Designing Games to Discourage Sedentary Behaviour

Regan L. Mandryk, Kathrin M. Gerling and Kevin G. Stanley

Abstract Regular physical activity has many physical, cognitive and emotional benefits. Health researchers have shown that there are also risks to too much sedentary behaviour, regardless of a person's level of physical activity, and there are now anti-sedentary guidelines alongside the guidelines for physical activity. Exergames (games that require physical exertion) have been successful at encouraging physical activity through fun and engaging gameplay; however, an individual can be both physically active (e.g. by going for a jog in the morning) and sedentary (e.g. by sitting at a computer for the rest of the day). In this chapter, we analyse existing exertion games through the lens of the anti-sedentary guidelines to determine which types of games also meet the requirements for anti-sedentary game design. We review our own game designs in this space and conclude with an identification of design opportunities and research challenges for the new area of anti-sedentary game design.

Keywords Energames · Exergames · Sedentary behaviour · Cognitive benefits · Exercise · Games

1 Introduction

Regular physical activity has many benefits, including to a person's physical (Garber et al. 2011; Pate et al. 1995; U.S. Department of Health and Human Services 1996), emotional (Hassmén et al. 2000) and cognitive well-being (Etnier et al. 2006; Hillman et al. 2008). The Canadian Society of Exercise Physiologists recommends that adults achieve 150 min of moderate-to-vigorous-intensity physical activity per week (Tremblay et al. 2011); however, only 15 % of adults

R. L. Mandryk (✉) · K. M. Gerling · K. G. Stanley
Department of Computer Science, University of Saskatchewan,
Saskatoon, S7N 5C9 Saskatchewan, Canada
e-mail: regan@cs.usask.ca

A. Nijholt (ed.), *Playful User Interfaces*, Gaming Media and Social Effects,
DOI: 10.1007/978-981-4560-96-2_12,

meet these guidelines in at least 10-min bouts, and only 5 % of adults meet these guidelines on at least 5 days per week (Colley et al. 2011a, b). To encourage physical activity, researchers and developers have created a variety of exergames that encourage people to exercise, by integrating exercise into the game mechanics (e.g. (Ahn et al. 2009; Berkovsky et al. 2012; Gao and Mandryk 2011; Hernandez et al. 2012; Mueller et al. 2010; Stanley et al. 2011; Xu et al. 2012)). For example, in GrabApple (Gao and Mandryk 2011) (a Kinect-based digital exergame), the player has to move, jump and duck to collect apples. Because the player's body weight acts as resistance in GrabApple, playing the game yields moderate to vigorous exertion levels, but it is rated as fun as a sedentary mouse-based version of the game (Gao and Mandryk 2012).

Recent work among health researchers has shown that alongside the benefits provided by physical activity, there are also negative consequences associated with sedentary behaviour (Garber et al. 2011; Tremblay et al. 2010). For example, sedentary behaviour has been shown to influence carbohydrate metabolism (Chilibeck et al. 1999), reduce bone mineral density (Zwart et al. 2007) and affect vascular health (Hamburg et al. 2007). Interestingly, the physiological changes that result from sedentary behaviour are distinct from those that result from a lack of physical activity (Tremblay et al. 2010). A lack of exercise changes the body in different and unique ways from an overall sedentary lifestyle (Hamilton et al. 2008). Although this may seem surprising, physical activity and sedentary behaviour are not mutually exclusive; as Fig. 1 shows, even if a person is physically active (e.g. goes for a jog first thing in the morning), she can also be sedentary (e.g. by primarily sitting for the remaining waking hours); the effects of too much sitting are physiologically distinct from too little exercise (Owen et al. 2010). Thus, a physically active individual could be susceptible to the negative effects of a sedentary lifestyle (Tremblay et al. 2010). Because exercise and sedentary behaviours influence the body in different ways, the benefits of meeting the physical activity guidelines could be undone if people spent the remaining hours of the day engaging in largely sedentary behaviours (Hamilton et al. 2008). Because of the potential negative effects on health, many groups are now exploring the need for anti-sedentary guidelines to exist alongside guidelines for physical activity. For example, the Canadian Society of Exercise Physiologists now has sedentary guidelines for children and youth (Tremblay et al. 2011); however, more foundational research on the detrimental effects of sedentary behaviour on physiology is needed to establish evidence-based guidelines for all populations (Tremblay et al. 2011).

As researchers who design digital game-based interventions to promote health, we have been focused on designing games to promote physical activity; however, these exergames may or may not also work to combat sedentary behaviours. For example, a game designed to encourage a jogger to commit to and follow through with a daily jog will help a player meet the physical activity guidelines, but will not help to combat sedentary behaviour over the remaining waking hours. There simply exists no analysis of the design requirements for anti-sedentary games to

Fig. 1 Daily activity charts (*grey* = sedentary time, *black* = active time, time passes from *top* to *bottom*) representing three activity profiles. *Left* sedentary person, *Middle* Physically active person, *Right* Physically active person who is also sedentary

help inform researchers how the designs of anti-sedentary exergames should differ from physical activity-promoting exergames.

In this chapter, we first present and contrast the medical guidelines for physical activity and those for sedentary behaviours. We discuss compliance with the guidelines and common barriers to an active lifestyle. We then identify how exergames have addressed these barriers by following a series of design principles, and what additional principles need to be considered for anti-sedentary game design. We dub these anti-sedentary games energames, and provide a review of examples from the literature for digital games that partially meet the criteria of principled energame design. This critical analysis is followed by a further discussion of the fundamental design principles for energames and their differentiation from traditional exergames. We conclude by considering the challenges and opportunities in this new area of designing, deploying and evaluating digital games that combat sedentary behaviours.

2 Guidelines for Physical Activity and Anti-sedentary Behaviour

Combating inactivity has frequently been addressed through the compilation of guidelines. Physical activity recommendations aim to provide guidance for setting goals in daily life to provide sufficient exercise to improve overall health. In contrast, anti-sedentary guidelines aim to combat sedentary lifestyles, shifting the focus from increasing physical exertion to encouraging frequent, low-intensity physical activity to avoid negative health effects. In this section, we present an overview of guidelines for physical activity, guidelines to combat sedentary lifestyles and adherence to these guidelines.

2.1 Physical Activity Guidelines

The Canadian Society for Exercise Physiology (CSEP) provides guidelines for physical activity to help individuals set exercise goals that will result in health benefits (csep.ca/guidelines). For children and teenagers, they recommend at least 60 min of moderate-to-vigorous physical activity per day. To achieve this goal, the recommendations suggest vigorous-intensity exercise three times a week in addition to muscle and bone-strengthening exercises on three or more days (Tremblay et al. 2011). For adults, recommended levels of physical activity can be reached by engaging in 150 min of moderate-to-vigorous-intensity physical activity per week (Tremblay et al. 2011), which can be broken up into chunks of as small as 10 minutes. Additionally, adults are recommended to include muscle and bone-strengthening activities twice a week. Similar guidelines are provided by the American College of Sports Medicine (Garber et al. 2011) and the American Heart Association (see heart.org).

