

Sports and Technology

Ashutosh Pandey

Abstract

This research article examines the use of technology in sports from a double-edged perspective. This article focuses on some of the remarkable technological advancement which has revolutionized and impeded the sport industry as whole. From introduction of modern technology in training of players to reducing the faults in game through various measures like Video Assistant Referee and Goal Line Technology, the development and implementation of technology in sports has played a vital role in improving the standard of game, for players as well as for spectators. However, only a few research works have been conducted and a minimum of articles have been written on the hindrances caused by those technology and problems with proper implementation of technology in sports. This paper is prepared after in-depth research of news by various sports portals, channels and magazines along with the views of experts of different sports who have recognized the need and development of technology in sports. This paper further elucidates on how the advancement has benefitted and the field of sports with substantial influence on game results by mitigation of errors which were inevitable when technology was not used in past. Based on elucidation of different primary and secondary sources, such as journal articles, newspapers, magazines,

sports portals and events, case laws, statutes, this research article is mostly qualitative than quantitative.

Keywords: sports, performance enhancement, moral issue, technology, quality

Introduction

Advancement and use of technology in sports has always been a hot debatable topic. Theorists, scientists, sportsmen and coaches around the globe have been persistently working to prove their hypothesis, based on facts and instances, as to whether the use of technology is morally and legally justifiable or not. The beginning of new millennium has marked its strong impact in the developing roots of artificial intelligence, innovation, science and technology. In the twenty-first century, science and technology has been an integral part of our life, without which it is very difficult to carry out our day-to-day activities. In that sense, technology has immensely influenced the field of sports. The use of science and technology in sports has been rampant since last few decades and there has also been significant advancement in the technology of sports equipment. The fundamental rationale behind the introduction of technology in sports is to enhance the performance of athletes, minimize injury, improve the quality of sport and most importantly minimize the error in

the game. The advancement in technology in sports went beyond imagination during the 2008 Beijing Olympics when China invested \$ 30 million and aimed to control the weather by breaking up clouds that appeared to have rain in them (Schindel, 2011, p. 1). In recent years, the LED Stumps developed by Bronte Eckermann, an Australian mechanical industrial designer, has also become one of the sensations in cricket industry which has helped improve the quality of game, attract audience and minimize the error to a large extent. Similarly, the tracking systems like MiCoach and Under Armour 39 have been used to assist coaches and athletes to maintain their health in regards to fatigue, overtraining, heart rate, speed, jump height, distance ran and other important health related and performance related information (Oppermann, 2019, p. 1). Apart from these, there has been significant development in performance enhancing body suits and sports wears such as shoes, drugs and sports equipment which is of utmost importance to the players and athletes who are looking forward to maximize their overall performance in their field of sport. It cannot be more rightly contested that the introduction of new technology should be done in such a way as to maintain the justice of decisions and that justice is not the same as accuracy (Collins, 2010, p. 1). However, there are some of the debatable ethical and moral issues revolving around along with the advancement and implementation of technology in field of sports. Some people are against the use of technology in sports, as they believe that it provides an unfair advantage and raises a moral question as to equity of access.

Research Methodology

Amidst the fear of COVID-19 and nationwide lockdown restrictions imposed

by the government, it was impossible to visit the field and collect data. This research article was, therefore, written mainly with analysis of case laws, legislations, news on various sports portals, channels, newspapers and magazines along with expert opinion on different sports. Qualitative methodology is the base of this research article as it deals with collection and analysis of non-numerical data like texts, videos, pictures and sounds. To be more precise, Phenomenological approach of data collection was done where there was use of combination of methods, such as conducting interviews, reading documents, watching videos, or visiting places and events. After that, a case study was carried out which involved a deep understanding through multiple types of data sources collected from phenomenological approach of data collection. Similarly, qualitative data analysis was also done of those extracted data to find the research gap and further research was done as to attempt to fill those gaps. Personal opinions and examples are also included to make this research article more logical and easily understandable. Similarly, comparative analysis was also conducted to better understand the stance of using technology in sports by developed and underdeveloped civilized nations. Precise data have been collected from official websites of the government and sports ministries of various nations, and also from reputed sports channels and websites. Basically, triangulation method of data collection and analysis was carried out so as to minimize error and to produce a better and diverse research article.

