Position paper[1]

Virtual Reality; A threat to fairness in Elite Sports?

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Abstract: Increasing technological innovation in the past decades has profoundly impacted and completely transformed the sport. Technology influences the way sport is practiced, the analysis and improvement of performance and understanding of training methods. Virtual Reality is an application of these technological innovations in sports and brings many benefits for athletes, but also for their trainers and coaches. It is used as a training method in many sports and is applied as an aid to measure athletic performance as well as analyzing technique. This raises the question: does Virtual Reality affect the fairness in elite sports? This paper examines how Virtual Reality can be applied in elite sports from various angles and looks at what the influence is of Virtual Reality in elite sports. It can be concluded that Virtual Reality does not significantly affect fairness in elite sports.

Keywords: Technological innovation; Athletic performance; Virtual Reality; Fairness; Cycling

1. Introduction

It is clear that Virtual Reality influences elite sports in many different ways. It offers a good coaching tool for coaches and trainers. Virtual arenas can be simulated in which real game situations can be created. Also, real-time feedback from the athletes can be collected and tactical and strategic skills of players and teams can be greatly improved. With a Virtual Reality (VR) environment, athletes can enhance their training regime even when they are on the road, and get the chance to perform unlimited reps in the most realistic environment possible, so they are ready to perform at their very best when it really matters. It gives athletes the opportunity to train more effectively in an environment in which there are enormous possibilities for an effective improvement of their sports performances [1].

An example of the application of Virtual Reality is 360 degrees video that can be used in cycling. 360 degree video is the most simple application of Virtual Reality. It is a wide video projected around the viewer. In cycling, it is often used to collect preliminary information by cycling the route on an exercise bike that corresponds to the Virtual Reality world they are cycling in. This means, for example, that when they cycle uphill, they can feel it on the bike as well. During cycling races, cyclists who train with VR have an advantage over cyclists who have not trained with it. By training with Virtual Reality, the cyclists can train on the mountain they will be riding during the race. They gain knowledge about the route, the danger of curves and the optimal speed they should have in order to reach the finish line in the quickest possible time [2].

Fairness is an important concept here, we believe it is very important that the sport is not affected by the use of Virtual Reality. Elite sports should always be about the performance of the athlete and not about who has the best (technological) tools. Therefore the focus of this paper will be on the question whether VR can be a threat to fairness in elite sport. We will focus on top athletes and their use of

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Virtual Reality as a training technique to prepare for matches. The results of our research lead us to the conclusion that VR can't be seen a thread to the fairness in elite sport.

The next section continues with societal user challenges. Afterwards the state of art for this study is presented. The paper continues with the envisioning of the future and ethical considerations, and concludes with some critical reflections in the final section.

2. Societal – User challenges

By using Virtual Reality during practice, for example, the athletes can prepare for big games against other athletes who cannot use this. The Virtual Reality can also have mental advantages, as it improves the imaginary skills of the athlete and it doesn't affect the athlete physically [3].

So one of the biggest questions we have to answer is whether it is fair to allow athletes to use technology without restriction. Elite athletes are known to do everything they can do to win a game. So when technology would help the athlete become better and helps them to prepare better for their game they would probably use this technology. When this means that the athlete with more economical resources is able to use it and his/her opponents can't use it, he/she probably would still use this technology as an advantage.

If these benefits are actually seen as 'doping', a solution would be to give all athletes the same means to prepare for a competition and also check it. When a list is drawn up by the sports organization of technological means that are allowed (and available to everyone), all technological products that are not on this list can be seen as prohibited substances. This prevents athletes from benefiting from technology that other athletes cannot afford. This keeps the competition fair and the best athlete wins.

In cycling there are a lot of different technologies that can be used to improve the performances of the cyclists. According to Theo Eltink, ex-pro cyclist & physiotherapist, the technologies currently used in cycling are: a wattage meter, an electric switching, aerodynamics and cycling altitude training. In the cycling industry not all teams have the same economical resources. Some teams have a lot of money to spend on technology other teams do have the money and don't want to spend it or don't have the money to spend on technology. According to Eltink expensive technologies that can't be paid by all the teams aren't completely fair to use. But in case of an inexpensive technology that can be paid by all teams, it's the teams choice to make use of this technology or not [2].

Another technology that is often used in cycling is Virtual Reality as a road reconnaissance. The question occurring from this is if it is fair that cyclist are able to use VR as a road exploration. According to Pieter van Gorkom, Virtual Reality applicator, and Eltink, Virtual Reality is a technology that is available for all the elite cyclists [4]. So regarding economical resources, this technology is available for all the elite athletes within the field of cycling. Which means using VR as a road exploration is fair within the field of elite cyclists. By using VR as road reconnaissance the cyclist doesn't need to leave his house, because the exploration can be done on a stationary trainer at home. Nevertheless the road exploration can also be done at the destination itself or through a briefing, which means there isn't a real advantage using Virtual Reality. According to van Gorkom and Eltink VR can mainly be used as a mental advantage and not as a physical advantage. This applies to analysis and prior knowledge, because as said by Eltink: ''In the end you will have to cycle up the mountain yourself.'' [2].

