Position paper

Blade prosthetics; their impact on the sport and the technical aspects that come with them.

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Abstract: This paper will discuss the impact of blade prosthetics on elite sports events. Furthermore, the paper elaborates on a future where technology might improve the chances for disabled athletes in such events. When doing so, there is a focus on the ethical aspect of fairness. The question is whether it is correct to allow disabled and non-disabled athletes to compete against each other in the same competition. This is argued with sources found by research and interviews with two experts, Paralympic Athlete Marlene van Gansewinkel and orthopedic instrument maker Gijs van Gent. The main challenge to overcome is to make running with prosthetic legs comparable to running without them. Even when this era is reached, discussions about the fairness of the improved prosthetic legs will not cause sports events to be different as they are now.

Keywords: Running; Prosthetic; Advantage; Fairness; Disability

1. Introduction

Figure 1. Oscar Pistorius on blades [1]

At the Paralympics, people without legs can participate in the running competitions with the help of leg prosthetics. However, people argue about whether it's an unfair advantage over people with normal legs when the disabled user uses this in a competition with non-disabled athletes[2].

The running blades were invented by the American inventor Van Phillips, who introduced his concept ‘flexfoot cheetah’ first in 1984[3]. He got the idea by observing certain animals like cheetahs and kangaroos. The blades are made of thin layers of carbon-fiber, which makes them light and strong. Almost all of the Paralympic runners still use a variation of Phillips his original design. In 2012 disabled runner Oscar Pistorius (Figure 1) was the first disabled runner who was allowed to compete in the Olympics for able people. This resulted in a lot of arguments whether it was fair that someone with technical aids competed against people who did not have any.

Whether they give people an advantage or not: they give disabled people a chance to do exercise and compete against others, which brings up the question if this discussion is even important. There is a much larger group of disabled people that don’t think about competing at the highest level. There are no gyms for disabled, and often disabled people cannot fit in with regular sports clubs.

More insight into these challenges are given by full time athlete and holder of two world records Marlene van Gansewinkel, as well as orthopedic instrument maker since 2004 Gijs van Gent. In this position paper, multiple views will be given on the impact of the running blades on the sport: The impact on the users, in which their view on it is compared to the outside view, and the impact on the highest level of sports, in which the ethical aspect of fairness and unfair advantages are researched.

2. Societal – User challenges

When different users make use of a sports prosthetic in a competition it is debatable if this has an influence on the performance of the athletes. Every user must run through a trial of different measurements in order to make a prosthetic specific aligned to that person. Therefore, in theory every running prosthetic is different, and users cannot be compared equally when judging a running competition[4].

Furthermore, the topic can be viewed with focus on the user's health. With a prosthetic leg it is almost certain different issues will occur. Injuries can occur in both the specific area of the attached point of the prosthetic and the whole body of the user itself as well. Van Gansewinkel says this is because the athletes are only able to use their upper leg which puts a lot of pressure on the hamstring and buttock areas. The risks of injuries in this area are a lot higher compared to abled athletes.

The missing lower leg also causes lactic acids to pile up in the upper leg. When wearing a prosthetic, an additional and atypical amount of time and pressure are borne down through the intact limb. Especially when injuries take place in the intact limb, it can be hard for the user to perform evenly well as without injuries. When wearing a prosthetic, sometimes weight bearing pressure can be caused due to an ill-fitting socket. Sockets are designed to distribute forces over the whole area of the limb. This is done to let the prosthetic be of best use as the prosthetic is measured in this state when aligning it perfectly to the user[5].

Another challenge disabled athletes face is the accessibility of running with a sport prosthetic. A custom prosthetic has to be made, which cost a lot of time, effort and money. According to Gijs van Gent the making and applying of a prosthetic can take up to three months until the costumer can properly walk on them. A standard model running prosthetic costs around €2.300 and for a top model you pay twice that much[6]. Especially for starting athletes this can be a major thing holding them back and still only the top athletes earn enough from sponsor income to buy the best equipment by running.