Despite the wide availability of guidelines that can help inform individuals about the benefits of regular physical activity, research reports that many people only partially achieve activity goals (e.g., they do exercise at required intensity levels, but do not engage in activity frequently throughout the week), with particularly poor compliance rates among teenagers (Pate et al. 2002). As a result, many people do not reach recommended levels of physical activity (Colley et al. 2011a, b) and health risks remain, particularly among children and teenagers (Sothern et al. 1999).

2.2 Anti-sedentary Guidelines

As a response to the growing body of evidence showing that there are distinct physiological responses to a lack of physical activity and to sedentary behaviour (Tremblay et al. 2010), the CESP has recently released guidelines to combat sedentary lifestyles among children and youth. In contrast to existing physical activity guidelines aiming to encourage physical exertion, these anti-sedentary guidelines focus on re-introducing physical activity into daily routines. Based on an analysis of behaviours that can lead to sedentary lifestyles, such as using motorized transportation, watching television, playing sedentary video games and using computers, the CSEP suggests that families introduce activity by replacing sedentary means of transportation and introducing active family time. Their guidelines suggest limiting sedentary transport, prolonged sitting and time spent indoors. Furthermore, they recommend limiting sedentary leisure activities including television and computer use to two hours per day (Tremblay et al. 2011).

The approach suggested in this chapter—applying video games to combat sedentary lifestyles—seems to contradict the CSEP recommendations. However, it is important to make a distinction between sedentary and active video games. In the context of our work, we believe that engaging with video games that encourage physical activity can help fight sedentary lifestyles despite increasing the overall time that is spent playing video games, by combining a popular leisure activity with physical activity, potentially facilitating a transition into a more active lifestyle. In this chapter, we outline how physical activity can be designed into games that support the goal of combating sedentary lifestyles, thereby encouraging players to be more active and helping them to adopt healthier lifestyles.

3 Barriers to Healthy Behaviour

As noted in previous sections, many people do not get the recommended levels of physical activity per day (Colley et al. 2011a, b). Researchers and governmental institutions have identified common barriers to physical activity to provide recommendations for persons wishing to transition from a sedentary lifestyle into more active daily routines.

3.1 Common Barriers to Physical Activity

Research results (Salmon et al. 2003) suggest that environmental issues (e.g. bad weather), the cost of exercise and individual aspects of personality (e.g., one's intrinsic motivation and perceived self-efficacy) have an impact on whether a person gets sufficient physical activity. Many initiatives aiming to foster physical activity and combat sedentary lifestyles discuss these barriers in detail. According to the Centres for Disease Control and Prevention (CDC, cdc.gov), common barriers to participating in physical activity are a lack of time, low interest in activity, low self-efficacy, a lack of social support and access to suitable facilities. Likewise, Healthy Families BC (healthyfamilies.bc) mentions that being busy, lacking exercise partners, not knowing how to approach physical activity and not wanting to sweat or feel hot are common barriers. These identified barriers can be roughly categorised into three main types: *psychological barriers* (i.e. physical activity is often boring, and antisocial, with significant skill, physical fitness and perceived capability barriers to entry), *temporal barriers* (i.e. physical activity is often disruptive to modern schedules and often has significant start-up and recovery times) and *physical barriers* (i.e. physical activity often requires access to specialised hardware or locations, or is constrained by physical processes outside the player's control such as the weather).

3.2 Barriers to Non-sedentary Lifestyles

In addition to the lack of physical activity, many people simply spend too much time sitting, and sedentary behaviours can result in negative health outcomes that are physiologically distinct from those associated with a lack of physical activity (Hamilton et al. 2008; Tremblay et al. 2010). Technological innovations have a lot to do with the amount of time spent sitting. People drive or ride buses to work, engage in computer-based jobs (where sitting is the norm) and indulge in screen-based leisure activities, such as watching television and playing video games. Consider the average day for many people—it begins with riding in a vehicle to work, sitting throughout the day, commuting home, a sit-down dinner and a few hours spent watching television, playing games or reading a book. Going to the gym or playing a sport can displace some of the time spent sitting, but modern routines themselves form a significant barrier to non-sedentary behaviour.

In addition, the aforementioned psychological barriers to exercise are also barriers applicable to people who wish to change their sedentary lifestyle. Taking breaks from sitting by climbing stairs or stretching is not particularly compelling, whereas physical fitness might prevent a person from choosing to cycle to work, rather than ride in a vehicle. Physical barriers are also still relevant; cycling to work or going for a walk over your lunch break can be difficult in many climates due to seasonal weather. However, if planned correctly, the temporal barriers to exercising—start-up and recovery (e.g. shower and change) times and finding time in a busy schedule to exercise—are not as relevant in the context of combating sedentary behaviour as they are to promoting physical activity. If designed correctly, anti-sedentary games could slot into a player's day in opportunistic moments, while the short duration and light activity of a game to combat sedentary behaviour does not require a player to change or shower. As such, there is an opportunity for anti-sedentary games to easily address the temporal barriers, while specifically targeting the physical and psychological barriers to an active lifestyle, thus improving overall health.

4 Design Principles for Exergames and Energames

To help people meet the recommendations for physical activity, and to overcome the barriers to exercise, researchers have created a variety of exergames, usually by replacing a regular game input device with controllers that require physical effort to foster activity among players and thus encourage healthier lifestyles. Mueller et al. define exergames as games "in which the outcome is predominantly determined by physical effort" (Mueller et al. 2011) and that "demand intense physical effort from players" (Mueller et al. 2010), highlighting that such games focus on providing sports-like exertion, which goes beyond simply encouraging players to be more active. The term "exergame" generally implies that physical activity resulting from game play is of moderate or vigorous intensity. In contrast, games that combat sedentary behaviour do not require intense physical effort or sport-like exertion, but encourage movement throughout the day to combat long periods spent sitting. In contrast to exergames, we dub these games *energames*, i.e. *games that reduce sedentary time by requiring frequent bursts of light physical activity throughout the day*.

In this section, we first present the guiding principles for exergame design to investigate whether they can be leveraged to facilitate the design of energames. This is followed by several examples of commercial and research-based exergames. We then define new guiding principles for energame design, followed by examples of several exergames that could be adapted to meet these principles and thus successfully combat sedentary behaviours.