In Malaysia Virtual Reality is used by the national track cyclist team, since it is a lot cheaper than training abroad. Next to that track cycling can be a very dangerous sport, which often occurs in accidents and injuries. Since VR is safer this would mean less accidents and injuries, which in the end would also lead to a decrease in costs for medical cases. Besides the medical costs, Virtual Reality simulations also save costs and space for training facilities. In these situations VR could be a good alternative to normal practice on the Velodrome tracks. In these cases you could say that VR could actually be an good alternative for athletes with less economical resources. On the other hand nowadays Virtual Realoty technology cannot fully replace practice on the Velodrome tracks, since the VR technology is

still invaluable for human gait analysis for example. Next to that it is still uncertain if the Virtual Reality stimulator is effective in raising performance of athletes. According to Yap: ‘’Virtual Reality scenarios coupled with real time presence and interaction offers great potential for enhancing sports performance in track cycling.’’ [5]. This would mean that athletes would still need to do real time training as well as VR training to achieve the best results. When looking at the use of Virtual Reality from this perspective it would probably mean that some athletes need to choose between real time practice and VR practice in order to be able to pay it.

3. State of the art

3.1. History of Virtual Reality

From the 19th century people started making panorama paintings. This can of course not be compared with the current presentation of Virtual Reality [6]. Yet this is a first attempt at a 360 degree experience, to create an illusion that we are present somewhere where in reality we are not [7]. Virtual Reality is invented in the 1950s and was first used by training and simulation in the US military and the National Aeronautics and Space Administration (NASA) [8]. In the early 1990s mass production of VR systems began which opened dedicated Virtual Reality Arcades [9]. In the 1990s Virtual Reality was also first applied to sport research [10]. Over the last decade VR has rapidly transformed into a consumer technology. With companies such as Oculus Rift, Facebook and Zwift, Virtual Reality becomes accessible for more and more people and branches [11].

3.1. Current applications

There are currently many applications of Virtual Reality in everyday life. It is used, among other things, for leisure / entertainment, in healthcare, in business and in schools for training and education [12]. Van Gorkom is a nursing teacher at the Fontys in Eindhoven and is working on applying Virtual Reality in education. According to Van Gorkom VR can be a very useful and safe way to teach students new things. Since students aren’t watched by other students, it is easier to make mistakes and learn from them. According to Van Gorkom this leads to students becoming more confident within their discipline, leading to mental benefits [4].

There are also a lot of applications of Virtual Reality in elite sport. Coaches typically analyze and dissect movements of their athletes into subunits using performance analysis methods [14]. Recording such information has become increasingly important over the last decade in gaining an edge over competitors. The technology improvements in visualization, motion capture, and computing capability have addressed the challenges in developing a simulation VR for training sensorimotor components of sport.

With regard to using Virtual Reality as a technology during training, Van Gorkom thinks VR cannot be used for every sport, since you are completely closed off for the outside world. In his opinion cycling is one of the only sports which could actually benefit from VR. Van Gorkom states that the main application of Virtual Reality within cycling would be using it as an alternative way of course exploration. So via the Virtual experience the cyclist will be prepared for its race in the form of knowing when there is an ascent or when a curve is coming up [4]. According to Eltink this way of course exploration within cycling has evolved over the last couple of years and wasn’t available when he was a prof [2].

Within the field of cycling; brands such as Zwift, RGT, TrainerRoad, Sufferfest, Rouvy and Bkool are on the rise. These brands offer Virtual Reality experiences to cyclists on every level at their own home. Eltink used Zwift to train and to keep in shape. According to Eltink there are a lot of elite cyclists using Zwift as well, for example the cyclists form Jumbo Visma. Eltink thinks these online virtual experiences can be very valuable ways of training as well as a good technique that can be used for rehabilitation. These virtual experiences are also a good alternative to outside training, when you can’t

train outside yet. These virtual experiences are a good way of maintaining your condition and it is mentally easier to keep up with the virtual training compared to an outside training as Eltink says [2].

4. Envisioning the future

We expect that the role that Virtual Reality will play in the future in the world of elite sport, especially cycling, will be significantly growing. Nowadays, Virtual Reality is being used much more than 3 years ago. The use of Virtual Reality will increase even more in the future [2]. It will therefore become easier for all top athletes to have access to this technology, so that also in 10 or 20 years it will not affect the fairness within the world of elite sports. At the moment, the athletes can get a lot of mental support from it, because they already have prior knowledge of the route they are going to cycle. In the future, athletes will also benefit physically when they start training with VR. In cycling, this will be through a good exercise bike that corresponds to a VR world that reflects reality.

The recently used technological devices are aimed at making the training and preparation for the competition more effective and getting a better management of injury risks. So far the equipment is sport specific and generalization will be necessary with caution, so that the training method can be used in all sports for injury prevention strategies [14]. Research also indicates that VR can be a promising addition to existing real world training and participation in sport. There are several advantages to a VR-bases system for training and participation. For example, athletes can continue to train regardless of weather conditions, compete against other athletes in a different geographical location, and have accurate and replicable control over features of the virtual environment. Characteristics of both the user and the system are important factors that can influence a spectrum of physical, physiological and psychological outcomes. Future research will benefit from a theoretical understanding of Virtual Reality applications to sport. And ultimately, researchers, coaches and the athletes will all be able to apply the technology for the benefit of athletes and society in general [10].

As Virtual Reality advances, it will be used more and more deeply, and it can be used in every game occasion. In order to assess the athletes' effort and to be able to quickly change the preparation plan, it is important that the coach can assess the effect of the preparation. By collecting daily preparation information, the coach can mimic the preparation activity on the computer. With the help of advanced technology in the future, these preparation activities will be simulated increasingly better [15]. It will therefore not only be about the application of VR in elite sports, but it will be about the combination of VR with other technologies to get the most benefit out of this application.

By every game occasion, truly every game occasion is meant. Virtual Reality will be used not only by top athletes, but also by fans who will be able to watch games in the arena while in reality sitting at home on the sofa. Also, the sports exercises of amateur athletes will soon be influenced by VR technology [12]. In addition to the application in sports, Virtual Reality will be used more in everyday life, for example, by engineers. In the future, every engineer will be able to test his/her projects using VR. This is a cheaper and less time-consuming alternative to current design processes that take a long time and can therefore require a lot of money. Not only will engineers be able to design with the help of VR, but average people will eventually also be able to design their houses, hairstyles of clothes and see the result immediately in a virtual environment [12].

