Turning the classic Snake mobile game into a location–based exergame that encourages walking

Luca Chittaro and Riccardo Sioni
Human-Computer Interaction Lab
University of Udine
via delle Scienze 206
33100 Udine, Italy
http://hcilab.uniud.it

Abstract. Exergames (video games that combine exercise and play) could encourage physical activity by making it more enjoyable. Mobile devices are an interesting platform for exergames because they can support outdoors activities such as walking and running. Different mobile exergames have been proposed in the literature, and typically evaluated with informal interviews and ad–hoc questionnaires. The research we present in this paper had two main goals. First, we wanted to design a fun and easy-to-use mobile exergame to encourage walking. To this purpose, we propose a location–based version of the classic Snake mobile game, in which users can control the snake by walking. Second, we wanted to introduce important measures (such as users' attitude towards walking) in the evaluation of exergames, by adopting validated questionnaires employed in the medical literature. The results of the study presented in this paper shed light on how differences in users' lifestyle can be related to exergame enjoyment and to attitude change fostered by the exergame.

Keywords: Mobile games, Exergames, Location–based games, Attitude change

1 Introduction

Regular physical activity can improve people's health and quality of life, lowering the risk of diseases like stroke and diabetes, improving cardiorespiratory and muscular fitness, decreasing levels of body fat and reducing symptoms of depression [1]. Moreover, for people who are inactive, even small increases in physical activity are associated with health benefits [1].

Video gaming is often blamed as a contributor to sedentary lifestyle, especially in children and teenagers. However, exergames, i.e., video games that combine play and exercise [2] such as Konami's Dance Dance Revolution, Nintendo's Wii Sports and Wii Fit, can make physical activity enjoyable for users, significantly increasing energy expenditure with respect to sedentary activities [3].

Mobile devices are a particularly interesting platform for designing novel exergames. Unlike desktop PCs and home consoles, mobile phones follow their users anywhere and are always available, allowing the creation of exergames that promote

outdoors physical activities such as walking and running. Different mobile exergames have been proposed in the literature (e.g., [4][5]). However, thorough and standard user evaluation practices are lacking. In particular, ad–hoc questionnaires are often used, which do not exploit the existing body of knowledge in measuring users' level of physical activity (e.g., [6]) or attitude towards physical activity (e.g., [7]).

The goal of our research was twofold. First, we wanted to design a mobile exergame that is fun and easy to understand. To this purpose, we decided to take the classic Snake mobile game (Fig. 1) and turn it into a location–based mobile exergame, which allows players to bring the snake into any real–world location and then control it by simply walking. The game (called LocoSnake, a blend of the words localization and snake) aims at engaging players in moderate outdoors physical activity. Seen as a persuasive technology, the game aims at encouraging walking and having a positive effect on the attitude of players towards walking.

Fig. 1. The classic Snake mobile game.

Second, we wanted to set the evaluation of the exergame on a solid basis. To this purpose, we looked at the medical literature for possible standardized and widely adopted measures that could be employed to study mobile exergames and their effects in a reliable way. The study we present also focuses on possible differences in users' lifestyle concerning physical activity that might be related to game enjoyment and to the effects on attitude towards walking that the exergame might produce.

The paper is structured as follows. In section 2, we review the mobile exergame area and the evaluation techniques and instruments it has employed. Then, we describe LocoSnake (Section 3) and the method (Section 4) we employed in our evaluation. Section 5 and 6 respectively illustrate and discuss the findings of the study, while Section 7 illustrates conclusions and future work.

2 Related work

Some of the existing mobile exergames run on dedicated devices. For example, Nintendo's Pokéwalker [8] is a small handheld device that includes a pedometer, which allows users to load a Pokémon character, put it in a pocket and take it with them for a walk, obtaining experience points and rare items.

Other mobile exergames rely instead on common smartphones, exploiting their internal sensors, such as accelerometers and GPS to build a stronger link between the game world and the real world. For example, GoldWalker [9] is an iPhone game inspired by the California Gold Rush. By walking in the real world, players travel in

the game world among cities, banks and mining camps, recruiting workers, buying tools and storing gold. Similarly, World of Workout [4] detects user's steps and wraps exergaming into a more conventional role–playing game. Players complete quests by walking for a given number of steps. In Hidden Park [10], players have to find magical creatures hidden in various locations in the real world by walking and solving puzzles. In Seek 'n Spell [11], a game for iPhone and Android phones, players walk in the real world to collect virtual letters located on the on–screen map. Points are earned as words are spelled. In PiNiZoRo [12], players have to find enemies by walking in the real world, playing various puzzle games to defeat them.

