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Cases on Immersive Virtual Reality Techniques

Kenneth C.C. Yang

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Chapter 2

Multi-User Virtual Environments for Physical Education and Sport Training

Pooya Soltani
Aix-Marseille University, France & University of Porto, Portugal

João Paulo Vilas-Boas
University of Porto, Portugal

EXECUTIVE SUMMARY

For effective learning and training, virtual environments may provide lifelike opportunities, and researchers are actively investigating their potential for educational purposes. Minimal research attention has been paid to the integration of multi-user virtual environments (MUVE) technology for teaching and practicing real sports. In this chapter, the authors reviewed the justifications, possibilities, challenges, and future directions of using MUVE systems. The authors addressed issues such as informal learning, design, engagement, collaboration, learning style, learning evaluation, motivation, and gender, followed by the identification of required elements for successful implementations. In the second part, the authors talked about exergames, the necessity of evaluation, and examples on exploring the behavior of players during playing. Finally, insights on the application of sports exergames in teaching, practicing, and encouraging real sports were discussed.

INTRODUCTION

The new generation of students is growing up in a digital world, where they can multi-task and communicate the information rapidly (Prensky, 2001). Computer games and virtual environments are visibly present in the lives of these “digital natives” from a young age. They are comfortable with digital technologies and have different attitudes, expectations, and abilities towards technology (Beck & Wade, 2006). Advanced educational technologies can enhance several skills that traditional settings cannot account for (Passig, 2015). Students’ reading, writing, and communication have already been affected by the new technology, and educators are looking for possible engaging ways to increase their learning

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capabilities (Fee, 2007; Malliarakis, Tomos, Shabalina, Mozelius, & Balan, 2015). Rather than only considering the outcome, effective teaching also focuses on context, process, and learning outcome. It also considers identity, individuality, approach, and knowledge of the learners (Kyriacou, 2009). More schools are incorporating informal techniques into their curriculum, and as a result, the boundaries of formal and informal schooling are blurring (Ketelhut & Nelson, 2016). A shift from teacher-centered environments to student-centered interventions may also increase students' motivation. Therefore, integrating technology into practice could be a viable tool for supporting different types of learners (Miyares, 2013). Debates also exist around the use of technology in sports learning and whether technology can eventually replace physical educators for promoting physical activity and health (Casey, Goodyear, & Armour, 2017).

In this book chapter, the authors talk about the integration of multi-user virtual environments (MUVE) technology for teaching and practicing sports. In the first part, the authors discuss various elements of the technology, and how virtual sports and sports exergames could be used in physical education. In the second part, the authors also characterize a swimming exergame from different aspects of biomechanics, physiology, and psychology. Based on the results of the chapter, physical education (PE) teachers and curriculum designer can decide how to use MUVE systems in their practice. Game designers could also benefit from the results of this book chapter to create more realistic and meaningful MUVE systems.

BACKGROUND

Three dimensional (3D) virtual environments resemble physical spaces and allow players to generate virtual selves (avatars) to interact with objects, virtual ambient, and other avatars. Impractical, costly, and dangerous real-life activities can be performed in virtual environments (Adams, Klowden, & Hannaford, 2001). These systems also have positive effects on learning and provide higher immersion, engagement, and motivation compared to common instruction techniques (Webster, 2016). Therefore, they may create opportunities for distance education and collaborative learning. Studies suggest that properly designed 3D virtual games may improve information retention and enable the situation to be practiced safely (Dutton, 2013). MUVE is a computer, server, or internet-based virtual environment that can be accessed by multiple users simultaneously. These systems provide low-cost and safe collaborative ambient for problem-based learning activities. They could offer similar learning outcome and satisfaction to the real-world conditions while being more pleasurable and informal compared to the stressful reality (Vrellis, Avouris, & Mikropoulos, 2016). MUVE systems provide the chance of deep learning experiences where various skills, cognitive, perceptual/motor, interpersonal, leadership, and team building could be considered at the same time (Chang & Lin, 2014; Clayton, 2017). MUVE-based interpersonal education is also easier to navigate and may fulfill pedagogical objectives (Morley et al., 2015). In recent years, there was a considerable hype around the use of virtual worlds in a variety of fields, but for efficient use of MUVE systems, some topics need to be addressed.

Various initiatives will have limited success if students are not motivated to participate actively in PE. Understanding the mechanism underlying motivation, engagement, and collaboration can optimize the system's interactions with students and increase the likelihood of realizing the potential benefits of PE participation. Gender also plays an important role in PE and overcoming traditional shortcomings (e.g., boys receiving more attention and feedback compared to girls) can ensure fair and active PE participation for everyone. In the following paragraphs, the authors will discuss these elements in MUVE systems.