At last, it is very hard for a disabled athlete to find a good place to exercise. Almost all gyms are made for the masses and therefore not well equipped for a disabled person. There are also very few sports clubs that provide classes and teams for athletes with prostheses on top level. When an disabled athlete just wants to take part in sports on a recreational level it would not be a problem if

they joined the local sports club, but at a high level there are very few places athletes can go. This may hold some people with prostheses back from trying to compete on the highest level, Van Gent says.

3. State of the art

The current state of art is that there are no disabled competitors in the non-disabled competition. The last one was Oscar Pistorius, his fastest time on the 400m sprint was a 45.07, which made him eligible to compete in the 2012 Olympic games[7]. This is on this day still the world record for his category (T43: Double below knee amputation). In Brazil, 2016, Liam Malone ran the 400m in 46.20, which is the current Paralympic record[8]. This shows that the discussion about the fairness of competing in non-disabled competitions is currently irrelevant. However, this might be different in the future.

While the flex foot cheetah was invented by Phillips in 1984, current prosthetics are made by by orthopaedic instrument makers at Össur[3, 9]. According to van Gent, not all prosthetics have to be made different for each individual, only the sockets are unique. Van Gent describes the process of making and applying the socket as follows. First the stub has to be measured, this can be done digitally, but still happens with casting resin most of the time. After that, the first socket is made by the prosthetic getting fitted. Adjustments to the fit of a prosthetic socket are inevitable. The number of adjustments is kept as low as possible without interfering with quality of the fit. This is done at a manner that the costumer has as few visits to the clinic as possible. After the fit and alignment is correct, a final tube will be delivered. The process of a disabled person to walk properly with a prosthetic can take up to three months.

In its current state, the running blade still has a massive disadvantage compared to normal legs. According to Van Gansewinkel this is mainly caused by the fact that blades miss an ankle. The ankle gives some extra power to an able athlete when sprinting that athletes who run with blades therefore miss compared to their normal leg competitors. This however is not the only disadvantage of missing an ankle. Normally when an athlete makes a misstep while running they can partly correct that misstep by adjusting the angle of their ankle. When running with blades the athlete does not have the ability to adjust such thing, thus making the impact of a misstep much bigger for disabled athletes.

Van Gansewinkel mentioned however there is one advantage the blade gives an athlete over a normal leg. The blade ought to have more grip than a shoe, due to the fact that there are less materials between the blade and the ground. The sole of the blade gets glued directly to the surface of the track, making it the only material between the blade and the ground, while a shoe on a normal foot consist of much more materials between the foot of the able runner and the ground.

When times of disabled runners are compared to able runners it also shows the blades are not even nearly as fast as normal legs. Van Gansewinkel, who has the world record in her class for the 100 and 200 meter sprint, still is about 1,5 seconds slower on the 100 meter compared to the non-disabled Dutch top athletes. This big difference in times is also visible when the times ran on the Olympic games 2016 are compared to the Paralympic games. The difference between gold Olympic medal winner Usain bolt 9.81 seconds and gold Paralympic medal winner in the T44 class Jonnie Peacock 10.81 seconds is 1 full second. In the final round of the Olympic 100 meter six out of eight athletes finished with a time below the 10 seconds, while Peacock was the only athlete in the Paralympic T44 class final round who was able to finish below the 11 seconds. The difference in time could also be seen in the 200 meter men and the 100 and 200 meter woman[10,11].

Not only are there big differences between the blades and normal legs, there are also big differences between blades itself, which can give certain athletes an advantage. Physiology and biomechanics professor Alena Grabowski studied the advantages from different blades. In her study she compared blades with different parameters: length, stiffness and shape. She found that the

length of the blade did not have any overall effect on the running speed. Stiffness did help the runner, but not on high speed. The stiffness had a positive effect on long distance running rather than sprinting[12].

