, we show how some of these requirements are addressed in the Life is a Village game.

## 2. GAMES WITH A PHYSICAL COMPONENT
Exercise games (or more broadly, games with kinetic interfaces [15]) are a fertile area for game design. Examples of games requiring physical input include a hang-gliding game [13], a game where players use their bodies to control a virtual diving bell [17] and a game where players kick, jump and punch to control kung-fu moves of their avatar [6].

There are many ways in which physical interfaces can be added to games. Table 1 presents a taxonomy of these approaches. The first axis captures the style of user interaction of the game,

**Table 1. Taxonomy of exercise games categorized by user interface and game world**

| *User Interface vs Game World* | **Free motion interface** | **Equipment based physical interface** | **Traditional Electronic Interface** |
|---|---|---|---|
| **Virtual World** | Kick ass Kung fu,<br>Nautilus,<br>EyeToy,<br>Paranoia Syndrome,<br>Breakout for Two,<br>Wii Sports,<br>Dance Dance Revolution | Life is a Village,<br>FlyGuy,<br>Push N' Pull,<br>GameBike,<br>PowerGrid Fitness | Human Pacman (helper),<br>Age Invaders (helper/opponent) |
| **Augmented Reality** | Human Pacman,<br>Age Invaders,<br>Laser Tag | Open for research | Open for research |
| **Reality** | Soccer | Cycling | Radio Controlled Cars |

ranging from free motion (as in traditional sports such as soccer) to equipment-based exercise (as in traditional cycling or weight-training exercise.) The mouse/keyboard/gamepad input techniques of traditional computer games are presented for comparison. The second axis captures the style of world in which players interact. Virtual worlds are typical of computer games, in which players see a representation of themselves in a synthetic world presented on a display device. Augmented reality overlays digital information onto the real world. And of course, reality represents the real world unadorned by virtual information.

## 2.1 REALITY BASED GAMES

Games involving physical exercise have existed for thousands of years. Soccer is an example of a free-motion interface, where players move their entire body to interact with the ball and with other players. Players are free to carry out actions such as running, jumping and kicking. Other games are intimately bound to equipment which enhances and constrains the players' motions. In a cycling or sailing race, competitors enjoy a cybernetic connection to their bicycle or boat, sensing through it the road, wind or water. Reality-based games enter the digital world when an electronic interface is used to control a real-world entity, such as with RC car racing, where competitors use a controller to navigate a radio-controlled car around a track.

## 2.2 VIRTUAL WORLD GAMES

Many exercise games allow players to interact with a virtual world (as with traditional computer games) while the game controls require physical movement.

As with the reality games discussed in the last section, virtual world games may involve free-motion or equipment-based interfaces. *Kick Ass Kung-Fu* [6] is a martial arts game where players must defeat virtual opponents. Users play in a large open space with two screens on opposing sides. The game is projected on to these screens while a real-time image of the player is captured by the camera and placed in to the game. Due to this one-to-one mapping of the player to their digital representation, every action performed in the real world is transferred in to the virtual world. Physically walking, jumping, kicking and punching are all directly translated in to the game. Another example of a free-motion game is *Nautilus* [17], a cooperative game where players free a trapped dolphin by navigating a diving bell to the bottom of a lake (figure 1). Players control the diving bell by physically walking around a room. Players group can raise the bell by stamping their feet or flapping their arms. They may also lower the bell by standing still or crouching. This detection is possible through the use of floor sensors which can sense varying degrees of pressure. The virtual world is projected on to a large wall, while lighting and aquatic sounds were added to increase the sense of immersion.

Other free-motion, virtual world interfaces include *Breakout for Two* [13], where two players in different locations kick a physical soccer ball at a virtual set of blocks (figure 2), *Wii Sports* [16], where a six degree of freedom accelerometer is used to allow players to mimic the actions required to play sports such as tennis and baseball, *EyeToy* (Sony Corp), where a video camera captures body movements as input, and *Dance Dance Revolution* (Konami Corp), a dancing game that requires the player to step on pressure sensitive tiles in time with music.

There are many examples of games in which exercise equipment is used to control activities in a virtual world.

