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ORIGINAL ARTICLE

Virtual bodies (avatars) and sport exercises: some important thoughts

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ABSTRACT

In sport sociology several studies and theoretical research examine the body and emerging technologies, whereas discussions on exercise and virtual bodies (Avatars) are limited. In line with the accelerated developments in computer graphics and especially advanced computer interfaces, this study seeks to explain how the sport exercises of avatars could be a significant theme in sport sociological analysis. We are looking for explanations and an understanding of the novel forms of (sport) embodiment which could unavoidably arise in the case of avatar exercises through very complicated, and in many ways, paradoxical interactions and interpenetrations between the physical body and the virtual body. This theoretical study, based on interdisciplinary literature and research data, adds to the formulation of a more coherent theoretical model, which could be useful to future researchers.

KEYWORDS

Virtual body; physical body; virtual exercises; embodiment; virtual sport identity

Introduction and background

Although some studies and theoretical research on the body and emerging technologies have been conducted in sport sociology (Butryn, 2003; Butryn & Masucci, 2003; Crawford & Gosling, 2009; Kamberidou, 2019, 2020), underrepresented are those on virtual bodies (avatars) and exercise, along with discussions on the effects of these virtual exercises on the users behind the screens. Also lacking are studies on sporting embodiment in the case of virtual exercises, on the processes of constructing and reconstructing virtual (sport) selves and identities. This study seeks to describe and clarify, through the embodiment perspective, how the exercising avatars in the virtual fitness club, as non-physical part(s) of ourselves, are or are becoming an influential factor to our self: to our way of constructing and reconstructing (sport) identities, to our physical-biological existence, to our physical body. Inspired by evidence-based

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research conducted in 2013 for a seminar—organized for my graduate students—which included participant observation of the virtual fitness club of a three-dimensional virtual world called Second Life. In this virtual world, virtual bodies known as avatars performed sport exercises.

A theoretical reflection concerning virtual exercise in relation to its effects and influence on our physical, social, and cultural existence appears to be a very complicated issue. It is not possible to discuss it by focussing only on one theory, or one scientific field. An interdisciplinary road needs to be followed here. The contributions of other scientific fields are required today to approach, explain, and understand such sport sociological questions (Donnelly, 2015; Pringle & Falcous, 2018). For example, studies from the cognitive science field would be useful here. This interdisciplinary matrix includes neuroscience, cognitive psychology, artificial intelligence, and in many levels, philosophy. Indeed, there is some experimental research taking place in laboratories that investigates the motions of simulated bodies, controlled directly by the participant's thoughts (and motions), via BCI (brain–computer interface) control (Plante et al., 2003; Vogt et al., 2015). Although such studies do not focus on the exercising avatars in the virtual fitness clubs, they are useful for developing our theoretical perspective.

In the broader social sciences, as in the computer sciences, an increasingly growing number of theoretical studies and empirical research is appearing, focussing on virtual environments and virtual bodies (avatars), which is very important for the the objective of this study (Beasley & Standley, 2002; Hardey, 2002; Kamberidou, 2020; Klimmt et al., 2010; Villani et al., 2016; Yang et al., 2017).

Also important are theoretical and empirical studies spotlighting complicated mechanisms, through which virtual bodies act as intermediaries for experiencing novel forms of embodiment, and subsequently constructing and reconstructing new selves and identities (Biocca, 1997; Ott, 2003; Schau & Gilly, 2003; Taylor, 2002; Vicdan & Ulusoy, 2008). Such studies reveal the ways individuals define and/or make sense of their own interactions with avatars, viz. ways which are (multi-)complex and contingent. Users immersed in virtual environments identify themselves at one moment with their physical body and at another with their avatar. In the virtual world, in digital places, an individual seems to be able to leave behind his/her embodied self, and consequently, researchers and scholars use this perspective to discuss the relationship between the avatar and his/her human operator, composing in this manner an embodiment/disembodiment duality (Beetham, 2006; Meijsing, 2007). However, in contrast, this study will not follow the embodiment/disembodiment duality debate, instead we will use data and studies from the cognitive sciences (Kilteni et al., 2013; Longo et al., 2008), combined with foundational arguments, primarily those of Maurice Merleau-Ponty (1962, 1968), so as to understand the existence of sport avatars from an embodiment perspective and to explain the possible (contingent) novel forms of sporting embodiment in the case of the exercising avatars.

Starting from these premises, this study explores how the users—namely the designers/creators of the avatars—construct a virtual sport self and identity in virtual sport places (fitness clubs, etc.). It also examines, by means of their exercising avatars, the effects on the actual identities and physical habits of the users.

Virtual bodies (avatars) in the digital fitness club

Avatars in three dimensional (3D) virtual environments, in virtual worlds, can mimic the morphology, motion, and communication behaviours of human beings. Today, many computer-based, simulated multi-media environments, immersive virtual environments offer numerous opportunities to experience, via virtual body representations, sport-related simulated experiences like skiing, biking, and horse riding. This shows that the sporting body, in another dimension, is also present in the virtual world. The possibilities of creating, shaping, forming, using an avatar (animated bodies in general), including its motion ability and behaviour, depend primarily on the existing platform (Yang et al., 2017).

In the case of the fitness club of Second Life—the starting point and focus of this study, and our theoretical reflection—avatars are three-dimensional graphical things: 3D characters or figures with a three-dimensional form, like small puppets used in standard computer interfaces, in regular computer monitors, which represent, a person-user in this virtual sport place. In such virtual worlds the participants/users may choose a virtual body provided by the platform or they may design their own avatar, according to their preference and with the greatest degree of freedom by editing and customising their avatars' height, body thickness, body fat, legs etc., along with their virtual profiles.

Virtual fitness clubs are virtual sporting spaces, where the users (human operators behind the screen) can have, through simulation, a virtual experience of sport exercises, by directly controlling via a mouse or joystick, the motion of their own graphical representations, namely their own virtual bodies or avatars.

At a first glance, the avatars per se are perceived—in strictly physiological and biological terms—as equivalent to 'nothing', if we take into account that they are digital objects and symbolic representations incapable of self-generated movements, just passive bodies the motions of which are completely controlled by their 'creators', the users behind the screen. An avatar's existence is only in the context of particular processes which indicate that something exists under the condition of one other existence.

In contrast, research suggests that avatars involved in virtual actions and situations, make sense to the users or have meaning for users, affecting them in a variety of ways, by offering them the opportunity to represent multiple digital selves; create multiple virtual identities; play multiple roles. In most studies avatars are connected to issues or questions on subjectivity, self, identity, embodiment, presence, body-ownership and so forth (Ott, 2003; Serino et al., 2013; Tsakiris, 2010; Vicdan & Ulusoy, 2008).