Another category of mobile exergames employs supplementary sensors to exploit additional user data, such as external accelerometers and heart rate (HR) sensors. Nike+ [13] for the iPhone, although not strictly a game, records the number of user's steps through a sensor inside Nike shoes, allowing the user to compare her activity with other users' and friends' data. Kazakos et al. [14] proposed some mobile exergames which employ an accelerometer attached to the user's waist to measure physical activity: for example, in NEAT-o-Race, when the user moves in the physical world, her avatar moves on a virtual racetrack, accumulating "activity points" and competing for them with friends. UbiFit Garden [15] relies on a wearable fitness device to detect and classify users' movements. It allows users to set weekly physical activity goals and, as they perform physical activities, it makes flowers bloom in a garden on the screen background. Butterflies appear when a goal is reached. Health defender [5], a Space Invaders–style game, reads users' HR and, at random intervals during the playing session, it requires users to reach the target HR shown on screen to gain bonus items. In Monster&Gold [16], HR is recorded while the user jogs outdoors, and game events are dynamically generated to keep the user in her optimal exercise range.

The mobile exergames surveyed above were evaluated in different ways. For some of them (generally commercial products), no evaluations are reported. Some of the others were informally evaluated through interviews after a brief gaming session or with more structured tasks and pilot trials which in a few cases lasted for days or weeks. For example, Health Defender [5] was informally evaluated by collecting users' opinions and remarks about the game, while PiNiZoRo [12] was evaluated by carrying out a pilot study with 4 adults who have children in the game target age, interviewing them after making them play with a pre–defined map, and then creating a custom one.

World of Workout [4] and Monster&Gold [16] were instead studied in more detail. Ten users played two missions in World of Workout. HR measurements were recorded before and after a gaming session, to check if the game provided a sufficient degree of physical activity. A 10–item Likert scale was then employed to assess participants' enjoyment and motivation. Monster&Gold was first evaluated on 14 users who played the game for up to 15 minutes with a questionnaire to assess game understandability and its motivational effects. A second evaluation was then carried out on an improved version of Monster&Gold using a more extensive questionnaire, focusing in more detail on the motivational effects of the game. NEAT-o-Race [14] was evaluated with four different two–day sessions, in which 8 users played the

game, each time adding new options. Finally, UbiFit Garden [15] was evaluated through a 3–week field trial, during which users were encouraged to wear the fitness device, carry the phone with them and confirm a daily activity list. Participants were interviewed at the beginning as well as during the field trial about their experience in the study.

In general, the reported evaluations showed positive results about exergames' effects on both motivation and amount of users' physical activity.

3 The proposed exergame

3.1 Game design

In the classic Snake (Fig. 1), a virtual snake moves at constant speed inside a closed virtual playing field. Players have to direct the snake up, down, left or right to prevent its head from colliding with walls or with its tail. To get points, the snake has to eat on–screen items. This causes its tail to grow longer, requiring the user to be more careful in planning her movements.

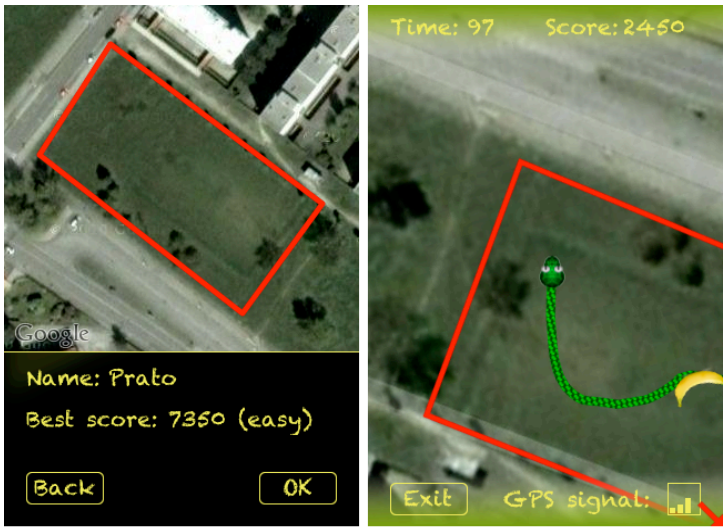

Fig. 2. Locosnake screenshots: (a) choosing the playing field; (b) playing (the red arrow at the bottom right angle points to an off–screen fruit).