Grabowski also found that different shapes of blades make a difference in performance. She found that a C-shaped blade is good for long distance running (10 km and more). While a blade in a J-shape would be better for sprinting up to 400 meters. From her research she concluded that the J-shaped blades are 3.8% up till 10.7% faster than the C-shaped ones[13].

4. Envisioning the future

As mentioned in the state of the art, the discussion about the fairness of competing in non-disabled competitions is currently irrelevant. However, in the future this might be different. The Paralympic record (200m sprint) of Malone in 2016 broke the 2012 Paralympic record of Pistorius: 46.68. Furthermore, Malone was not the only athlete close or below the record of Oscar Pistorius. David Behre (46.23) and Hunter Woodhall (46.70) also show that the sport in this category is evolving[8]. In the four years since 2012, there are 3 athletes capable of running times close to the times of Pistorius, whose performance was seen as exceptional[14].

In the future, the complex technology regarding prostheses have very much to offer. Both the attachment between the prosthesis and the amputation stub and the prostheses itself are in development. In the interview with van Gent, he states that currently there is development regarding osseo bone integrated anchord prosthetics, in which the prosthesis is attached directly to the bone instead of with a socket to the amputation stub. While this causes more comfort for the user, it would not have an influence on the sport prosthetics. As van Gent states, there will be forces on the bone it can't withstand, while usually those forces spread over the amputation blunt.

Furthermore, the current sockets are made manually, but there are already machines that can do this fully digitally, by means of a 3D printer. This would increase the speed at which prosthesis sockets can be made. However, this is more expensive. Because the current user-challenge of not enough accessibility of 3D-printers, the transition to digitally made sockets would not be preferable. As this would be a small improvement in terms of efficiency, this is not the real future according to van Gent '*3D printed sockets are physically not better than the current sockets'*. However, as these sockets are 3D printed, there are some possibilities for the future. 3D printing is also being developed, which could result into stronger and/or lighter, but also cheaper sockets. This could have a positive impact on respectively the performance of disabled runners and the accessibility of a prosthetic for the disabled.

There is also development regarding the actual prosthetic, which could have more influence on the disabled runners than the development in sockets. The current seller of the 'flex foot cheetah', Össur, signed an agreement with the Alfred Mann Foundation (AMF) about mind-controlled prosthetics, which only shows how promising but also complex the prosthetics are for the future[15]. The Alfred Mann Foundation is a foundation with the goal "To develop and commercialize innovative solutions for significant unmet or poorly met medical conditions"[16]. Companies like Össur and AMF are based on biomedical engineering, as it's the direct implementation of mechanical inventions regarding the human body. With the promising future for the technology of prosthetics, there is a possibility that in the future, disabled runners outperform the non-disabled runners by an unfair advantage.

However, technology can play a part in this as well. When Pistorius competed in the 2012 London Olympic games, he was tested very briefly to see whether he had an unfair advantage, as there was originally a ban on competing in the non-disabled Olympics with prosthetics. "Based on the study, the group was able to determine that Pistorius' running abilities are very similar to able-bodied runners", as stated in an article from Kaleb Schoolman[12]. Due to this study by Alena

Grabowski, Schoolman is hopeful for the future, as researchers like Grabowski are able to determine that there is no unfair advantage for runners with prosthetic legs.

David James, from the Centre for Sports Engineering Research at Sheffield Hallam University, predicts that Paralympians will soon be outperforming able bodied athletes due to future developments in prosthetics[17]. For example, the increasing possibilities regarding powered knees and ankle joints will increase the speed of a disabled athlete drastically, giving them a debatable unfair advantage.

Altogether, the blade prostheses become more complex in the future which might result into competitions with disabled and non-disabled athletes. On a competitive level, it will require studies that can determine if disabled runners have an unfair advantage, as it will be required that the prosthetics are evolved in a way that the running abilities of the disabled athlete are comparable to non-disabled runners. On a non-competitive level, this could make it easier for disabled people to fit in within a regular sports club. As technology only keeps getting better, this should be achievable in the future.

