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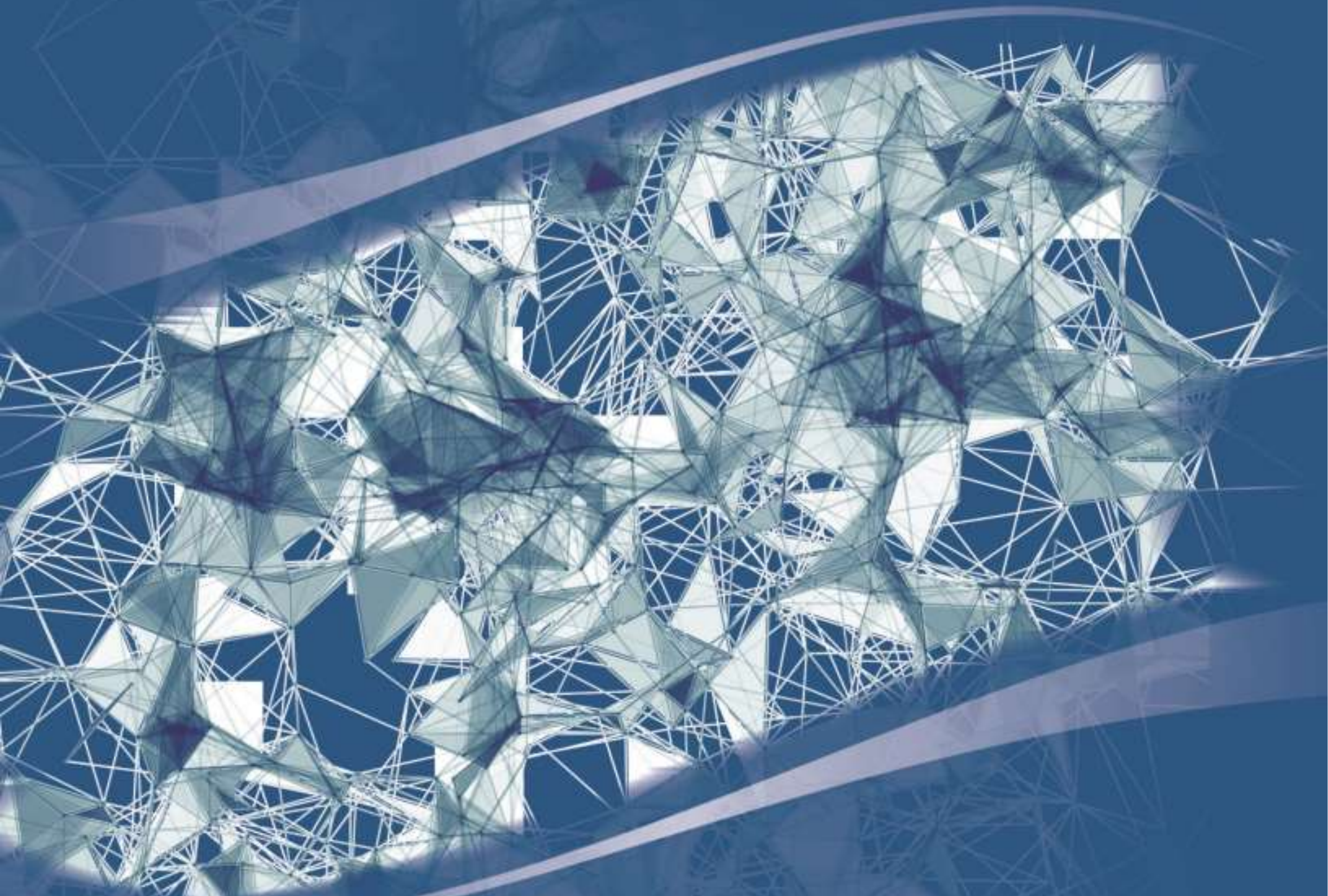

Mehdi Khosrow-Pour

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Mehdi Khosrow-Pour
Information Resources Management Association, USA

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Sport Exergames for Physical Education