4.1 Guiding Principles for Exergame Design

Research has previously addressed the design of effective exergames by providing design principles for integrating physical activity into games while fostering player motivation. A meta-level approach is provided by Consolvo et al. (2006), where they highlight the importance of providing feedback on activity levels, drawing awareness to past and current activity levels and providing feedback regarding goal achievement. Furthermore, the authors underline the importance of social influence for long-term user engagement, particularly social pressure that can be increased by sharing users' levels of activity and social support that can be achieved through the connection of users. Finally, they point out that accounting for users' lifestyles is crucial to facilitate the integration of activity-motivating technologies in daily life, which is particularly important when designing games to combat sedentary lifestyles. In the remainder of this section, we present additional considerations for exergame design by compiling guiding principles from a variety of sources and categorising them into five core areas of interest.

(1) Providing an easy entry into play. Lowering the barrier to foster physical activity can be accomplished by offering players an easy entry into play (Väätänen and Leikas 2009) using accessible core game mechanics (Campbell et al. 2008). Providing tips or hints can support entry along with advice to new players (e.g. tutorials) and coaching mechanisms that help players grasp the physical dimension of the game, e.g. learning gestures and the development of motor skills (Thin and Poole 2010).

(2) Implementing achievable short-term challenges to foster long-term motivation. To engage players over a longer period of time, many guiding principles comment on the inclusion of achievable short-term goals in order to foster long-term player motivation (Campbell et al. 2008; Thin and Poole 2010; Yim and Graham 2007). Yim and Graham (2007) refer to the concept of self-efficacy—the degree to which people attribute change in their lives to their own actions—to underline the importance of achievable goals.

(3) Providing users with appropriate feedback on their exercise effort. Providing players the opportunity to review their exercise efforts, for instance through progress charts that can be accessed after play or in-game feedback that informs players about their current performance (Thin and Poole 2010) can improve performance. Likewise, it is recommended to hide players' fitness levels in multi-player environments to avoid direct competition between players, which might discourage novice users or players with lower fitness levels (Yim and Graham 2007).

(4) Implementing individual skill-matching to keep players engaged. Adapting in-game challenges to match players' individual skill levels is one of the most important aspects of exergame design. Campbell et al. (2008) recommend the inclusion of marginal challenge to address this issue: providing the player with challenging, yet achievable in-game tasks. This is not only relevant to adapt games to the skill level of players; balancing between different players to provide enjoyable multi-player experiences is another important factor. Mueller et al. (2012) elaborate on this issue and provide a list of design tactics: to balance between players, they recommend facilitating empathy by creating awareness of other players' workout intensities and allowing players to negotiate the duration of physical activity. Stach et al. (2009) recommend that exergames be balanced for people of different fitness levels by driving play mechanics by a player's exertion relative to their own fitness level (e.g. through percent of target heart rate), rather than through absolute metrics of effort (e.g. through cycling revolutions per minute).

(5) Supporting social play to foster interaction and increase exercise motivation. Supporting social play and fostering interaction between players is a core component when trying to increase long-term exercise motivation. Campbell et al. (2008) distinguish between internal (specific to the game context) and external (brought into the game from outside) social relations that have to be accommodated by exergames. Mueller et al. (2009, 2010) provide a detailed analysis of social interaction in exergames, and offer additional design recommendations for social play, including considerations regarding the importance of meta-gaming (game-related activity that occurs outside of actual gameplay) between sessions to foster social bonding.

Because many of these principles focus on motivational aspects of exergame design, they hold valuable information for game designers, and can help overcome some of the barriers to exercise presented in the previous section. However, additional considerations are necessary to create games that fully address all design challenges that go along with combating sedentary lifestyles, rather than fostering physical exertion. In the following section, we further investigate how exergame design can help inform the creation of energames: we provide an overview of successful exergame examples, and investigate how their core mechanics can be leveraged to help inform the design of energames that can help address the barriers to an active lifestyle.

4.2 Successful Exergame Examples

To explore how games can help individuals be more active, we analyse currently available exergames, and discuss how principles applied in these games can be applied in the design of games to combat sedentary behaviour. In our analysis, we do not provide an exhaustive overview of currently available exergames; we choose successful exemplars spanning from commercially available exergames to games that were developed as research tools.

Commercially available exergames. A very popular platform for commercial exergames is Nintendo's Wii console (http://wii.com), which features the Wii Remote controller that uses different buttons and accelerometer information to track user input; an increasing number of games that require physical player input have been released for the console. One of the most successful commercially available games on that platform is Wii Sports (http://nintendo.com/games). The game consists of four different mini games that implement the Wii Remote controller in different ways, Wii Sports Bowling, Tennis, Golf, and Boxing. Research has shown that except for Wii Sports boxing, the games do not cause significant energy expenditure among players, and none of the games provide activity levels similar to the actual sport (Graves et al. 2008). However, games like Wii Sports show how integrating physical input into video games can shift sedentary playing time to more active behaviour. While levels of energy expenditure may not be sufficient to replace traditional physical activity, such games may be suitable to combat sedentary behaviour by reaching out to gaming audiences that exhibit sedentary behaviour by nature (high amounts of daily screen time) and replacing sedentary play with active alternatives.

Higher levels of energy expenditure are achieved by video games that use music and simulate dancing, and they are among the most successful commercially available exergames. A prominent example is Konami's Dance Dance Revolution (DDR) (konami.com/ddr). DDR uses a custom controller—a mat equipped with sensors to detect the player's steps—and invites players to dance along with different songs, displaying the necessary steps on screen. Because of the fast pacing and increasingly difficult dance moves, the game encourages higher levels of energy expenditure than many other exergames, partially reaching recommendations of intensity levels of physical activity by the American College of Sports Medicine (Unnithan et al. 2005). Similar to DDR, Dance Central (DC) by Harmonix integrates music and physical activity to engage players in the game (dancecentral.com). Players perform Kinect-tracked dance moves along with music, requiring complex physical input sequences. By integrating the whole body in play, the game has the potential of providing higher levels of physical activity than other systems such as Nintendo Wii Sports. When designing games to combat sedentary lifestyles, the motivational pull of music can be leveraged to encourage individuals to become more active. However, an issue that designers must address is the difference in energy expenditure caused by currently available games. Some motion-based games require so little activity that there is little benefit over playing with a standard game controller (sedentary game); however, the energy required to play some dancing games may be too high to engage players used to sedentary play (i.e. the fitness barrier may be insurmountable). Energames targeted at sedentary players need to tune energy expenditure requirements to promote active screen time, while not discouraging people accustomed to sedentary play.