Limitation and Significance of Study

Due to COVID-19 field visit and one-to-one interview was not possible, so the research article had to be generated from books and internet sources. Verification of the online

information was a major challenge. Similarly, accessing other nations' sports ministry websites was another. As the research gap mainly revolves around moral and ethical issues, it was hard to access concrete data, facts, figures and articles. The author had to observe the present status of different athletes and financial budget of different nations so as to derive conclusion based on logic, practicality and the in-field experiences of athletes and coaches. Some of the reputed sports journals and research papers were not accessible as they required paid subscription. Hence, they were not referred during the course of generating this research article. The major significance of this research is to explore and accentuate the unnoticed moral aspects of use of technology in sports and also appreciate and strive to introduce those technological advancements in Nepalese Sports for better performance and results.

Technology in Sports: A Double Edged Observation

A number of studies have pointed to a plateauing of athletic performance, with the suggestion that further improvements will need to be driven by revolutions in scientific technology or technique (Balmer, Pleasence, & Nevill, 2011, p. 1075). Introducing the technology in sports has been praised by some clusters of people and also criticized by some. The alteration of sports industry by introducing technology has been one of the ways which has increased the quality of sports, for athletes as well as spectators, and also has helped minimize the errors in the game. There has been notable use of Hawk-Eye Technology in Tennis, Rugby and Cricket since past few years and the Virtual Assistant Referee (VAR) along with Goal Line Technology in Football has taken the game to next level and the audience are

enjoying the sport more often because of the correct decisions being made through use of those technologies. Replay vision and Decision Review are occasionally used in various sports and the advanced swim suits are made of polyurethane which reduces the skin friction against the body, pulls the body in and reduces the cross section area of the body presented to the water, thereby reducing the hydrodynamic drag. The cricket stumps and bails are fitted with LED which lights up when the bails are completely dislodged from the stumps and there are also various camera angles from Spider Cam to Stump Cam and Snick meter which has been designed to aid umpires in making more precise and correct decisions. Similarly, there are high tech computer applicants and training tracking systems used by coaches to keep track of athletes' performance and progress.

However, despite these many advantages, some critics are of view that use of technology in sports is not fair and raises some serious moral questions. Their main argument is that accessing those technologies is expensive and all the athletes and coaches around the globe are not lucky or fortunate enough to have access to them, especially the athletes from poor and developing countries, including Nepal, Bangladesh and Ethiopia. This equity of access favours the elite athletes from elite nations only and disregards the hard work, consistency and dedication of athletes from poor countries who cannot afford those technologies, making the whole competitor unfair and unjust. Sports technology could be considered inappropriate if people can't access it, afford to purchase it, or safely use it (Dyer, 2015, p. 2). Similarly, the technology also seems to be undermining the decision of on-field sport officials, umpires and referees. With frequent review of decisions made

by the on-field referee, the technological advancement has made us question the existence of those officials. Likewise, the technological advancement in sports has provoked some athletes and coaches to adopt unfair means. Precisely, performance enhancement chemicals and technologies have adverse consequences for the athletes and teams.

The Brighter Side

In the report of Research and Markets, one can find that the global sports market reached a value of nearly \$ 488.5 Billion US in 2018, having grown at a compound annual growth rate of 4.3% since 2014, and is expected to grow at a compound annual growth rate of 5.9% to nearly \$ 614.1 Billion US by 2022 (Wood, 2019, para. 2). Similarly, according to another report by Research and Markets, the Sports Technology Market was estimated to be at around \$ 8.9 Billion US in 2018 and is expected to grow at a compound annual growth rate of 20.63% to reach \$ 31.1 Billion US by 2024 (Research and Markets, 2019, n.p.). These numbers reflect the sports market of the entertainment industry in the modern western world in which games have become market products.