Pooya Soltani
University of Porto, Portugal

João Paulo Vilas-Boas
University of Porto, Portugal

INTRODUCTION

Insufficient physical activity is one the main parameters for mortality, and obesity is a growing concern in post-industrial countries. A combination of physical exercise and healthy nutrition is essential for decreasing obesity. Active video games (exergames) are becoming popular as ways of motivating people to exercise more. However, it is not clear whether these serious games could also be used in physical education (PE) and serve as more than mere entertainment. In this chapter, we will examine existing academic literature based on the characteristics of sport exergames that are important in the domain of PE. We also provide a practical example of psycho-biophysical evaluation of a sport exergame to see how close and encouraging these games are, compared to the real sports.

BACKGROUND

PE is considered to be a crucial part of primary school curriculum around the world which include both physical and educational contents (Lindberg, Seo, & Laine, 2016). Thanks to digital technologies, new learning environments provide opportunities for skill acquisition and socializing, and researchers are now examining the role, efficacy, and opportunities that these environments provide. On the other hand, several reasons including lack of time, lack of skills of PE instructors, and lack of support might reduce the quality and quantity of PE education (Lindberg, Seo, & Laine, 2016). Moreover, pedagogy has always tried to innovate teaching, and PE is also emerging regarding integrating technology into regular classes. One exciting area in which technology and education could merge is by using video games that include visual (and/or audio) stimulus. Video games can be applied to improve attention, executive functions, and reasoning (Neugnot-Cerioli, Gagner, & Beauchamp, 2015). They are also shown to increase several types of intelligence (e.g. visual-spatial and bodily-kinesthetic) while providing a playful-formative experience (del Moral-Pérez, Fernández-García, & Guzmán-Duque, 2015).

On the other hand, previous psychological research has linked aggression with video gaming (Anderson et al., 2010) and content analysis of video games was mainly concerned about violence and role of gender (Lee & Peng, 2006). As excessive use of technology, which also includes video gaming, is suggested to be a contributing factor in obesity, a new approach has been proposed to include active video games (exergames) that incorporate motion sensor technology and could be played using whole body movements. While gamification of regular exercise activities (e.g. GPS-based virtual reality zombie run) has been previously reported, active video games are not frequently used in the context of PE (Lindberg, Seo, & Laine, 2016), and insufficient evidence about efficacy of exergames exist within schools (Norris, Hamer, & Stamatakis, 2016). Previously, Ennis (2013) considered exergames in three categories of recreation (light to moderate intensity), public health (moderate to intensive physical activity - PA), and educational (to facilitate skills).

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MAIN FOCUS OF THE ARTICLE

Motivation/Literacy to Play and Exercise

Several methods are used to increase players' motivation in sporting activities (Keegan, Harwood, Spray, & Lavallee, 2009) and game-based learning and storytelling are the primary ways to provide intrinsic motivation for learning (Laine, Nygren, Dirin, & Suk, 2016). Exergames provide a non-scary environment to develop components of mastering of fundamental movement skills (George, Rohr, & Byrne, 2016). For example, children might improve aiming and catching skills during virtual tennis without the fear of getting hit by the physical ball. In children with sensory dysfunction, exergames are used to increase their learning motivation and to make them more confident in facing various learning challenges (Chuang & Kuo, 2016). By embedding elements of nature, exergames can also provide a sense of connectedness and environmental concern, which might be important for exercising outdoor (Öhman, Öhman, & Sandell, 2016). Wittland, Brauner, and Ziefle (2015) also suggested that accepting serious games for physical fitness, is not dependent on gender, expertise, and gaming habits. However, when used with older adults, "guided hands-on" and "1-on-1" teaching methods might be used to increase their engagement when facing technology (Seides & Mitzner, 2015), because older adults need more time to master the skills necessary to play active video games (Santamaría-Guzmán, Salicetti-Fonseca, & Moncada-Jiménez, 2015). Sun (2013) evaluated the effects of exergame in primary school students and showed that PA situational interest decreases over time, but exergame intensity increases. Therefore, strategies to balance the activities should be considered during the game design phase. Many models of have been created to explore game characteristics from designers and consumers' perspectives (cf. Mildner, Stamer, & Effelsberg, 2015). Gender, age, game type, players' characteristics and personalities are motivators for gameplay (cf. Jabbar & Felicia, 2015). For example, Shaw, Tourrel, Wunsche, & Lutteroth (2016) showed that considering personality and motivation of players in a virtual training exergame with two modes of competitive and cooperative gameplay might increase exercise, especially in competitive individuals.