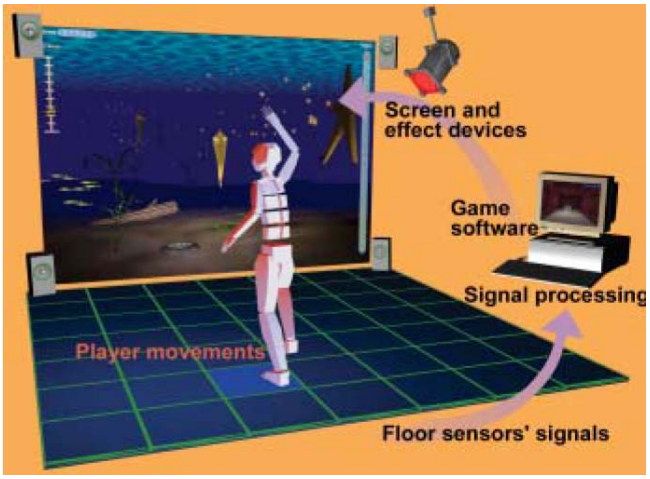


**Figure 1. Nautilus: players control a diving bell by stomping, flapping and crouching [17]**

**Figure 2. Breakout for Two: players at remote locations kick down a virtual wall using a soccer ball [13]**

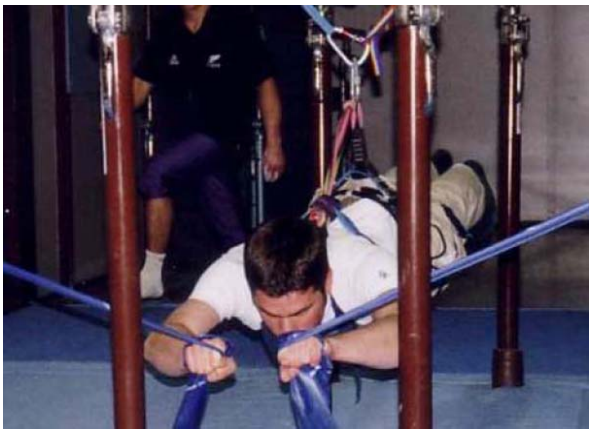

**Figure 3. FlyGuy: players fly in a virtual world using a physical hang glider [13]**

*FlyGuy* [13] is a hang gliding simulator used to foster social interaction (figure 3). Participants are placed into a harness from a hanging aluminum frame. From this position, they twist and turn their body using the frame as a support to navigate their avatar.

*GameBike* (CatEye Corp) is a stationary bike that controls racing games on the PlayStation 2 console. The GameBike uses the bicycle's speed and handle bars as speed and steering controls. *Virku* [14] is a research project where users pedal through a virtual environment using a stationary bicycle. The virtual environment is generated with map information, and affects pedaling effort. Resistance increases or decreases depending on the slope of the hill.

*Push'N'Pull* [13] is a resistance training game that requires two players to exert synchronized actions on a PowerGridFitness joystick (Interaction Laboratories Inc.) Players communicate with one another over a videoconference system. The goal is to move a shared virtual object to capture a number of particles. To do this, players must push and pull their respective input devices in the same direction.

From these examples, we see that there are many ways that games allow players to physically interact with a virtual world, based on both free motion interfaces and exercise equipment.

## 2.3 AUGMENTED REALITY GAMES

Augmented reality systems overlay virtual information onto the physical world. A number of exercise games have taken this approach, allowing players to play compute games within a real-world setting. *Laser Tag* is an early augmented reality game with a free motion interface. Players' can move freely within an enclosed environment. Reality is augmented by virtual laser blasts which lead to LEDs indicating that a player has been hit.

*Age Invaders* [10] is both a competitive and cooperative game. The goal of the game is to eliminate opponents by shooting rockets. Players may physically walk on a grid embedded with LEDs, or play using a traditional desktop computer. The LEDs light up to represent varying objects and actions in the game such as rockets, barriers, and hits.

*Paranoia Syndrome* [8] is a cooperative game where players physically walk around a number of rooms. Using a PDA, users can view invisible aliens that reside in the physical world around them. Vital information such as the health and location of your team mates is displayed on this screen. Additionally, physical objects with RFID tags are scanned using the PDA.

In *Human Pacman* [4], players take on the role of Pacman and the ghosts. The goal for Pacman is to collect a series of pellets scattered throughout the environment. The ghosts in turn attempt to stop Pacman from completing his task. Therefore moving around in the physical world directly translates to moving Pacman in the virtual world. Virtual artifacts overlay the physical world; e.g., Pacman's power pellets are represented as spheres floating in space. Ghosts are similarly represented by other people walking around in the real world.

There are currently no augmented reality games that are based on equipment interfaces, but it is easy to imagine possibilities such as a game based on cycling outdoors.