Error Minimization

With such huge amount of investment in this sector, there has been significant development in the quality of sports and improvement in performance of athletes. Sports, in modern days, have also adopted certain new mechanisms and technologies that have been of great help to minimize the error, making the game more fair, interesting and just. The Virtual Assistant Referee (VAR), the LED stumps, the Goal Line Technology, the Fully Automatic Time System (FAT) and Video Replay Review are the most widely used

error minimization technology in variety of sports to make the game fair.

Smart Stadium and Auditoriums

Technicians and Scientists have developed the concept of smart stadiums which will incorporate cameras at various angles, better lighting system, replay boards, high speed internet connections for all the spectators. Such genuine infrastructures would help them make the game more interesting for the viewer making it the future of live sports entertainment. Smart Stadiums also provides the spectators and staffs with various other information regarding the stadium like the parking availability, restrooms, concession lines and stands, seat upgrades, gift shops, waiting spaces etc. All these facilities provide a safe and convenient space for the spectators to enjoy the game of any sport.

Injury Prevention and Safety Technology

Various new technologies have also been introduced and implemented to provide safety for athletes and players as to avoid horrific medical conditions and death during game play. One of such primary technology is the Riddell HITS technology helmet which is embedded with multiple sensors that measure the magnitude and direction of impacts to a player's head. The impact data is then transmitted wirelessly to a computer at the bench where it is analysed by the medical team to determine whether the player has a concussion and take that player out of game or not (Chua, 2013, p. 1). Similar to this Riddell helmet there is another technology named as "The i1 Biometrics Impact Intelligence System" which is a mouth guard with built-in sensors to detect excess impact (Chua, 2013, p. 2). Another such technology is the Head and Neck Support (HANS) devices which is basically a U-shaped device placed behind

the neck with its two arms placed over the pectoral muscles of the chest so as to prevent the head of athlete from whipping forward or backward during a crash. To prevent drowning death in swimming pool, there is an Electronic Swimmer Monitoring System designed in the form of wearables (swim suit, wrist band or goggles) which is to be worn by a swimmer. This system measures the time of submersion and if detects the risk of drowning, a monitoring system at the pool will alert the lifeguards on duty (Chua, 2013, p. 2).

Coaching and Supervision

Small body-worn electronic computers have been designed to facilitate the interaction between humans and the computer. These small devices, in the form of Sportswear or Augmented Reality (AR) devices, allows the coaches and training team to conduct hands-free operations, real-time data monitoring, network communication and data analytics. MI Coach and Under Armour 39 are two of those many technologies in which an athlete inserts a small device in his/her shoes or body which will capture the movement of the athlete in each and every direction, also records the total distance and speed every second, tracks the heart rate, calories burned and intensity etc. All of which can be later viewed by logging in into a mobile application or a webpage. Similarly, contrary to manual diet chart and calorie counter, mobile applications like *HealthifyMe* and *MyFitnessPal* have helped athletes, mostly thebody builders, powerlifters, strong mans and weight lifters, and coaches around the globe by tracking the nutrients intake, counting calories, helping in managing weight, suggesting food for weight loss/gain and maintenance.

Better Sport Equipments and Sportswear

Technological advancements have also contributed to manufacture better and advanced sportswears and equipments. People have manufactured equipments, using composite materials which reduce weight while yielding increased strength and extended life spans. Composite materials can certainly be found in high level competitive equipment such as bikes, skis, racquets, bats, balls, golf clubs and other types of gear which are targeted toward the elite competitor (Rosandich, 2000, p. 4). The sports flooring and playing surfaces have also been modified by technological advancement for better performance of athletes. All these advancement and improvements help to make the game more interesting for the spectators, safe for athletes and convenient for the referees and officials.

The Stumbling Block

Despite such advantages, the use of technology in sports also comes with some disadvantages. It is noticed that the problems of introduction of technology in sports emerge only after some time. Hence the technology needs to be embedded, modified and improved several times before it is fully implemented in any sport.

Increased Cost

The advanced technologies and sportswears, for obvious reasons, cost more than usual. This high cost will in turn create a division between the “haves” and the “have nots” and will make the whole sport industry exclusive to wealthy athletes and nations. Every athlete or coaches cannot afford such technology, during training or during gameplay, which will again give an unfair advantage to those elite class athletes who can easily afford

these technologies. Due to high investment in sports technology, the investors also get distracted from sponsoring the athletes out of their choice to invest in technology for profit motives.