Exergames in research. Research on exergame design has approached the topic from two sides. Games such as Jogging over a Distance by Mueller et al. (2010), where persons in remote locations are connected to allow them to go on runs together, aim to bring game elements into the realm of traditional exercise. Another slightly different approach towards augmented outdoor sports experiences is the skateboarding game Tilt 'n' Roll by Anlauff et al. (2010), which requires users to ride a skateboard that is equipped with sensors to detect board movements and tricks. This set-up is extended by a mobile application that keeps track of user achievements. Such sports-like exergames focus on augmenting the real-world experience with technology to motivate players, and to provide an engaging player experience. Sensor-based approaches provide an example of how gaming technologies can be applied to overcome barriers to physical activity, which may be an interesting design opportunity for games to combat sedentary lifestyles: connecting persons in remote locations can help provide social support for exercise, and adding game elements to sports can help increase their motivational pull. Likewise, research on exergames has addressed their design from the perspective of game development. Projects such as Heart Burn (Stach et al. 2009)—a racing game that is controlled using a recumbent stationary bike—and Swan Boat (Ahn et al. 2009)—a multi-player game where two players' hand and arm gestures combined with treadmill input to collaboratively steer a boat on its way down a virtual river—integrate sports equipment to implement physical activity into games. These projects demonstrate that it is possible to create games with engaging game mechanics that have the added benefit of physical activity, with greater creative freedom than when trying to combine existing sports with entertainment technologies. Such games may provide the opportunity of encouraging people who are not interested in sports in different kinds of physical activity, contributing to their overall activity levels. In addition, the use of custom hardware can introduce people who are unable to participate in traditional sports to exertion-based play, such as Liberi's adapted bicycle that allows children with Cerebral Palsy to play a multi-player open world game (Hernandez et al. 2012). Finally, to better fit physical activity into a person's busy day, and to address the barrier of users feeling too hot or too sweaty (cf. Sect. 3), the casual exergame GrabApple by Gao and Mandryk (2011), shown in Fig. 2 is based on the idea of providing players with short, 10-minute chunks of exercise to help them obtain the recommended levels of exercise by making it easier to fit physical activity into daily schedules.

Summary. Commercially available and research-based digital exergames integrate physical activity into video games by drawing from aspects of sport and game design. The aforementioned examples of successful exergames show that certain aspects of such games can encourage physical activity. This potential may also be leveraged for the design of energames; however, further considerations are

Fig. 2 GrabApple, a casual exergame

necessary to account for differences when encouraging individuals to integrate frequent, light-intensity physical activity into daily routines as compared to encouraging them to participate in moderate-to-vigorous physical exercise.

4.3 Guiding Principles for Games that Combat Sedentary Behaviour

Exergames that encourage physical activity have seen some success in providing individuals with moderate-intensity exercise in an engaging play session. The goal of energames, however, is not to provide moderate-intensity physical activity, but to reduce the amount of sedentary time. Whether a game is built to promote moderate-intensity sustained exercise, or to reduce the amount of time spent sitting, the aforementioned principles of good exergame design still apply. Games should still provide easy entry, implement achievable challenges to foster long-term motivation, provide feedback, offer adequate and balanced challenge, and support social play. However, for successful energames, there are additional requirements related to providing low-intensity activity, multiple times over the course of the day.

Casual interaction. GrabApple was the first exergame engineered specifically as a *casual exergame*, which is defined as “computer games that players can learn easily and access quickly, using simple rules and special game mechanics, to motivate them to exercise at a moderate intensity for short periods of play” (Gao and Mandryk 2011). The goal of GrabApple was to create an exergame that could be played in 10-min bursts multiple times throughout the day to meet the recommended guidelines for physical activity. By applying the principles of casual game design to the design of an exergame, Gao and Mandryk created a game that was easy to access, produced moderate-to-vigorous-intensity exercise similar to

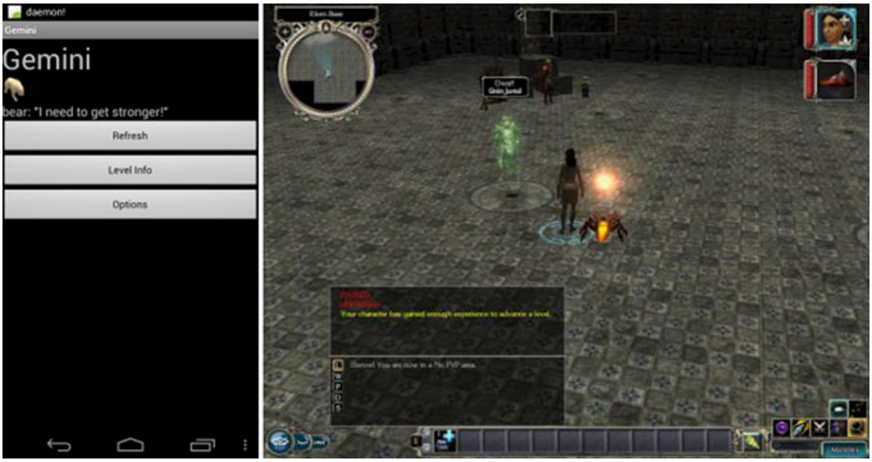

Fig. 3 Gemini: an accumulated context exergame. Screenshots of phone interface (*left*) and RPG game (*right*)

running on a treadmill, but was as fun to play as a sedentary version of the game (Gao and Mandryk 2012). Although GrabApple was designed to promote physical activity, the concepts behind casual play are important when considering games that combat sedentary behaviour. Anti-sedentary guidelines promote lower intensity activity frequently throughout the day, thus game-based interventions require accessible games with short set-up times, and the use of readily-available equipment. Therefore, the first additional principle for energame design is:

(6) Keeping interaction casual. To support users playing the game multiple times per day, start-up interfaces, play time and equipment must be kept casual. Following the guide for casual exergame design (Gao and Mandryk 2011, 2012) will help to create energames that can be accessed quickly and easily.

Pull to repeat. The intention of GrabApple was that it should be played multiple times per day to meet the recommended levels of physical activity; however, the design of the game did not explicitly encourage repeated play sessions. To combat sedentary behaviour, energames should ideally motivate users to play frequently, with play sessions spread throughout the day. There are many examples of games that encourage repeated play through the use of social play mechanics (e.g. Zynga's Farmville (http://Farmville.com), persistent worlds (e.g. Blizzard's World of Warcraft (http://battle.net/wow)), or simple but addictive interactions (e.g. Rovio's Angry Birds (http://angrybirds.com)). Although some of these games allow for the short play sessions of a casual game (e.g. Farmville, Angry Birds), others are designed to be more immersive and thus promote longer play sessions (e.g. World of Warcraft). In an alternate approach to promote frequent play, some exergames have been designed to decouple the physical activity from game play. Gemini (Stanley et al. 2011) (shown in Fig. 3) is a role-playing game that allows users to collect their activity over the course of a day and integrate these real-world behaviours for in-game rewards in a standard immersive play session. This approach (described in more detail in the next section) helps to encourage physical activity over the entire course of a day, and not just during the play session. Because anti-sedentary guidelines promote lower intensity activity frequently throughout the day, the second additional principle for energame design is:

(7) Motivating repeated play sessions throughout the day. To break up long periods of sitting, energames should be played frequently over the course of the day. Using social games mechanics, persistent worlds, or accumulated activity could motivate players to repeat play sessions multiple times in a day.