In LocoSnake, the player embodies the snake and walks in the physical world to control it. Using GPS localization, the user can set the four–sided playing field (highlighted by red lines) on the visualized satellite map (Fig. 2a). Player's location in the real world determines the position of the snake head on the playing field (Fig. 2b). To get points, the snake has to reach and eat virtual fruits located on the playing field. Unlike classic Snake, in LocoSnake the borders of the playing field can be hit by the

snake without losing the game: if the GPS locates the player outside the playing field, the snake remains in the closest position inside the playing field. The player must instead be careful in avoiding collisions between the head and the body of the snake.

3.2 Game setup

LocoSnake allows users to create and name their own playing fields (Fig. 2a). By creating their own playing field, users can play the game in any safe place they like, and by changing the playing field size as well as the difficulty level, users can change the intensity of the physical exercise, thus making the game more enthralling. Furthermore, the ability to play the game on a variety of different maps can allow enjoyment to last longer.

Users can choose among three difficulty levels, which change the time a fruit remains on the field: (i) Easy: a fruit disappears only when the snake eats it; (ii) Medium: a fruit, if not eaten, changes its position after a period of time proportional to the size of the playing field; (iii) Hard: analogous to medium, but fruit persistence time is halved. We related fruit persistence to the size of playing field in the medium and hard levels because users can create a playing field of arbitrary size: simply defining absolute time limits for eating a fruit could thus result in the game to be too hard with larger maps and too easy with smaller ones.

The map moves on the screen in such a way that the snake head is always at the center of the screen and map orientation is kept forward–up, so users can freely move around the field without the need to rotate the phone.

3.3 The gaming session

A level of the game is set to last 5 minutes. When playing, the time left and the current score are shown at the top of the screen. At the bottom, an “Exit” button allows the player to quit the game, and a small icon gives an indication of the accuracy of GPS data. Before or during a gaming session, the player can thus be warned about possible poor location data accuracy which is an issue for any location–based application. For this reason, before the user study, we tested the game for tens of hours in park lawns, and the level of GPS accuracy was always sufficient to successfully play the game.

There are always an apple and a banana simultaneously available inside the LocoSnake playing field. When the snake head comes close to a fruit, the phone vibrates, the snake shows its tongue and a biting sound is played. The fruit then disappears, the current score is updated and a new fruit appears in a random position inside the playing field.

When the game is over, it plays a tune and warns the user that level time has expired or the snake has bitten its tail. After that, a “Game Over” screen appears, showing the score and the distance in meters covered by the user.

4 User study

The study we carried out focuses on three main aspects. First, we wanted to assess if LocoSnake is an enjoyable mobile game for users. Second, we wanted to evaluate the persuasive aspects of the exergame in terms of possible effects on attitude towards moderate physical activity, in particular walking. Third, we wanted to explore possible relations among users' lifestyle (in terms of physical activity), exergame enjoyment and possible effects on attitude towards walking. In the following, we describe the study in detail.

4.1 Design, Participants and Materials

Our study follows a within–subject design with walking activity (walking while playing LocoSnake and walking without playing LocoSnake) as the independent variable. For conciseness, we will refer to the first condition (walking while playing LocoSnake) as LS and to the other condition as NLS.

The evaluation involved a sample of 15 users (14 M, 1 F) recruited among computer science and mathematics graduate and undergraduate students at our university. Age ranged from 22 to 39 (M = 28.4, SD = 5.36). Video game usage in the sample was as follows: 2 participants never play video games, 5 participants play them a few times a month and 8 participants play at least a few times a week; 7 participants do not play exergames for PC or consoles, 5 participants play them about once a month, and 3 participants play them at least a few times a week; 14 participants do not play mobile exergames. Familiarity with GPS was as follows: 6 participants do not use GPS devices, 4 participants use them a few times a month, 5 participants use them a few times a week.