Motivation

Educational and health-related virtual games can enhance players' motivation (Hamari et al., 2016). Motivation is the principal element of participation, progression, and retention in gaming environments (Konetes, 2010). According to Yee (2006), players are motivated to play games in three areas of *achievement* (progression within the game, understanding the game mechanics, and competing with others), *social* (socializing, building relationships with others, and teamwork), and *immersion* (discovering things within games, role-playing, customization, and escapism from real-life problems). Theories on need satisfaction also mention that people continue engaging in activities that satisfy motivational needs, such as competence, autonomy, or relatedness (Ryan & Deci, 2000). Different strategies can be used to create competition, cooperation, skills, role-playing, performance, and simulation (cf. Macklin & Sharp, 2016).

Each video game consists of *actions* (that players carry out to meet the game goals), *rules* (on how to play the game), *objects* (to reach the game goals), the *space* (defined by rules on which the game is played), and the *operators* (or players) of the game. To maximize the educational and health potential, virtual environments should increase players' inner desire to participate and enjoy the activity. Extrinsic motivation is also offered by the instructor or previously included rules of the game. In the academic or medical environment, extrinsic motivation is used for skill improvement or rehabilitation, through which the goal is to complete the course (Hansen, 2008). Additionally, paradigms that include both virtual and real environments might also be relevant in fostering health-related behaviors by using motivational reinforcement, personalized teaching methods, and social networking (Bordnick, Carter, & Traylor, 2011; Ershow, Peterson, Riley, Rizzo, & Wansink, 2011; Preziosa, Grassi, Gaggioli, & Riva, 2009). For example, they may clinically improve treatments of health problems such as obesity by increasing adherence through an extended sense of presence, anonymous targeted social support, and real-time feedback (Riva, Wiederhold, Mantovani, & Gaggioli, 2011).

Learning and Engagement

Teachers at all educational levels are concerned with students' engagement and learning. Although engagement might happen even without the use of technology, it can provide opportunities in ways that may otherwise be difficult to achieve (Kearsley & Shneiderman, 1998). With the recent shift in learning styles to informal and voluntary education (Clarke, Dede, & Dieterle, 2008), 3D MUVE systems could cover a broad range of educational pedagogies that extend from structured and rationalist approaches to social constructivist (Hollins & Robbins, 2009). MUVE systems may facilitate knowledge transfer from virtual to real environments in different types of participants (Freina & Canessa, 2015). Therefore, educators have many opportunities and challenges to create educational approaches with students who are familiar with these types of technologies. MUVE systems may also have the potential to increase students' engagement by offering dynamic and engaging student-centered learning environments that increase socializing, exploration, creativity, and discovery. Virtual environments such as Second Life seem to be viable learning environments because they are immersive and provide a sense of tele- and co-presence (Chen, 2016; Claman, 2015).

On the other hand, the previous adoption of learning content management systems and virtual learning environments such as Blackboard showed that such investments were mainly used for content structuring and presentation (Britain & Liber, 1999). Earlier educational MUVE systems such as Zora, SciCenter, MOOSE Crossing, and Whyville were also executed in informal settings like after-school programs, which may reflect the lack of acceptance as part of a curriculum in classrooms (Nelson & Ketelhut, 2007). Most MUVE users in informal settings may not also participate in the curriculum actively (Foley & Kobaissi, 2006). Complexity, open-ended nature, and division between formal and informal learning settings of MUVE systems may also cause students to "turn out" (Nelson & Ketelhut, 2007). In online learning environments, learners' engagement overrides learning success (Herrington, Oliver, & Reeves, 2003), and although MUVE applications may enhance communication behaviors (Tang, Lan, & Chang, 2012), lack of human interaction might be a problem in attaining proper levels of engagement (So & Brush, 2008). While students perceive virtual activities to be helpful, we should also keep in mind that the unstructuredness and informal aspects of using MUVE (as a form of self-discovery learning; Bruner, 1961) might be an obstacle in keeping learners interested in learning (Schmidt & Stewart, 2010; Hai-Jew, 2012). Bush (2009) also discussed that to keep students information-literate, educators should also be updated, learn from students, and welcome change. Other parameters such as identity conceptions, belief in the virtual world, and technical skills may also affect players' cohesion and learning within virtual worlds (deNoyelles & Kyeong-Ju Seo, 2012).

Collaborative Learning

Several studies have been performed in MUVE settings to understand the effects of games on collaboration, presence levels, team building, and teamwork (Bluemink, Hämäläinen, Manninen, & Järvelä, 2010; de Leo, Goodman, Radici, Secrhist, & Mastaglio, 2011; Ellis, Luther, Bessiere, & Kellogg, 2008; Roberts, Wolff, Otto, & Steed, 2003). Researchers have observed that increased sense of shared presence, social interaction and collaborative learning, and lower social anxiety are associated with such systems (Cook, 2009; Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). Using MUVE systems as part of collaborative team-based projects improves students' self-efficacy beliefs (Scullion, Baxter, & Stansfield, 2015). Kang et al. (2016) described the participatory design process with school teachers and suggested that a combination of physical interaction, sensing, and visualization in MUVE promote engagement, and shapes social interactions and playful experiences. By gaining collaborative experience, students increase their skill levels and feel more competent with technology (Nickerson, Corter, Esche, & Chassapis, 2007). Because of visual components of MUVE, students may also feel more connected and co-present (Leonard, Withers, & Sherblom, 2011).