Summing up, we see that there are many different ways in which physical activity can be integrated into games. Video game design has stagnated in recent years, with safe releases of sequels and remakes. Games with kinetic interfaces offer a new and exciting arena for highly immersive games.

# 3. EXERCISE MOTIVATION

One of the underlying goals of games with kinetic interfaces is to help motivate people to do exercise. The promise is that if we combine the fun of video games with physical activity, people will be more likely to exercise. It is clear from the broad success of commercial games such as DDR and Wii Sports that this can be true for some games and some people.

However, there has to date been little attempt to analyze what makes a successful exercise game. Is it enough to simply bolt a kinetic interface onto current mass-market games? How should we design such games to help motivate people who are currently sedentary to try them out? What game features will help motivate people to *continue* an exercise program once begun?

Fortunately, there is a breadth of literature on exercise motivation. We have reviewed this literature, and have drawn from it

requirements for exercise games. To our knowledge, this is the first attempt to tie the exercise motivation literature to the design of exercise games. As will be shown in section four, we have applied some of these requirements in the *Life is a Village* exercise game. We now review these requirements.

## 3.1 Requirement 1: Integrate Music

Wininger *et al*. performed a study of three factors influencing enjoyment of exercise: music, satisfaction with the instructor, and exercise role-identity [21]. The study concluded that music was the most important of the three. This is consistent with the great success of DDR, a game fundamentally centred around music. Wales found that upbeat music significantly decreased feelings of anger, fatigue and depression compared to slower music [19]. Corroborating these results, by examining the effects of musical tempo on treadmill running, Lee determined that exercising to upbeat music led to higher positive mood states compared to slower music [11].

Separate experiments by Steptoe and Cox and Boutcher and Trenske discovered that people report a lower level of physical exertion when exercising to music versus exercising to a metronome [18] or to no music at all [2]. This shows that the presence of music can reduce peoples' perception of how hard they are exercising. Boutcher and Trenske explain that these results occur because of two factors. First is that music may act as a distracter to physical discomfort. The second is music may lead to positive states due to its content or because of its association with past experiences.

To summarize, music increases exercise enjoyment by increasing positive mood states and reducing feelings of physical discomfort, anger, fatigue, and depression. This would suggest that to enhance enjoyment, an exercise game should have music that is upbeat. However such music may not be appropriate for all games. For instance in *FlyGuy*, it may not be appropriate to play techno music while players calmly fly through the skies. Therefore it appears that music must fit within the context of the game. As found by Boutcher and Trenske, music chosen by the game player may have the most positive effects.

## 3.2 Requirement 2: Facilitate leadership for novice players

Starting an exercise program can be intimidating, and so people cite the importance of instructors in their enjoyment of their programs.

Wininger et al. found that the instructor is the second most important factor in peoples' enjoyment of aerobics classes [21], both for their knowledge of physical fitness and their encouragement of the participants. Westcott [20] conducted a study where health club members were asked to rank characteristics of exercise instructors. The most important characteristic cited is the instructor's knowledge of physical fitness. The next most important factors are the instructor's teaching skill, enthusiasm, and amount of personal attention they gave to participants.

Games therefore should facilitate leadership of players, and particularly of novices. This leadership should impart necessary fitness knowledge to the players, as well as providing structure to their session and encouragement to continue.

Leadership in games can be provided similarly to real life exercise classes. A group leader (either paid or simply a more experienced player) could help other players learn basic skills, and help in developing workout strategies. The game Neverwinter Nights perhaps provides a model for this kind of game structure, where a "dungeon master" guides a group of players. As another model, the online game Earth and Beyond granted experience rewards to advanced players who provided galaxy tours to new arrivals in the game. A leader who is knowledgeable and supportive would enhance the enjoyment of the experience. Therefore the game must have a mechanism to designate qualified group leaders. Alternatively, the game's publisher could provide certified instructors for an additional game fee.

Games can of course take advantage of the fact that they are based on a computer to use artificial intelligence to provide guidance to players. This could be directly, by providing a non-player character (NPC) leader, or indirectly, for example using quests to guide players.

The game setting provides multiple ways of providing guidance to players, ranging from live experts, other players acting as leaders, or simply embedding direction into the game mechanics. As we have seen, examples of how to do this can be drawn from existing non-exercise games.

## 3.3 Requirement 3: Provide achievable short and long-term goals

Bandura [1] defines self-efficacy as an individual's belief of their ability to control events in their lives. These beliefs influence how people feel, think, motivate themselves and behave. Self-efficacy affects a person's outlook, aspirations, and the belief in their ability to complete goals, including exercise goals.