LocoSnake was run on an Apple iPhone 3GS equipped with a 3.5'', 320 x 480 pixels display. When playing LocoSnake, participants held the device in portrait orientation.

4.2 Measures

Game enjoyment.
To evaluate the enjoyment provided by LocoSnake, we employed 11 of the 13 items of the Player Enjoyment Scale (PES) [17], which derives from the EGameFlow scale [18] and is based on the concept of flow [19]. PES includes 13 bipolar statements, both positive and negative, with scores from 1 (strongly disagree) to 7 (strongly agree). We removed the 7th and 12th items ("The difficulty of challenges in the game increased as my skills improved" and "I experienced an altered sense of time while playing the game") because no increase of difficulty was planned (participants played a single level of the game) and the gaming session was short (5 minutes). We had to slightly change the 8th item ("The game provided new challenges with an appropriate pacing") into "The game proceeded with an appropriated pacing", because no new challenges were introduced during the single level played. This modified version of the scale (for brevity, mPES) returns a total enjoyment score in the 11–77 range,

obtained by reversing the negative item scores and summing them to positive item scores.

We also asked players four open questions about the exergame: what they liked and did not like about LocoSnake, if the game was difficult to use and if (and how) they would like to see it improved.

Perceived exertion and walking speed.

To measure the level of physical exertion perceived during the two experimental conditions, we employed Borg's Rating of Perceived Exertion (RPE) [20], a well–known and widely used instrument in the medical domain [21]. In this scale, users choose a number between 6 and 20 to describe their perceived exertion, being 6 "no exertion" and 20 "maximum exertion possible". We also computed the mean walking speed of participants in the two conditions. In the LS condition, the game recorded the distance covered by the participant using GPS data. In the NLS condition, we asked participants to keep the phone with them (without interacting with it) so that we were able to use GPS data for distance recording.

While we believed the game could receive good ratings in terms of player enjoyment, it was more difficult to formulate a hypothesis about the effects of the exergame on participants' perceived exertion and mean walking speed. On one hand, if the exergame is enjoyable and engaging, it can greatly absorb users' attention and distract them from the walking activity: this could lead users to perceive a lower exertion level and possibly walk faster to achieve the game goals. On the other hand, the continuous attention required by the game as well as the need to multitask in order to control walking and achieve game goals at the same time might actually cause the walking activity to be perceived as more fatiguing than a condition in which one can focus on simply walking.

Physical activity enjoyment and attitude change.

To compare user's attitude towards walking in general and walking with LocoSnake, we employed the Physical Activity Enjoyment Scale (PACES) [7], an instrument thoroughly validated in the sports and exercise literature (e.g., [22]). This scale includes 18 bipolar statements with scores from 1 (strongly disagree) to 7 (strongly agree). The PACES produces a total enjoyment score in the 18–126 range.

In our study, each participant filled a PACES at the beginning of the evaluation concerning her general perception of the walking activity, and a PACES after playing LocoSnake concerning her perception of the walking activity when playing the exergame. We hypothesized that, by adding a gaming element to the physical activity, the exergame could have an effect on user's attitude, improving users' enjoyment of walking. We thus expected the score for the second PACES to be higher than the score for the first PACES.

Level of physical activity in user's lifestyle.

To assess level of physical activity in user's lifestyle, we employed the standardized Global Physical Activity Questionnaire (GPAQ) [6]. The GPAQ

contains 16 questions that collect information on physical activity participation in three settings (activity at work, travel to and from places and recreational activities), as well as sedentary behavior. After defining the MET (metabolic equivalent) as the energy cost of sitting quietly, the GPAQ analysis guide [6] specifies how to calculate the weekly amount of physical activity of a person in terms of MET–minutes per week (METM), i.e., the weighted time spent on moderate– and vigorous–intensity activities. The METM value is an indicator of how much a person is physically active.

We hypothesize that people with sedentary lifestyles could respond better to an exergame such as LocoSnake rather than more active people, in terms of game enjoyment as well as positive effects on attitude towards physical activity. For active people who are already motivated to walk, playing a game while walking might indeed be perceived more as added cognitive load rather than a pleasant distraction.

4.3 Procedure

We met each user at our university and guided her/him to a nearby lawn. Users were told that the goal of the study was to evaluate a game for the iPhone. They filled a demographic questionnaire to record age, gender and current occupation, video game usage, desktop exergames usage, mobile exergames usage and GPS devices and software usage. Then, they answered the GPAQ questions and filled the first PACES.