5. Ethical considerations

Since the current Virtual Reality application still lack of physical forces, motion- or cyber-sickness, sickness occurring from virtual experiences, is a very well-known problem within Virtual Reality. After a few moments in the VR space, vertigo, headache and a feeling of nausea can occur. The theory behind this is called: the Sensory Conflict Theory [16]. ''It is based on the premise, that discrepancies between the senses which provide information about the body's orientation and motion cause a perceptual conflict which the body does not know how to handle.'' [17]. An future implementation of a hydraulic platform which stimulates the physical forces could help decrease the issue of motion sickness. But

since this is an future implementation it is not clear if this would indeed help overcome the motion sickness. So till then all athletes suffering from motion- or cyber-sickness should of course not use these types of training techniques.

When looking at physical benefits or disadvantages of Virtual Reality used as a training technique, the current applications of VR don't show much physical advantage of the use of VR. The advantages currently encountered are mainly mentally. In the future we expect the physical advantages to become bigger, which could lead to some problems. Currently some of the Virtual Reality experiences are not realistic, which could lead to unnatural patterns of movement as well as injuries [18]. When looking at cycling this isn't the case, but this could become a problem in the future when new Virtual Experiences within cycling are being made. Next to that when exercising in Virtual Reality athletes may be prone to falling or collision of nearby objects [10]. This is mainly the case when using a head-mounted display, which is nowadays not used in cycling. Nevertheless a head-mounted display could be an future implementation of VR within cycling, so this is something to keep in mind regarding athletes safety.

This does lead to another ethical consideration. Since we mainly talked about mental advantages of Virtual Rreality, other researches show that VR can also have mental disadvantages. After using VR users commonly experience significant psychological symptoms such as difficulty in readjusting to the real world [19]. Next to that VR creates the illusion of embodiment and ''consensual hallucinations'' [20], which could lead to mental health risks. These mental health risks mainly apply to heavy usage of Virtual Reality, which is currently not the case for cyclists. Because of this we don't think VR will lead to mental health risks among cyclists.

Regarding physical benefits other researches show that Virtual Reality decreases the risk of accidents and injuries within cycling. This is the case, since the cyclist doesn't cycle on the public road or on a Velodrome track, which means the cyclist isn't exposed to others. Next to that a virtual bike training system lets the cyclist get out and ride no matter the time or weather, while still receiving valuable data [5]. This benefit of being able to quickly go for a ride, not needing someone else and still receiving valuable data does bring up some issues.

One of the risks of being able to train on your own, while still receiving coaching and data via the virtual experience, is social isolation [21]. The fact that cyclists are able to train this easy on their own could in the end lead to social isolation. This is however only the case when Virtual Reality is the only trainings technique used. Currently the VR trainings aren't advanced enough to fully replace the real time practice [5], but looking at the future this is something that could be possible in a few years. When VR becomes one of the better ways of training, social isolation should be something to watch out for.

Another risk occurring from using VR as a trainings technique to receive data is about privacy and personal data [18]. Since the VR systems collect a lot of personal health and performance related data about the cyclists' efforts, it is important to keep this data safe and protected from outside access. When this data would leak, it could be used against the cyclists by its opponents during races. Next to that the data could also be used against the cyclists in ways that threaten personal privacy [21]. We think the privacy of the athlete should be taken very seriously, that's why we think the privacy of the personal data occurring from the VR trainings should be prioritized by the cycling teams.

6. Some critical reflections

In the case of the use of VR in elite sports, there are many different fields that must be taken into account. How the VR is applied and what benefits it could have on the performance of athletes are important aspects that are reflected in the paper. By focusing mainly on the concept of cycling, clear examples of possible benefits of VR in elite sports can be assessed, but of course there are many more applications of technology in elite sports and in all these cases the question must be asked whether the top athlete is not influenced to such a degree that it can affect the fairness in the sport.

At the state of the art, the current applications of Virtual Reality are addressed and because future/new applications of VR are discussed in elite sports at envisioning the future, we see that Virtual Reality can be applied more and more and can ensure that athletes can derive clear benefits from using improving technology. The concept of using a virtual environment in VR can be expanded and in terms of technology in the future there will be developments that are not yet predictable.

The concept of fairness is a key concept in the way Virtual Reality in elite sports has been looked at and is a very important concept. It is not fair if in a competition someone has a significant advantage over their opponents. If you look at all the technologies that are already in place and approved for use during preparations, Virtual Reality can fit into that category. It makes assessing your preparation and performance easier, just like a heart rate monitor for example. But because Virtual Reality does not (yet) bring about clear physical improvements, but mainly provides mental support, it can be stated that fairness in elite sports is not significantly influenced by the use of Virtual Reality. VR can improve the athletes' training, but the athletes still have to deliver the performance themselves in the race.

When looking at the issue from an industrial design perspective, there are a number of concepts that come up that an industrial designer has to deal with: when designing something, you should always keep in mind for who you are designing. Who is your target group? Designing for elite athletes does not mean there is no budget limit. Not everyone has sponsors/can afford expensive technologies. When designing something not available for the entire target group, think about the influence it has and if it causes a separation in the target group, for example rich/poor. These kind of problems remind us of inclusive design, were you look for solutions that fit everyone. In the case of VR this would mean that the VR application would be accessible for all the athletes competing for the same game. During our research we however came to the conclusion that including as many people as possible can sometimes be hard, especially regarding economical resources.