Tempts to Cheating

Over the course of time, athletes and coaches have found numerous new ways to cheat mainly in sports like baseball, cycling, running and swimming. Athletes in sports, not only use Performance Enhancing Drugs (PEDs), but also go beyond that and use technology to gain an unfair advantage over their opponents. After many unfortunate situations regarding PEDs, athletes have now begun to look for new innovative and scientific ways to cheating different sports. Technical and mechanical doping are the new forms of cheating that all sport-governing bodies need to acknowledge (Consenstein, 2016, para. 12). Advanced Embedded technologies like the artificial muscles or hidden motors, could someday give athletes another way to cheat in future. A physicist at NASA's Jet Propulsion Lab, Yoseph Bar-Cohen, says that "Electroactive polymers (EAPs) bend and stretch like real muscle fibre in response to an electrical charge; clothing woven with EAPs might augment an athlete's muscle power thereby increasing their performance in an unfair manner" (Aschwanden, 2012, para. 5). This simply means that technology can easily alter the sport equipment and working performance of athletes which gives them an unfair advantage over other athletes. All the governing bodies need to urgently look upon these technologies and immediately take strict action or ban them permanently.

Undermines Field Officials

Technologies like VAR and Video Review have been introduced for the purpose of

minimizing error and reducing the harsh criticisms targeted at on-field officials who have to make crucial decisions in a matter of seconds. However, these technological advancements in sports have resulted in undermining the role of in-field officials and have hindered in the development of momentum in live sport. Umpires and referees should be rewarded, in the form of respect, for their tireless efforts in the field over a prolonged period of time to make the game fair and smooth (Beruwalage, 2019, para 6). So when decisions made by those officials are reviewed again and again, a question arises with regards to the existence of those referees and in-field officials.

Decrease in Interest

Another major disadvantage of technology is that the spectator/audience(s) will lose interest in those sport events which do not support technology. Only those sports which use fancy graphics, technologies and equipments like football, cricket, basketball etc. will be supported by spectators, whereas sports like chess, fencing, snooker, darts etc. which do not use technology will be of less importance and interest for the audience. People will tend to term to those events "boring" and also not respect the athletes who play those sports thereby sabotaging their hard work, dedication and motivation.

The Infamous Moral Issue

The major goal of sport is to empower the youth and engage them in physical, mental and emotional recreation. The sports industry basically demands demonstration of skills which will possibly excite the spectators, but in only such environment which creates equality for the contest. When the technology interferes with the sports, it provides an unfair advantage to those elite class athletes

who can easily afford such technology, be it in the form of training, nutrition, equipment or body wear. If the technology has been employed with questions of unfairness or negativity surrounding its use, this has also been termed as *techno doping* (Wolbring & Tynedal, 2013, p. 177). Such effects of techno doping have affected not only Olympics but also Paralympics. The materials used in assistive technology in Paralympics vary from person to person. Nevertheless, mostly the elite athletes would take a maximum of advantage of techno doping because only they could afford it easily.

A 2017 record breaking marathon race of 36 year old Kenyan runner Eliud Kipchog attracted more negative controversies rather than a celebration of remarkable athletic performance. In the event, he was found wearing a brand new pair of custom running shoes with added airbags and more carbon fibre plates. Those shoes were called the “alphaFLY” and was specially designed by Nike that included three carbon fibre plates and four pods of air or foam that were designed to make running more efficient (Burgess, 2019, para. 28). An instance like these goes against the ethics and demotivates the athletes who could not get hold of the advanced sport wear or equipment and are left with a competitive disadvantage. Hence, the need of further in-depth research and regulatory body or mechanism to limit the use of excessive technology is indispensable. The aftermath of Eliud Kipchog’s controversial run raised a serious question upon the spirit of the universality of athletics as those shoes were specially designed by Nike for him, which allegedly gave him an unfair advantage.