Each user was asked to walk while playing LocoSnake (LS condition) and to take a free walk around the lawn (NLS condition). In both conditions, users were asked to walk normally. To avoid possible confounds, in the NLS condition users could not carry out other activities (e.g., listening to music or talking on the phone). In this way, any difference in the observed results could reasonably be ascribed to the use of LocoSnake. The order of the two conditions was varied, so that for 7 out of 15 users the LS condition preceded the NLS one.

Before the LS condition, the experimenter showed the user the game and briefly explained how it works, then let her play the game for about 1 min for familiarization purposes. Then, the LS condition started and the user played a 5–minutes session with LocoSnake at the "Easy" difficulty level. After the session, users filled the RPE scale, the second PACES and the mPES. Finally, they could answer the four open questions.

In the NLS condition, the experimenter asked users to simply keep the iPhone (which recorded GPS data) with them, without interacting with it, and walk a lap around the lawn. Users were stopped after 5 min of walking and filled the RPE scale.

Finally, users were debriefed and thanked for their participation.

5 Results

5.1 Means

The reliability of the mPES was confirmed by calculating Cronbach's alpha (α=0.74). The mean mPES score obtained by LocoSnake was 60.13 (SD = 6.58).

Wilcoxon test revealed that the difference between the RPE scores for the LS condition (M=9.07, SD=2.05) and those for the NLS condition (M=7.80, SD=1.52)

was statistically significant (W=59, $p < 0.05$): users perceived a greater exertion when playing with LocoSnake than when walking without playing the game.

Average walking speed was slightly faster in the LS condition than NLS (1.62 m/s and 1.45 m/s), but a t–test revealed that the difference was not statistically significant.

The mean score for the second PACES (M=99.53, SD=9.29) was slightly lower than the score for the first PACES (M=102.07, SD=12.52) and the difference was not statistically significant. The difference between the PACES scores (ΔPACES) was negative for 8 participants, positive for 5, and zero for 2 participants.

5.2 Correlations

Spearman's test revealed a negative correlation between METM values and mPES scores ($\rho(15) = -0.66$, $p < 0.01$), a negative correlation between METM values and ΔPACES scores ($\rho(15) = -0.59$, $p < 0.05$), a positive correlation between mPES and ΔPACES scores ($\rho(15) = 0.56$, $p < 0.05$. Fig. 3 graphically summarizes the correlations: users with greater METM values (i.e., who have a more active lifestyle) tend to enjoy LocoSnake less than users who are more sedentary, and the difference in attitude towards walking with and without the exergame (ΔPACES) is lower with more active users. Finally, users who find the exergame more enjoyable (mPES) are associated with higher values for the obtained difference in attitude.

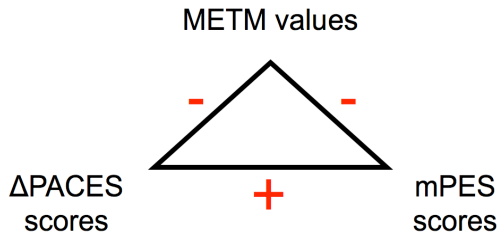

Fig. 3. Correlations among variables.

5.3 Answers to open questions

Users gave the following answers to the question "What did you like about LocoSnake?": (i) The link between the game and the real world (6 users); (ii) Feedback provided by the game (4 users) such as real–time map rotation, vibration when eating a fruit, arrows pointing to off–screen fruits; (iii) the connection between physical activity and video gaming (3 users); (iv) The originality of the idea (3 users). Answers provided by single users reported liking for: similarity with the original Snake game; relaxing music; graphics; fun; challenge; ease of use.

In answering the question "What did you dislike about LocoSnake?", 9 users mentioned GPS–related problems, i.e. GPS lag and/or inaccuracy. Answers provided by single users reported disliking for: graphics, colors of the map, background music.

Five users replied to the question “Did you experience difficulties in using the game?”: they reported difficulties related to GPS inaccuracy such as “the snake was moving jerkily” or “sometimes the snake had difficulties in following me”.

