Review Paper

Virtual reality in sports coaching, skill acquisition and application to surfing: A review

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ABSTRACT

The last decade, notably the past two years, have seen significant advancements in virtual reality (VR) technology, especially within the development of 3D and 360° virtual environments. Smart Phone technology now allows for head mounted display of this environment which is much more user friendly and cost effective. Sport training can now take full advantage of the improved quality of operating systems and as a result, VR provides visual simulations and immersive, interactive environments. VR technology is becoming more popular with evident influence on collecting various physiological aspects, identifying and improving sensorimotor capabilities, replicating competition and environment situations where reaction time is critical, and developing skill acquisition. This paper, therefore, reviews the existing literature relating to VR and the use of the technology used within sport, skill acquisition and coaching. Specifically, the paper describes VR, examines the uses of VR in sports, the applicability of methodological approaches used along with findings, limitations and the implications for coaching and athlete practice. Additionally, this review reports on VR used within skill acquisition learning/teaching and identifies how the technology can apply to surfing skill development. This paper will promote new ways to hone specific, hard to obtain skills, encouraging novel thinking for coaches.

Keywords: Virtual reality; Coaching; Athlete development; Skill acquisition; Technology.

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INTRODUCTION

In order to develop expert athletic performance, coaches typically analyse and dissect athlete movements into subunits using performance analysis methods (Farley, Abbiss, & Sheppard, 2017). Recording such information has become increasingly important over the last decade in gaining an edge over competitors (Carling, Bloomfield, Nelsen, & Reilly, 2005; Farley et al., 2017; Mackenzie & Cushion, 2013; Williams & Hodges, 2005). Enhanced performance data (such as the physical demands and technical aspects of a sport) better equips coaches and trainers as to the skills, movements, and physical qualities of their athlete.

For every athlete, substantial practice time (i.e. 10 years of deliberate practice) is required to develop sports-specific automatous skills/movements (Chase & Simon, 1973; Ericsson, Krampe, & Tesch-Römer, 1993; Miles, Pop, Watt, Lawrence, & John, 2012; Starkes, Deakin, Allard, Hodges, & Hayes, 1996). During the phases of development, coaching and skill acquisition involve three distinct processes: conveying information (i.e. observational learning), structuring practice (i.e., contextual interference) and administration of feedback (i.e. feedback frequency, timing, and precision) (Lawrence & Kingtson, 2008; Miles et al., 2012). The learning processes that occur during sport are characterised by complex displacements and movements, requiring a selective gathering of information under a variety of environmental conditions. It has been suggested that when learning sports skills, it is highly beneficial for athletes to learn a variety of skills in a single training session and practise in a random fashion (i.e. the practice environment is very diverse and challenging, similar to the demands of a competition or game) (Battig, 1966, 1979; Brady, 2004; Lee & Magill, 1985; Miles et al., 2012; Perez, Meira Jr, & Tani, 2005; Vickers, 2007). Henry (1968) proposed that optimal learning experiences occur when the movements closely resemble that of the target skill, and the environmental conditions replicate the target context (i.e. specificity of practice). It has been suggested that during skill acquisition, athletes develop a movement plan to optimise the sensory information present (Elliott, Chua, Pollock, & Lyons, 1995; Khan & Franks, 2000; Khan, Franks, & Goodman, 1998; Mackrous & Proteau, 2007; Miles et al., 2012).

A sport environment is dictated by the complex displacements and movements that an athlete is immersed in, therefore, learning/coaching the sport specific movements requires a selective gathering of information under a variety of environmental conditions. The actions within a sporting environment are often limited in time, are unique, complex and dependent on visual cues which the athlete obtains from their surroundings (Craig, 2013; Kulpa, Bideau, & Brault, 2013). The athlete's performance is therefore dependent upon their perception, and ability to anticipate and execute skills under time constraints (Craig, 2013). Within any sports code (team or individual), the competitive environment relies on a diverse set of physical and mental skills (Appelbaum & Erickson, 2016). Perception is fundamental to the athletic performance (Kulpa et al., 2013). As such, movements are dependent on visual information that the athlete gathers from the environment, including the opponent's actions (Kulpa et al., 2013). Due to the perceptually demanding nature of sport, visual perceptual and visual–motor skills are often targeted in sport training programs (Appelbaum & Erickson, 2016). It is these skill sets that coaches/trainers and athletes are eager to optimise for competitive performance, and in doing so, embrace new technologies to gain an edge through improved training practices (Covaci, Postelnicu, Panfir, & Talaba, 2012).