Accordingly, the exercising avatar in the virtual fitness club is not equivalent to 'nothing', since it can be perceived as a tool, as a new factor that enables people to 'playfully' engage—according to circumstances—in constructing and reconstructing several novel virtual sporting selves and identities which may but need not correspond to any identity in physical life.

In a virtual fitness club, the user can watch other avatars exercising and vice versa, namely his/her avatar can also be observed by other users. Moreover, the avatars can interact between themselves through their users. Digital fitness clubs offer the contexts in which the operators behind the screen, by means of their avatars, can have

simulated experiences of social interaction related to sport exercises. In this framework, a specific social situation with a sport-social meaning is formed.

When someone enters such a virtual fitness club, he/she could for example observe avatars working out, performing aerobic activities and strength-training workouts, running on the treadmill, using the swimming pool, biking, etc. Such fitness clubs are virtual-digital simulated sporting spaces, and exact copies of a gym in the physical world. Here users have the opportunity, through their avatars, to experience sport exercises. These exercises are carried out mimetically, like the exercises of the physical body in the gym, with the same equipment and in the same way but at the same time are full of refractions or alterations from both physical and virtual worlds (Patsantaras & Kamberidou, 2017). People involved in such activities in using their imagination can customise a virtual sport profile freed from the material constrains of the physical (biological) body. This release from their concrete physical body, does not mean or indicate in any way the end of their physicality! By no means does it mean that the exercising virtual body refers to the annihilation or disappearance of the physical body. However, it succeeds in changing our perceptions and senses regarding the limits/boundaries between physicality and 'virtuality' between what is natural and what is artificial. In this framework, new possibilities are formulated concerning the construction of both a physical and virtual culture, to wit a 'border-sport'. Following Hemphill's arguments (2005, p. 199), virtual body exercises could be understood as a new alternative sport reality, as a new subset of the set (family) of sports.[1]

The exercising avatar appears as an intermediary tool that opens horizons for novel sport-selves and identities and can influence or set off a reaction on his/her user in a variety of ways.

How could the exercising avatars affect the physical and social habits of their designers/controllers?

Researchers pairing virtual environments and actual exercise argue that virtual reality enhances the desire for exercise (Plante et al., 2003) and encourages individuals to exercise more regularly (Vogt et al., 2015). Research suggests that participants who watched avatars exercising began exercising in physical life by imitating their avatar's behaviour. Studies also show that virtual exercises improved movement performance and had the potential to change behaviour regarding health (Batson et al., 2011; Fox & Bailenson, 2009).

Even the observation of virtual objects, and mainly avatars in virtual worlds, as emphasised in behavioural and neural research, through the mediation of the canonical neuron system (Kilteni et al., 2013; Martin, 2007) could cause changes in the physical body, in motor behaviour in the physical world as well as body distortions with regard to body image/schema, among others. Additionally, the avatar experience in virtual worlds can provoke changes in body ownership[2] and affect social cognition, causing changes in our social behaviour (Maister et al., 2015).

Studies also indicated that such virtual experiences—playing with virtual identities—influence a user's behaviour in the physical world, provoking or leading to changes in the user's self-perception (Lee & Nass, 2012). Furthermore, additional

factors that have a catalytic effect are associated with the avatar's similarity to the human body which enhances embodiment, the feeling of presence[3] in the virtual world while avatar customisation increases the extent to which people feel connected to their avatars. This plays a decisive role as regards the question of embodiment, self and identity (Aymerich-Franch & Ganesh, 2016).

Then again, studies also show that in virtual worlds, the social role of the avatar's body, virtual identity and so forth, are partially determined, but not decisively designated, by implicit and explicit social norms that may be imported from the user's social-cultural environment. Occasionally, the experiences lived or experienced through avatars in virtual worlds can be affected by the users 'first life' selves and identities and vice versa (Biocca, 1997; Villani et al., 2016).

Nevertheless, a variety of factors play a decisive role as regards how the exercising avatar affects his/her human user/designer/controller. For instance, the frequency of the avatar's exercises in the digital fitness club and the degree of the user's identification with his/her avatar (Tsakiris, 2010; Tsakiris et al., 2006). Another variable is the level of simulation that creates fluid and volatile boundaries, not only between human organisms (biological body) and technological constructions, but also between perception and simulation of perception. Additional contingencies are the characteristics of the virtual environment: screen size, duration of exposure, user's age, realism of the presentation, credibility and speed of the avatar's motion and bodily-kinetic abilities etc. (See among others Ratan & Dawson, 2016; Yang et al., 2017). This includes the possibilities given to the users to modify or make alterations associated with the physical and symbolic attributes of their avatars, such as their appearance, social skills, and moral standards (Jin, 2012).

All these data indicate that the exercising avatars (digital objects and symbolic representations), influence the users' bodies and behaviours, along with their physical life. The impact of all these contingencies will be discussed in the perceptive of embodiment.

Applying embodiment for bridging interdisciplinary research

Discussions on embodiment are usually formulated in line with the views of Merleau-Ponty who 'distinguishes between the objective body, which is the body regarded as a physiological entity, and "the phenomenal body", meaning it is not just *some* body, some particular physiological entity, but *my* (or your) body as I (or you) experience it' (The Cambridge Dictionary of Philosophy, 1999, 258). Embodiment appears clearly as a kind of subjective experience.

However perceptions concerning this topic in sociology, sport sociology, philosophy, and in the social and cognitive sciences in general, as well as other disciplines vary and diversify (Allen-Collinson, 2009; Ambrosini et al., 2012; Biocca, 1997; Csordas, 1999; Hardey, 2002; Kamberidou, 2019; Longo et al., 2008; Meijsing, 2007; Shilling, 2005; Varela et al., 1991; Vicdan & Ulusoy, 2008).

Embodiment (in the social sciences) does not refer to the physical body per se, but to the experiences and subjectivity, in accordance to existing social and cultural conditions, insofar as these can be understood from the standpoint of 'bodily being-in-the-

world' (Csordas, 1999, p. 143). Hence the body is understood in the perspective of embodiment as a process, rather than as a fixed thing (entity).[4]

In the cognitive sciences, this concept (embodiment) encompasses both the body as a physical-biological-corporeal existence, as a lived, 'experiential structure and the body as the context or milieu of cognitive mechanisms' (Varela et al.,1991, p. xvi). In these scientific fields and the philosophy of mind, embodiment underlines the relevance of the role the body in shaping the mind, in addition to the subjective experience of being a body or using and 'having' a body (Blanke & Metzinger, 2009). These views reflect basic thoughts by Merleau-Ponty (1968, p. 137) according to which the subjective and living body can be perceived as subject and object at the same time, as something we have and as what we are. Mind and body are intertwined in perceiving and experiencing the world (Merleau-Ponty, 1962, p. 160).[5]

Embodiment, primarily in phenomenological tradition is used as a starting point for theories of self–concept and subjectivity, among others. The self and identities are understood initially as embodied cognitive phenomena that play a fundamental role on the whole living body, while interacting in particular social worlds: natural-physical or virtual (Varela et al.,1991, pp. 146–184).