From the field of biomedical engineering, the main focus will be on the health benefits that Virtual Reality glasses can bring about. Questions such as whether the athletes can experience real physical benefits from this way of training can be analyzed through research. The health conditions of the athletes can be tested and tracked and thus real numbers can be linked to the physical benefits of VR. The effects that Virtual Reality can have on mental/physical health can thus be assessed and the data can be processed.

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Appendix

Appendix A – B

In the appendix the interviews with Pieter van Gorkom and Theo Eltink have been added. The interviews were conducted via Microsoft Teams and the answers are summarized.

Appendix C – I

Furthermore, the weekly assignments that were handed in each week during the course have been added in the appendix. These were made in weeks 1 to 7 and are related to the preparation of writing the position paper.

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Appendix A - Interview Pieter van Gorkom

How does Virtual Reality work/How are the images made?

There are several forms of Virtual Reality. 360 degrees video, AR (Augmented Reality) and VR (Virtual Reality) are often confused. In the case of cycling, we are talking about 360 degrees video.

Images are made with a 360 degree camera, put the camera in the place you want the images to appear in the vr glasses and the environment is recorded.

With the application in sports, I can clearly imagine the use of VR in cycling, because when you put on such glasses you close yourself off from the outside world.

With cycling you can have a 360 degree video of the environment in which you will be cycling in advance, while they can sit on a stationary bike and not have to cycle hard. They can easily explore the route. While you are cycling you see the environment in those glasses.

Cycling is really the only elite sport of which I think 360 degree video really has added value to use in a training. You can just sit on a stationary bike, put on those glasses and then do a course reconnaissance. However I think the course reconnaissance is already done quite a lot with fencing or a briefing of the route. By course reconnaissance you know when I've passed that village, the climb starts or the road gets bad. The cyclist can take this into account and adapt during the race. There are more and more programs which have more uses like moving the bicycle, which I think is a really good way to use VR.

When using VR in team sports you can use it to evaluate afterwards. The camera can be placed in the middle of the field or slightly above the field, so you can later see how the players are distributed in the field. That is a very different idea than with individual sports.

If you're really looking at ‘Technology doping’, I'd focus on cycling and using VR during track exploration.

How can Virtual Reality be used as technology during training of top athletes?

I don't think it can be used much in sports. VR closes you off from the outside world and in almost every sport you need contact with the outside world. For cycling it can be used, but for the rest I don't think so.

Can Virtual Reality affect people/top athletes mentally, if so how?

Yes, you can actually let people experience certain situations that could happen during exercise. You are cut off from the outside world so you can't really respond in real life, but some tactics could be filmed in advance and then played back to experience certain things. For example in football, when the players enter a new stadium they don't know where to change, etc. This could also be shown to the players in advance by VR so that they are better prepared. Is that doping? I do not think so. It is only a better preparation for your match.

You could film all kinds of tactics and then let athletes make choices. I don't think it affects honesty.

A lot of equipment has already been made for cyclists, for example to climb the Alpes D'Huez. Then you know if there is an extra bit of rise after that bend, you are then influenced by sport if you know that and the other person does not know that. That is also stated in the itinerary. It's just another way of preparing.

You can also apply VR in other sports where tactics of athletes can be improved. By allowing the athletes to make different choices in training with VR, the athletes can improve. I don't think this affects the fairness in sports.

A lot of equipment has already been made for cyclists, for example to climb the Alpes D'Huez. The cyclists know that there is an extra bit of rise after that bend, so are they influenced by

sport if they know this and the other person does not know that. That is also just stated in the itinerary, it's just another way of preparing.

Is Virtual Reality available to everyone?

Yes, Virtual Reality is available to everyone. You can watch the 360 degree videos on your phone and you can put them in a cardboard box and look around. Is that Virtual Reality? We can talk about that, but you can watch 360 degree videos, so it's achievable for everyone. It's more beautiful if you look at it through real glasses, but that's not necessary of course.

Within cycling, the same use VR could be available to everyone. Doping means that you use something that makes you unfairly better, and this is actually just a more modern way of the course booklet or preparation for a course. The images give you the feeling that you are really there. Is that doping? I actually don't know. I think doping is unfairly using something that makes you put yourself at a bit more risk, giving you more advantage because your body becomes different based on the doping you take. This can be short-term or long-term.

VR and doping? Then reading a book is also doping in chess or watching a match analysis is also doping. It's a different way of preparing, I don't think it's doping.

Do you think Virtual Reality influences fairness in elite sports?

No, I don't think so, it's only a better preparation.

What kind of experiences do your students have with Virtual Reality? (good and/or bad experiences)

We bring our students into an environment for which they are educated, but where they have never been before. Half of our students end up in hospitals, but more than half of the students have never been to hospitals. So what we can do very easily is give our students guided tours in such a hospital. What does that look like now:
What we're doing is case studies, so students work in 360 degrees with a patient. You cannot simulate this with a paper case. Everyone's perception is different and everyone has their own images. If you simply place the students in a hospital setting it's easier for the students that they've already seen what it looks like and how it works.