The collaborative social environments may also provide opportunities to address the commitment problems. Bozanta, Kutlu, Nowlan, and Shirmohammadi (2016) mentioned that serious games are beneficial for team cohesion in MUVE environments, which could result in effective intra-group communication (Evans & Jarvis, 1980) and increased team performance (Dionne, Yammarino, Atwater, & Spangler, 2004). By using collaborative virtual environments, people can work together over networks to share experience and different tasks (Park & Kenyon, 1999). Shared virtual environments have the potential to be used for problem-solving and act as online communities (Meyers, 2009). In collaborative learning, the whole task is done by the group, and each person makes a contribution in line with the overall cognitive, interactive, and social goals. The interaction between players plays a great role in completing the task and creates an interdependence of players while developing interpersonal skills (Lorenzo, Sicilia, & Sanchez, 2012).

General guidelines (Arango, Chang, Esche, & Chassapis, 2007) for successful implementation of learning in virtual environments include: contextualizing learning in a way that makes sense to the learners, objective-based learning in which each activity should meet an objective and correctly represent the theoretical models that were previously studied by the learners, challenges that are coherent with learners' abilities, exploratory learning that allows learners to make their own decisions and see the consequences of their actions, and feedback to motivate student and enhance their performance continuously.

Design

As designers should consider interaction elements, feedback components, pedagogical, and other graphical aspects, developing a 3D MUVE environment is a complicated process (Harel & Papert, 1991). Integration factors involve pedagogical (relevance and complexity), contextual (players' prior experience, duration, and frequency of events), and logistical (usability, technical support, and hardware issues; Mayrath, Traphagan, Jarmon, Trivedi, & Resta, 2010). Pedagogical principles include curriculum content, technological content, and subject knowledge content (de Freitas & Jarvis, 2007). The flexible structure of virtual environments may cause learners to lose their attention (Ho, Rappa, & Chee, 2009). Strategies should be tailored carefully to avoid overloading players with unnecessary information and inhibiting overall learning (Ritz & Buss, 2016). Virtual worlds also increase interactivity and put students in the spatial dimension. Therefore, for better usage of these systems, users' technical skills should be improved (Petrakou, 2010). Additionally, the complexity of virtual environments that require significant computing power and high-speed internet to run smoothly are among issues that might make educators hesitate to use them. The cost of developing virtual worlds is another matter that is highly dependent on the amount of required modeling (Dutton, 2013).

Gender

Historically, gender was a good predictor of participation in virtual environments such as video games. Male and female players are different in type and duration play (Lowrie & Jorgensen, 2011). Four categories of memory task that could be affected by gender include spatial, verbal, autobiographical, and emotional. It is commonly agreed that males have better performance in spatial tasks and females in verbal tasks (Li, 2014). Additionally, male players spend more time playing video games and prefer action games compared to female players who prefer games featuring adventure, simulation, role-playing, and strategy. Moreover, males prefer games that require visual and spatial skills (e.g., dealing with maps), while females are interested in problem-solving video games. A previous study also suggests that female players are more active in virtual dance active video games and have more physical activity levels because they accept the platform as an activity consistent with their gender norms (Gao, Podlog, & Lee, 2014). Female players may also choose virtual activities that are considered as feminine, are accepted by their classmates, and are in line with their socially approved gender roles (Whitehead & Biddle, 2008). In the same way, female non-gamers tend to relate identity with physical appearance while male gamers were associating identity with personality characteristics. Moreover, female players who use virtual experimentation learn more, but male players outperform their counterparts (Ketelhut, Nelson, Clarke, & Dede, 2010). Previous research on the cognitive engagement of students also shows that male students tend to show higher levels of cognitive engagement such as self-regulation, task-focused learning, and resource management (Mandinach & Corno, 1985). On the other hand, Brom, Preuss, & Klement (2011) showed no gender differences in emotional engagement between the two genders.

VIRTUAL SPORTS FOR PHYSICAL EDUCATION

The popularity of the video game industry is ever increasing. The majority of young people own game devices and spend considerable amounts of time playing video games (Rideout, Foehr, & Roberts, 2010). Many people prefer to play video games during their leisure times than to read books or watch movies (Entertainment Software Association, 2018). Video games are usually blamed for providing aggression, violence, and making the children sedentary (Anderson et al., 2010; Lee & Peng, 2006). Insufficient physical activity (PA) which is one of the main parameters of mortality and obesity is also associated with sedentary gaming. Despite concerns regarding psychological effects of video games on the academic performance of players (Maass, Kollhorster, Riediger, MacDonald, & Lohaus, 2011), many educational researchers believe that these games could benefit the academic engagement of students, and are investigating the role of video games, their learning potential, and engagement (Young et al. 2012). These video games show reasons that might contribute to increase the quality and quantity of improved attention, executive functions, and reasoning (Neugnot-Cerioli, Gagner, & Beauchamp, 2015). Video games could also involve competition, collaboration, and might help in the development of learning communities sharing (Gee, 2008). They could also motivate players by using positive emotions to grab attention, memory, and motor skills to process information. Physical education and sports are important parts of the primary school curriculum around the world (Lindberg, Seo, & Laine, 2016). However, several reasons including instructors' lack of skills, time, and support, might contribute to reducing the quality and quantity of physical education (Lindberg, Seo, & Laine, 2016).