Thus, in the perspective of embodiment, we cannot understand subjectivity,[6] the self and the virtual self one-dimensionally: as a mental construction, as something totally abstract and independent of the physical body or vice versa as something isolated from virtual contexts and social and cultural situations. Conversely, beyond embodied subjectivity, embodiment means that the body is also sensoriality and without the flesh/corporeal body, we are not able to live in the (virtual) world, experience the (virtual) world, think about that world and perceive that world. In this context the subjective experience of the body is not inexplicable. It is not a self-sufficient thing/entity that exists beyond the physical-biological body.

Meijsing (2007, pp. 2–3) goes even further, pointing out that our 'self-consciousness *is* indeed essentially a corporeal, spatial thing, as much as it is a conscious thing'. Consequently, embodiment also encompasses the sense of one's body, which is intimately related to the sense of self, including 'bodily self-consciousness' and 'corporeal awareness' (Longo et al., 2008).

Researchers argue that the main component of bodily self-consciousness is the experience of owning a body (body ownership); the experience of being a body with a given location within the environment (self-location); and a subjective body-centered experience of the body on that environment (Serino et al., 2013). Therefore, in the perspective of the subjective dimension, the body is understood as a constitutive and inseparable part of the conscious subject complex. Part of this conscious subject complex in the perspective of subjectivity—and in the case of virtual exercises— becomes the virtual body, the latter as a virtual self-representation referring to the 'psychological state in which the virtuality of experience is unnoticed' (Lee, 2004, p. 23).

Understanding the existence of sport avatars from an embodiment perspective

In this section we will see how novel forms of sporting embodiment can appear in the case of virtual exercises. For this reason, we need to first examine how the

biological body (physical body)—which may occasionally have a passive or an active role behind the computer screen—is related to the exercising avatar.

In sport sociology, the idea of embodiment, in this case sporting embodiment, centres on the biological body which provides the link by which we simultaneously perceive the world and connect/anchor ourselves within it, in an ongoing dynamic of interrelations (Allen-Collinson, 2009; Tulle, 2007; Van Amsterdam et al., 2017). Summing up all views, we can ascertain that sporting embodiment refers to the multiplicity of the experiences, which are related to the lived sporting body. It relates to situated experiences of the lived sporting body in the frame of which, the biological body—understood as organs and physiological processes (Birke, 1999)—cannot be conceived simply as a generating factor of this experience that remains static, but also as a dynamic factor that co-formulates this experience and is encompassed in it.

It means that the experience of sporting embodiment in the case of the virtual exercises of the avatars, requires a real physical/biological body as the 'gateway' (Kim, 2001) to the virtual worlds. We experience these worlds with and through our physical bodies.

A significant question arising here is whether the body incorporates digital technology in the same way as it does, in the physical world.

Studies beyond sport show that the connections between the avatar and the physical body could take place in the same way that people experience various types of physical connections with artificial objects (Ratan & Dawson, 2016), such as the 'rubber hand illusion' (Botvinick & Cohen, 1998) or fake limbs in a virtual environment (Kilteni et al., 2013). Neuroscientific (and phenomenological) evidence indicates that perception and embodiment in a virtual environment are similar to those in a real environment (Slater et al., 2009; Van Amsterdam et al., 2017). By using Hesslow's (2002) arguments we can confirm that users controlling the motions of their sport avatars behind the screen perceive the structure of the virtual fitness place in ways or manners similar to those that construct the physical world, since perceiving through imagination is essentially the same as actually perceiving the virtual fitness place, as perceptual activity is generated by the brain itself rather than by external stimuli.

In following Biocca's (1997) views to discuss sporting embodiment in the perspective of computer technology, we are describing the interaction between the physical-biological body 'via close coupling to the interface' body and the Avatar, the representation of this 'coupled body' that exercises. This is an experience that arises through the coupling of the physical body and the virtual body, by taking into consideration the situation under which these take place.

The generation of an action—in this case virtual exercise—and the building of a conscious experience of that action (agency) is achieved with and through the natural body. In the phenomenological perspective, our experiences through the avatars that exercise, are initially perceived through the senses (i.e., sight) and as experiences are always embodied, the human operator transforms it into conscious thought. 'The senses mediate the relationship between self and society, mind and body, idea and object. The senses are everywhere' (Bull et al., 2006, p. 5). Accordingly, social and cultural concepts are processed in close interaction with sensory systems (Schubert & Koole, 2009). To paraphrase Merleau-Ponty (1962, p. 206), the virtual exercises of the

avatar are sensed from the standpoint of the body, the lived body and sensory processes and perception are fundamentally inseparable from that (body). We conceive our bodies as physical structures and as lived, experiential structures, in short, as both 'outer' and 'inner', biological and phenomenological and we continuously circulate back and forth between them, and through this circulation we form and live our experience (Varela et al.,1991, p. xv). Moreover, this back and forth circulation creates the feeling in some people that they can feel their avatars, feel that they are natural extensions of themselves, an extension of their physical bodies and that the virtual bodies 'count as being situated and embodied' (Dobbyn & Stuart, 2003).

The sport exercises of the virtual body can appear as a factor that influences, regulates, reforms and modifies 'internal' states as well as biological ones.[7] So the avatar can be considered a co-modulation factor of internal relations. It is not the virtual body, the avatar per se that is important. Avatars, in this perspective cannot be simplified into things or puppets which do exercises for 'their own sake'. Virtual exercises penetrate the physical body through its receptors, affecting the 'whole body's' perception. Regarding this point, while citing Allen-Collinson (2009, p. 285), I would like to pose the following question. Could the user through simulation have 'a cognitive understanding' of virtual bodily exercises, 'but also an embedded corporeal, 'fleshy' knowledge and memory', as that of the exercises in the physical world?

Following research in Neuroscience (Aymerich-Franch & Ganesh, 2016; Slater et al., 2009), we can argue that people experience presence and self-presence in a virtual fitness club, and their behaviour within this virtual environment in relation to virtual objects and virtual people is very similar to that in the physical world. Consequently, they can respond to sport-events and situations within virtual reality as if these were real. Additionally, research findings (Ratan & Dawson, 2016) provide us with the prospect of integrating the sport avatar into the neurological gestalt of the self, into body schema. Repeated virtual exercising can become established in memory as situated concepts which may influence the internal milieu of subjectivity (Seibt et al., 2008).