Response students:

- I am now doing a survey to see how students experience this and we are still researching. We want to see whether the self-confidence of walking into such a hospital after VR and having to do work with patients will improve. What students say is that they find it very interesting because the setting is real. The patients lying there are not real patients, so you have options. You enter the room, the video stops and you have 4-5 choices. If you choose something wrong, the nurse will still do the wrong thing with that patient. Then you immediately see this is not a smart thing to do, because the patient has still not received oxygen or you see that the patient is getting more and more anxious, things like that. So you immediately notice if you make wrong choices, because you see that what you have done has an effect. You will also immediately receive feedback from a teacher, who will indicate why your choice is not right. Students find it much easier this way. Normally at a test or in the classroom, a simulation patient is in bed playing something and the whole class is standing around it and you have to do something in that situation. That is quite threatening for you, because everyone is watching. There is a little laugh now and then and if you do something stupid, you have to hear that another week. If you do something stupid in that VR environment, you are the only one who has seen or heard it and yet you can learn from it, so it is much easier for you to make mistakes. Students find the environment much less threatening than the whole class watching. So they like this application of VR.
- We are now in the process of incorporating these types of lessons into the curriculum so that they can learn and train a number of acute skills in this way. In fact, these kinds of materials

are sold to hospitals to train nurses at all levels. It started with students, but I think it will go further.

Other notes:

- Maybe in basketball and football augmented reality can be applied. The players can see what they're doing and get immediate feedback.
- Golf can be virtual, so you don't have to walk to pick up the ball. Then you can practice a lot with starting strokes.
- One big advantage of VR is that you don't need a coach and no space. In principle you could achieve the same with coach or without. I think having a coach might be better, because with VR you have glasses on your head which makes the situation different.

Summary interview Pieter van Gorkom:

- I don't think Virtual Reality influences the fairness in sports.
- There are many different ways of learning such as reading a book, a briefing, etching. VR will therefore not have a very important influence on the performance of the athletes.

Appendix B - Interview Theo Eltink

What did your trainings look like when you were a top cyclist?

I stopped 10 years ago with cycling at elite sport level. In my training sessions I usually started from home, this area was flat and little hills. Sometimes I lived together with other athletes (10-15 men) this resulted in better quality training sessions. The trainings could be an hour of cycling, but also 6 hours. The intensity in a training then differed a lot.

What training techniques have you used during your elite sport career?

Innovation that came in was electric switching. That was smoother than the mechanical shifting, but not necessarily harder. In addition, they started driving with wattage meters. This allowed them to monitor the the training they did themselves more accurately. If you could cycle a certain value in a test that corresponded to a zone, you could train better. The clearer the zones, the more specific you could train. Before that, they used heart rate monitors. This is still used and is still very functional. In the cycling field, wattage meters are used much more often. While cycling, they also looked at aerodynamics, trying to sit on the bike as efficiently as possible. Wind tunnel tests were used to make training better. GPS systems on watch/bike counter were used to cycle different routes. You don't go faster and it gives training no technical advantage, but it does make the training sessions easier.

Have you ever used technology in your trainings? If so, which technique?

See above question, these technologies are still all used.
Another training technique that is used is LHTH (liveHighTrainHigh) → You have to sleep at a certain height. Then you can influence your blood supply by allowing more capillaries to grow in. The moment you start training low again, you have more capillaries than you normally have and you can therefore cycle faster. (14.55 look back).
I did this myself. This must be at least 1800 meters above sea level. You will feel the difference if you sleep lower, you can rest and recover better than when you sleep high. You are then less equipped for your next training and it is also noticeable in your heart rate (higher heart rate, because it takes effort). If you cycle down you have an advantage if you have trained at altitude.

Have you ever used Virtual Reality during trainings?

Myself I have never worked with 360 degrees in trainings. I did use Virtual Reality. This was training on a kind of exercise bike, where you try to imitate the race environment as best as possible. We used zwift for this, an interactive trainer who corresponds with your laptop. You are then an avatar. When the avatar rides up, you can feel it on the bike. The avatar can then cycle against himself, but also against others.

A variant now widely used is a program where you literally see yourself as a doll on a mountain that actually exists (example: you can see yourself cycling up the Alpe d'Huez). You can feel cycling uphill on the trainer. It is not 100% equal to reality, but you can explore certain routes. I have never used this myself. I was open to it and sometimes needed it, but it simply wasn't there yet. It has only been used for the last 3 years.

In the online world of zwift that I used, I met many other professional cyclists. Jumbo Visma uses this. It is mainly used for training, but also for rehabilitation. If you can't train outside yet, you can already start cycling on the exercise bike to maintain your condition. It's easier mentally to keep up than outside workouts.

Do you think technology influences the performance of elite athletes? (Mentally/physically)

Yes, by using technology you can analyze a lot. If you know how to analyze certain game types, you can benefit a lot from this. For example in football: You can watch tired players to avoid injuries. You can also learn from technology to be able to act better in a competition program.

Not everyone has equal resources. Some teams have money and want to spend it on technology. Other teams don't want to spend money on it or don't have the money. If it's cheap, the choice lies with the team itself. If the technology is expensive, not everyone can use it and it is not entirely fair.

Influence of Virtual Reality → If you can already pre-cycle the route, you already have information about what to expect and you will not be surprised how dangerous/difficult something is. There are not very big differences, but it definitely gives you an advantage.

Do you think technology influences fairness in elite sport?

Yes, because not everyone can use every application of technology. Virtual Reality can only influence honesty in the preliminary phase because you have prior knowledge. But in the end you will have to cycle up the mountain yourself (under your own power).

Do you think the use of Virtual Reality as a training technique has an impact on fairness in elite sports?

Virtual Reality mainly helps mentally, because you know what to expect. You have to train yourself physically too. But cycling uphill can now be imitated better. For top athletes, Virtual Reality will now mainly be a mental support.

As a physiotherapist, what influence do you think technology has on the performance of elite athletes?

Xsens is an example of a new technology. These are motion sensors that assess to what extent you move good or not good. We look at the difference left and right, and whether there are complaints we can assess. For a top athlete it would be good to be able to position himself even better on a bicycle. There is more data to get the best out of such a measurement. There are many more devices that can give you information about that.

Have you ever used Virtual Reality to treat a patient?