One exciting way of incorporating technology and teaching is by using active video games (exergames) that include visual or auditory stimulus. It provides an illusion of interacting with a virtual world and provides immediate feedback. Although it does not completely block the field of view of players, it is still capable of immersing players (Soltani, 2018). This new approach uses motion sensor technology and involves movements of body limbs during gaming. Exergames are increasingly popular as they combine gaming and exercise so that the motivation to play can encourage the individual to participate in some levels of physical activity. During the games, players have to perform active tasks such as jumping, running, dancing, virtual cycling, boxing, or tennis. Exergames might have the potential to produce more minutes of PA while being socially acceptable among both students and physical education teachers (Fogel, Miltenberger, Graves, & Koehler, 2010).

EXERGAME EVALUATION

Sports exergames are replications of real-world activities. Because they might be used for purposes such as instruction and training, they are also referred as serious games (Susi, Johannesson, & Backland, 2007). To successfully apply them in other contexts, they should be fun and provide challenges, skill, knowledge, or attitude that could be used in real-world scenarios. With various informal and voluntary learning tools and if sports exergames can improve motor skills of real sports, they might potentially facilitate familiarity with sports. To maximize their effectiveness and attractiveness, and augment their health benefits, sports exergames should be evaluated holistically. In this part, the authors analyzed a swimming exergame from different aspects of biomechanics, physiology, and psychology. The primary purpose of the biomechanical evaluation is to understand human movements better and to reveal that movements can be performed in many different ways. Another purpose of the biomechanical analysis is to increase safety. Because exergame activities involve repeated upper- and lower-limb movements, biomechanical procedures can estimate the internal loads and angles, and human-computer interaction is monitored carefully to guarantee safer experience and protect players from muscular overload.

For a realistic and meaningful experience, various design and safety considerations should also be met; especially when MUVE systems are intended to be used unsupervised and within the venerable community. Exercise physiology testing aims to understand how human systems work under different exercise conditions. Such situations might affect force production and neural control of movement pattern. Physiology also offers tools to monitor players' health via standardized tests and considers design and safety issues for unsupervised use. Finally, as motivating may ensure participation, progression, and retention in the MUVE systems, the psychological evaluation deals with players' enjoyment and motivation for playing. It also evaluates whether MUVE systems could establish a connection between virtual and real sport participation. Considering gender in this holistic framework allows tailoring various game elements carefully for both female and male players.

SWIMMING EXERGAME

Out of the water, subjects played different techniques of a swimming exergame with Microsoft Xbox and Kinect (Michael Phelps: Push the Limit, 505 Games, Italy). The game was divided into two phases of normal and fast, both controlled by visual on-screen feedback. Players had to stand in front of the Kinect sensor and bend forward (Parts B and C in Figure 1 below). With the visual command, they had to return to the standing position with arms in front (Part D in Figure 1). Afterward, they had to swim according to each technique and move the avatar inside the game (Parts E to L in Figure 1). To prevent players from swimming too slow or too fast, on-screen visual feedback indicated if the speed was moderate. In the middle of the second lap, there was a possibility of swimming as fast as possible without any limitation (Push the Limit). At the end of the event, players had to drop their upper limbs (Part M in Figure 1) and then raise one to finish the race (Part N in Figure 1). For all studies, participants were categorized based on gender, exergame experience, in-game performance, and real swimming background.

Biomechanical Evaluation

To understand the movement patterns of players, reflective markers were placed on the anatomical landmarks of the players, and their movements were captured using a 3D motion analysis system (Qualisys Track Manager, Qualisys AB, Sweden) and processed using a biomechanical analysis software (Visual3D, C-Motion Inc., U.S.A.). Due to lack of forces applied to the body from water and different body positions, kinematic differences were expectable. The evaluation showed that subjects had similar biomechanical parameters and, for better performance inside the game, they were encouraged to change their movement patterns (Table 1). Participants with real swimming background had the intention to keep their movement patterns close to real swimming, but as the device was not able to detect their precise movements, they change their patterns to just win the game (Figure 2). Additionally, experienced players were also playing the game with less effort (Soltani, Figueiredo, Fernandes, & Vilas-Boas, 2016).