Persuasive games. Although playing an energame that follows the principles of casual game design multiple times a day could help to decrease sedentary behaviours, helping a user change their habits and routines to decrease sedentary time will also have a positive impact on a user's health. Persuasive games (game-based persuasive technologies that aim to bring about desirable change in attitude and behaviour without using coercion or deception (Fogg 2002)) could help users to replace sedentary behaviours with active ones. For example, a persuasive game that encourages users to commute via bicycle (rather than by car) to reduce carbon emissions also has potential to reduce sedentary behaviour, and thus has value as an energame. Persuasive games could also be designed with the specific goal of reducing sedentary time (e.g. by encouraging cycling or walking to work instead of driving or taking the stairs instead of the elevator). A key idea behind persuasive games for behaviour change is that they scaffold new routines—unlike some other approaches, the new behaviour should remain after the game intervention is removed. These games are not outside of the context of sedentary game design, but simply represent a specific approach to reducing the time spent sitting. The third energame principle is:

(8) Persuading players to change their routines and habits. To scaffold routines that better fit the guidelines for non-sedentary behaviour, principles from persuasive game design can be used to help users make small changes with big impact.

Summary. These new guiding principles for energame design suggest that video games can be applied to reduce sedentary behaviours and thus improve player health. In the following section, we review examples from the exergame literature that either fit the principles for energame design or could be adapted to fit the principles and reduce sedentary behaviours.

4.4 Successful Energame Examples

Exergames have been traditionally designed to increase physical activity; there has been little direct intention to create games that combat sedentary behaviour. However, there are several games in the larger space of ubiquitous games, casual exergames, and accumulated activity games that overcome some of the barriers to non-sedentary behaviour identified in this chapter.

Fig. 4 PiNiZoRo, a low-intensity ubiquitous exergame. Screenshots of (*left*) orienteering interface and (*right*) one of several minigames

Ubiquitous games. Ubiquitous games in general (Magerkurth et al. 2005) and mixed reality games in particular (Lindt et al. 2007) utilise real-world context as a game mechanic or input, often focusing on the player's location in the world (see (Magerkurth et al. 2005) for a review). Because these location-based games are driven by a player's movement through the world (e.g. (Bell et al. 2006; Benford et al. 2006; Stanley et al. 2010)), they can be considered exergames so long as the player is propelling themselves (as opposed to riding in a vehicle). Fast-paced ubigames such as Can You See Me Now (Benford et al. 2006), which pitches virtualand real players against each other in a game of team tag or Zombies, Run! (http://www.zombiesrungame.com), which has the player performing interval training to escape a zombie hoard, can fit the traditional definition of an exergame; whereas slower-paced walking games inspired by geocaching like Feeding Yoshi (Bell et al. 2006)—in which the player moves through the world to plant seeds and gather fruit for their virtual character—and PiNiZoRo (Stanley et al. 2010)—an orienteering game for families that has players 'walk a beat' in their neighbourhood (Fig. 4)—tend to provide lower-impact activities. These games that require low-intensity physical activity could be construed as early energames; however, they do fall short of addressing all the energame design requirements. Games like PiNiZoRo have a not-inconsequential set-up time as minigame rewards must be placed sensibly around the local environment by a game designer, often a parent. Likegeocaching, levels are typically designed to take 20–30 min to complete, too long to be played frequently, multiple times per day. Designing casual walking games that promote activity throughout the day could be a promising first step in energame design.

Casual exergames. Casual exergames such as GrabApple (Gao and Mandryk 2012) do fit the temporal requirements for energames, in that they are designed to be played in short bursts. However, as an academic effort, GrabApple has a lower replay value than commercially-designed games. Although a leaderboard or other competition-based incentives could motivate more frequent play, GrabApple requires fixed hardware (i.e. a Kinect sensor) and thus is not accessible at any time to any individual. As smartphone activity sensing improves, and reduces cheating in accelerometer-based play (e.g. shaking a pedometer), the use of compelling game mechanics, such as those demonstrated in Angry Birds (http://angrybirds.com) or Temple Run (http://imangistudios.com), could create low-barrier, highly-repeatable games. Although attempted in a number of commercial applications such as Teemo (http://goteemo.com), the design and implementation of smartphone-based casual exergames is subject to 'cheating' accelerometer-based input and the social awkwardness that results from performing the game mechanics (e.g. squatting) in public places (Gao and Mandryk 2012).

Accumulated activity games. Accumulated activity exergames decouple exercise and play to provide asynchronous in-game rewards (often in a traditional sedentary game) for previously-completed activity in the real world. Gemini (Stanley et al. 2008, 2011), Neat-o-Games (Fujiki et al. 2008), Move2Play (Bielik et al. 2012), American Horsepower Challenge (Xu et al. 2012), Play, Mate! (Berkovsky et al. 2009), and Neverball (Berkovsky et al. 2012) are examples of this concept in the academic literature. Pokewalker from Nintendo (http://nintendo.com/consumer/systems/ds/pokewalker.jsp), where pedometer-enhanced pokemon battle for supremacy, is the best-known commercial instantiation of an accumulated activity game. Interaction can be designed to provide players with directly mapped in-game benefits such as more powerful pieces (Stanley et al. 2008) or companions (Stanley et al. 2011), in-game currency to purchase mechanic-impacting (Fujiki et al. 2008) or cosmetic (Xu et al. 2012) virtual items, or unlocks for in-game capabilities (Berkovsky et al. 2012) or new games or minigames (Bielik et al. 2012). This class of games sidesteps some of the design requirements for short duration, and ease of accessibility in energames by measuring activity continuously. Whenever activity occurs, it is measured, accumulated, and credited for digital rewards in the offline game. Players are implicitly encouraged to fit in small bouts of activity whenever possible to increase their benefit in the sedentary portion of the game. However, the reward structure for these games does not perfectly match the requirements for energames. In a typical example, exercise is accumulated over the day, but the in-game impact of physical activity may be scaled based on individual factors, such as fitness level or historical activity levels, to encourage continued play and prevent disengagement (Berkovsky et al. 2012). However, the sequence of activities is not generally prescribed. In simple accumulated activity games, a single bout of walking for an hour is given the same weighting as six 10-minute walks. While both activities are desirable, according to anti-sedentary guidelines, the six shorter walks spread throughout the day would be preferable to the single long walk. Finally, accumulated activity games are often linked to sedentary gaming experiences, so the non-sedentary portion of the game is facilitating the sedentary activity. Careful cost-benefit balancing is required to combat this issue.