Virtual Reality is used in physiotherapy. Example: the elderly are given glasses, so they can play games interactively. Because of this they will get physical activity when they are normally not active. The physiotherapists get good results with this. It is uncomfortable for older people, but there is a group that is open to it and is positive about it. This way they still get exercise and stay mobile

Do you think Virtual Reality affects the fairness of elite sport?

You can't see technology in sports as doping, because nothing else happens to your body. It is certainly an advantage if you have technological knowledge around you. This can also be about diet (ketones). If you have the right people around you, you are more likely to use them. Big other technological changes are the swimsuit and clap skates. These also made huge differences.

At the top of cycling, everyone has access to Virtual Reality. If they don't get it through sponsors, they are all able to buy it themselves, because it's not that big of a price.

Appendix C - Assignment week 1

Week 1 --- USE Introduction to Sport, Physical Activity and Vitality

Motivation USE Introduction to Sport, Physical Activity and Vitality

Student photos

Names	Faculties	Student numbers
Fleur Martens	**Biomedical Engineering**	**1630652**
Anna Siebers	**Industrial Design**	**1581171**
Puck Verbeek	**Industrial Design**	**1575589**

Student 1: Describe shortly your motivation to follow this course and give an example of a good and a bad (less good) application of technology in sport, physical activity or vitality.

As soon as I saw the word sports in the name of the course, I was hooked. At my secondary school I had the extra subject BSM (Movement, sports and society) and I love to exercise myself, you can escape from real-world troubles for a while. I also enjoy watching sports on television even though I don't always have time for that. Combining sports and vitality with the role that technology can play therefore sounds like a perfect combination.

For me the best example of an application of technology in sport is with Paralympic athletes (such as prostheses or adapted material). Technology gives them an opportunity to just sport and it's not an addition or a luxury for them.

The application of technology in sports is bad when there is a possibility that the best athlete might not always win as other athletes may have better technology.

Student 2: Describe shortly your motivation to follow this course and give an example of a good and a bad (less good) application of technology in sport, physical activity or vitality.

I chose this USE learning line because I enjoy playing sports and watching others play sports. Because physical activity is important for your health, I would like to see as many people as possible playing sports. For some people, the threshold to start exercising is higher. This threshold can have different reasons. I think the combination of sport and technology can lower this threshold.

A good application of technology is a heart rate monitor. Keeping track of your heart rate, for example, while running, can make your workouts more effective.

Because of all the applications, playing sports can be expensive. All the equipment required is becoming more expensive and therefore not everyone can play their favorite sport.

Student 3: Describe shortly your motivation to follow this course and give an example of a good and a bad (less good) application of technology in sport, physical activity or vitality.

Ever since I was little I really liked to exercise and try different sports. This resulted in my interest in sport, vitality and human movement. So when I had to choose a study I was interested in three studies: Human movement science, Biomedical engineering and Industrial Design. Eventually I chose Industrial Design. So the reason I chose this course is because it has aspects of all those three studies, that cover my interest.

When I was thinking about good applications of technology within vitality I immediately thought of Prothesis 2.0 by Lucas Balcilar. I saw this prothesis at the DDW in 2019. This prothesis as well as other protheses make it possible for people with a disability to function in everyday life, which I think is a great improvement within technology as well as vitality and wellbeing.

As for a bad or less good example I would say the VAR in football can be a really good addition to football, but I think that the VAR is currently still lacking a lot and is not as efficient as it should be. I think it now takes much more time than necessary. Personally I think the referees in football should have a look at the VAR in hockey, since this is way more efficient than in football.

Appendix D - Assignment week 2

Week 2 --- USE Introduction to Sport, Physical Activity and Vitality

Brainstorm as a group about possible topics for your positionpaper. Select 1 or 2 topic(s) and give a short explanation in the field below why you choose this at the moment.

There are a number of topics we would find interesting to write our position paper about. These are the use of smartwatches (improving health vs no digital rest), the VAR (differences between sports), neuroscience (the Halo headband: is this manipulation?).

the topics we prefer at the moment are:

- *Benefit through sponsorships in elite sports*
  Even among the Greeks and Romans sports sponsorship took place, but what is the influence of sports sponsorship on elite sport itself? The fairness of the sport is definitely affected by this, so the question is whether the best athlete always wins.

  We would choose this topic because we are interested in the influence of sponsorships on the fairness of sports. In elite sports it has to be about who is the best athlete and not about who has the most money. We believe that everyone should receive the same quality products and that there should be no difference.

- *The concept 'Technology Doping'*
  Technology in sport is continuously developing and you can argue that gaining a competitive advantage is what sport is all about. The question is when does it become about the technology and not the athlete's skill?

  Again fairness is an important concept here, we believe it is very important that the sport is not affected by the improving technology. Technology is changing, but fairness in sport must remain the same.

Brainstorm about the possible social challenges associatedwith this topic. Write these down in the field below.

Health care availability, civil rights, racial discrimination, gender inequality, climate change, are all examples of social challenges in our world. In sports social challenges such as, gender inequality, health, education/training, economical, social needs, development needs and psychological needs are most common.

The possible social challenges that come with our topics are for example economical differences between athletes and countries, which leads to a difference in access to materials, but also to new technologies. This challenge could have an influence on the results of the athletes.

Another challenge associated with these topics is gender inequality. It is a long known fact that men earn more money that women in sports. This leads to different possibilities of development, since men and women have a different budget for their trainings.

Another well known fact is that the sport industry has a big influence on climate change. With new technologies evolving within sports it is a must to have a look on the sustainability of those techniques.

Think about possible experts who you could interview and notethem down in the field below.