Also, the user's control of the avatar's movements allows for a tighter coupling between the two (the avatar and the user): the user may have a subjective sensation or 'illusion' that he/she is physically and mentally inside the virtual fitness club. According to Wirth et al. (2007), we can argue that the user controlling the motion and observing-watching his/her avatar exercising, could more easily experience spatial presence, in other words feel he/she is in the virtual environment, in the virtual fitness club. The user's mental (cognitive) capacities are absorbed by the mediated environment instead of reality (Garbarini & Adenzato, 2004). They may be unaware of where their physical body ends and where that of the avatar begins (Villani et al., 2016; Wirth et al., 2007, p. 496). Therefore, experience presence and self-presence in a virtual sport space-environment can also experience virtual sport situations as if they were real through alterations to bodily self-consciousness and 'corporeal awareness'.

When the virtual body exercises in the virtual fitness club, the user perceives himself/herself as situated in this virtual space, which offers opportunities for simulated sport-related experiences that allow changes to the subjective dimension of the body. So the user has the opportunity through his/her exercising avatar to experience a

physical transcendence' from his/her physical space, experiencing an 'essential copy' of sport exercises

In such situations the biological body is represented but not present. It is there and at the same time is not there. Using a philosophical perspective, we can argue that the physical body is present, although invisible in the case of the avatar's virtual exercises. In line with Badiou's (2006, p. 99) thought, at the moment that the physical body finds itself (re)presented in the fitness club, this means it belongs to the situation of virtual exercises and is equally included in that situation.[8] The body, through which presence in the fitness club is being constructed, is both the physical-corporeal and the virtual, the latter 'used to root the self' in the virtual space (Taylor, 2002, p. 42). In Merleau-Ponty's words (1968, p. 151), the physical body 'is therefore not a de facto invisible, like an object hidden behind another, and not an absolute invisible, that would have nothing to do with the visible. Rather it is the invisible of this world, that which inhabits this world, sustains it, and renders it visible'.

All these arguments indicate that accelerated technological developments provoke novel forms of sporting embodiment and provide users with opportunities to construct-create unpredictable virtual sport selves and identities!

How a virtual sport identity can be shaped in a virtual sport place/virtual fitness club

The virtual body that exercises and also has interactions with other virtual bodies in virtual sport places (digital fitness clubs), could be considered a 'causative factor' and can also emerge as a constitutive element for shaping a (virtual) sport identity.

The exercising avatar as a virtual self-representation is characterised by duality (stability and variability), displaying both chronic identities and temporarily activated states in technology-mediated virtual identity construction (Jin, 2012).

The formation of a virtual sport identity could be understood and explained if we incorporate in our sociological thinking the concept of the 'phenomenal body' which refers to the mental or internal representation of one's own body, as a representation of the whole/entire body (Taylor, 2002, p. 57).

The 'phenomenal body' does not necessarily correspond to the physical body. It is not a static internal copy of the physical body, nor 'some mysterious thing or individual substance', but an ongoing process of tracking and controlling the entire body's properties (Blanke & Metzinger, 2009, p. 8). In the case of the virtual exercises at a virtual fitness club, the user's physical body controls the virtual body; and the digital body performs exercises in the digital environment. Undeniably the physical/biological body—part of which is the brain—is the cause for the creation of the phenomenal body, but does not constitute a priori or exclusively the unique constitutive condition for having a conscious experience (a subjective sensation) of a sport bodily self and accordingly, for building—among others—a sport identity in the case of digital exercising. The interactions and interpenetrations of the physical and virtual body form or condition the phenomenal perception of the body. The dialectic of the physical/virtual leads to the perception of the phenomenal body, which itself is a multiplicity that passes through the filter of presentation/representation within the situation-set of the

virtual fitness club. Accordingly, our subjective experience of the corporeal (physical) body and the virtual body are both elements for experiencing whole body embodiment and a resource for self- and identity construction.

These two bodies are in different spaces and in different locations! The exercising avatar does not exist in an intemporal and aspatial ideality. We have a second body which is our own[9] in an extracorporeal space (Blanke & Metzinger, 2009, p. 9), namely a second digital body in a different position in space, where a (novel) bodily self can be created. This cause changes or confusion regarding our perceptions of the embodied self because the sense of our embodied self is transformed. Our subjective body-centered experience of the body, our bodily self-consciousness is changed. The mental/internal perception of the whole/entire body ('phenomenal body') can be changed (Biocca, 1997). This sensation—in line with Haraway's (1985) views—arises through an elimination of the basic opposition between what is natural-physical and what is artificial.

This occurs because the self and identity begin with a physical sense of the boundaries of one's body and where it is in space. Respectively, when our avatar exercises or does his/her exercises in a fitness club we not only experience that virtual body as our own, but also experience ourselves (our bodily selves) as occupying this virtual location which is a virtual sport location.

However this new bodily self is a basic component of the phenomenal body, which is understood as my (or your) body as I (or you) experience it. The influence of virtual exercising on the physical body penetrate the phenomenal body, which is co-created by the virtual sporting experiences. Through the phenomenal body—understood as a coherent whole-body representation could emerge a sense of 'sporting selfhood', which is associated with bodily self- consciousness.

Experimental studies that investigate bodily self-consciousness in the perspective of sensory, emotional or cognitive layers argue that one could experience a virtual body as if it were his/her own and localise one's self or selves outside the body borders at a different position in space (Lenggenhager et al., 2007, p. 1096). With regard to the avatars examined in this paper, when a virtual body exercises in the virtual fitness club, a new version of (sport) bodily selfhood is created, a new virtual identity is being displayed which is associated with the virtual body's position (virtual fitness club) and the (virtual-social) situation in which it is involved. Incarnation of the virtual sport self is closely linked to the concept of virtual sport identity and both are highly sensitive to virtual 'social and situational structuring' (Oyserman, 2001).

This virtual sport identity which is formed in the 'social situation' of the virtual fitness club, could exist in our embodied consciousness as well as after the virtual experience because our self/selves is/are always present in our consciousness, and as a result a representation of our self/selves is/are present in our consciousness.[10]

Studies in the cognitive sciences (using the simulation approach) suggest that play in the virtual environment leaves cognitive traces that exist after play (Ambrosini et al., 2012; Garbarini & Adenzato, 2004; Hesslow, 2002; Klimmt et al., 2010). This applies to the case of virtual exercise which—as previously cited—is an embodied action, meaning that this action is integrated into the neurological gestalt of the self, into the self-concept which is understood among others as a 'cognitive concept and

memory structure' (Oyserman, 2001, p. 501). The action then becomes part of the self-concept and is embedded in the memory structure of the user.

Accordingly, virtual exercises can leave cognitive traces on the users, affecting their physical and social habits.