The last decade has seen significant advancements in technology, especially within the development of virtual environments (VE). Such advancements have allowed for the integration of VE that were previously limited by highly expensive systems, safety, or perception restrictions (Covaci et al., 2012; Ruffaldi & Filippeschi, 2013). Traditionally, understanding the links between the performance of an athlete and the information perceived, for example, opponent's kinematics or ball trajectory, has been determined using video footage (Zaal & Bootsma, 2011). However, the position of the camera during video recording determines the resulting viewpoint and has several limitations (Abernethy, Thomas, & Thomas, 1993; Bideau et al., 2010; Williams, Davids, Burwitz, & Williams, 1994) such as the prevention of interactivity and environmental observation, which are essential for athlete learning. When an athlete trains in a VE, their movement is subject to the view captured from the camera during recording. If the camera films from a fixed viewpoint, different visual information cannot be extracted from the environment that would normally occur during real sporting situations. The two-dimensional video display means that the athlete cannot extract the stereoscopic information which is present in real life situations and reported to influence motor responses (Mazyn, Lenoir, Montagne, & Savelsbergh, 2004; Yeh & Silverstein, 1992). One such area of technological advancement that has only recently been investigated is computerised simulations and virtual reality (VR) as alternate means to simulate sporting environments (Appelbaum & Erickson, 2016; Vignais, Kulpa, Brault, Presse, & Bideau, 2015).

The emergence of three dimensional (3D) virtual technology has brought tremendous changes in VR, immersing individuals in an environment that would normally be unobtainable (Covaci et al., 2012). In doing so, VR can overcome the fixed viewpoint video limitations by providing visual simulations and immersive, interactive environments (Bideau et al., 2010; Craig, 2013; Katz et al., 2006; Vignais et al., 2015). Exploring previous literature that addresses the establishment of VR and VE within sport as a means to develop athlete's skills will improve our understanding of how this technology can aid in sporting success. It is important to explore the current literature in order to provide insights into methodological protocols, the uses of VR for skill acquisition, and the delimitations of this technology. Specifically, this review will describe and examine the use of VR in sports research and skill acquisition learning/teaching methods and identify how such technology can pertain to surfing skill development.

VIRTUAL REALITY

VR is a sophisticated system utilising advanced technology and computer graphics to produce a realistic-looking virtual world for multiple sensory experiences (Burdea & Coiffet, 2003) determined by the tracking system (input) and the display system (output) (Kulpa, Multon, & Argelaguet, 2016). In a VR environment, using a head mounted display (HMD) to tracks a user's head motions relays information to the VR simulation, and correspondingly adjusts the viewpoint seen within the user's display, thereby changing their perspective and enhancing the full immersion presence within the reality (Hendrix & Barfield, 1996; Kulpa et al., 2016; Sanchez-Vives & Slater, 2005; Slater, Khanna, Mortensen, & Yu, 2009; Slater & Sanchez-Vives, 2016). In addition, images displayed in a virtual environment are stereoscopic, giving an illusion of depth, to provide the subject with salient motion-in-depth information (Vignais et al., 2015)) According to Steuer (1992), VR technology relies on two main components. Firstly, depth of information refers to the amount and quality of data in the signals a user receives when interacting in a virtual environment (i.e. display's resolution, complexity of environment's graphics, and sophistication of system's audio output). Secondly, breadth of information refers to the number of sensory dimensions simultaneously presented during immersion. Most VE experiences prioritise visual and audio components over other sensory stimulation.

