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# A Focused Review and Initial Conceptual Design for Merging Exergame and Activity Monitoring Technologies

Reem Altamimi<sup>1</sup>, Geoff Skinner<sup>2</sup>, Keith Nesbitt<sup>2</sup>

<sup>1</sup> The University of Newcastle, NSW, Australia

Reem.Altamimi@uon.edu.au

<sup>2</sup> The University of Newcastle, NSW, Australia

{Geoff.Skinner,Keith.Nesbitt}@newcastle.edu.au

**Abstract.** In an era of increasing technology use, it has been recognized that children and adolescents have become more sedentary and engage in less physical activity. Motivating children to be more physically active is not an easy task given their preference for seated leisure activities. Video games are a favorite leisure activity amongst children and adolescents. Exergames have been suggested as one form of game that may make children more active. Activity monitoring technologies are another proposed solution. This paper reviews literature in the areas of exergaming and activity tracking technology and proposes an initial design that involves merging the two areas. This work builds on our previous research in this area and makes an original contribution through the suggestion of added benefits that stem from the integration of exergames and activity tracking technologies. Furthermore, we plan to expand our research beyond the scope of this paper to propose a model based on this incorporation. Here we conclude that the careful integration of exergames and physical activity tracking technology provides the greatest potential to increase and maintain physical activity levels in children and adolescents.

**Keywords:** Physical Activity. Exergames. Activity Monitoring Technologies.

## 1 Introduction

Physical activity in children is an important issue that has previously been considered in the literature [1, 2]. The implication of physical activity on children and adolescents' health and development is the driving reason behind this interest. Regular participation in physical activity has been found to reduce the risk of many diseases including heart disease and diabetes and also improves physiological and psychological function [1]. Unfortunately, it has been identified that when indoors, children spend large amounts of their time engaged in sedentary or light level physical activities and when outdoors spend less than 15% of their time engaged in vigorous physical activity [3]. Another study confirmed that children approximately 20% of their time engaged in high-intensity physical activity [2]. Yet educating young children about the importance of regular physical activity remains a key in helping to reduce levels of inactivity in adulthood [1, 2].

One factor that contributes to a healthy, active life-style is ensuring children adhere to the daily recommendations for physical activity which is 60 minutes of moderate to vigorous intensity physical activity for children and adolescents [1], [4]. Measuring levels of physical activity in this age group is therefore important [5]. Likewise it is important to study what motivates children and adolescents to exercise. Children between the ages of 8 and 18 spend numerous hours playing video games either on gaming consoles, handheld platforms or cell phones [6] on a daily basis [7]. The wide range of options in gaming platforms and game content is factor that contributes to the increased amount of time young people spend playing video games [6]. Unfortunately, most of the popular games increase screen time and led to more sedentary behavior amongst children and adolescents. However, a new generation of video games that involves physical exertion along with gameplay, called “Exergames”, are being developed with the express aim of decreasing sedentary behavior and motivating active living.

It has been suggested that active video games provide an opportunity to improve physical activity levels in children and adolescents [8, 9]. Activity tracking technologies provide further potential for promoting exercise in children and adolescents as they can be used to track and monitor the intensity and level of physical activity [5]. Our research is designed to explore the best available technology-based solutions for physical activity promotion in children and adolescents. In this paper, we examine the use of exergames and activity monitoring technology with regard to their ability to promote and maintain exercise levels in children and adolescents. This paper reviews literature in these areas and proposes an initial design that combines exergaming and activity tracking technology.

## **2 Exergames and Activity Tracking Technologies**

### **2.1 Exergames**

Exergames have the benefit of motivating exercise by providing a safe, entertaining and engaging fitness experience. Exergames are important as they may encourage children to exercise and reduce the burden of obesity in this population [10]. However, it remains to be seen whether active video games really promote physical activity in children and adolescents. Some literature reports that active video games increase physical activity levels [11, 12] while other studies report that active video games have no effect on improving rates of physical activity [13, 14].

When developing applications for exergaming there is a spread of reports in the literature across broad age ranges from young children to adolescents, adults and even senior citizens. Indeed the age of targeted players is an important factor that games developers need to be aware of when developing games [15, 16]. Video games that attract younger players may not attract adolescents or adults due to the differences in their thoughts, perceptions and experience [15].

Exergame interfaces typically incorporate sensing devices that detect and track players’ body motion during the game play. Examples of these devices include the Wii Remote Plus & Sensor Bar, the Wii Balance Board, the PlayStation Move Eye &

Motion Controller and the Xbox 360 Kinect sensor. There are several differences between the various exergame interfaces. For example, the Xbox 360 Kinect sensor uses both the player's body and voice as controllers while the Wii Remote involves a physical prop that needs to be held by the player [17]. In a study that developed an exergame prototype called "Wii!!! Soccer" [8], Wiimote technology is used to capture a player's foot motion for playing a game of virtual soccer. Although this game simulates a real life soccer experience, it limits players' movements as they have to strap an infrared sensor bar to their legs while playing the game [8].