The ideal goal of sports exergames would be to mimic the real-sport movements, but because of passive-playing nature of many games, players use different ways to exert. Movement patterns may vary depending on games, systems, and players' experiences. Movement comparisons show differences in

Figure 1. Body position during different phases of the game

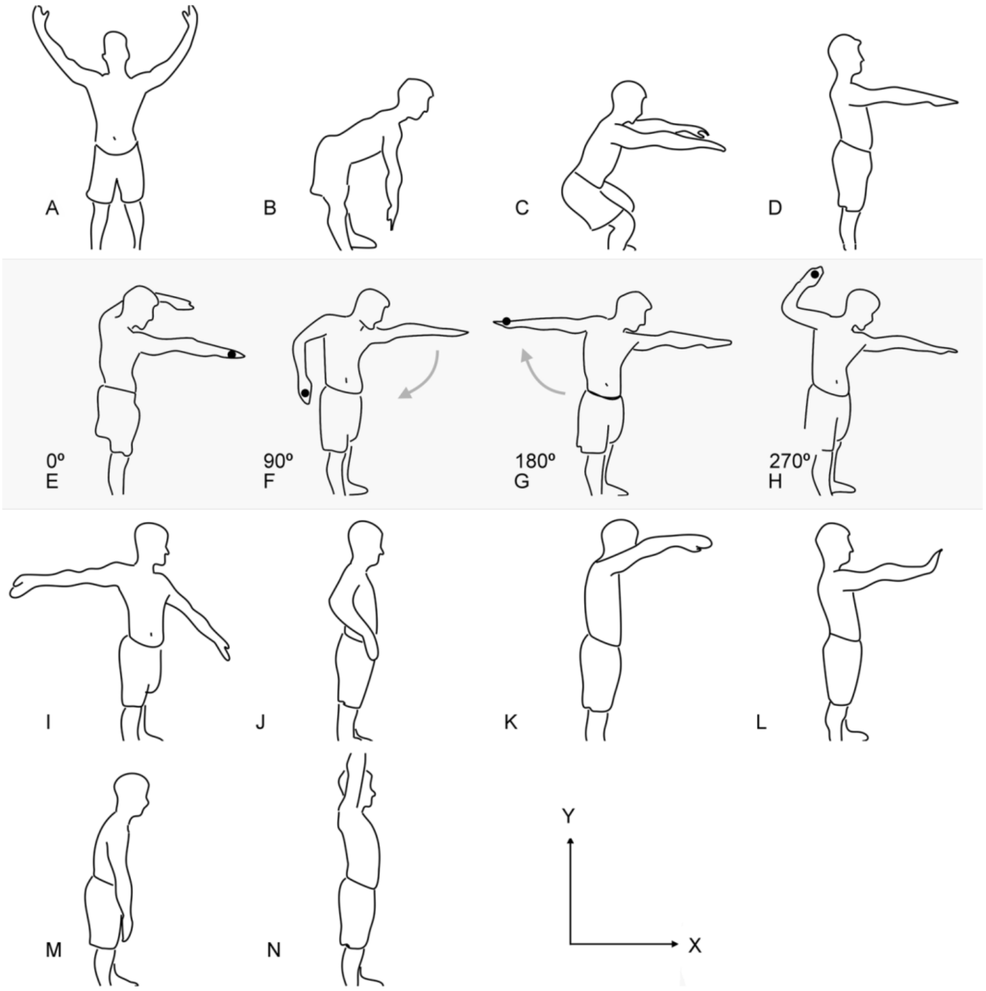
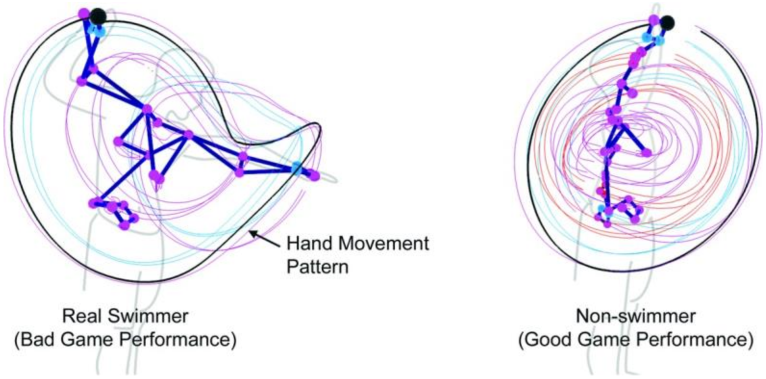


Table 1. Biomechanical parameters of swimming exergame

Variables		**Swimming Experience**		**Exergame Experience**		**Gender**	
		Swimmer	**Non-Swimmer**	**Experienced**	**Novice**	**Male**	**Female**
Total time (s)		49.97±3.58	49.36±2.50	49.24±1.82	50.17±3.96	49.29±2.69	51.55±4.61
Number of cycle	Normal	29.20±4.73	28.82±3.57	27.82±1.70	29.86±5.35	28.11±2.82	32.27±6.90
	Fast	10.23±2.23	10.36±3.35	9.71±1.82	10.59±2.81	9.94±2.04	11.27±3.55
Hand path distance		120.51±30	120.36±19.70	117.82±25.99	122.03±29.41	117.91±28.30	128.64±26.49
Trunk rotation (°)	Normal	40.17±15.85	32.09±8.58	41.29±15.15	36.45±14.52	39.60±15.47	33.91±11.91
	Fast	36.66±13.25	29.91±11.51	36.00±14.90	34.48±12.10	35.46±13.78	33.73±10.93

Data are presented as mean±SD.