Learning and Skill Acquisition

Digital games have become great tools in knowledge transfer due to fostering intrinsic motivation in players to acquire more knowledge (Mildner, Stamer, & Effelsberg, 2015). Some sports games may be used to simulate the real sports skills; for example, shooting exergames might have a positive skill transfer for increasing hitting scores (Eliöz, Vedat, Küçük, & Karakaş, 2016), and Vernadakis, Papastergiou, Zetou, & Antoniou (2015) showed that exergame-based interventions could improve object control skills in children. Moreover, players' interactions with the game and other players, affect their learning while sports exergaming (Meckbach, Gibbs, Almqvist, & Quennerstedt, 2014). Exergames might also increase PA while developing motor skills among overweight children and adolescents (do Carmo, Goncalves, Batalau, & Palmeira, 2013). Body tracking technologies have also been used as a live correcting tool for free weight exercises (Conner & Poor, 2016), and improved motor skills (balance) after exergaming was observed with higher scores in female players (Norris et al., 2016).

On the other hand, these games may not be as effective as traditional PE instructions for psychomotor development (Pedersen, Cooley, & Cruickshank, 2016). For example, virtual swimming in the air does not replicate the physical fidelity connected with moving water. A previous systematic review also showed that virtual reality applications have the ability to change behavior but have little gain in knowledge (Omaki et al., 2016). While cognitive functions are crucial for the functional autonomy, Monteiro-Junior et al. (2016) showed that a single bout of virtual reality training does not have any effect on cognitive function in older adults. Johnson, Ridgers, Hulteen, Mellecker, & Barnett (2015) also showed that short bouts of exergame playing may not influence perceived and actual ball control skill competence. Previous research also argues that when mastery is achieved, a gradual decrease in performance is expected (Adi-Japha, Karni, Parnes, Loewenschuss, & Vakil, 2016). Therefore, player balancing techniques should be used to provide an equilibrium between enjoyment and skill acquisition for players with different levels of expertise (Vicencio-Moreira, Mandryk, & Gutwin, 2015).

Competition vs. Cooperation

To gamify traditional sports, researchers and game designer are often challenged to provide a socially-enriching experience without bombarding players with game information (Choi, Oh, Edge, Kim, & Lee, 2016). Characteristics of different players should also be taken into account; for example, Staiano et al. (2012) concluded that in a group of adolescents, competitive players outperform cooperative participants on executive function test. Girls also play exergames mostly for social interaction and rather than competition, and boys play games for intrinsic reasons (O'Loughlin et al., 2012). Online cooperative exergaming can also increase social relatedness in players compared to the time when they play against a computer character (Kooiman & Sheehan, 2015).