5. Ethical considerations

Giving everyone a fair chance when competing at a high level in sports is crucial for both athletes and the organizations of the competition. Fair play is next to integrity, responsibility and respect one of the 4 key virtues of ethics required when competing in sports[18]. Although these virtues are stated, there remains a large grey area of what is fair in sports as every athlete is unique and must defeat his opponent in order to win. In which extend you can differ from the rest, with new technologies in mind in the future, is therefore difficult to determine to be acceptable.

At this moment, athletes with a blade prosthetic are rejected from the Olympics and therefore do not have a fair chance to be the best at their field. Since Oscar Pistorius broke records on running blades in the Paralympics, with now his best time 45.07 seconds in 400 meters[19], he comes close to the world record holder of 43.03 seconds run by Wayde van Niekerk[20]. Many experts predict there will be a time Paralympians will outrun able bodied athletes due to the progressive development of prosthetics[21]. As we stated before, in the future nanotube technology might assure producing a similar structure as a biological leg, providing the same amount of energy a full functioning lower limb brings. when sophisticated biomechatronic body parts come to use, it is debatable if disabled athletes can compete against able bodied athletes in the Olympics. However, If the current rate of growth in bionic prostheses is maintained it can't be long before these prostheses outstrip biological function, therefore giving disabled athletes an advantage over abled athletes. When bionic legs are superior to biological legs breaking world records with these prosthetics, a new era might occur where able bodied athletes are willing to amputate their own legs in order to defeat the world record holder in athletics[22]. The problem remains, also in this possible era, that athletes especially with future advanced prosthetics cannot be compared to one another, falling back at the current situation of rules of classification in the Paralympics[23], and disabled athletes like Oscar Pistorius being rejected to participate in the Olympics.

As we stated before, because every athlete is uniquely built, it is possible to organize sports events where there is a difference outcome in the results. However, where can we draw the line of which athletes are allowed to compete against each other in the same competition? Disabled athletes in the category athletics differ from each other due to different parts of their legs replaced with a prosthetic, starting from the beginning of their leg, knee or ankle. This results in a huge difference of how an athlete performs during the competition. According to van Gansewinkel, fatigue can be felt clearly at different parts of your body when comparing your able limb to your leg with prosthetic. "*In my prosthetic leg I feel fatigue first in both my hamstring and buttock whereas in my able leg my ankle is carrying most of the fatigue. Therefore, fatigue is present in a different part of the chain of motion*". Although a subdivision is made by the IAAF (the international organization governing for

the sports of athletics, International Amateur Athletic Federation) between which disabled athlete may compete in which competition, it is unethical one single measure rules above all.

Apart from that, the international Paralympic Committee promotes a more inclusive society for people with an impairment by successfully attracting media attention, stating everyone has a fair chance of competing in the Paralympics. The image this global governing body brings can be seen as challenging stereotypes reducing the social barriers of discrimination against people with an impairment. Outsiders therefore believe the greater good of the greatest number of people is reached, giving everyone a fair chance to participate, also known as Utilitarian ethics. However, studies showed both economic factors and affordability played a crucial role in the participation and success of the Paralympic sports of athletics, where in particular woman living in low to middle income countries had a distinct disadvantage[24]. Although the Paralympic Committee is not assigned to resolve these issues, the image they bring forward is misleading, as it is not fair and equal. We hope to see achievable change in the possibilities for people in low to middle income countries having an equal chance to participate in the Paralympics or changing the unrealistic image the Paralympic Committee lets us believe as fair and equal. The Olympics however, do not put forward an image where everyone has a fair chance to compete in the elite competition. When looking at the chance of winning in both elite competitions, Paralympians have a higher chance of going home with a medal as they are in the minority of possible participants. As van Gent says: '*The very small group that is an Olympic athlete has 1 advantage over regular Olympic athletes: more chance of a medal!*'. Apart from that, although the Paralympic Committee lets us believe there are no social barriers for disabled athletes to train for competitions, disabled athletes do not always have these opportunities. According to van Gent: '*It certainly works in sports that if you are not looked at or judged on prosthesis use, it is very motivating if you can participate with your local acquaintances from a local sports club*' Therefore, able-bodied athletes are in an advantage, as they do not face this problem.