One need point out here that the existence and intervention of the virtual body makes the process of tracking and controlling the whole/entire body's properties unpredictable and complicated. For example, bodily awareness disorders can be induced since the users of an exercising avatar could at one moment identify their selves with their physical body and at another with their avatar's (Serino et al., 2013). Respectively if, for example, a user's virtual athletic identity represented in the form of an avatar in the virtual environment, deviates from the user's actual athletic identity in the physical world, then discrepancies and paradoxes could occur, as studies beyond sport show (Flichy, 2007; Villani et al., 2016). Consequently, in such cases, emerges the issue of balancing discrepancies between the different selves, identities and bodies, both online and offline,[11] which unavoidably could have consequences on the physical body, the last recipient, because our mode of being is based on the union of the 'psychic' and the 'physiological' elements (Allen-Collinson, 2009).

Undeniably the physical body is the cause for the creation of the phenomenal body but does not constitute a priori or exclusively the unique constitutive condition for building a sport bodily self, a sport identity in the case of digital exercising. In other words, by doing (occasionally also) without requiring real physical exercise, a sporting selfhood, a sport identity can be formed.

As it appears, in the case of virtual sport situations, contemporary technology has the potential to transform our sense of embodied self, sporting embodiment, sport self and sport identities. In such places, such as the virtual fitness club, the virtual body (as per case and user) can have an equal value and importance to the physical-biological body with regard to the formation of sporting identities.

This is obviously a broad and general theoretical perspective which needs to be considered in future research which will need to take into account a plethora of factors to obtain reliable results.

The purpose of this study, however, was to show that the virtual exercising body emerges as a new and dynamic factor, transforming/changing the ways the sport self and identities are constructed. In virtual sport places individuals have the opportunity to rethink the relation to their corporeal bodies and to create a version of themselves that was previously unrealised.[12] As Taylor (2002, p. 58) argues: 'If I can embody, I can be made deeply real.'

Concluding remarks

This study, in providing a theoretical perspective and an analysis of basic concepts and key terms like virtual body, exercising avatar, embodiment, sporting embodiment and virtual sport identity offers a stepping-stone for future researchers and studies in the field of sport sociology. It proposes a model of thinking for sport sociological analysis in areas where research is limited. As shown in the case of the avatar exercises—

between the physical body and the virtual body—an unstable, complex, ambivalent and paradoxical relationship is formed, making interdisciplinary research a necessity.

The avatar, as a role playing tool-medium in a virtual fitness club or in other virtual sport places in general—a virtual space with a different social frame/conditions and social behaviour patterns—can have both intended and unintended consequences or influence on the user behind the screen. In approaching virtual exercise as an alternative kind or version of sport, the objective of this study was to show that we need to take into account novel forms of sporting embodiment and sport identities, which may have both positive and negative consequences in the user's life.

Consequently, sport sociological issues arise concerning the effects of such virtual activities on physical presence (physical body), virtual presence (virtual body) and selfhood (phenomenal body). Sport sociological research could also consider and examine how participation in virtual bodily exercises is shaped along the lines of gender, class, age, and disability (Kamberidou et al., 2019), in addition to what extent this virtual participation supports, undermines or fits into existing social patterns.

In examining the avatar's role in creating alternative athletic bodies and sport identities, this study highlights that we need to approach the boundaries and interactions between human nature and technology in complex and often contradictory ways. Future research focussing on virtual sporting bodies or avatars exercising cannot be one-dimensionally based. Studies cannot be focussed on superficial interviews (subjective assessments) that ignore theoretical models which allow for a more objective analysis.

In using an array of theoretical approaches and empirical studies from different disciplines, this study contributes to the contemporary debates surrounding the issue of sport exercises and the virtual body which provides fertile ground for multiple analyses and emerges as a significant topic in the field of sport sociology.[13]

This study confirms that the accelerating advancements of computer technologies, computer graphics and computer interfaces are altering, not only our relationship to the world and our perceptions of it, but notions of our self and our physical existence as well. All this, which is occurring at an inconceivable pace, leads us to continuously redefine the boundaries between the biological-natural and the 'artificial/technological'.

But then, no matter how one's experiences of his/her body are being transformed through technological developments and cultural influences, eliminating basic opposition between what is physicality and what is virtuality—as shown in this study on exercising avatars in the virtual world—'yet at the same time my body is as it were a 'natural' subject' (Merleau-Ponty, 1962, p. 231).

Notes

1. Research indicates that this continues to be an open question: i.e. Crawford & Gosling, 2009; Thiel & John, 2018).
2. The sensation, the feeling that 'this is my body', the feeling that 'my body' belongs to me, the body I inhabit is 'my own', and ever-present in my mental life, is called body-ownership (Tsakiris, 2010).