Summary. While no existing game or game genre meets all the requirements for energames, analysing how different genres do and do not match the principles can provide some insight into how future games should be designed to counter sedentary behaviour. Classic exergames often have too high a barrier to entry and too long a duration for use as energames. Casual exergames overcome the duration and accessability barriers, but have typically not provided sufficiently rewarding experiences to entice players into multiple bouts through a day, week in, week out. Accumulated activity games completely remove the barriers to entry by always

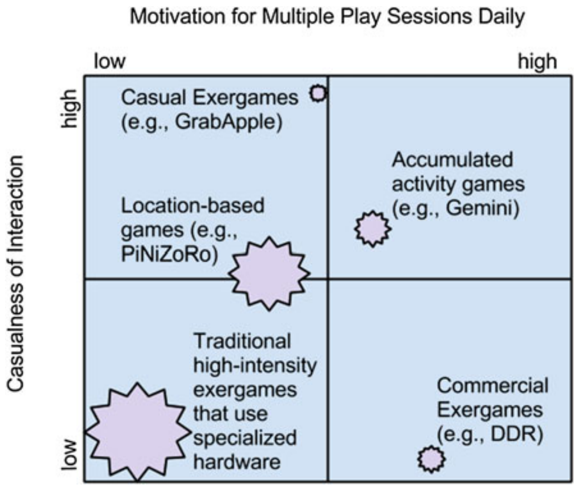

Fig. 5 Exergames plotted on a matrix of casualness and motivation for multiple play sessions. Energames should appear in the upper right quadrant, which is largely unexplored

measuring activity level, but do not currently distinguish whether activity is occurring frequently throughout the day, or in a single burst (although this could be incorporated into gameplay). In addition, these games also require a delayed gratification by decoupling exercise and play, which may inhibit transfer of game-based routines to general lifestyle choices through scaffolding.

If we consider the design of energames, and where existing exergames fail to combat sedentary behaviour, it seems apparent that energames should possess a low barrier to entry in terms of physical or game ability, access to specialised equipment or locations and required recovery time, but also have a high replay ability factor to allow users to continue to repeat the experiences multiple times per day, every day of the week. If we plot existing games on a matrix with casualness (low-to-high) on one axis, and motivation for multiple play sessions (low-to-high) on the other, we demonstrate how applying the principles of energame design should result in games in the upper right quadrant (see Fig. 5). We also find that most traditional academic games fall within the lower left quadrant, having a generally high barrier to entry (i.e. due to specialised hardware), a design for moderate-intensity activity and no pull to repeat, either due to a game design that targets a single session of play, or having mechanics that simply are not compelling enough to engage players frequently throughout the day. The casual exergame GrabApple (Gao and Mandryk 2011) fits in the upper left quadrant, because although high in terms of the requirement for casual play, it has little to compel a player to repeat play multiple times throughout the day. The commercial exergame DDR sits in the lower right quadrant matrix, having a mechanic that encourages replayability in multiple play session, but has significant barriers to entry (requiring specific hardware). Smartphone-based (or pedometer-based) accumulated activity games have exceptionally low barriers to entry, being always on, but have a more diffuse pull to repeat due to the delayed gratification of a single play session. The current instantiations of accumulated activity games sometimes integrate with a non-casual game engine (e.g. as in the role-playing game Gemini based on Neverwinter Nights); however, the smartphone-based portion of the game that encourages activity throughout the day is very casual. It is not surprising that current exergame types do not also meet the principles for energame design; they were generally designed to promote moderate-intensity exercise for a dedicated and sustained period of play, not to reduce sedentary time. As is apparent from the figure, the upper right quadrant—which should be inhabited by energames—is largely unexplored, providing fertile ground for additional research. The properties of the upper quadrant and its future potential are explored in the following section.

5 Opportunities and Challenges

5.1 Towards Energames

Casual games and accumulated activity games address some, but not all, of the requirement for energames. These games experience temporal shortcomings as energames: casual games are not sufficiently compelling in the long-term, and accumulated activity games do not address the timing of activity with sufficient resolution. Being compelling both in short bursts and over the long term is a daunting design challenge. However, certain game genres, such as MMORPGs or casual games, can provide compelling examples of how games can have a high pull to repeat, encouraging players to come back multiple times a day, several times a week over prolonged periods of time. Analysing the pacing and mechanics of examples such as the MMORPG World of Warcraft (http://battle.net/wow) or casual games such as Farmville (http://farmville.com) or Bejeweled (http://bejeweled.popcap.com) can provide additional insight into the creation of energames. For example, people spend 300 million minutes a day playing the casual game Angry Birds (McGonigal 2012), showing that a compelling game mechanic has a lot of motivational pull. The wide variety of highly-motivating sedentary casual games and their broad appeal from hardcore gamers to casual players shows how carefully designed energame concepts can be tailored towards different audiences, potentially encouraging children, teenagers and adults to adopt more active lifestyles.

5.2 Research Challenges and Opportunities

As previously discussed, one of the main barriers to non-sedentary behaviours is the modern professional's need to be sitting at a desk or using a computer. While it may be easier to fit several small bouts of physical activity—rather than a prolonged high-intensity activity—into a sedentary-office worker's workday, it is still difficult to incorporate multiple bouts of physical activity within a workday context. Because non-sedentary tasks must be performed repeatedly, the player cannot be left to play only outside of work, as this could lead to long sedentary periods at work. However, game-based interruptions to sedentary behaviour must be sensitive to both larger routines, and specific individual schedules. Asking the player to go for a walk in the middle of their carpool commute, or to perform jumping-jacks in the middle of a scheduled meeting would be inappropriate and potentially unsafe. Research advances in context-sensitive interruption from the field of ubiquitous and pervasive computing could determine if the player is in an interruptible state, prior to triggering a reminder to encourage the player to engage with the game.

Even if the player has the physical space during a meeting, performing jumping-jacks while the CEO is addressing the company would be considered socially unacceptable. Even performing callisthenic exercises outside of work contexts (e.g. waiting at a bus stop) could be socially awkward. Novel mixed reality game designs might be a potential solution to this problem. Context-appropriate missions could be triggered to allow the player to engage in a short period of movement without seeming to be socially inappropriate. Examples of such tasks include pretending to deliver a file to another floor in an office environment in an "OfficeDash"-style game, or walking briskly, but unobtrusively for five minutes without anyone noticing you in a spy-themed game, or using the social lubricant of children or pets to perform socially acceptable short bursts of free-play.