We envision a future where improvements in protheses will be reached on a level they outperform the capabilities of the best abled athletes. It is necessary we start debating these ethical issues in an early stage, as the technology might be advanced in such a way it is unnoticeable for outsiders to judge. Furthermore, another level of rules must be applied when indeed nanotechnology succeeds in creating prosthetics that come close to biological limbs. When the technology in prosthetics is advanced is such a way that in competitions not the athlete itself, but in the end in fact the capabilities of the prosthetics are measured, we believe this is an unethical competition of sports, as you are testing the technique rather than the capabilities of the athlete.

6. Critical reflection

When finding a topic for our position paper we were intrigued by the example of Oscar Pistorius of his running prestation with a prosthetic leg. The fact he comes close to the world record holder of the athletics in the Olympics raised questions within our group of the possible advantage or disadvantage running with a prosthetic leg brings. When reading sources about investigations that already had been done, we concluded mankind still is debating about this issue today. We were curious about investigating ourselves about finding the exact differences running with a bionic leg brings compared to a biological leg. We gained a lot of new information from the people we reached out to and interviewed. Apparently running with a blade causes your whole body to move differently, making it hard to compare and investigate the differences between disabled and able-bodied athletes. According to Marlene van Gansewinkel totally different body parts are affected, lactic acid is built up differently and therefore causes fatigue in different body parts, even the steps you make with a prosthetic leg are totally different then with an able leg. She stated when it is allowed to participate in the Olympics, she would not participate because it can almost be seen as a different competition in sport.

As we are all studying at a Technical University, we were interested in investigating the technique and working of the prosthetics in order to find out what causes the bionic limb at this point to

perform minor to the biological leg. In the beginning we thought aligning a prosthetic leg to a user is a critical process, where every athlete in our eyes was unique. Disabled athletes would therefore lay further away in similarity then able-bodied athletes do. However, due to the interview with Gijs van Gent we learned the basic process of making a prosthetic is in the basic similar for every user, resulting in our vision of the uniqueness of disabled athletes completely different.

When speculating about possible features prosthetics might bring in the future, we learned the future in advanced bionic prosthetics is promising as now seeing protheses being close to fully articulated hands. Although it might be strange to envision a world where disabled athletes become faster, stronger, and quicker than abled-bodied athletes, we think it is important to speculate about what this era would bring. When technological parts take over the human body in a competition, we believe not the athlete, but the capabilities of the advanced prosthetics are measured. The division of athletics in the Olympics we know now therefore remains a competition which is ethically fair as disabled athletes now are not able to participate, even when in the future prosthetics outperform biological body parts.

During this course we have learned looking at a subject matter from different ethical stand points, as well as the importance of doing research before stating conclusions. Also interviewing applicable people regarding our position paper is necessary to support our findings, giving strength to our paper, as actual words and opinions said come over differently than written sources. Looking back at the process of gathering information about people to interview, we forced ourselves in an unfortunate position where people we have asked to participate with interviewing eventually did not respond for quite some time. It turned out we contacted the different kind of orthopedic expert, namely persons who are trained to perform medical surgery instead of an orthopedic instrument maker. Because of this lost time, we had to improvise of who to contact as the deadline of the position paper being finished came close. Eventually by doing more thoroughly research we managed to contact the right persons, where Gijs van Gent replied with thoroughly answers on our questions. In the future we should first do better research in who to contact, together with not underestimating the needed time for interviewing people in these different times with the corona pandemic, as Marlene van Gansewinkel responded rather quickly. In general, we have learned the basics of writing a position paper, seeing stand points from different points of view, learned to not being afraid envision possible outcomes happening in the future, and questioning if even decisions in the sports world have happened ethically.