Theo Eltink → Ex-pro cyclist & physiotherapist
Rob Harmeling → Ex-pro cyclist & owner Sportgeluk and Sportsbalm
Rob Haantjes → Trainer Royal Herakles Hockey Club & performance manager KBHB
Milan Broens → Physical therapists
Milan Lemmens → Physical therapist
Edith Cup → Ergotherapist

Appendix E - Assignment week 3

Week 3 --- USE Introduction to Sport, Physical Activity and Vitality

Write down the topic you have selected for your position paper and the key aspects you want to focus on in the positionpaper.

Technology Doping in combination with Virtual Reality.
The improving technologies have an affect on the performances of elite athletes. Technology in sport is continuously developing and you can argue that gaining a competitive advantage is what sport is all about. The question is when does it become about the technology and not the athlete's skill? Fairness is an important concept here, we believe it is very important that the sport is not affected by the improving technology. Technology is changing, but fairness in sport must remain the same.
When looking at technology doping we want to use Virtual Reality as an example that can be used as a technical doping when practicing for an big game or match. By using Virtual Reality during practice the athletes can prepare for big games against other athletes who cannot use this. The Virtual Reality can also have mental advantages, as it improves the imaginary skills of the athlete and it doesn't affect the athlete physically.

Brainstorm about possible USER challenges that could be associated with this topic. Write these down in the field below.

Athletes are known to do everything they can do to win a game. So when technology would help the athletebecome better and helps them to prepare better for their game they would probably use this technology.
When this means that the athlete with more economical resources is able to use it and his/her opponentscan't use it, he/she probably would still use this technology as an advantage.
If these benefits are actually seen as doping, a solution would be to give all athletes the same means toprepare for a competition and also check it.
Doping is defined as prohibited substances. When a list is drawn up by the sports organization of technological means that are allowed (and available to everyone), all technological products that are not onthis list can be seen as prohibited substances. This prevents athletes from benefiting from technology that other athletes cannot afford. This keeps the competition fair and the best athlete wins.

Give an outline for the state of the art section of your paper(based on scientific literature).

There are currently many applications of VR in elite sports. Coaches typically analyze and dissect movements of their athletes into subunits using performance analysis methods. Recording such information has become increasingly important over the last decade in gaining an edge over competitors. The technology improvements in visualization, motion capture, and computing capability have addressed the challenges in developing a simulation VE for training sensorimotor components of sport.
The articles stated below give different insights on Virtual Reality and the world of doping. The articles talk about how Virtual Reality can help athletes mentally prepare for a game and how to cope with the pressure that comes with big games, for example.

- Argelaguet Sanz, F., Multon, F., & Lécuyer, A. (2015). A methodology for introducing competitive anxiety and pressure in VR sports training. doi: https://doi.org/10.3389/frobt.2015.00010
- Farley, O., Spencer, K., & Baudinet, L. (2020). Virtual reality in sports coaching, skill acquisition and application to surfing: A review. Journal of Human Sport and Exercise, 15(3), 535-548. doi: https://doi.org/10.14198/jhse.2020.153.06
- Møller, V., Christiansen, A.V. Neuro-Doping – a Serious Threat to the Integrity of Sport?. Neuroethics (2020). https://doi.org/10.1007/s12152-020-09446-4
- Sigmund Loland (2009) The Ethics of Performance-Enhancing Technology in Sport, Journal of the Philosophy of Sport, 36:2, 152-161, DOI: 10.1080/00948705.2009.9714754

Appendix F - Assignment Week 4

Week 4 --- USE Introduction to Sport, Physical Activity and Vitality

Write down the working title for your position paper

Technology; a threat to fairness in sports

Which elements / parts of your position paper are difficult orchallenging? Why?

So far, we have mainly encountered difficulties with how best to word the report. We know very well what wewant to say, but we find it difficult to express it clearly in the paper. Still, we think that if we think more about what exactly we want to discuss in our paper, we can write a clear piece about the issue.
Of the 3 parts of the paper that we have had to write so far, we have the most difficulty with the state of art.We now have a setup but there is a good chance that we will adjust it.
Furthermore, we don't have a good idea about who we want to interview about the technological side of our issue. On the sports side, we already have a person we want to interview (ex-top athlete and physiotherapist)and we have already prepared some questions, but we are still thinking about who we could interview for the technological aspect.

Appendix G - Assignment week 5

Week 5 --- USE Introduction to Sport, Physical Activity and Vitality

Write down the working title of your position paper.

Virtual Reality; a threat to fairness in sports

Write down the names and functions of the people you will interview (or already have interviewed).

- Theo Eltink (ex-top cyclist & physiotherapist)
- A company with specialists in Virtual Reality
  Options: Technology2enjoy, Courseware
- Kristof De Mey (Sports Technology / Business Development)

Which questions do you need to ask the people you will interview? (If you already interviewed them, which insights did you get?)

Questions for Theo Eltink:

- What training techniques did you use during your elite sport career?
- Have you ever used technology during training?
- Have you ever used Virtual Reality during training?

  → What does a training session look like when using Virtual Reality?

- Do you think that technology has influence on the performance of top athletes? (mentally and physically)
- Do you think that Virtual Reality has influence on the performance of top athletes? (mentally and physically)
- Do you think the use of Virtual Reality as an training technique influences fairness in elite sports?
- Do you think Virtual Reality changes sports?
- As an physiotherapist what influence do you think technology has on the performance of top athletes?
- Have you ever used Virtual Reality when treating a patient
- What influence do you think Virtual Reality technology has on the performance of top athletes?
- Do you think Virtual Reality influences fairness in elite sports?

  → If so, do you think Virtual Reality should be put on the prohibited list of WADA.