3. Presence has many versions and dimensions, such as self-presence, social presence, spatial presence etc. Presence appears as a very contested term in a broad range of academic disciplines: computer sciences, neuroscience, social sciences, philosophy, etc. (Badiou, 2006; Lee, 2004; Taylor, 2002). Initially, in this study, the sense of presence is understood as a feeling of immersion when exposed to a virtual environment (Vogt et al., 2015), the feeling, the sense of 'being there', inside the virtual world. This sensation of being there is psychological state in which virtual objects are experienced in sensory and non-sensory ways as actual (Lee, 2004). However, only a few studies have investigated the neural responses that underlie the sense of presence perception (Vogt et al., 2015).
4. This methodological distinction between the body and embodiment has led in many cases to the disregarding of the biological body from explanations of social life in postmodern sociological thought: i.e. social constructionist explanations of the body (Papoulias & Callard, 2010; Shilling, 2003, 2005) and to a great extent, in sport sociological thought as well, and of course not without reason (see Pringle & Falcous, 2018; Probyn, 2000; Thorpe, 2014).
5. In line with these arguments, our thinking develops beyond the mind-body dilemma. Interdisciplinary research show that the Cartesian body-mind separation is insufficient for understanding the origin of perception, thought and behavior (Papoulias & Callard, 2010). We cannot think of the body and mind, reason, and emotion as separate systems (Butryn & Masucci, 2003; Freund, 1990; Varela et al., 1991).
6. This concept is understood in a variety of ways in different scientific fields, but also within the same scientific field because it is strongly related to contemporary thinking on self and identities (Dobbyn & Stuart, 2003; Schubert & Koole, 2009; Shilling, 2005).
7. The appearance of an inner world in the case of simulation which is based on the bodily motions (exercises) of the avatar, controlled by the user, can also penetrate the body and mind of the user. It can also model/formulate the user's internal experiences which occur whether or not the moving object, the exercising avatar, has intelligence or intentionality (Biocca, 1997). The avatar is a thing which is perceived from our conscious, not as a being but as a phenomenon (Merleau-Ponty, 1962, p. 345). As a phenomenon itself, it is then a product of the structure of our own cognitive system (Varela et al., 1991, p. 11).
8. In the philosophical thinking of Badiou (2006) and in the perspective of the power set axiom, a set is a structured presentation, that can be understood as a multiple, or multiplicity. Accordingly, presence—i.e. the sensation of being inside a Virtual Fitness Club (VFC) by means of an avatar as medium for representation—can be conceived as a multiplicity, as a set that embodies the physical and the virtual body. Badiou (2006, p. 25) equates presentation with situation: 'a term of a situation is what that situation presents and counts as one.' In this context, situation is any type of presented multiplicity, e.g. a virtual FC. The situation is the place and the taking place of bodily exercises in a virtual environment. We suppose the physical body is a given set *(α)*, an existing multiple and the virtual body *(β)* is a subset (or part) of α, meaning it is included (or represented) in α. Mathematically this is written $\beta \subset \alpha$. Every multiple is thought without unity or totality, with two distinguished types of relations between them: Belonging (ϵ), i.e. multiple as element of another multiple, and inclusion (⊂), i.e. multiple as part (or subset) of another multiple. In fact, the power set axiom posits that all multiples included in a set belong to another set. If a set α exists then there also exists the set of all subsets of α, written *P(α)*: $[\beta \in P(\alpha)] \leftrightarrow (\beta \subset \alpha)$. Following this line of thinking, we can consider the Virtual Fitness Club (VFC) as a multiplicity, or situation-set in which the virtual body performs exercises. The virtual body (*β*) belongs to the situation-set *VFC* (presentation) and is equally included in the situation (representation). Mathematically, this is written $\beta \in VFC$ and $\beta \subset VFC$ (because $\beta \in P(VFC)$). Consequently, *β* is a term-part in the situation *VFC*. However, the physical body is included (represented) in the situation-set but not presented: $\alpha \subset VFC$ and $\alpha \notin VFC$ (but $\alpha \in P(VFC)$). It follows that α is a part in the situation *VFC*. From the viewpoint within the situation-set *VFC*, the physical body *(α)* is represented without being present. However, it is

presented (belongs to) the state of the situation-set, *P(VFC)*, that conditions or regulates the interactions and interpenetrations between the physical body *(α)* and the virtual body *(β)*. In other words, the physical body can be considered a part of the VFC.

9. A detailed analysis of studies focusing on the concept body- ownership reveals an 'other body', a reproduction or representation of a human body, and in this case the exercising virtual body could trigger an experience of ownership (Tsakiris, 2010). Even avatars with non-anthropomorphic shapes can be embodied by human beings-subjects (Aymerich-Franch & Ganesh, 2016).
10. In the phenomenological framework, consciousness is not understood as an abstract disembodied entity: the senses and feelings are not only expressed through mental activities, but through the mind and the body acting as a unity (Freund, 1990).
11. Goffman's (1959) classic theory of self-presentation, complex intraself negotiations, identity and social performance could be useful in such sport sociological issues. Especially when it comes to discrepancies between virtual ideal self which a given person aspires to have but may not be able to maintain in physical life and the self-manifested in daily behaviors and interactions in physical life.
12. In this perspective even disability in the virtual sport places is invisible and irrelevant (Kamberidou et al., 2019; Patsantaras & Kamberidou, 2017).
13. Additionally, in view of the current global Covid-19 pandemic—necessitating social distancing and lockdowns—sport sociologists need investigate further and discuss the social effects of exercising at home, among other things. As people no longer visit their fitness clubs or gyms, virtual reality technologies—such as Exergaming (Exercise + gaming) platforms: Nintendo Wii, Microsoft Xbox Kinect etc.—could provide alternative solutions. Exergaming combines video games and virtual reality technologies, requiring the user to apply full body motion to participate in virtual sports, in group fitness exercises or other interactive physical activities (social interaction). This gives him/her (the user) the opportunity to establish or retain a healthy lifestyle, a sporting identity and sporting selfhood during this health crisis. Clearly, research is required to confirm this hypothesis, including studies on the social effects of exergames which are also limited (see among others: Li et al., 2018).

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References

Allen-Collinson, J. (2009). Sporting embodiment: Sports studies and the (continuing) promise of phenomenology. *Qualitative Research in Sport and Exercise*, *1*(3), 279–296. https://doi.org/10.1080/19398440903192340

Ambrosini, E., Scorolli, C., Borghi, A. M., & Costantini, M. (2012). Which body for embodied cognition? Affordance and language within actual and perceived reaching space. *Consciousness and Cognition*, *21*(3), 1551–1557. https://doi.org/10.1016/j.concog.2012.06.010

Audi, R. (Ed.). (1999). *The Cambridge* dictionary of philosophy (2nd ed.). University Press.

Aymerich-Franch, L., & Ganesh, G. (2016). The role of functionality in the body model for self-attribution. *Neuroscience Research*, *104*, 31–37. https://doi.org/10.1016/j.neures.2015.11.001

Badiou, A. (2006). *Being and event* (O. Feltham, Transl.). Continuum.

Batson, C. D., Brady, R. A., Peters, B. T., Ploutz-Snyder, R. J., Mulavara, A. P., Cohen, H. S., & Bloomberg, J. J. (2011). Gait training improves performance in healthy adults exposed to novel sensory discordant conditions. *Experimental Brain Research*, *209*(4), 515–524. https://doi.org/10.1007/s00221-011-2574-6

Beasley, B., & Standley, T. C. (2002). Shirts vs skins: Clothing as an indicator of gender role stereotyping in video games. *Mass Communication and Society*, *5*(3), 279–293. https://doi.org/10.1207/S15327825MCS0503_3

Beetham, M. (2006). Periodicals and the new media: Women and imagined communities. *Women's Studies International Forum*, *29*(3), 231–240. https://doi.org/10.1016/j.wsif.2006.04.002

Biocca, F. (1997). The cyborg's dilemma: Progressive embodiment in virtual environments. *Journal of Computer-Mediated Communication*, *3*(2), 12–26.

Birke, L. (1999). *Feminism and the biological body*. Edinburgh University Press.