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Appendix B; Interviews

When reaching out to both athletes performing with a prosthetic leg and experts in the orthopedic field we informed at the beginning of our contact stating our goal of the interview:

Before we start with this interview, we would like to inform you we are gathering information from both people who are an expert or have researched orthopaedics next to people who have been actually using prostheses when doing sports in order to deliver a well-formed position paper regarding an ethical course we are following on the TU/e. Our position paper states the question:

'*Do blade prostheses give adaptive athletes an advantage when competing in the same sport as non-disabled athletes?*'

We will discuss both the pro's and cons regarding running with blade prosthetics with an ethical point of view. The information you will give us during this interview will be used to support our findings of this topic and ultimately add opinions of outsiders to our paper.
Above all we would like you to always feel comfortable answering questions during our interview. We have made the questions keeping you in mind, asking them with respect. When you think you can't answer a question properly because you have the opinion you don't have the authority or simply are not willing to answer it, we totally understand, please let us know when this is applicable.

Interview 1:

Name: Gijs van Gent
Profession: orthopedic instrument maker since 2004

Q1: Could you explain the steps in the process of making and applying a prosthese to a person and how it is adapted to the individual?

A1: "1. Measuring the amputation stub: Possible with a digital scanner, casting. Nowadays always on a liner.

2. Make and fit the first stub socket. Obviously with the prosthesis parts underneath that are selected based on activity level and desired functionality of the customer.

3. Adjustments to the fit of a prosthetic socket are inevitable. The trick is to do this so well that the number of adjustments remains low. So there are fewer visiting times for the customer.

4. If the fit and alignment is okay, a final tube will be delivered, whether or not cosmetically finished.

That is roughly the method. With new amputees, it can certainly take up to 3 months for the customer to walk properly with the prosthesis."

Q2: Is there a big difference in the process of making and applying a (sports) prosthesis for different users? If so, what differences are crucial?

"The fitting methods are no different from how I fit a highly active person or a low-active person: for every amputation level I work, regarding the measuring, according to a fixed method.

The materials to be used - and in particular the purchasing materials - do depend and differ per individual. Everything depends on user purpose.

The socket is the most essential. The better I get it comfortably fitted, the better the acceptance.

The correct volume control is necessary during all activities on a day. That's the main goal. The parts that do not make skin contact are absolutely subordinate to this.

That applies to top athletes, but also the very elderly who move 3m a day. "

Q3: Is there a big difference between the process of making and applying a "normal" prosthesis and making a sports prosthesis?

First of all: (high level) sports prosthesis users are physically in their best years of life. In other words: no underlying physical reasons that make high physical activities out of sight.

This top category therefore also has the best vascular and muscular status. Can therefore tolerate and even appreciate a tighter fitting without becoming uncomfortable.

The geriatric group; in the fall of life, which deteriorate due to e.g. diabetes or vascular disease, this group wants to be able to move mobile and safely, but can tolerate much less tight fitting of prosthetic sockets.

In this target group, the self-healing physical capacity is also low compared to athletes. Creating a comfortable fit that is well tolerated is more difficult than for (high level) athletes.

Q4: What do you think the future looks like with regard to leg prostheses? And do you think this will also affect the prostheses used in sports?

For spectators who look at the prosthesis area and people who only have a contemplative / advisory / sales task in the prosthesis world, 2 things seem completely hot:

- Osseo integrated bone anchord prosthesis,

- measure and produce the sockets fully digitally.

According to these people, that is the future.

If Osseo integration is going to be widely used after amputation, then socket prostheses are unnecessary: even the show around 3d scanning and printing!