Figure 2. Movement patterns of real swimmer vs. non-swimmer during virtual swimming



Real Swimmer
(Bad Game Performance)

Non-swimmer
(Good Game Performance)

anticipatory performance in which skilled players are more attentive to the game mechanics and such information could be interpreted as movement adaptation or learning (Soltani et al., 2016). In the game, players frequently mentioned that their real swimming movements were not applied inside the game correctly and they were encouraged to do simple movements just to win the game. Detailed biomechanical evaluation during the game design phase might help in the elimination of some of these boundaries and provide a more meaningful experience, especially if participation in real sport happens before virtual sport participation (Mueller, Agamanolis, Vetere, & Gibbs, 2009). It should be noted that there are also some modifiable and non-modifiable parameters while designing virtual sports. Non-modifiable limitations (lack of real forces from water or holding a physical object in hand) may result in differences in movement patterns and the sense of performing a real activity. Modifiable parameters are those imposed on players by the gaming platforms that affect posture and muscle loading, and might lead to cheating (Lui, Szeto, & Jones, 2011).

Physiological Evaluation

Compared to traditional methods of measuring the impacts of video games (e.g., questionnaires), physiological measurements provide more objective responses of players' experiences. While real-world sport activities may usually generate higher muscle activation compared to virtual equivalents, evaluating muscle activation during the gameplay can be used to make sports exergames closer to real activities.

Electromyography (EMG) profiling offers information in real time about the timing of muscle activities. It also allows understanding the changes in muscular activity during training and learning adaptations. With higher exergame engagement, muscle activation levels may also increase, and speed-based exergames might be used to create physical demand and to avoid boredom when players' engagements diminish (Soltani et al., 2017a). Twenty subjects played the swimming video game and activation of *biceps brachii* (BB), *triceps brachii* (TB), *upper trapezius* (UT), *latissimus dorsi* (LD), *erector spinae* (ES) muscles were monitored in two different playing velocities. Although higher muscle activation was seen in fast gameplay compared to the normal phase, after normalizing the muscle activation to the playing velocity, selective behavior was observed between the muscles (Table 2). More specifically, higher muscle activation was found in muscles that were responsible for pragmatic gameplay (swimming just to win the game). For example, during the front crawl, differences were observed between LD and ES.

Table 2. Activation of various muscles during front crawl

Event	Velocity	BB	TB	LD	UT	ES
Crawl	Normal	10.0±4.5*	17.2±14.2*	12.3±12.8*	53.9±39.6*	7.9±3.9*
	Fast	19.1±7.9	24.5±12.7	31.5±30.9	80.65±55.1	18.2±10.2
Crawl normalized	Normal	3.8±2.3	6.4±5.7	4.5±5.6*	19.8±14.3	2.9±1.7*
	Fast	4.5±2.2	5.8±3.3	7.8±9.1	19.2±13.4	4.3±2.3

*: Differences were observed between normal and fast swimming in muscles.

These two muscles are responsible for lowering the arms to start a new cycle to quickly finish the game. With this selective behavior in activating the muscles that contribute to swimming, the video game may not be used as a training device.

Heart rate, the rate of perceived exertion, and energy expenditure are other physiological parameters for measuring the intensity of exergames. These are particularly important as exergames are often promoted as means of increasing PA. Forty players played the game and oxygen uptake, and blood lactate were collected during the gameplay. From these two values, energy expenditure was measured which was also not different between performing groups. Only higher heart rate was observed in players with real swimming experience and only in the first technique. This shows that real swimmers tend to exert higher at the beginning of the gameplay, but as soon as they understood the mechanics of the game, they changed their behavior just to win the game. Each player was also filmed during the activity to measure the activity time. Total playing time, effective playing time, resting time, and effort to rest ratio were also calculated using video analysis. Recordings were tagged as total playing time (TPT), and effective playing time (EPT) in which players' movements were necessary to advance within the game. The results also showed that novice players had higher TPT and EPT compared to experienced counterparts (Table 3; Soltani et al., 2017b). This shows that novice players need more time to adapt to the game mechanics. It might also be possible that short-term positive results of an increase in PA levels are due to lack of experience of the players.

Psychological Evaluation

In the psychology part, the authors discuss both assessment of enjoyment as well as its role in changing PA and exercise intention. The concept is usually assessed by PA enjoyment scale (i.e., PACES) (Kendzierski & DeCarlo, 1991) which includes 18 items and requires respondents to select a point along a 7-point continuum between two opposite descriptors related to the enjoyment of PA (enjoy and hate, dislike and like, etc.). It is a robust predictor and correlator of PA behavior in children, youth, and older adults. The authors also used game experience questionnaire that deals with consumers' dynamic perceptions and responses of games and consists of different components including flow, a state in which there is a balance between the difficulty of the task and the skills that the performers possess (Csikszentmihalyi, 1991). With the occurrence of flow, players become immersed, ignoring the world around them (Brown & Cairns, 2004). A state of deep involvement in the game is recognized as absorption (Agarwal & Karahanna, 2000). Presence is also a psychological feeling of being in a virtual environment (Slater, Usoh, & Steed, 1994), and shows how engaged people are while playing video games (Schmierbach, Limperos, & Woolley, 2012). The System Usability Scale (SUS) is a measurement of learning, control,