The International Association of Athletics Federations (IAAF’s) Rules and Regulations

has provided under Rule 143 (2) that “the shoes used by athletes must not be constructed so as to give athletes any unfair assistance or advantage and any type of shoe used must be reasonably available to all the athletes in the spirit of the universality of athletics.”

Similarly, in 2012, a South African sprinter, Oscar Leonard Carl Pistorius (“Blade Runner”) became the first double amputee participant to compete in the Summer Olympics. For the run, he used a J-shaped carbon-fibre prostheses called the “Flex-Foot Cheetah” which is developed by biomedical engineer Van Phillips and manufactured by Össur (Birthday Wiki, 2020). However, controversies sparked globally in regards to the prostheses which people believed, will give an unfair advantage to Oscar over sprinters with biological legs during the run.

Before that, in January 2008, he was banned from the able-bodied sport events by the International Association of Athletics Federations (IAAF) because his prostheses were ineligible for use in competitions conducted under Rule 144.3 (a & c) of IAAF which prohibits the use of any technical device that incorporates springs, wheels or any other element that provides the user with an advantage over another athlete not using such a device (Mr. Oscar Pistorius v. International Association of Athletics Federation, 2008, p. 145). He then lodged an appeal in the Court of Arbitration for Sport (CAS) in Lausanne, Switzerland against the decision. After a two-day hearing, on 16 May 2008, based on substantial lack evidence that Oscar had any net advantage over non-disabled athletes, the CAS upheld Pistorius’ appeal and the IAAF council decision was revoked with immediate effect (Mr. Oscar Pistorius v. International Association of Athletics Federation, 2008, p. 163).

Following the aftermath of Oscar's run in 2012 Olympics, Rule 144.3 (d) of the IAAF now considers that prostheses are a form of mechanical aid and the burden of proving that the mechanical aid does not provide the athlete with an overall competitive advantage over an athlete not using such an aid rests with the athlete who wishes to use it.

Similar incident happened recently with a double-amputee sprinter, Blake Leeper. In this case, the CAS ruled that "Leeper could not compete in any World Athletics-sanctioned events, including the Olympics, because his prostheses enable him to run at a height that is several inches taller than his maximum possible height if he had intact biological legs" (Blake Leeper v. International Association of Athletics Federations, 2020, p. 108). On a brighter side, the court reversed the rule requiring the athletes to bear the burden of proof that they do not have an unfair advantage is "unlawful and invalid" and hence the burden of proof, will now, rest upon World Athletics (Blake Leeper v. International Association of Athletics Federations, 2020, p. 100).

Sports Budget Analysis

In a particular country, the budget allocated for the sports sector plays a vital role in improving athletes' performance and development of technology in sports. The actual ethical issues as to use of technology in sports arise only when there is a significant numerical contrast in total amount of capital invested on sports industry by different countries. In simple words, funds are directly proportional to athletes' performances. When the government or other regulatory body invests tremendous amount of capital in sports, athletes get better and advanced sports equipment, technological driven

training, coaching and dieting which will in turn keep them in a dominant position compared to those who get normal training, coaching, dieting and equipment. Hence, we now need to scrutinize upon the sports budget of different developed and poor nations to better understand this ethical issue and the advantage of use of technology in sports.

Chinese Sports sector is regulated by a government agency named as The General Administration of Sport. In 2018, this body estimated budget for sports was around 352.2 Billion Yuan which is more than \$ 53 Billion US (Pande, 2020, para. 5). Similarly, in the fiscal year 2020/21 Indian government allocated Rs. 2826.92 crore (around \$3.8 Billion US) which is an increase of Rs. 50 crores from the budget of previous fiscal year 2019/20 (The Economic Times, 2020, para 1). In United Kingdom, the government agency responsible for investing in sport is UK Sport and on 2018 it has announced an investment of around £345 million for the Summer Olympic and Paralympic Sports and around £24 million for the Winter Olympic and Paralympic Sports (UK Sport, 2018, para. 1). Japan's Ministry of Education, Culture, Sports, Science and Technology has separated 35.1 Billion Japanese (\$337 Million US) Yen for the sports industry which is increase in 1.1 Billion Yen from the past fiscal year of 2019/20 (MEXT, 2020, para. 15). Lastly, even though the United States Federal Government does not provide any funding from sports, the total fund used by American sports sector, athletes and the United States Olympics & Paralympics Committee in 2019 was roughly around \$385.4 Million US (Pande, 2020, para. 5).