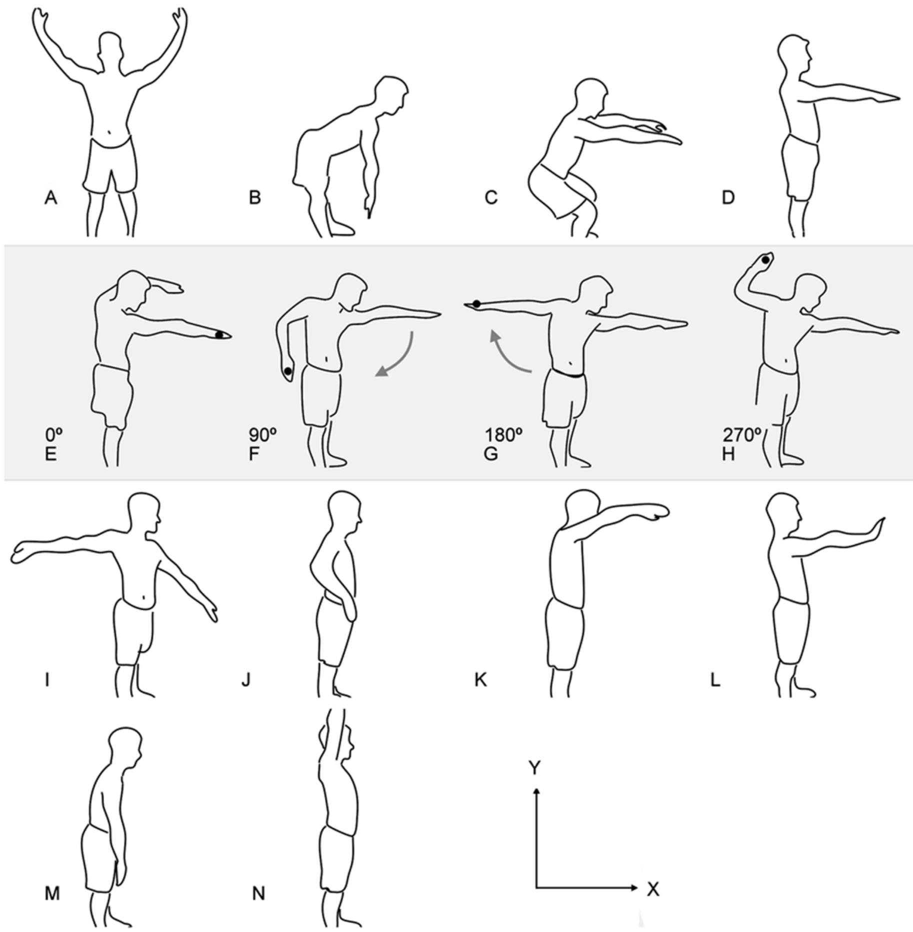
Opinion

Previous research suggests that if PE instructors decide to use exergames in their teaching, they should justify why and how they want to apply them, and design strategies for the students to interact with exergames (Gibbs, Quennerstedt, & Larsson, 2016). For example, a meta-analytic review suggests that playing exergames can improve older adults' physical balance, balance confidence, functional mobility, executive function, and processing speed (Zhang & Kaufman, 2015), and coaches may use these ideas to design more effective exercise programs. Exergame inclusion in PE curriculum may also provide additional tools to meet PA standards and to motivate and engage the student in practice (Rudella & Butz, 2015). On the other hand, Hulteen, Johnson, Ridgers, Mellecker, & Barnett (2015) showed that while players had correct skill performance (during table tennis, tennis, and basketball), they also had proper movement during skill assessment, which shows that presence of evaluator may affect the way participants play. According to Kooiman, Sheehan, Wesolek, & Reategui (2016), exergames should not be seen as the primary tool in PE because there are several parameters that expand the activity beyond virtual environments. Using technology in education is mostly affected by teachers' attitudes towards using technology (Albirini, 2006). While Bransford et al. (1999) talked about the four different learning environment as learner-centered, knowledge-centered, assessment centered, and community centered, it is important to decide which area benefit learning new skills in exergames more.

Characterization

In this part of the book chapter, the authors mention studies that were included in the Ph.D. thesis of the first author about characterizing a sport exergame. In the first part, the authors compared movement patterns of forty-six college students, with different performance (novice vs. experienced, and real-swimmers vs. non-swimmers) and gender. Reflective markers were placed over the skin, and the 3D position of each marker was recorded using a motion capture system. Subject played different techniques (100 m each) of a swimming exergame designed for Microsoft Xbox and Kinect (Michael Phelps: Push the Limit, 505 Games, Milan, Italy). Subjects had to stand in front of Kinect and start their gameplays by "hyping" for the virtual crowd (Figure 1, Panel A). Then they had to slightly bend forward (mimicking start