The process of integrating VR technology into sport performance enhancement generally involves three steps (Figure 1). The initial step involves recording athletes' actions in a given sport. These actions are not only useful for the virtual characters' animation but also provide a way to compare the subject's movements in real and immersed situations. Latest video recording technology permits filming of a full 360° environment with a single light-weight camera that can be easily mounted onto a participant (i.e. head camera). The second step involves either animation of the virtual humanoids and their adaptation to specific movements (i.e. players to dodge/sidestep, kick a ball past) as one part of the simulation (Bideau et al., 2010), or stitched together 360° film that can be viewed on a smartphone within a VR HMD headset. It is important to acknowledge the distinction between filmed 360° VR and animated model or graphics-based VR. Primarily, the 360° recorded environment does not allow participants to move around within the environment or observe objects arbitrarily from any angle. Instead, a single viewing angle is determined by the position of the camera when filming, and the head movements within an HMD allow for the 360° immersion within that scene. Therefore, interaction with the wider environment is non-existent compared to that of a computer-generated model where participants have the ability to control their point of view, integrating the environment by switching to any viewpoint in the scene. However, building computer-generated environments is timely, costly, and limited in its ability to display full realism (Slater & Sanchez-Vives, 2016). The third step of VR integration involves the virtual environment's presentation (Bideau et al., 2010). The presentation is dictated by the coach/observer who decide which environment to immerse the participant in, and what tasks they are to perform.

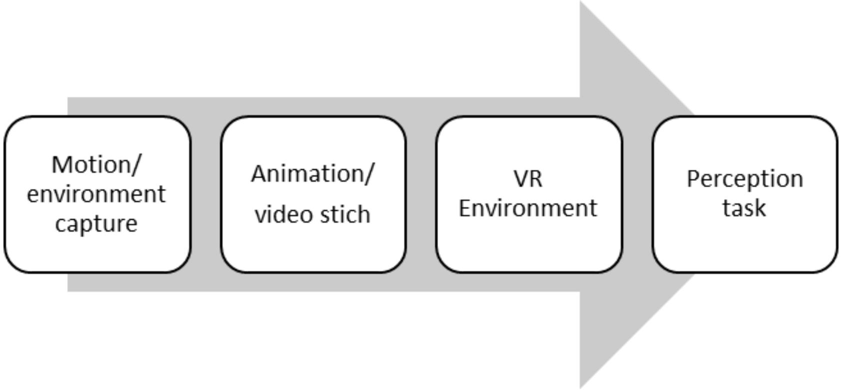

Figure 1. An overview of the process of a virtual reality. (Adapted from Bideau et al. (2010)).

The technology improvements in visualisation, motion capture, and computing capability have addressed the challenges in developing a simulation VE for training sensorimotor components of sport (Bailenson et al., 2008; Bideau et al., 2010). Modern sport training can now take full advantage of the improved quality of operating systems and as a result, VR can provide visual simulations and immersive, interactive environments (Bideau et al., 2010; Craig, 2013; Katz et al., 2006; Vignais et al., 2015). Kulpa et al. (2013) suggested that it is necessary for top athletes to be immersed in a VE in order to enhance their perspectives and resulting opportunities of action from the environment. Further, VR provides the capability to alter the display parameters and tune in a systematic manner, ensuring reproducibility between trials, allowing for an accurate and standardised experimental protocol (Tarr & Warren, 2002), thus helping further develop skill acquisition in athletes (Ruffaldi & Filippeschi, 2013). The effectiveness of VR in acquiring a new skill, or improving upon existing skills has also been demonstrated diversely across areas such as surgery (Howell, Conatser, Williams, Burns, & Eland, 2008; Pedowitz, 2017), rehabilitation (Gokeler et al., 2016; Holden, 2005), concussion assessment (Slobounov, Slobounov, & Newell, 2006), and sport (Bideau et al., 2010; Ruffaldi et al., 2011). Within rehabilitation (Gokeler et al., 2016), the VR immersion of patients after anterior cruciate ligament (ACL) reconstruction changed movement patterns, approximating those of healthy subjects. Such reporting's support the integration of VR in enhancing both the assessment and rehabilitation of motor learning capabilities, thereby aiding in reducing risk factors for a second ACL injury (Gokeler et al., 2016). It is owing to these capabilities that VR has been implemented in studies determining visual perception during interceptive tasks, particularly human action when catching fly balls in baseball (Chardenon, Montagne, Buekers, & Laurent, 2002; Fink, Foo, & Warren, 2009; Vignais et al., 2015; Zaal & Bootsma, 2011) and used for skill acquisition (Bergamasco, Bardy, & Gopher, 2012; Covaci et al., 2012; Miles et al., 2012).