People can have varying levels of self-efficacy. Those with high self-efficacy are motivated and expect positive outcomes from events. They set high goals and view difficulties as tasks that can be surmounted through self improvement. Those with low self-efficacy expect their actions to result in poor outcomes. They see challenges as insurmountable, and may quit before trying.

Low self-efficacy is therefore a barrier to starting and continuing exercise programs. It is easy for unfit people to fixate on the enormity of the challenge of achieving fitness goals (such as achieving a goal weight), and therefore become quickly demotivated. According to a study by Mitchell *et al*. of participants in a Weight Watchers program, 75% of dropouts from the program had been identified with low self-efficacy, whereas 2/3 of those who remained had high self-efficacy. The dropouts were experiencing similar weight loss to people who continued [12], and so were defeated by their own expectation of failure rather than by objective analysis of their performance.

To mitigate low self-efficacy, well-designed exercise programs are built around short-term goals that can be readily achieved, allowing participants to immediately feel a sense of progress and achievement. Attaining short term success – e.g., progressing from 10 minutes per session on an exercise bike to 15 minutes per session – breaks up long term goals into manageable steps.

Similarly, exercise games must provide activities in the game that represent short and long term goals. Many games provide lessons in how this might be done. World of Warcraft, for example, is

structured around quests. As players progress, they gain levels, and access to new regions with new quests. Initial quests are easy and can be completed within a few minutes. Advanced quests can take hours to complete.

## 3.4 Requirement 4: Hide players' fitness level

According to Hagger *et al*. [7], people with low self-efficacy expect their actions to yield negative outcomes. They are easily convinced of the futility of their actions. Therefore when they face difficulties in performing a task, they are prone to giving up. People with low self-efficacy require guidance and encouragement to overcome their difficulties.

Ideally, people should be in an environment where they feel confident and comfortable. Unfortunately, it may be hard for an obese person to feel comfortable at the swimming pool, or a skinny person to feel confident in a weight room. The simple fact of having a non-athletic body type can in of itself be sufficiently demotivating to cause people to quit.

Games have the potential to greatly help this situation. However, some traditional game mechanics can greatly exacerbate it. For example, in Warcraft 3, players compete against each other. Practice is important, and new players face frequent and decisive challenges. New players may be derided as "newbs" until their skill improves. In an exercise game, an obvious design choice is to link performance to fitness level. This approach can be dangerous if it throws players into a Warcraft 3-like atmosphere, where they will suffer the demotivating experience of losing consistently until their fitness improves. For example, GameBike uses a bicycle to control the speed of a player's car in a racing game; fitter players will always win, since they can pedal harder and longer. A better approach might be to use biometric feedback (such as the player's heart rate) to scale the player's speed, allowing an unfit player to be competitive with an athlete as long as he is working hard relative to his own fitness level.

Other games reward progress by reflecting a player's advances in his avatar, such as through fancier armour or weapons. An obvious way of carrying this approach into an exercise game would be to show the avatar becoming progressively fitter over time. This approach would negatively affect self-efficacy, recreating the discouraging atmosphere of being the unfit person at the gym or swimming pool, and opening the player up to mocking "trash talk".

In summary, designers of exercise games should be aware of the importance of self-efficacy in starting and continuing exercise programs. Games should avoid situations where players perceive themselves to be hopelessly behind their fitter opponents, or open themselves up to mockery based on their own lack of fitness. To accomplish this, games should not reveal the fitness levels of other players.

## 3.5 Requirement 5: Avoid systemic barriers to grouping

In a study conducted by Hohepa *et al*., 44 students from a New Zealand high school were questioned on their views on participating in physical activities [9]. The students cited barriers to physical activity as being a lack of peer support, perceived incompetence, pressure to participate in non-physical activities, and restrictions to entering teams.

Perceived incompetence was noted as a barrier because students did not wish to be judged by their peers. Students were concerned that skilled players would flaunt their abilities and therefore demotivate the new players. They also feared they would let the team down if they played. As a result of the perceived incompetence through peer influences, players had disincentives to begin or continue their physical activity. This result is consistent with those of Wininger et al. [21] and Hagger et al. [7], who relate poor exercise role identity and poor self-efficacy to unwillingness to perform exercise.

Particularly interesting in this study is the importance of groups in exercise. The barriers cited by the surveyed students include being heavily influenced by the activities that friends do, by feeling they would fail to do well in a group exercise situation, or by simply not being allowed to join a team at all. In general, people are far more likely to be active if they have supportive peers to exercise with.