Figure 1. Body position during each phase of the game

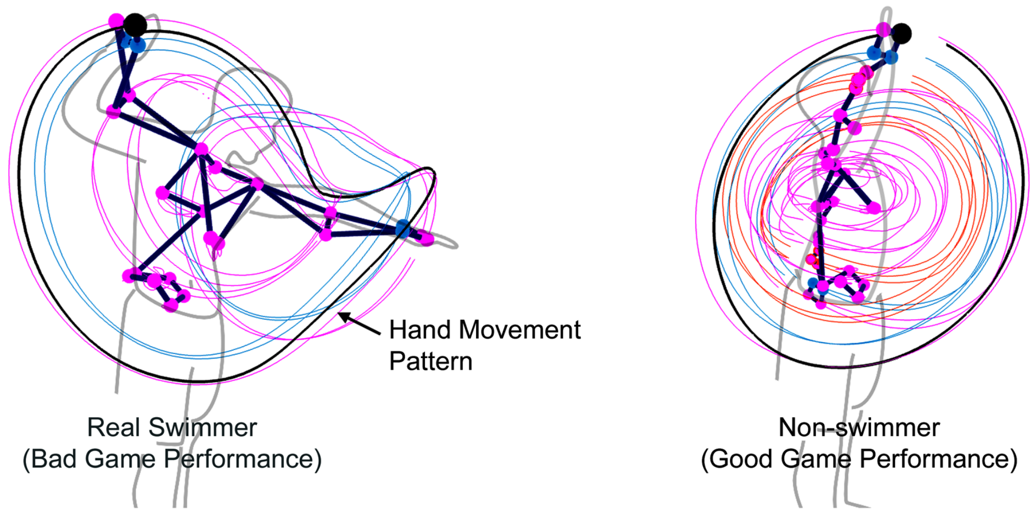


for the crawl, breaststroke, and butterfly; Figure 1, Panel B). For the backstroke technique, the start is shown in Figure 1, Panel C. Following the "Go!" command, they had to extend their back (Figure 1, Panel D) and swim according to the techniques (Figure 1, Panel E to H for crawl; Panel I for backstroke; Panel J for breaststroke, and panel K for butterfly). To start a new lap, they had to extend their arm forward (Figure 1, Panel L) and continue swimming. For terminating the race, they had to drop both arms (Figure 1, Panel M) and raise one arm immediately (Figure 1, Panel N).

The gameplay was divided into two phases of normal (with on-screen visual feedback to prevent players from playing too fast or too slow) and fast (playing without any feedback). Players' performances were ranked from 1st to 8th. The results showed that players who ranked better in the game (Figure 2), completed the game faster and with fewer arm cycles. By visually inspecting Figure 2, we can see that movement patterns of good performers were different that bad performers, who were mostly real-swimmers, meaning that the game does not encourage players to swim correctly. Moreover, those who had prior experience with the game had fewer arm cycles and real-swimming experience and gender did not affect biomechanical parameters.

In the second study, the authors measured and compared aerobic and anaerobic energy systems contributions and the activity profiles of participants while sport exergaming. Players were equipped with a gas analyzer to measure oxygen consumption, and blood lactate was measured us-

Figure 2. Movement patterns during swimming exergame



ing a small amount of blood from their ear lobe after each technique and following the gameplay. From these two parameters, we were able to measure the total energy expenditure (EE) during the gameplay. Players' gameplays were also filmed to measure total playing time (TPT), effective playing time (EPT), resting time (RT) and effort to rest ratio (E:R) using video analysis. Our results showed that anaerobic lactic pathway accounted for around 9% of total EE and EE was not different between performing groups. This shows that although the level of EE is lower compared to real-swimming, both energy systems should be considered when analyzing sports exergames. Heart rate (HR) was also measured during the gameplay and differences were observed between real-swimmers and non-swimmers in the first technique. This confirms that real-swimmers tend to swim correctly and exert more at the beginning of the game, but as soon as they realized the mechanisms of the game, they tend to exert less. Players were active around 57% of total time, and E:R was approximately 1.3. Our results also show that although players dedicated more time playing than resting, the changes were not different between players. Experienced players had lower TPT, EPT, and E:R compared to their novice counterparts, suggesting that experienced players learn the strategies to play the game with lower exertion. This confirms the necessity of designing games with lower resting times (loading of the game, navigating between the menus, etc.), dedicating more time to the actual gameplay.