Users gave the following answers to the question “What would you change to improve the LocoSnake game?”: (i) improve position accuracy (7 users); (ii) add more types of fruits (2 users); (iii) show the score given by each fruit in a better way, e.g. by making it flash for a moment over the eaten fruit (2 users). Answers provided by single users suggested to: make the tail grow faster and longer, add different colors for the snake, add side effects to some fruits (e.g. slowing down the snake), add virtual obstacles on the playing field, add multiplayer, provide an alternative character and items (e.g., a car running over zombies).

6 Discussion

As indicated by mPES scores, users generally enjoyed the exergame. The fact that LocoSnake is based on a well–known mobile game helped user to immediately understand how to play: all users gave the highest rating to the 4th item in the mPES scale (“Overall, game goals were presented clearly”). Moreover, the answers to the last two items (“I temporarily forgot worries about everyday life while playing the game” and “I felt emotionally involved in the game”) received a mean score of 5.47 (SD=1.46) and 5.27 (SD=1.58). Answers to the first open question (as seen in the previous section) provide some specific reasons for users’ liking.

Users perceived a higher physical exertion in the LS condition with respect to the NLS condition. Some users reported “a greater exertion” because they “felt very engrossed in reaching the fruits”, and perceiving that they were “walking fast” while playing LocoSnake (although in general average speed was not significantly different between the two conditions). We also observed that walking speed in the LS condition was higher when the fruit was far from the user, while it was lower when the user was closer to the fruit. This indicates that users modulated their speed while carefully navigating the physical environment as a strategy to accurately get the fruits in a short time. This could also have contributed to the perception of higher physical exertion.

A clear result of the open questions is that many users felt that the snake did not move as precisely as they expected, as confirmed by the mean scores obtained by the mPES items “I received immediate feedback on my actions in the game” and “I felt a sense of control over the game”, respectively 3 (SD=1.13) and 4.73 (SD=1.39).

Unexpectedly, the difference between the scores of the second and the first PACES was positive only for a minority of participants. However, the correlations among METM, ΔPACES and mPES reported in the previous section seem to suggest that the mobile exergame can be more successful as well as more useful for people who have more sedentary lifestyles. Interestingly, two of the most physically active users provided the same explanation for their negative ΔPACES: they reported that walking is for them an activity in which “the mind can be left to wander” and the focus required by the exergame made thus the activity less pleasant.

7 Conclusions and future work

In this paper, we proposed a mobile exergame aimed at encouraging outdoor walking and we carried out an in–depth user evaluation, employing instruments proposed by international organizations (GPAQ) or whose reliability was thoroughly assessed in the literature (PACES and PES). The results suggest possible relationships among users' lifestyle, exergame enjoyment and the effects on the attitude towards walking that the exergame could bring. It would now be important to replicate the study with female participants (our sample was mostly male) as well as with other exergames, to test if the correlations can be generalized.

We are currently interested in introducing multiplayer features into LocoSnake, allowing multiple snakes to compete on the same playing field. Adding a social dimension to the game might indeed make the exergame more interesting and engaging also for physically active people. As discussed by Mueller et al. [23], having other human beings join a mediated exertion activity can positively contribute to the experience.

A limitation of the study is that it did not evaluate long–term effects of the exergame. Klasnja et al. [24] point out that longitudinal studies and randomized control trials of persuasive technologies for encouraging physical activity are difficult to carry out and not always feasible [24], but they also provide some recommendations to evaluate these technologies over time that we will consider for future studies. For example, a new version of LocoSnake could record the distance walked by the player during the various gaming sessions, as well as the time spent playing the game, keeping an automatic diary that could be useful to the user (to support a self–monitoring persuasive strategy as in UbiFit Garden [15]) as well as to the experimenter (to analyze changes in user's behavior over time).