Incidentally, Sports with an Osseo integration prosthesis is very risky due to the immense breakout forces at the implant. Those forces on a femur, for example, are already bizarrely high with, for example, a jump load in an intact vital person, let alone if you allow the same jump load on that implant that is not protected by muscle mass!

However, the wearing comfort with Osseo integration is very high for ideal wound healing.

3D printed prosthetic sockets are already available, but they are supplied to orthopedic companies by external companies. This causes logistical delays and financially it remains more expensive than in-house production of the (carbon, glass, nylon) fiber-reinforced casting resin methods, which are still super strong, post-moldable, super lightweight and quick to produce.

If a 3d printer were installed at every location so that you have a new socket in an hour when replacement is needed, there is a profit point that offers perspective.

But at the moment, 3d printing is mainly outsourcing the core of the current profession. Every intermediate layer wants to earn money, so costs per socket are sky-high.

And at what point is the user better off with 3D cartridges? Better wearing comfort? Better volume control? Unfortunately, none of these statements are true in reality.

Q5: Could you give your opinion, based on arguments, about whether athletes with a sports prosthesis have, in general, an advantage over those without a prosthesis?

The very small group that is an Olympic athlete has 1 advantage over regular Olympic athletes: more chance of a medal! People who just exercise with a prosthesis, i.e. who want to exercise in their village or city with their prosthesis, are really disadvantaged compared to people without a prosthesis. Gyms are there for the masses, and unfortunately not equipped for the 'disabled'. Although luckily there are individual initiatives for sports with disabilities locally!

It certainly works in sports that if you are not looked at or judged on prosthesis use, it is very motivating if you can participate with your local acquaintances from a local sports club.

But if you are, for example, a prosthesis runner on a top level, then with a blade prosthesis you are not of the same 'basic material' as a valid athlete. At that price level, where all the details determine the outcome, things will never be normal.

Interview 2:

Name: Marlene van Gansewinkel
Profession: Athlete in the T44 class.

1. **Q: Do your legs feel different after a sprint or run, does one of your legs feel more exhausted for example?**

   A: Both legs are exhausted, my prosthese leg feels however feels more exhausted in the hamstring and buttock area (the upper part), while my normal leg feels more exhausted in the calf (lower leg).

2. **Q: Do you feel like the blade works like a spring for you?**

   A: For me it does not feel like a spring, it is hard to explain what it feels like.

3. **Q: How would you describe the grip of your blade, does it have more or less grip compared to normal shoes?**