In the third study, the authors measured muscle activation during sport gaming. Surface electromyography electrodes were placed over Biceps Brachii, Triceps Brachii, Latissimus Dorsi, Upper Trapezius, and Erector Spinae muscles. These muscles were chosen as they are frequently activated during swimming or were relevant because of the game itself. Maximum voluntary isometric contraction (MVIC) of each of the muscle was also measured to normalize the activation in percentages. Our results showed that muscle activation ranged from 5 to 95% MVIC, and differed between normal and fast swimming for all techniques. Muscular coordination was also investigated using biomechanics and observed that when participant plays faster, they complete different stages of the game faster, which results in higher stress some of the muscles more. Measuring muscle activation is important because it can show if players with greater experience, exert and engage less or not. While challenges in sedentary games are usually controlled by adjusting the complexity of mental tasks, employing in-game physical challenges can be unique characteristics of exergame design and muscle activation evaluation can provide guidelines to make sports exergames closer to real activities. Such evaluations can also address the Concerns regarding long-time computer/video game use, repetitive movements, and musculoskeletal disorders, such as neck and shoulder pain. Moreover, although sports exergames may not produce as much muscle activation as the real activity, such activities might still benefit participants to develop muscular endurance, especially when participation in real sport is not possible or practical due to disability, fear, or injury.

In the last study, the authors evaluated the game experience, usability, and enjoyment during sport exergaming to see if they affect future participation if PA and/or real sport. Enjoyment can both predict and be an outcome of PA participation and is one of the reasons why people play video games. System usability scale (SUS) is a measurement of learning, control, and understanding a game, and higher SUS grade means easier interaction between human, different games and menus, and various controllers and gaming platforms. User experience (UX) deals with consumers' dynamic perceptions and responses of products and systems and is an important factor for game design and positioning of the problems. For measuring enjoyment, a short version of physical activity enjoyment scale (PACES) questionnaire with two additional questions was used to measure future intentions of participation in physical activity and real swimming. Game usability was measured by System Usability Scale and playability aspects using Game Experience Questionnaire. Our results showed that Female players with real swimming and exergame experience enjoyed the game more. Usability score was around 75 which is considered as good with high acceptability. PA intentions did not change within performing groups, but swimming intentions were increased for all players. A possible explanation might be that future PA intentions of those who frequently exercise, may not be affected by playing exergames. Another explanation might be that those who do not exercise regularly, may think that the health benefits attained through exergaming are enough, and there is no need for further PA participation. It might be possible that novelty and entertainment elements of swimming exergame, played a role in influencing players' attitudes towards real swimming intention.

FUTURE RESEARCH DIRECTIONS

In our research, most of the players had sports science background and were physically active. This might have influenced the way they were interacting with the game. The presence of the researchers themselves might have affected players' performance to play differently. It might be possible that novelty and entertainment elements of swimming exergame, played a role in influencing players' attitudes towards real swimming intention and therefore, longitudinal studies should be conducted to check the changes in intentions in the long run.

CONCLUSION

In general, our data suggest that better performance inside the game does not necessarily mean better performance in real swimming. The motion capture sensor is also not capable of capturing delicate movements of swimming, and it does not encourage players to swim correctly. Therefore, the game may not be used as a training tool for real swimming and may only be used as a motivational tool for teaching basic movements of swimming (e.g. coordination of the upper limbs). While we do not deny the possible role of video games in PE settings, we believe that there is still a long way to use sport exergames in the PE.

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KEY TERMS AND DEFINITIONS

Exergame: A combination of “exercise” and “game” is a term used for video games that are also a form of exercise.

Game User Research: It focuses on players’ behavior via techniques such as playtesting, analytics, expert analysis, and others.

Game-Based Learning: A type of game play that has defined learning outcomes.

Skill Acquisition: A specific form of learning as the representation of information in memory concerning some environmental or cognitive event.