Previous sports research has implemented computer simulation to present carefully controlled visual information and evaluate the corresponding behavioural responses in different sporting situations (Araújo, Davids, & Serpa, 2005; Craig, Berton, Rao, Fernandez, & Bootsma, 2006; Vignais et al., 2015; Watson et al., 2011). The ability to control what the athlete sees, manipulate what affects their performance, and assess their influence (and provide appropriate feedback) is a methodological advantage when using VR to simulate events, especially for sporting situations that are highly dynamic in their natural setting (i.e. Rugby, Football) (Hoffmann, Filippeschi, Ruffaldi, & Bardy, 2014; Watson et al., 2011). In regard to coaching application, the manipulation of variables such as visual information, spin, trajectory, speed, projections of record lines to keep up with, and gap closure are some examples that can be adjusted and controlled within a computer-based environmental recreation whilst also allowing replication of identical trials. As such, the latest developments in VR technology offer a new, more pertinent and accurate perspective for users (Kulpa et al., 2013).

VR IN SPORT

To date, research implementing VR within different sport codes has been applied with success. Tennis studies have created virtual environments with an interaction between an immersed subject and a virtual humanoid (Molet et al., 1999; Noser, Pandzic, Capin, Thalmann, & Thalmann, 1997), football research has analysed whether adding spin to a ball during a free-kick situation affects professional football players' perception of the ball's future arrival position (Craig et al., 2006). Motorsport implements VR to enhance the driver's decision making skills, thus decreasing the risk of accidents, and the costs associated with track hiring, car maintenance, and crew (de Groot, de Winter, Mulder, & Wieringa, 2011). Rowing research has demonstrated the effectiveness of VR for the acquisition, retention, and transfer of energetic skills and the associated improvement in performance (Hoffmann et al., 2014; Ruffaldi & Filippeschi, 2013). Basketball free-throw skill development results support the idea that VR can assist athletes in training (Covaci et al., 2012) and similar results have been reported in cricket batting (Dhawan, Cummins, Spratford, Dessing, & Craig, 2016). VR simulation has also been used as a standardised environment to analyse perception-action coupling, such as duels between two players in handball (Bideau et al., 2004) and rugby (Brault, Bideau, Craig, & Kulpa, 2010), or the perception from a goalkeeper in soccer (Craig et al., 2009), and as a simulator for ski jump training (Staurset & Prasolova-Førland, 2016). Objective kinematical validation of the presence between a handball goalkeeper and a thrower studied by Bideau et al. (2003) indicated that the movements were similar between the real and virtual environments, suggesting validity. VR has also been utilised in developing complex motor tasks such as juggling (von Zitzewitz et al., 2008), and perceptual skills necessary to perform complex motor tasks (Multon, Kulpa, & Bideau, 2011).