Blanke, O., & Metzinger, T. (2009). Full-body illusions and minimal phenomenal selfhood. *Trends in Cognitive Sciences*, *13*(1), 7–13. https://doi.org/10.1016/j.tics.2008.10.003

Botvinick, M., & Cohen, J. (1998). Rubber hands 'feel' touch that eyes see. *Nature*, *391*(6669), 756. https://doi.org/10.1038/35784

Bull, M., Gilroy, P., Howes, D., & Kahn, D. (2006). Introducing sensory studies. *The Senses and Society*, *1*(1), 5–8. https://doi.org/10.2752/174589206778055655

Butryn, T. M. (2003). Posthuman podiums: Cyborg narratives of elite track and field athletes. *Sociology of Sport Journal*, *20*(1), 17–39. https://doi.org/10.1123/ssj.20.1.17

Butryn, T. M., & Masucci, M. A. (2003). It's not about the bike: A cyborg counternarrative of Lance Armstrong. *Journal of Sport and Social Issues*, *27*, 124–144.

Crawford, G., & Gosling, V. K. (2009). More than a game: Sports-themed video games and player narratives. *Sociology of Sport Journal*, *26*(1), 50–66. https://doi.org/10.1123/ssj.26.1.50

Csordas, T. J. (1999). Embodiment and cultural phenomenology. In G. Weiss & H. Haber (Eds.), *Perspectives on embodiment* (pp. 143–163). Routledge.

Dobbyn, C., & Stuart, S. (2003). The self as an embedded agent. *Minds and Machines*, *13*(2), 187–201. https://doi.org/10.1023/A:1022997315561

Donnelly, P. (2015). Assessing the sociology of sport: On public sociology of sport and research that makes a difference. *International Review for the Sociology of Sport*, *50*(4–5), 419–423. https://doi.org/10.1177/1012690214550510

Flichy, P. (2007). *The internet imaginaire*. MIT Press.

Fox, J., & Bailenson, N. J. (2009). Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychology*, *12*(1), 1–25. https://doi.org/10.1080/15213260802669474

Freund, P. E. S. (1990). The expressive body: A common ground for the sociology of emotions and health and illness. *Sociology of Health and Illness*, *12*(4), 452–477. https://doi.org/10.1111/1467-9566.ep11340419

Garbarini, F., & Adenzato, M. (2004). At the root of embodied cognition: Cognitive science meets neurophysiology. *Brain and Cognition*, *56*(1), 100–106. https://doi.org/10.1016/j.bandc.2004.06.003

Goffman, E. (1959). *The presentation of self in everyday life*. The Overlook Press.

Haraway, D. J. (1985). A manifesto for cyborgs: Science, technology, and socialist feminism in the 1980s. *Socialist Review*, *80*, 65–107.

Hardey, M. (2002). Life beyond the Screen: Embodiment and Identity through the Internet. *The Sociological Review*, *50*(4), 570–585. https://doi.org/10.1177/003802610205000406

Hemphill, D. (2005). Cybersport. *Journal of the Philosophy of Sport*, *32*(2), 195–207. https://doi.org/10.1080/00948705.2005.9714682

Hesslow, G. (2002). Conscious thought as simulation of behaviour and perception. *Trends in Cognitive Sciences*, 6(6), 242–247. https://doi.org/10.1016/s1364-6613(02)01913-7

Jin, S. (2012). The virtual malleable self and the virtual identity discrepancy model: Investigative frameworks for virtual possible selves and others in avatar-based identity constructions and social interaction. *Computers in Human Behavior*, *28*(6), 2160–2168. https://doi.org/10.1016/j.chb.2012.06.022

Kamberidou, I. (2019). Gender integration in the military: Gender-neutral standards and coed sports. *European Journal of Physical Education and Sport Science*, *5*(11), 23–45. https://doi.org/10.5281/zenodo.3364728

Kamberidou, I. (2020). "Distinguished" women entrepreneurs in the digital economy and the multitasking whirlpool. *Journal of Innovation and Entrepreneurship*, *9*(1), 1–26. https://doi.org/10.1186/s13731-020-0114-y

Kamberidou, I., Bonias, A., & Patsantaras, N. (2019). Sport as a means of inclusion and integration for "those of us with disabilities". *European Journal of Physical Education and Sport Science*, *5*(12), 99–128. https://doi.org/10.5281/zenodo.3464696

Kilteni, K., Bergstrom, I., & Slater, M. (2013). Drumming in immersive virtual reality: The Body Shapes The Way We Play. *IEEE Transactions on Visualization and Computer Graphics*, *19*(4), 597–605. https://doi.org/10.1109/TVCG.2013.29

Kim, H. W. (2001). Phenomenology of the body and its implications for humanistic ethics and politics. *Human Studies*, *24*(1–2), 69–85. https://doi.org/10.1023/A:1010706827877

Klimmt, C., Hefner, D., Vorderer, P., Roth, C., & Blake, C. (2010). Identification with video game characters as automatic shift of self-perceptions. *Media Psychology*, *13*(4), 323–338. https://doi.org/10.1080/15213269.2010.524911

Lee, K. M. (2004). Presence, explicated. *Communication Theory*, *14*(1), 27–50. https://doi.org/10.1111/j.1468-2885.2004.tb00302.x

Lee, J.-E. R., & Nass, C. (2012). Distinctiveness-based stereotype threat and the moderating role of coaction contexts. *Journal of Experimental Social Psychology*, *48*(1), 192–199. https://doi.org/10.1016/j.jesp.2011.06.018

Lenggenhager, B., Tadi, T., Metzinger, T., & Blanke, O. (2007). Video ergo sum: Manipulating bodily self-consciousness. *Science (New York, N.Y.)*, *317*(5841), 1096–1099. https://doi.org/10.1126/science.1143439

Li, J., Erdt, M., Chen, L., Cao, Y., Lee, S. Q., & Theng, Y. L. (2018). The social effects of exergames on older adults: Systematic review and metric analysis. *Journal of Medical Internet Research*, *20*(6), e10486. https://doi.org/10.2196/10486

Longo, M. R., Schüür, F., Kammers, M. P. M., Tsakiris, M., & Haggard, P. (2008). What is embodiment? A psychometric approach. *Cognition*, *107*(3), 978–998. https://doi.org/10.1016/j.cognition.2007.12.004

Maister, L., Slater, M., Sanchez-Vives, M. V., & Tsakiris, M. (2015). Changing bodies changes minds: Owning another body affects social cognition. *Trends in Cognitive Sciences*, *19*(1), 6–12. https://doi.org/10.1016/j.tics.2014.11.001

Martin, A. (2007). The representation of object concepts in the brain. *Annual Review of Psychology*, *58*, 25–45. https://doi.org/10.1146/annurev.psych.57.102904.190143

Meijsing, M. (2007). Real people and virtual bodies: How disembodied can embodiment be? *Minds and Machines*, *16*(4), 443–461. https://doi.org/10.1007/s11023-006-9044-0

Merleau-Ponty, M. (1962). *Phenomenology of perception*. Routledge.

Merleau-Ponty, M. (1968). *The visible and the invisible*. Northwestern University Press.