Multiplayer games often contain mechanics that make it impossible for particular players to group. Players may be divided by server, by team (e.g., Horde vs Alliance), or by level. These mechanics imply that friends may not be able to play together. It is important not to carry these restrictions over to exercise games.

Therefore, exercise games should avoid mechanics that segregate players. For example, exercise games should not include a leveling mechanism; if one is included, it should copy mechanics such as the City of Heroes "sidekick" system whereby players can be temporarily raised in level when joining a group.

## 3.6 Requirement 6: Actively assist players in forming groups

As discussed in the previous section, Hohepa *et al*. showed lack of peer support to be a key barrier to physical activity [9]. Students explained that they didn't have friends who were physically active, and therefore were themselves not active. Students also blamed peer expectations to participate in sedentary social activities. The students value having friends to exercise with, and when friends aren't available, themselves do not engage in physical activity. It is therefore important for exercise games to provide mechanisms that help participants find other people to play with and that foster a sense of community within the game.

Online games have mechanisms supporting grouping. Many games provide activities which require more than one player to complete. Games often include guild structures allowing larger numbers of players to associate, and building communities that last beyond a single play session.

It is important that grouping mechanisms require as little overhead as possible. Players should not have to travel long distances to link up with friends. There should be facilities for easily finding other players who are looking for company. Additionally, there should be easy ways of communicating with friends outside the game so that play dates can be arranged, since scheduled meetings may be more motivational than spontaneous ones.

To summarize, people view a lack of peers as a barrier to physical activity. Online games can greatly help in matching people to other interested peers. Mechanisms to develop online friendships


**Figure 4. Life is a Village**

and to schedule regular play dates can help with motivation to continue exercise.

## 3.7 Requirements and Tradeoffs

In the preceding sections, we have presented six requirements for computer-aided exercise games. These requirements are drawn from the exercise motivation literature. In many cases, standard game mechanics help meet these requirements; in others, the requirements help identify cases where the usual way of organizing games would be lead to reduced motivation to perform exercise.

There are many important requirements that are not listed here. Perhaps the most important is simply that games should be fun. If a game is not enjoyable, it will be hard to motivate people to play it, no matter how beneficial its exercise component. Additionally, it is important that games provide balanced exercise appropriate to the player's abilities, without risk of injury. Finally, since these requirements come from the exercise motivation literature, some requirements specific to virtual worlds are not revealed, for example, a tennis game will benefit from haptic feedback.

Some of our requirements conflict. For example, in order to provide players with long-term goals (requirement 3), a game normally requires some sense of progression, where players gain rewards for achieving goals. However, other requirements imply that progression must be hidden (requirement 4) to avoid revealing other players' fitness levels and that progression not affect game play (requirement 5) to avoid systemic barriers to grouping.

Similarly, games must provide a supportive environment (requirements 2 and 4), but should provide access to a peer group (requirement 6). It is difficult to police players of multiplayer games to ensure that they do not mock or "smack talk" other players. This behaviour is common in online games, and certainly does not foster a welcoming environment. Although the requirements suggest that group play is vital to increasing motivation, often people may prefer to play alone. Such players should not be penalized by the game. Game designers must choose how to trade off these conflicts to achieve a successful design.

In the next section, we describe the design of our computer-aided exercise game *Life is a Village*, and discuss our approach to meeting these requirements (figure 4).

# 4. LIFE IS A VILLAGE

We have developed Life is a Village (LIAV) as a multi-player computer-aided exercise game taking place in a virtual world. The player controls an avatar by pedaling a Tunturi E6R recumbent bicycle and steering with a wireless PS2 controller. The bicycle's controls obey the physics of the world – pedaling harder increases speed; it is harder to pedal when going uphill, and easier when going downhill. Players can adjust the bicycles "gear", trading off higher tension on the pedals for faster speed. The recumbent bicycle is stable and comfortable to sit in, therefore more approachable than a traditional bicycle for people who are overweight or unused to exercise. Cycling is a low-impact exercise with low risk of injury. It is easy to take breaks as necessary, simply by stopping pedaling. Therefore, this equipment is suitable for people who have previously done little exercise.