The unique standardised and reproducible VR environment offers advantages such as the ability to control stimuli, the virtual world (i.e. object variables and virtual opponents), and the adaptation of viewpoint due to head tracking system (Kulpa et al., 2016). VR simulations support the design of complex training protocols by mimicking real game activities, allowing athletes to gain 'mental repetitions' (Appelbaum & Erickson, 2016), increase track performance, and introduce effects not easily replicated in real training conditions (Miles et al., 2012; Ruffaldi & Filippeschi, 2013). Creating immersive interactive environments allows experimental control to be maintained while allowing accurate manipulation of all other variables. Simulation training in sporting contexts helps athletes develop necessary skills that can be transferred into competition, thus improving the proficiency of skill execution and reducing error (de Groot et al., 2011; Washington, Dogramaci, Steel, & Ellem, 2016). On top of this, such training can aid athletes to predict opponents deceptive movements, by directing attention to specific moves or body parts that signal such intentions (Slater & Sanchez-Vives, 2016). Furthermore, simulations can be customised to desired scenarios, such as plays derived from game footage, and can yield quantitative information about performance under pressure (i.e. training for worst case scenarios), with little to no risk of injury that can occur in traditional team based sport trainings (Appelbaum & Erickson, 2016). Replaying video recording or creating virtual simulations allows athletes to practice these cognitive skills anywhere without limitations of field space, time, and athlete numbers. VR can be easily manipulated to change variables of interest, such as opposition movement. Additionally, athletes could become visually acquainted with a competition environment (Miller et al., 2017) prior to arriving at the venue with the use of 360° recordings of the actual environment (i.e. ski slope, surf break). Repetition of aforementioned scenarios would give an athlete the upper hand over competitors by helping to reduce errors through improvements to mental, perceptual (visual awareness), and physical coordination, as well as reaction times. However, Craig (2013) suggests, it is still critical of coaches to provide appropriate cues to the athletes to avoid inadequate skill learning.

BENEFITS AND LIMITATIONS OF VIRTUAL REALITY TECHNOLOGY FOR SKILL ACQUISITION

For VR technology to be effective in developing skill acquisition and improving sensorimotor skills in athletes, the learning environment must mimic movements of the targeted skill and the environmental conditions of the target context (i.e. specificity of practice) (Henry, 1968; Miles et al., 2012). The repeatable VR environment is optimal for developing skills that are difficult to replicate in real-world training settings but are optimal for developing skills. Sports that are dictated by environmental conditions (i.e. surfing) could potentially benefit greatly from such technology. Within surfing, the environment is heavily dictated by environmental variables (wave size, formation of wave, currents, ocean chop) that are ever-changing and dependent on swell and wind factors (Farley et al., 2017). Simulating the environment though 360° video recordings of real waves and mimicking surfing through the use of a skateboard that replicates surfing movements gives the ability to replicate and practice skills on land when there is no surf to practice in. Additionally, the use of VR eliminates contact, replacing it with controlled visuals and mimicking that can be replicated in a safe environment. Eliminating these factors during practice minimises the potential risk for injury prior to competition, which is the hinderance of any form of practice. However, the use of such technology for skill acquisition training needs to be implemented in a way that it is beneficial for performance. Previous research has discussed benefits and limitations of such technology (Appelbaum & Erickson, 2016; Bailenson et al., 2008; Bideau et al., 2010; Covaci et al., 2012; Kulpa et al., 2013; Kulpa et al., 2016; Miles et al., 2012). It should be noted that the majority of the studies mentioned in the review are more than five years old and the last two years alone have seen dramatic improvements in VR technology. The feasibility of training with VR simulations has increased, and as such, skill development is a benefit of this technology.

In order to design and implement appropriate environments for developing performance and learning specific skills, coaches need a sound theoretical knowledge of the processes of learning. Research suggests that the way a coach organises the practice sessions will dictate the amount of skill learning attained from practice (Magill & Hall, 1990). Therefore, modelling how athletes acquire functional movement patterns remains essential. It is important to take into account practical issues such as: (i) selecting practical equipment; (ii) arrangement of learning environments and teaching tasks; (iii) preparation of practice programmes; (iv) safety and prevention of injury; and (v), understanding individual differences at various levels of performance are warranted (Renshaw, Chow, Davids, & Hammond, 2010). It has been suggested that athletes should develop a movement plan to optimise the sensory information present during skill acquisition and that this movement plan is specific to the information that is available during practice (Elliott et al., 1995; Khan & Franks, 2000;