Another challenge is associated with encouraging physical activity among special populations. For example, people with certain motor disabilities or chronic diseases, people who use wheelchairs, and institutionalised older adults are at a higher risk of sedentary behaviour as they often depend on the assistance of others to be able to engage in physical activity, and because side-effects of their condition (e.g. range of motion, gross motor control) may limit their ability to be physically active. Research has recently addressed this issue by studying how motion-based controls can be introduced in ways that lower accessibility barriers, for instance by integrating wheelchair-based game input (Gerling et al. 2013) that can turn sedentary video games into motion-based games, and by analysing how motion-based controls should be designed to be suitable for older adults (Gerling et al. 2013) to successfully encourage physical activity (Gerling et al. 2012). Likewise, research on the design of exergames for children with cerebral palsy (who have gross motor impairments) has shown that exergames are a great opportunity to encourage children with cerebral palsy to be more active; however, it was necessary for the researchers to design a specialised bike ergometer to enable play (Hernandez et al. 2012). Many game projects for populations with reduced motor ability resemble energames—requiring some physical effort, but focusing on gaming accessibility, and providing modest physical activity in order to reduce the negative effects of sedentary lifestyles. However, like most exergames, these academic efforts generally are intended to be played in a single dedicated session, and not multiple times per day.

Even if the scheduling can be appropriate managed, and suitable incentives and difficulty levels for a variety of gamer types and populations can be created, energames suffer from a difficult feedback problem—the health benefits are not immediately and clearly visible to the user. Many of the benefits of non-sedentary behaviour are preventative—reducing the risk of serious conditions from appearing later in life (Garber et al. 2011; Pate et al. 1995; Tremblay et al. 2010), and thus little immediate benefit is evident to a player. Changing lifestyle to reduce the risk of future coronary disease can be less compelling than the more immediately apparent gains—such as losing weight, or increased fitness—that are associated with traditional exercise. People may become disengaged with energames if they see no immediate or tangible return on their investment. Contributions from visual analytics that are built into game play could help address this problem. Providing players with visualisations of how their activities are affecting their long-term health, and how not pursuing these activities could be detrimental to their long-term health, could potentially help people understand why playing the energame has benefit. Integrating persuasive strategies (Oinas-Kukkonen and Harjumaa 2008) (such as simulating the long-term effect of short-term changes) into a game design could also make the future benefits of behaviour change more tangible for a player. In addition, highlighting the temporary benefits of short bursts of activity (e.g., improved concentration, working memory and mood; see (Gao and Mandryk 2012)) may help players to see that their efforts are paying off in immediate, although acute, benefits to their well-being.

6 Summary

In this chapter we motivate the concept of an energame—a *game that reduces sedentary time by requiring frequent bursts of light physical activity throughout the day*—to combat the negative health effects of sedentary behaviour. Because these effects are distinct from those due to a lack of physical activity, it is important to consider possible technological interventions for both classes of health behaviours. We arrive at the definition of an energame through scrutiny of the health guidelines for physical activity and non-sedentary behaviour, and consideration of the barriers to an active lifestyle. We employ the results of this investigation to extend existing exergame design principles to energames, particularly with respect to the temporal barriers. Energames must be played frequently for short bursts of time, requiring aspects of casualness and motivational pull not necessarily required of traditional exergames. While our analysis of existing games from both industrial and academic sources did not produce any examples that met all of the suggested design principles, several titles—particularly from the casual and accumulated activity genres—were approaching viable solutions. Drawing design wisdom from sedentary titles such as MMORPGs, casual games and social games, game designers and researchers should be able to build novel energames that manage the temporal, social and personal constraints imposed by the design principles. Sedentary behaviour is linked to many of the lifestyle diseases prevalent in the developed world, making this new class of digital game important for individual well-being.

References

Ahn M, Kwon S, Park B, Cho K, Choe SP, Hwang I, Jang H, Park J, Rhee Y, Song J (2009). Running or gaming. In: Proceedings of advances in computer entertainment (ACE), pp 345–348

Anlauff J, Weitnauer E, Lehnhardt A, Schirmers S, Zehe S, Tonekaboni K (2010) A method for outdoor skateboarding video games. In: Proceedings of advances in computer entertainment (ACE), pp 40–43

Bell M, Chalmers M, Barkhuus L, Hall M, Sherwood S, Tennent P, Brown B, Rowland D, Benford S, Capra M, Hampshire A (2006) Interweaving mobile games with everyday life. In: Proceedings of the SIGCHI conference on human factors in computing systems (CHI), pp 417–426

Benford S, Crabtree A, Flintham M, Drozd A, Anastasi R, Paxton M, Tandavanitj N, Adams M, Row-Farr J (2006) Can you see me now? ACM Trans Comput-Hum Interact (TOCHI) 13(1):100–133

Berkovsky S, Bhandari D, Kimani S, Colineau N, Paris C (2009) Designing games to motivate physical activity. In: Proceedings of the 4th international conference on persuasive technology, pp 37–40

Berkovsky S, Freyne J, Coombe M (2012) Physical activity motivating games: be active and get your own reward. ACM Trans Comput-Hum Interact (TOCHI) 19(4):32

Bielik P, Tomlein M, Krátky P, Mitrík Š, Barla M, Bieliková M (2012) Move2Play: an innovative approach to encouraging people to be more physically active. In: Proceedings of the 2nd ACM SIGHIT international health informatics symposium (IHI), pp 61–70

Campbell T, Ngo B, Fogarty J (2008) Game design principles in everyday fitness applications. In: Proceedings of the ACM conference on computer supported cooperative work (CSCW), pp 249–252

Chilibeck PD, Bell G, Jeon J, Weiss CB, Murdoch G, MacLean I et al (1999) Functional electrical stimulation exercise increases GLUT-1 and GLUT-4 in paralyzed skeletal muscle. Metabolism 48(11):1409–1413

Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS (2011a) Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian health measures survey. Health Rep 22(1):1–8

Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS (2011b) Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian health measures survey. Health Rep 22(1):15–23

Consolvo S, Everitt K, Smith I, Landay JA (2006) Design requirements for technologies that encourage physical activity. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 457–466

Etnier JL, Nowell PM, Landers DM, Sibley BA (2006) A meta-regression to examine the relationship between aerobic fitness and cognitive performance. Brain Res Rev 52(1):119–130

Fogg BJ (2002) Persuasive technology: using computers to change what we think and do. Ubiquity, 2002(5)

Fujiki Y, Kazakos K, Puri C, Buddharaju P, Pavlidis I, Levine J (2008) NEAT-o-Games: blending physical activity and fun in the daily routine. Comput Entertain (CIE) 6(2):21

Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Swain DP (2011) American college of sports medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 43(7):1334–1359

Gerling KM, Dergousoff KK, Mandryk RL (2013) Is movement better? comparing sedentary and motion-based game controls for older adults. In: Proceedings of graphics interface 2013, pp 133–140