8 References

1. US Department of Health and Human Services, http://healthypeople.gov/2020/topicsobjectives2020/overview.aspx?topicid=33
2. Bogost, I.: The rhetoric of exergaming. In: 42nd Design Automation Conference (2005). Online at http://www.bogost.com/downloads/I.%20Boogst%20The%20Rhetoric%20of%20Exergaming.pdf
3. Graf, D.L., Pratt, L.V., Hester, C.N., Short, K.R.: Playing Active Video Games Increases Energy Expenditure in Children. Pediatrics 124, 2, 534–540 (2009)
4. Doran, K., Pickford, S., Austin, C., Walker, T., Barnes, T.: World of Workout: Towards Pervasive, Intrinsically Motivated, Mobile Exergaming. In: Meaningful Play 2010 Conference, Michigan State University (2010)
5. Wylie, C.G., Coulton, P.: Mobile Exergaming. In: 2008 International Conference on Advances in Computer Entertainment Technology, pp. 338–341. ACM Press, New York (2008)
6. World Health Organization: Chronic diseases and health promotion — Global Physical Activity Surveillance,

http://www.who.int/chp/steps/GPAQ/en/index.html
7. Kendzierski, D., DeCarlo, K.J.: Physical Activity Enjoyment Scale: Two Validation Studies. J. Sport Exerc. Psychol. 13, 1, 50–64 (1991)
8. Pokéwalker, http://www.pokemongoldsilver.com/us/#/features/pokewalker/
9. GoldWalker, http://itunes.apple.com/us/app/goldwalker/id372683234?mt=8
10. The Hidden Park, http://www.thehiddenpark.com/
11. Seek 'n Spell, http://www.seeknspell.com/
12. Stanley, K.G., Livingston, I., Bandurka, A., Kapiszka, R., Mandryk, R.L.: PiNiZoRo: A GPS–Based Exercise Game for Families. In: 2010 International Academic Conference on the Future of Game Design and Technology, pp. 243–246. ACM Press, New York (2010)
13. Nike+, http://nikerunning.nike.com/nikeos/p/nikeplus/en_US/plus/#//dashboard/
14. Kazakos, K., Fujiki, Y., Puri, C., Bhuddaraju, P., Pavlidis, I., Levine, J.: NEAT-o-Games: Exertion Interface Interwoven in Daily Life. In: 26th ACM Conference on Human Factors in Computing Systems Workshop on Exertion Interfaces, pp. 1–3. ACM Press, New York (2008)
15. Consolvo, S., McDonald, D.W., Toscos, T., Chen, M.Y., Froehlich, J., Harrison, B., Klasnja, P., LaMarca, A., LeGrand, L., Libby, R., Smith, I., Landay, J.A.: Activity Sensing in the Wild: A Field Trial of UbiFit Garden. In: 26th ACM Conference on Human Factors in Computing Systems, pp. 1797–1806. ACM Press, New York (2008)
16. Buttussi, F., Chittaro, L.: Smarter Phones for Healthier Lifestyles: An Adaptive Fitness Game and Its Evaluation. IEEE Pervasive Computing 9, 4, 51–57 (2010)
17. Chu Yew Lee, S.L., Been-Lirn Duh, H., Quek, F.: Investigating Narrative in Mobile Games for Seniors. In: 28th ACM Conference on Human Factors in Computing Systems, pp. 669–672. ACM Press, New York (2010)
18. Fu, F.L., Su, R.C., Yu, S.C.: EGameFlow: A Scale to Measure Learners' Enjoyment of E–Learning Games. Computers and Education 52, 1, 101–112 (2009)
19. Csikszentmihalyi, M.: Flow: The Psychology of Optimal Experience. Harper Collins, New York (1991)
20. Borg, G.: Perceived Exertion as an Indicator of Somatic Stress. Scand. J. Rehabil. Med. 2, 2, 92–98 (1970)
21. U.S. Centers for Disease Control and Prevention, http://www.cdc.gov/physicalactivity/everyone/measuring/exertion.html
22. Croker, P.R.E., Bouffard, M., Gessaroli, M.E.: Measuring Enjoyment in Youth Sport Settings: A Confirmatory Factor Analysis of Physical Activity Enjoyment Scale. J. Sport Exerc. Psychol. 17, 2, 200–205 (1995)
23. Mueller, F., Vetere, F., Gibbs, M.R., Agamanolis, S., Sheridan, J.: Jogging Over a Distance: The Influence of Design in Parallel Exertion Games. In: 5th ACM SIGGRAPH Symposium on Video Games, pp. 63–68. ACM Press, New York (2010)
24. Klasnja, P., Consolvo, S., Pratt, W.: How to Evaluate Technologies for Health Behavior Change in HCI Research. In: 29th ACM Conference on Human Factors in Computing Systems, pp. 3063–3072. ACM Press, New York (2011)