Ott, B. (2003). "I'm Bart Simpson, who the hell are you?" A study in postmodern identity (re)construction. *The Journal of Popular Culture*, *37*(1), 56–82. https://doi.org/10.1111/1540-5931.00054

Oyserman, D. (2001). Self-concept and identity. In A. Tesser & N. Schwarz (Eds.), *The blackwell handbook of social psychology* (pp. 499–517). Blackwell.

Papoulias, C., & Callard, F. (2010). Biology's gift: Interrogating the turn to affect. *Body & Society*, *16*(1), 29–56. https://doi.org/10.1177/1357034X09355231

Patsantaras, N., & Kamberidou, I. (2017, September 01–05). *Virtual bodies and sport activities: The case of the Avatars in second life fitness club* [Presentation]. 13th Conference of the European Sociological Association "(Un)Making Europe: Capitalism, Solidarities, Subjectivities". Panteion University of Social & Political Sciences, Athens, Greece. http://scholar.uoa.gr/sites/default/files/ikamper/files/virtual_bodies-avatars_and_sport_activities_0.pdf

Plante, T. G., Aldridge, A., Bogden, R., & Hanelin, C. (2003). Might virtual reality promote the mood benefits of exercise? *Computers in Human Behavior*, *19*(4), 495–509. https://doi.org/10.1016/S0747-5632(02)00074-2

Pringle, R., & Falcous, M. (2018). Transformative research and epistemological hierarchies: Ruminating on how the sociology of the sport field could make more of a difference.

International Review for the Sociology of Sport, *53*(3), 261–277. https://doi.org/10.1177/1012690216654297

Probyn, E. (2000). Sporting bodies: Dynamics of shame and pride. *Body & Society*, *6*(1), 13–28. https://doi.org/10.1177/1357034X00006001002

Ratan, R. A., & Dawson, M. (2016). When Mii is me: A psychophysiological examination of avatar self-relevance. *Communication Research*, *43*(8), 1065–1093. https://doi.org/10.1177/0093650215570652

Schau, H. J., & Gilly, M. C. (2003). We are what we post? Self-presentation in personal web space. *Journal of Consumer Research*, *30*(3), 385–404. https://doi.org/10.1086/378616

Schubert, W. T., & Koole, L. S. (2009). The embodied self: Making a fist enhances men's power-related self-conceptions. *Journal of Experimental Social Psychology*, *45*(4), 828–834. https://doi.org/10.1016/j.jesp.2009.02.003

Seibt, B., Neumann, R., Nussinson, R., & Strack, F. (2008). Movement direction or change in distance? Self- and object-related approach–avoidance motions. *Journal of Experimental Social Psychology*, *44*(3), 713–720. https://doi.org/10.1016/j.jesp.2007.04.013

Serino, A., Alsmith, A., Costantini, M., Mandrigin, A., Tajadura-Jimenez, A., & Lopez, C. (2013). Bodily ownership and self-location: Components of bodily self-consciousness. *Consciousness and Cognition*, *22*(4), 1239–1252. https://doi.org/10.1016/j.concog.2013.08.013

Shilling, C. (2003). *The body and social theory*. Sage.

Shilling, C. (2005). *The body in culture, technology and society*. Sage.

Slater, M., Perez-Marcos, D., Ehrsson, H. H., & Sanchez-Vives, M. V. (2009). Inducing illusory ownership of a virtual body. *Frontiers in Neuroscience*, *3*(2), 214–220. https://doi.org/10.3389/neuro.01.029.2009

Taylor, T. L. (2002). Living digitally: Embodiment in virtual worlds. In R. Schroeder (Ed.), *The social life of Avatars: Presence and interaction in shared virtual environments* (pp. 40–62). Springer-Verlag.

Thiel, A., & John, J. M. (2018). Is eSport a 'real' sport? Reflections on the spread of virtual competitions. *European Journal for Sport and Society*, *15*(4), 311–315. https://doi.org/10.1080/16138171.2018.1559019

Thorpe, H. (2014). Moving bodies beyond the social/biological divide: Toward theoretical and transdisciplinary adventures. *Sport, Education and Society*, *19*(5), 666–686. https://doi.org/10.1080/13573322.2012.691092

Tsakiris, M. (2010). My body in the brain: A neurocognitive model of body-ownership. *Neuropsychologia*, *48*(3), 703–712. https://doi.org/10.1016/j.neuropsychologia.2009.09.034

Tsakiris, M., Prabhu, G., & Haggard, P. (2006). Having a body versus moving your body: How agency structures body-ownership. *Consciousness and Cognition*, *15*(2), 423–432. https://doi.org/10.1016/j.concog.2005.09.004

Tulle, E. (2007). Running to run: Embodiment. *Sociology*, *41*(2), 329–346. https://doi.org/10.1177/0038038507074978

Van Amsterdam, N., Claringbould, I., & Knoppers, A. (2017). Bodies matter: Professional bodies and embodiment in institutional sport contexts. *Journal of Sport and Social Issues*, *41*(4), 335–353. https://doi.org/10.1177/0193723517708904

Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind. Cognitive science and human experience*. MIT Press.

Vicdan, H., & Ulusoy, E. (2008). Symbolic and experiential consumption of body in virtual worlds: From (dis)embodiment to symembodiment. *Journal of Virtual Worlds Research*, *1*(2), 1–22.

Villani, D., Gatti, E., Triberti, S., Confalonieri, E., & Riva, G. (2016). Exploration of virtual body-representation in adolescence: The role of age and sex in avatar customization (make or alter to personal or individual specifications). *Springerplus*, *5*(1), 740. https://doi.org/10.1186/s40064-016-2520-y

Vogt, T., Herpers, R., Askew, C., Scherfgen, D., Strüder, K., Strüder, H. K., & Schneider, S. (2015). Effects of exercise in immersive virtual environments on cortical neural oscillations and mental state. *Neural Plasticity*, *2015*, 523250. https://doi.org/10.1155/2015/523250

Wirth, W., Hartmann, T., Böcking, S., Vorderer, P., Klimmt, C., Schramm, H., Saari, T., Laarni, J., Ravaja, N., Gouveia, F. R., Biocca, F., Sacau, A., Jäncke, L., Baumgartner, T., & Jäncke, P. (2007). A process model of the formation of spatial presence experiences. *Media Psychology*, *9*(3), 493–525. https://doi.org/10.1080/15213260701283079

Yang, Y., Jucheng, Y., Xiaofei, Z., Jiangang, H., & Xiangbo, Z. (2017). Research of simulation in character animation based on physics engine. *International Journal of Digital Multimedia Broadcasting*, *2017*, 1–7. Article ID 4815932. https://doi.org/10.1155/2017/4815932. http://downloads.hindawi.com/journals/ijdmb/2017/4815932.pdf