## **2.2 Activity Tracking Technologies**

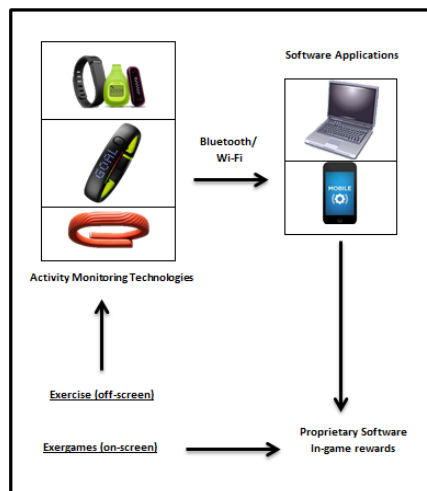
Direct observation, questionnaires and technology-based monitors are examples of techniques that have been used to monitor physical activity in children and adolescents. Examples of technology-based monitors include accelerometers, pedometers, and health life wristbands. These tools can be worn, for example, on an individual's wrist or arm or clipped to their belt or shoe in order to track and record their physical movements. Different accelerometer-based monitoring tools have been used to measure intensity, frequency, level, pattern and duration of physical activity in children and adolescents [2, 3], [18]. Some of these accelerometers have been validated for use in classifying sedentary behavior and levels of physical activity in children such as light, moderate and vigorous [18].

Pedometers are another example of wearable devices that have been investigated in the literature with regard to their ability to measure levels of physical activity. An early systematic review stated that, based on the literature, children between the ages of 8 and 10 were expected to take 12,000-16,000 steps/day and healthy young adults were expected to take 7,000-13,000 steps/day [19]. It has been shown that a pedometer can provide valid and reliable data [20]. Pedometers may prove useful in recording walking activities in free-living populations [20] and are simple and affordable [21]. Therefore, it has been suggested that pedometers are particularly useful for assessing physical activity and measuring daily activity in children [22]. Health life wristbands such as Nike+ bands, Fitbit FLEX and Jawbones Up are new examples of physical activity monitoring tools. They allow for regular self-monitoring and goal setting that provides essential feedback that serves to increase self-awareness that can lead to behavioral change [23] [24].

## **3 An Integrated Solution**

Reviewing the literature in exergaming has revealed the potential of these types of games to increase energy expenditure [11], [25, 26] and therefore facilitate the increase of physical activity levels in children and adolescents [12], [27]. However, some challenges have been identified in the ability of exergames to motivate children to exercise. While exergame play alone does not meet the daily amount of exercise recommended for children and adolescents [25], [13], there is some evidence to suggest that the use of exergames can contribute significantly to meeting some of the

daily requirements for physical activity [26]. An additional challenge is that some children and adolescents may lose interest in playing exergames over time [28]. Currently issues of motivation and sustained interest in exergame play are still under investigation and need to be assessed over longer periods of time. Another possible challenge with using this technology is the limited or restricted access to active video game play. These restrictions may result from the concern of children becoming addicted to active video game play which has the potential to negatively affect behavior and academic performance.



**Fig. 1.** The Integration Framework of On-screen and Off-screen Physical Activity (Activity monitoring technologies photos are adapted from [32] [33] [34])

Physical activity tracking technologies have been suggested as another method to increase individuals' motivation to exercise. These technologies are an effective means of increasing individuals' self-awareness through self-monitoring and goal setting. However, there is still concern about individuals losing motivation and interest over time, especially when goals associated with this technology are not achieved. An additional concern is that due to the variety of these technologies currently available, individuals may become confused about which is most appropriate for them. Inaccurate selection of an appropriate physical activity monitoring technology may result in a person giving up use of this technology.

Our previous work in this area has suggested the best solution involves the integration of active video game technology with physical activity tracking technology [29], [30], [31] to increase both on-screen exercise and off-screen exercise. The framework illustrated in Fig. 1 shows the two possible ways of exercising. Children are able to exercise in front of screens while playing exergames. In addition, their off-screen time exercising is also recorded by activity tracking devices and then this activity provides game rewards that are transferred through Bluetooth or Wi-Fi to the game software. Based on physical activity levels, the in-game or virtual rewards are applied and thus

the more physically active the child is, the more in-game rewards and progress they make in the game. In this way, both on-screen and off-screen physical activity support in-game performance and associated rewards.

“MetaKenkoh” is an Internet-based adventure game for children that uses a similar integrated approach. In order to play this game, children need to wear a pedometer that records their off-game steps. Pedometer data are uploaded daily to an internet database by parents. Children’s steps are then converted into energy units that are used in game play [27]. Likewise, “Fish’n’Steps” is a social computer game that uses a pedometer device to keep track of daily step counts in players. The participants are encouraged to take more daily steps as these steps are translated to the growth of their character in the game when data is uploaded [35]. ‘ibitz’ for Kids technology is developed by GeoPalz and includes a wireless pedometer and a free-downloaded application. Through the pedometer device, children’s physical steps can be tracked and then synchronized to the app where their physical exertion translates to virtual rewards [36].

## 4 Conclusion

We certainly agree with the notion that combining the appeal and motivation associated with active video games and also encouraging free physical play provides the most benefit. The ability of children to complete challenges and accumulate rewards in both on-screen and off-screen play may help reinforce physical activity in both of these environments.

This foundational paper has been developed to explore the potential to implement technology-based solutions to promote physical activity amongst children and adolescents. Exergames and activity tracking technologies have multiple implications for increasing physical activity levels in children and adolescents. The integration of both of these technologies may have even greater implications for increasing levels of physical activity in young people. This paper discusses the feasibility of combining exergames and activity tracking technologies. Based on the literature we reviewed, a preliminary model that integrates these two technologies has been proposed. This model could potentially be utilised to test the feasibility of the integration of these technologies. This work complements work performed in our previous studies. Based on this review and our previous work, we plan to further investigate and consequently integrate these technologies as a method of increasing physical activity among children and adolescents.

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