Table 3. Physiological evaluation of swimming exergame

Variables		Swimming Experience		Exergame Experience		Gender	
		Swimmer	Non-Swimmer	Experienced	Novice	Male	Female
$[La^-]$ $(mmol.l^{-1})$	$[La^-]$ Activity	3.0±1.4	2.3±0.8	2.4±1.0	3.0±1.3	2.7±1.2	2.1±0.5
	Crawl	3.0±3.0	2.0±0.7	2.1±1.6	3.0±2.7	2.5±2.3	2.0±0.7
	Backstroke	2.7±1.0	2.1±0.8	2.2±0.9	2.7±1.0	2.5±1.0	1.9±0.6
	Breaststroke	3.0±0.9	2.5±0.6	2.6±0.7	3.0±0.9	2.8±0.8	2.3±0.5
	Butterfly	3.3±2.1	2.7±1.4	2.6±1.4	3.5±2.1	3.1±1.9	2.4±0.8
EE (kJ)	EE_{TOTAL}	113.4±40.4	97.4±24.1	95.3±24.4	119.3±39.5	111.0±33.5	82.2±15.7
	EE_{LAC}	12.9±11.6	7.8±5.0	7.9±6.7	13.5±10.6	11.3±9.4	5.7±2.7
	EE_{AER}	100.5±32.8	89.6±23.0	87.4±22.4	105.8±32.6	99.7±28.6	76.4±14.6
	Lactic (%)	10.2±6.6	8.0±4.8	8.0±5.5	10.5±5.8	9.6±6.2	6.8±2.7
	Aerobic (%)	89.7±6.6	91.9±4.8	91.9±5.5	89.4±5.8	90.3±6.2	93.0±2.7
HR (bpm)	HR-Total	94.1±18.3	85.5±12.5	88.4±16.9	89.8±13.5	88.3±15.6	91.2±15.4
	HR-Activity	105.7±15.7	97.9±13.9	99.0±13.1	104.0±17.5	99.2±14.7	107.3±15.1
	Crawl	105.9±17.9*	96.8±11.8	100.0±15.3	101.1±15.1	98.8±15.8	106.1±11.0
	Backstroke	105.8±13.8	103.0±16.6	101.6±12.0	108.0±19.4	102.1±14.9	111.1±16.3
	Breaststroke	105.4±17.8	99.3±16.9	96.9±15.0	104.5±19.6	98.2±17.0	106.0±17.3
	Butterfly	106.0±15.8	98.2±16.9	97.8±15.5	103.7±17.0	98.3±16.3	106.4±18.8
RPE	RPE Activity	2.9±1.1	3.0±1.2	2.8±1.2	3.2±1.2	2.9±1.2	3.2±1.4
	Crawl	2.6±1.3	2.0±1.2	2.1±1.3	2.4±1.2	2.2±1.3	2.2±1.3
	Backstroke	2.8±1.0	3.0±1.6	2.6±1.3	3.4±1.5	2.7±1.3	3.6±1.5
	Breaststroke	3.0±1.4	3.2±1.5	3.0±1.5	3.3±1.5	3.0±1.4	3.5±1.6
	Butterfly	3.4±1.7	4.0±1.5	3.6±1.7	3.9±1.3	3.8±1.5	3.6±1.9
Activity profile	Active (%)	54.5±4.4	58.5±9.5	55.8±8.6	58.6±7.1	56.4±7.2	58.5±10.9
	Rest (%)	44.3±5.0	44.0±7.8	45.5±7.2	42.0±5.4	43.3±6.1	47.0±8.3
	E:R	1.2±0.2	1.3±0.4	1.2±0.3	1.4±0.3	1.3±0.3	1.2±0.2

*: Differences were observed between normal and fast swimming in muscles; EE_{LAC}: Anaerobic energy contribution; EE_{AER}: Aerobic energy contribution; Lactic: Relative anaerobic lactic percentage; Aerobic: relative aerobic percentage; HR-Total: HR from the onset of activity until the end of the last technique; HR-Activity: mean HR during the four swimming events; RPE Activity: Mean RPE during the four swimming techniques; E:R: effort to rest ratio.

and understanding a game, and offers a reliable tool for measuring usability. With ten questions of five responses (from strongly agree to strongly disagree), the game usability scale allows evaluating a wide variety of products and services. Items ask about whether the player would like to use the system frequently, if they found it unnecessarily complex, or if they need support to use the system. Additionally, the changes in intentions before and after the gameplay were monitored using the following items before and after the gameplay: “If I had a chance, I would participate in physical activity later today” and “If I had a chance to participate in physical activity, I would choose swimming.”