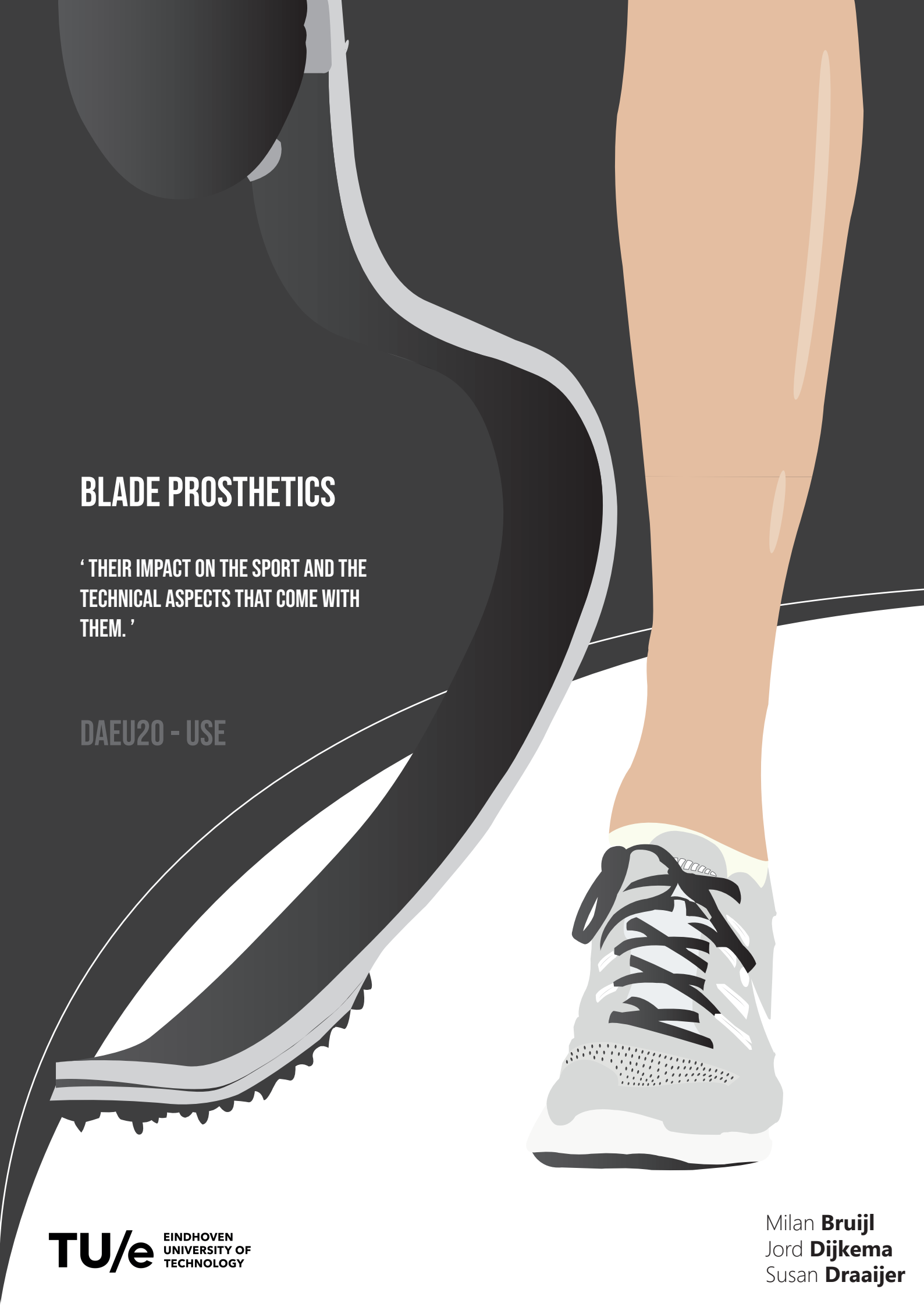
   A: When I wear spike soles on both the blade and my shoe (which is normally the case when sprinting), I feel like I have more grip with my blade. I suppose this due to the fact that there are less materials between the blade and the ground. The blade has its sole glued on it, while there are much more materials between the ground and the sole of my normal foot.

4. **Q: Does running on a blade, in your opinion, give the athlete an advantage compared to athletes with normal legs? And do you have any arguments for or against this.**

   A: I do not think that blades give an advantage. A big part is because of missing the ankle, which gives just a little more while running.
   Furthermore the lactic acid gets divided over a smaller part of the legs, because you miss your lower leg more lactic acid gets produced in your upper leg.
   When running with blades there is also less space for a correction in your step, one bad step can lead to a big deceleration. This is something you can compensate for by using your ankle, but not with a blade.
   Running with a blade is also harder for your knees and hips, because you miss part of the softening factor of the ankle.
   The only advantage I can think of is that you cannot get any Achilles tendon complaints.

5. **Q: Do you think it is fair to let athletes with blades compete with athletes with normal legs? And do you have any arguments for or against this.**

   A: It's a bit like comparing apples and oranges, there are also some little changes in how a race is held. You can let them compete against each other, but it would not be a fair race. As 100 meter world record holder I am still 1,5 seconds slower than the Dutch top athletes.



BLADE PROSTHETICS

‘ THEIR IMPACT ON THE SPORT AND THE TECHNICAL ASPECTS THAT COME WITH THEM. ’

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