Questions for the company:

- How does Virtual Reality work?
- How can Virtual Reality be used as technology during trainings?
- Is the use of Virtual Reality during trainings possible for every sport?
- How does Virtual Reality affect people's minds?
- Is Virtual Reality available to everyone?
- Are you in favor of the use of Virtual Reality in elite sports?
- How can Virtual Reality influence sports performance of top athletes?
- Do you think Virtual Reality influences fairness in elite sports?

  → If so, do you think Virtual Reality should be put on the prohibited list of WADA.

- What kind of experiences do your customers have with Virtual Reality? (good and/or bad experiences)
- How do you see the future with regard to Virtual Reality in sport?

Appendix H - Assignment week 6

Week 6 --- USE Introduction to Sport, Physical Activity and Vitality

Write down the (working) title of your position paper.

Virtual Reality; a threat to fairness in sports?

Write down 5-7 key scientific references (use a consistent referencing style) you willuse to support the claims you will make in the "introduction" and "societal /user challenges" sections of your position paper.

References we already used:

Dopingautoriteiten. (2001-2020). Definitie van doping. Retrieved from www.dopingautoriteit.nl: https://www.dopingautoriteit.nl/wat_is_doping/definitie_doping

He, B. (2021, 07 27). Technology doping in sport is in need of clear regulation. Retrieved from Chinadaily.com: https://www.chinadaily.com.cn/a/202107/27/WS60ff74bea310efa1bd664adb.html

Sanz, F. A., Multon, F., & Lécuyer, A. (2015, April 08). A methodology for introducing competitive anxiety and pressure in VR sports training. Retrieved from Frontiers in Robotics and AI: https://doi.org/10.3389/frobt.2015.00010

Strivr Labs, I. (2021). TAKE YOUR TEAM'S TRAINING TO THE NEXT LEVEL. Retrieved from STRIVR: https://www.strivr.com/use-cases/sports/

Other references we will/can use:

Loland, S. (2009, October). The Ethics of Performance-Enhancing Technology in Sport. Retrieved from Researchgate: https://www.researchgate.net/publication/254321047_The_Ethics_of_Performance-Enhancing_Technology_in_Sport

Møller, V., & Christiansen, A. V. (2020, July 09). Neuro-Doping – a Serious Threat to the Integrity of Sport? Retrieved from SpringerLink: https://link.springer.com/article/10.1007/s12152-020-09446-4

Write down 5-7 key scientific references (use a consistent referencing style) you willuse to support the claims you will make in the "state of the art", and "envisioning" sections of your position paper.

References we already used:

Farley, O. R., & Spencer, K. (2019, July). Virtual reality in sports coaching, skill acquisition and application to surfing: A review. Retrieved from Researchgate: https://www.researchgate.net/publication/334789304_Virtual_reality_in_sports_coaching_skill_acquisition_and_application_to_surfing_A_review

Other references we will/can use:

Akbaş, A., Marszałek, W., Kamieniarz, A., Polechoński, J., Słomka, K. J., & Juras, G. (2019, October 18). Application of Virtual Reality in Competitive Athletes – A Review. Retrieved from NCBI - PMC: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6815076/

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Düking, P., Holmberg, H.-C., & Sperlich, B. (2018, March 15). The Potential Usefulness of Virtual

Reality Systems for Athletes: A Short SWOT Analysis. Retrieved from Frontiers in Physiology: https://www.frontiersin.org/articles/10.3389/fphys.2018.00128/full

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Kittel, A., Larkina, P., Elsworthy, N., & Spittle, M. (2019, September). Using 360° virtual reality as a decision-making assessment tool in sport. Retrieved from ScienceDirect: https://www.sciencedirect.com/science/article/pii/S1440244018310715?casa_token=uoZpOrI2VPYAAAAA:8cI4cYo2t3_uzNO78yXgDNmizDlI7vP8GeBANlsQ_c0lazu9aXSPvizl3zo_0xjtstZF12aUxL_k

MacIntyre, T. E., Jones, M., Brewer, B. W., Raalte, J. V., O'Shea, D., & McCarthy, P. J. (2017, October 25). Editorial: Mental Health Challenges in Elite Sport: Balancing Risk with Reward. Retrieved from Frontiers in Psychology: https://www.frontiersin.org/articles/10.3389/fpsyg.2017.01892/full?&utm_source=Email_to_authors_&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers_in_Psychology&id=308946

Neumann, D. L., Moffitt, R. L., Thomas, P. R., Loveday, K., Watling, D. P., Lombard, C. L., . . . Tremeer, M. A. (2017, July 19). A systematic review of the application of interactive virtual reality to sport. Retrieved from SpringerLink: https://link.springer.com/article/10.1007%2Fs10055-017-0320-5

Appendix I - Assignment week 7

Week 7 --- USE Introduction to Sport, Physical Activity and Vitality

Write down the (working) title of your position paper.

Virtual Reality; a threat to fairness in sports

Write down how you envision the role technology will have on the topic of yourposition paper.

The role that Virtual Reality will have in the world of elite sport, especially cycling, in the future will be significant. Nowadays, Virtual Reality is being used much more than 3 years ago (Theo Eltink). We think that the use of Virtual Reality will increase even more in the future and will not affect the fairness of competitions. This is because it is already available to all professional cyclists and in the future we think it will be available to many more people, both top athletes and amateur athletes. At the moment, the athletes can get a lot of mental support from it, because they already have prior knowledge of the route they are going to cycle. In thefuture, we think they will also benefit physically when they start training with Virtual Reality. However, this will be in combination with a good exercise bike that reflects the Virtual Reality.

Write down 1 question you have about the/your position paper you want me toaddress in the lecture of Monday 25/10.

Should your point of view be based only on scientific articles or can you also defend your point of view withyour own arguments?