Twenty players participated in this study and filled the questionnaires after the gameplay. Twelve participants were female. Overall, psychological parameters were not different between performing groups, but female players with real and exergame experience enjoyed the game more (Table 4). The video game also earned a good usability score with high acceptability. GEQ components were also not different between performing groups, but in general, subjects rated the absorption part lower, which might have been affected by the perceived usefulness of the game (Agarwal & Karahana, 2000). As feedback functionality affects immersion of the players (Nogueira, Torres, Rodrigues, Oliveira, & Nacke, 2016), and while the movements of different players were detected similarly, they might have immersed equally. Moreover, physical activity intentions did not change but swimming intentions increased for all subjects. A possible explanation might be that exercise intentions of those who frequently exercise may not be affected by a single session of video game playing. Another explanation is that those who do not exercise regularly might think that the benefits obtained through exergame participation are enough and there is no need for further exercising.

CONCLUSION

Physical education is emerging regarding the use of technology in classes. Virtual environments such as sports exergames might provide promising short-term results in increasing energy expenditure and physical activity levels. However, data from this study showed that as players gain experience, they might change their gameplay behavior and therefore, these games may not offer long-term maintenance of physical activity and may not be used as a teaching or training device. Instructors and users who think that virtual environments might have a place in education should understand that due to a lack of institutional resources, a lack of familiarity, and other hesitations, it may still not be practical to use such systems in practice and research sites (Johnson, 2011). Moreover, traditional methods might still be more cost-effective and more efficient and therefore, should not be fully ignored (Webster, 2016). PE teachers

Table 4. Psychological evaluation of swimming exergame

Variables		**Swimming Experience**		**Exergame Experience**		**Gender**	
		Swimmer	**Non-Swimmer**	**Experienced**	**Novice**	**Male**	**Female**
PA intention	Before	4.84±1.18	4.71±1.40	4.861.07	4.66±1.58	4.85±1.33	4.62±1.11
	After	4.82±1.07	4.63±1.61	4.78±1.18	4.66±1.56	4.81±1.37	4.52±1.20
Swim intention	Before	2.82±1.30	1.89±0.93	2.33±1.21	2.55±1.29	2.41±1.26	2.43±1.20
	After	3.53±1.60	2.63±1.62	3.25±1.53	2.93±1.88	3.17±1.76	3.05±1.39
Enjoyment		5.99±0.80	5.90±1.21	6.13±0.82	5.64±1.19	5.89±0.97	6.11±1.05
SUS%		75.53±12.32	73.67±15.25	73.28±14.47	77.14±11.95	73.92±13.38	76.87±14.48
GEQ		2.83±0.72	2.70±0.50	2.77±0.64	2.77±0.62	2.80±0.67	2.70±0.50
GEQ components	Absorption	2.21±0.74	2.21±0.66	2.15±0.66	2.32±0.76	2.23±0.71	2.17±0.68
	Flow	2.87±0.72	2.76±0.53	2.88±0.63	2.72±0.66	2.79±0.67	2.91±0.56
	Presence	3.14±0.85	3.06±0.72	3.02±0.81	3.25±0.74	3.20±0.78	2.82±0.76
	Immersion	3.38±1.26	3.14±1.04	3.10±1.22	3.57±1.03	3.35±1.18	3.05±1.14

SUS: System usability scale; GEQ: Game experience questionnaire.

should justify why and how they want to use exergames in their practice and properly design ways for their students to interact with games. A combination of techniques (virtual and traditional instruction) might provide a more effective learning experience (Webster, 2016) due to shorter training time and possible long-term retention of knowledge and skills. Future studies should also examine whether physical activity and sport participation intentions result in actual exercise participation.

RECOMMENDATIONS AND FUTURE DIRECTIONS

While evaluating players' behaviors, various parameters such as gender, ethnicity, activity levels, and exercise background should be considered. Larger sample size might increase the power of analysis, and therefore conclusions made upon the results might be more realistic. It should also be noted that acquiring biophysical data is relatively time-consuming which might not be tolerable for some participants. The novelty of exergames might also cause players to rate their psychological variables (e.g., enjoyment) higher. While the majority of studies on exergame evaluation show promising short-term results for increasing PA levels, results in this study show that even after short exposure to the sports exergames, players change the movement patterns and reduce their activity levels. Future studies should analyze players' movements and behavior over longer periods of gameplay. Other studies may also look at the possibility of using virtual sports in decreasing fear of real activity (e.g., aqua-phobia). Creating a fitness index for each game based on psycho-biophysical evaluation could be another interesting area to use exergames in PA effectively.

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KEY TERMS AND DEFINITIONS

Biomechanics: This term refers to the study of structure and function of the mechanical aspects of biological systems.

Collaborative Learning: An educational approach to teaching and learning that involves students working together to complete a task or to solve a problem.

Exercise Physiology: The study of the acute responses and chronic adaptations to exercise.

Exergame: A term for video games that require some degree of exercise to operate them.

MUVE: A computer-, server-, or internet-based virtual environment that can be access by multiple users simultaneously.

Physical Education: An educational course related maintaining the human body through physical exercises.

Virtual Reality: Interactive computer generated experienced that take place in simulated environments and incorporates audiovisual and sensory feedback.

ENDNOTE

[1] All of the external links have been also saved on the Internet Archive WayBack Machine.