Khan et al., 1998; Mackrous & Proteau, 2007; Miles et al., 2012). Thus, if practice conditions are altered, the previously developed movement plan is no longer appropriate for successful performance. Therefore, it is important to match the VE as closely as possible with that of the real-world setting in order to maximise the transfer of learning. Athletes must perceive information gathered from their actions and environment in order to move, but they must also move in order to perceive further information for action (J. Gibson, 2014). Athletes can accustom their movements to essential information sources through practice, thus establishing strong 'information-movement couplings' to guide their behaviour (Renshaw et al., 2010). Furthermore, movement variability is not necessarily a hindrance to learning but is an important aspect prior to the acquisition of stable and functional movement patterns (Renshaw et al., 2010). Coaches therefore need to modify informational task constraints in order to direct learners towards functional information-movement couplings that will allow them to achieve task goals (Davids, Williams, Button, & Court, 2001). During skill acquisition, task constraints should also be manipulated so that information-movement couplings are maintained in a learning environment that is approximate to a real performance situation. This can be applied to a VR environment where the athlete is immersed in competition scenarios or actual footage, and practises appropriate judgement calls and movements.

The success of VE skill acquisition lies in retention and transfer to real-world situations, so training should provide opportunities to obtain all essential information required for development. To achieve this, the VE should; (i) require the athlete to produce actual movements identical to those required in the real-world setting (Hendrix, 1994), (ii) ensure that movements are performed with a variety of conditions, (iii) guarantee that the outcomes of these movements are available to learners, and (iv) attempt to provide sensory consequences of such actions (Miles et al., 2012). If one or more of these classes of information is omitted, or the VE does not adequately approximate the information in the real-world setting, transfer will be unlikely to occur (Miles et al., 2012). Consequently, it is important to simulate sport specific movements. Kulpa et al. (2013) advocate the importance of freedom of movements and displacements for the analysis of the athlete's performance. Such features are fundamental when studying sport, allowing the immersed subject to react realistically without constraints, acting as if in real a situation. If subjects are constricted by the equipment, this can lead to nonspecific or inefficient movements that are not applicable to the targeted skill. To successfully implement a VR environment within a sporting field, it needs to provide users full immersion, navigation, and manipulation (Hamit, 1994; Heim, 2000). Athletes during VE learning need to receive immediate, informative feedback and knowledge of their performance following repeated identical or similar tasks. Such feedback during practice will improve the accuracy and speed of performance on cognitive, perceptual, and motor tasks (Fitts & Posner, 1967; E. J. Gibson, 1969; Welford, 1968). In the absence of adequate feedback from a coach, efficient learning is impossible, and improvement only minimal even for highly motivated subjects (Ericsson et al., 1993). Hence, mere repetition of an activity will not automatically lead to improvement, especially in performance (Trowbridge & Cason, 1932). Providing augmented feedback (i.e. visual and auditory information about movement characteristics from a coach) to the athlete is a common strategy to enhance motor learning (Sigrist et al., 2011). As such, visual feedback (such as video recordings) has been successfully utilised in many studies on complex motor tasks in sport and rehabilitation (Ruffaldi et al., 2011). Ultimately, to assure effective learning, all athletes should be given explicit instructions around best practice and supervised by a coach to allow individualised diagnosis of errors, informative feedback, and remedial training (Ericsson et al., 1993).

VIRTUAL REALITY IMPLEMENTATION

Within VR immersion, the link between virtual and actual environments should incorporate and integrate the interaction between the immersed athlete and virtual opponent/s and or environment (Kulpa et al., 2013).