Gerling KM, Kalyn MR, Mandryk RL (2013) KINECTWheels: wheelchair-accessible motion-based game interaction. In: Extended abstracts of the ACM conference on human factors in computing systems (CHI), pp 3055–3058
Gerling KM, Livingston IJ, Nacke LR, Mandryk RL (2012) Full-body MOTION-based game interaction for older adults. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 1873–1882
Gao Y, Mandryk RL (2011) GrabApple: the design of a casual exergame. In: Entertainment computing (ICEC), LNCS, Springer, Heidelberg, pp 35–46
Gao Y, Mandryk R (2012) The acute cognitive benefits of casual exergame play. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 1863–1872
Graves L, Stratton G, Ridgers ND, Cable NT (2008) Energy expenditure in adolescents playing new generation computer games. Br J Sports Med 42(7):592–594
Hamburg NM, McMackin CJ, Huang AL, Shenouda SM, Widlansky ME, Schulz E et al (2007) Physical inactivity rapidly induces insulin resistance and microvascular dysfunction in healthy volunteers. Arterioscler Thromb Vasc Biol 27(12):2650–2656
Hamilton MT, Healy GN, Dunstan DW, Zderic TW, Owen N (2008) Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behaviour. Curr Cardiovasc Risk Rep 2(4):292–298
Hassmén P, Koivula N, Uutela A (2000) Physical exercise and psychological well-being: a population study in Finland. Prev Med 30(1):17–25
Hernandez HA, Graham TC, Fehlings D, Switzer L, Ye Z, Bellay Q, Hamza MA, Savery C, Stach T (2012) Design of an exergaming station for children with cerebral palsy. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 2619–2628
Hillman CH, Erickson KI, Kramer AF (2008) Be smart, exercise your heart: exercise effects on brain and cognition. Nat Rev Neurosci 9(1):58–65
Lindt I, Ohlenburg J, Pankoke-Babatz U, Ghellal S (2007) A report on the crossmedia game epidemic menace. Comput Entertain (CIE) 5(1):1–8(article 8)
Magerkurth C, Cheok AD, Mandryk RL, Nilsen T (2005) Pervasive games: bringing computer entertainment back to the real world. Comput Entertain (CIE) 3(3):4
McGonigal J (2012) Building resilience by wasting time. Harv Bus Rev 90(10):38
Mueller F, Gibbs MR, Vetere F (2009) Design influence on social play in distributed exertion games. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 1539–1548
Mueller F, Gibbs MR, Vetere F (2010a) Towards understanding how to design for social play in exertion games. Pers Ubiquit Comput 14:417–424
Mueller F, Vetere F, Gibbs MR, Agamanolis S, Sheridan J (2010) Jogging over a distance: the influence of design in parallel exertion games. In: Proceedings of the SIGGRAPH Sandbox, pp 63–68
Mueller F, Edge D, Vetere F, Gibbs MR, Agamanolis S, Bongers B, Sheridan JG (2011) Designing sports: a framework for exertion games. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 2651–2660
Mueller F, Vetere F, Gibbs MR, Edge D, Agamanolis S, Sheridan JG, Heer J (2012) Balancing exertion Experiences. In: Proceedings of the ACM conference on human factors in computing systems (CHI), pp 1853–1862
Oinas-Kukkonen H, Harjumaa M (2008) A systematic framework for designing and evaluating persuasive systems. In: Proceedings of persuasive technology'08, LNCS, Springer Berlin Heidelberg, pp 164–176
Owen N, Healy GN, Matthews CE, Dunstan DW (2010) Too much sitting: the population health science of sedentary behaviour. Exerc Sport Sci Rev 38(3):105–113
Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Wilmore JH (1995) Physical activity and public health. A recommendation from the centers for disease control and prevention and the American college of sports medicine. JAMA: J Am Med Assoc 273(5):402–407

Pate RR, Freedson PS, Sallis JF, Taylor WC, Sirard J, Trost SG, Dowda M (2002) Compliance with physical activity guidelines: prevalence in a population of children and youth. Ann Epidemiol 12(5):303–308

Salmon J, Owen N, Crawford D, Bauman A, Sallis JF (2003) Physical activity and sedentary behaviour: a population-based study of barriers, enjoyment, and preference. Health Psychol 22(2):178–188

Sothern MS, Loftin M, Suskind RM, Udall JN, Blecker U (1999) The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. Eur J Pediatr 158(4):271–274

Stach T, Graham N, Yim J, Rhodes RE (2009) Heart rate control of exercise video games. In: Proceedings of graphics interface (GI), pp 125–132

Stanley KG, Pinelle D, Bandurka A, McDine D, Mandryk RL (2008) Integrating cumulative context into computer games. In: Proceedings of the international academic conference on the future of game design and technology, pp 248–251

Stanley KG, Livingston I, Bandurka A, Kapiszka R, Mandryk RL (2010) PiNiZoRo: a GPS-based exercise game for families. In: Proceedings of the international academic conference on the future of game design and technology (FuturePlay), pp 243–246

Stanley KG, Livingston IJ, Bandurka A, Hashemian M, Mandryk RL (2011) Gemini: a pervasive accumulated context exergame. In: Entertainment computing (ICEC) 2011, pp 65–76

Thin AG, Poole N (2010) Dance-based exergaming: user experience design implications for maximizing health benefits based on exercise intensity and perceived enjoyment. In: Pan Z, Cheok AD, Müller W (eds) Transactions on edutainment IV. LNCS, Springer, Berlin, pp 189–199

Tremblay MS, Colley R, Saunders TJ, Healy GN, Owen N (2010) Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 35(6):725–740

Tremblay MS, Warburton DE, Janssen I, Paterson DH, Latimer AE, Rhodes RE, Kho ME, Hicks A, LeBlanc AG, Zehr L, Murumets K, Duggan M (2011) New Canadian physical activity guidelines. Appl Physiol Nutr Metab 36(1):36–46

Unnithan VB, Houser W, Fernhall B (2005) Evaluation of the energy cost of playing a dance simulation video game in overweight and non-overweight children and adolescents. Int J Sports Med 27(10):804–809

U.S. Department of Health and Human Services. (1996). Physical activity and health: a report of the surgeon general. Atlanta, Georgia: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion

Väätänen A, Leikas J (2009) Human-centered design and exercise games. In: Kankaanranta M, Neittaanmäki P (eds) Design and use of serious games. Springer Science and Business Media B.V, Heidelberg, pp 33–47

Xu Y, Poole ES, Miller AD, Eiriksdottir E, Kestranek D, Catrambone R, Mynatt ED (2012) This is not a one-horse race: understanding player types in multiplayer pervasive health games for youth. In: Proceedings of the ACM conference on computer supported cooperative work (CSCW), pp 843–852

Yim J, Graham TCN (2007). Using games to increase exercise motivation. In: Proceedings of future play, pp 166–173

Zwart SR, Hargens AR, Lee SM, Macias BR, Watenpaugh DE, Tse K, Smith SM (2007) Lower body negative pressure treadmill exercise as a countermeasure for bed rest-induced bone loss in female identical twins. Bone 40(2):529–537