Players' core goal is to build a village. This is a long-term goal that requires many hours of play over multiple play sessions to accomplish (requirement 3). To create a building for the village, the player must gather resources. For example, a log cabin is built from wood and stone. To gather a resource, a player must first find it (by cycling around in the virtual world, looking for a resource marker), and then dispatch one of her villagers to gather the resource. The villager travels to the resource, harvests, drops off the resource at the village, repeating until the resource is exhausted. Resources to build simple buildings are easily found, requiring only a few minutes of light cycling (figure 5). Rare resources allow more advanced and interesting buildings to be created, but are harder to find and access, perhaps being available only on a mountain top. This provides players with easily achievable initial goals, as well as longer term goals that can only be achieved as their fitness improves (requirement 3).

Initial versions of the game proved challenging for new players, as they were not sure how to begin. To aid this, we developed a quest system. Players can talk to a villager to receive a quest to gather some number of a random item (e.g., four umbrellas, five ninja statues). The player must then search for those items and return them to the quest giver. Quest rewards include items that can be added to the village. With the quest system, players are able to jump right into the game, with clear direction as to what to do (requirement 2). In a future extension, we plan to tie this feature to exercise goals, for example, linking the difficulty of the quest to players' fitness level or providing bonuses for completion within a time determined by the player's capabilities.

The game has a simple musical soundtrack (requirement 1). This could be integrated better with exercise by linking the pace and style of music to the player's actions. For example, if the game determines that the player should be resting (based on a heart-rate monitor), the game could slow the pace of the music.

Life is a Village has a novel cooperative play mode (requirement 6). Two players cooperate to collect items in a quest, while trying to avoid snowballs thrown by enemies. Being hit by a snowball impairs the players' vision (fogs up the display), slowing down the collection. Two co-located players control the same avatar. One (the cyclist) is responsible for cycling and navigating. The other (the swatter) stands, using a Wii Remote to fend off the snowballs by making tennis-like forehand or backhand gestures. To successfully hit an incoming snowball, the swatter must correctly choose between forehand or backhand swing, and time the swing correctly. Both players see feedback from their actions via the avatar: the cyclist in the avatar's speed and direction, and the swatter in the avatar's swinging animations. Snowballs make a 3D swooshing sound as they fly through the air, making the game engaging and fun (requirement 1). The two players have complementary roles, so people with radically different fitness levels can play together (requirement 5). We plan in the future to extend this approach to allow distributed players to play together (requirement 6).

## 4.1 Analysis of Life is a Village

The design of Life is a Village shows one of many possible ways to balance our requirements. Some requirements, such as "integrate music" (requirement 1) are relatively easy to meet. Others, such as "facilitate leadership for novice players" (requirement 2) are more challenging, but provide fascinating opportunities for inventive design.

**Figure 5. Recumbent Bicycle used to control Life is a Village**

Design becomes interesting once the requirements are combined. For example, as discussed above, the use of music can be combined with a leadership function by using the style and tempo of the music as a cue to the player to speed up or slow down the pace of the exercise. The requirements "hide players' fitness levels" (requirement 4) and "remove systemic barriers to grouping" (requirement 5) are complementary. LIAV uses asymmetric roles in groups to allow people of differing fitness levels to play together. When two people cycle together, it is difficult if one is faster than the other. However, by splitting the roles into cyclist and swatter, each can perform actions to the best of their abilities without directly hindering the other.

A highly useful tool for meeting these requirements is biometric feedback. A device as simple as a heart rate monitor can be used to determine whether the player is exercising at a desired intensity. This can help the game pace exercise appropriately (requirement 2), suggest appropriate goals (requirement 3), and scale the interaction between players (requirement 4). Our future plans are to build the use of biometric feedback into LIAV and experiment with its effectiveness.

# 5. CONCLUSION

There has been a proliferation of games in recent years that require players to physically exert themselves. An underlying hypothesis of such games is that people will find it fun to exercise, and consequently will improve their physical fitness. While anecdotal evidence has indicated some success stories, this paper has presented the first attempt to link the exercise motivation literature to requirements for exercise games. The literature suggests that to successfully motivate people who currently do not exercise, games should address problems of poor exercise self-identity and low self-efficacy. These problems are helped by providing strong guidance to players, providing access to a group of peers, and fostering a supportive and unintimidating environment.

We have shown how these can be translated into six requirements for exercise games. While adhering to these requirements will not

in themselves guarantee a fun and engaging game, they will help address barriers to taking part in an exercise program.

Finally, we have presented Life is a Village, a novel exercise game based on these requirements. The design of Life is a Village helps to illustrate the tradeoffs amongst the requirements, and the broad space of possible designs they open up. Life is a Village continues to be under development. Future work includes turning the game into a persistent, multiplayer world, and adding biometric feedback as a control mechanism to the game.

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