The environment must generate a high level of presence for the athlete to feel immersed within the VE (Barfield, Zeltzer, Sheridan, & Slater, 1995) with external (technology and materials used) and internal factors (psychological aspects) also considered (Slater & Usoh, 1993). For example, in surfing, virtual waves or real recorded 360° waves observed in an HMD must create a full sense, as though you are truly riding on a board along the wave. It is important that other equipment used, such as a skateboard that mimics surfing, is also incorporated to provide that link between virtual and actual environments. Furthermore, for the effectiveness of any VE as a training/coaching tool, it should be realistic, affordable, and validated (Kulpa et al., 2016). Real-time motion capture should therefore be utilised over still-shot cameras to not only provide better interaction and realism, but to also incorporate the viewpoint of the athlete as it happens. Video capture must be recorded at the highest level of recording ability (i.e. 4k) and filmed a high frame rate per second (fps) (60 fps is better than 24 fps) so it is a smooth, clear, and crisp video, rather than a ridged, pixelated video that looks distorted. User control or interactivity is considered paramount to the experience of VR as this directly relates to the level of behavioural realism experienced by the user (Brault et al., 2010; Craig, 2013; Dhawan et al., 2016; McMenemy & Ferguson, 2007). An egocentric viewpoint is vital to gather all the visual information one senses in an actual environment. For successful athlete development, the learning environment needs to be carefully planned in order to improve the athlete's ability when executing a skill, without encouraging negative training, such as ineffective technique. Lastly, the construct and content validity of the VR environment must be considered, meaning the transfer of skill acquisition is to be measured and validated by success in real-world situations, thereby providing an overall comparison between the effectiveness of conventional versus VR training (John, 2008). In summary, it is imperative to measure the transfer of training from the simulated environment to the real environment.

From an athletic performance perspective, head motion perspective of 3D or 360° video displayed by HMDs have been suggested to be advantageous due to the highly immersive, realistic experience of a task (Dhawan et al., 2016). However, HMDs have been suggested to interfere with the physical activity of the user, due to the use of large cables trailing from the headset to transfer the visual data (Miles et al., 2013). Some can be heavy and cumbersome, potentially distracting the user, or hampering their learning by allowing them to become accustomed to performing the activity whilst wearing the device (Miles et al., 2013). The aforementioned units are older and have been superseded by more user-friendly VR headsets without cables. Still, a problem that remains is the inability for HMD users to see their own hands, requiring the use of an avatar, which in turn can lead to issues with latency (Miles et al., 2013). HDMs have also been criticised in cricket batting, with a number of limitations identified relating to collision detection, equipment ergonomics, loss of data signal from trackers, and field of view (Dhawan et al., 2016). Within such environments it is important to minimise constraints on the athlete and allow freedom of movements that they would normally experience during such tasks. VR systems have also been suggested to modify the behaviour of the immersed subject by altering their perception and/or actions (Kulpa et al., 2016). As such, VR for sports analysis and skill acquisition does come with limitations like any form of training, and some components do need to be observed/implemented in a real-world setting. The VR training, coaching, and immersion aspects must be chosen with caution and inclusive of the skill acquisition learning progress (conveying information, structuring practice, and administration of feedback) when implementing any VE to study physical activity and athletic enhancement.

CONCLUSION

Virtual reality technology within sporting codes has significantly improved over the past two decades, highlighted specifically in the last two years with the arrival of VR HDMs and the addition of Smart phone technology. Implementing such technology has demonstrated successful results in skill acquisition and coaching, as well as limitations in terms of efficient technology and constraints on the user. VR technology is becoming more popular in competitive sports with evident influence on collecting various physiological aspects, identifying and improving sensorimotor capabilities, immersing athletes in competition situations where reaction time is critical, and developing skill acquisition. As such, technology advancements and methodologies will change the way coaches focus on developing skills required for athlete success. VR technology is providing increasing benefits to coaches; however, progress is limited by a distinct lack of current studies detailing skill acquisition within sport training. Many of the existing studies were conducted with now outdated technology and therefore do not provide a comparison. An increase in VR technology research implemented in sport will change the way coaches develop their athletes and promote new ways to immerse athletes into a virtual world to hone specific, hard to obtain skills.

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COMPETING INTERESTS

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