In 2018, the Ministry of Sports of Somalia allocated a total of \$0.7 Million US (0.2% of total budget) to support youth activities

including sports (UNICEF, 2018). Brazilian President Jair Bolsonaro's government proposed the investment in sports be \$ 55 Million for 2020, which is almost half of the budget proposed by Michel Temer in previous fiscal year of 2019/20 (Mann, 2019). In the budget of Kenya, Cabinet Secretary for National Treasury and Planning proposed a total amount of approximately \$125 Million US for sports, culture and arts for the year 2020/21, citing a reason that they are among the areas that contribute immensely to the country's economic development (Ayodi, 2020). Similarly, while presenting the fiscal budget of 2020/21, the then Finance Minister of Nepal allocated NRs 2.36 Billion, around \$20 Million US, for youth and sports sector which is a decrease from the previous budget of NRs 3.99 billion allocated for the fiscal year 2019/20 (The Himalayan Times, 2020, para. 1).

In Nepal, the most common sports include cricket, football, volleyball, swimming and athletics. Nepal had, for the first time, participated in the summer Tokyo Olympics at 1964 but till date has not been able to win any Olympic medals. Recently, with a whopping budget of NRs. 5.25 Billion, Nepal hosted the 13th South Asian Games on 2019 and also managed to win 206 medals, 51 gold medals, 60 silver medals and 95 bronze medals. For the aforementioned sport event, the Youth and Sports Ministry of Nepal had estimated the budget of around NRs. 881 million for preparing the Nepalese National Team (Oli, 2019, para. 4).

It is evident that there is a vast difference between the sports budget allocated by the developed countries like USA and China and developing countries like Somalia, Kenya and Nepal. This leads us to an assumption that the athletes of poor and developing countries

are not getting those advanced training technology and performance boosting sports kit which can be easily afforded by the athletes of developed nations providing them an advantage to excel in their field of sports.

Conclusion

All these instances across the globe suggest that there are certain grey areas where the concerned authorities shall scrutinize upon and resolve issues. Despite a bonafide purpose of introducing technology in sports, it has yet been an emerging challenge to make it more organized and easily accessible for all the athletes irrespective of their economic standards. The development of technology was to protect athletes, minimize error and improve performances. However, some moral and ethical issues relating to high cost and availability/accessibility has led to defame the same technology which revolutionized the sports world.

Recommendations

Recommendations would be explicitly for the government and the concerned sports authorities to invest more budgets on youths and sports so as to facilitate the athletes with better equipment, training methods, diets and sportswear. The national and international investors shall also take notice of this area and work accordingly to strengthen the technological advancement in the field of sport. The newest technology and equipment must be available to the athletes by their concerned government so as to boost their confidence and improve their performance.

Similarly, the International Association of Athletics Federations (IAAF), Federation Internationale de Football Association (FIFA), International Cricket Council (ICC), International Golf Federation (IGF),

International Olympic Committee (IOC), International Paralympic Committee (IPC), World Anti-Doping Authority (WADA), Australian Sports Anti-Doping Authority (ASADA), the United States Anti-Doping Agency (USADA) and every other international sport governing bodies shall make and implement necessary rules/laws to promote the sportsmanship spirit and to ban those technologies which help athletes in an unfair manner or is not easily available to all the players. With proper regulation and research, the use of technology can be of great assistance and can be the boon for sports industry.

References

- (2018, December 3). Retrieved from UK Sport: <http://www.uk sport.gov.uk/news/2016/12/08/goal-set-for-tokyo-2020-as-investment-figures-are-announced>
- (2020, February 1). Retrieved from The Economic Times: <https://economictimes.indiatimes.com/news/sports/government-allotates-rs-2826-92-crore-to-sports-budget-rs-50-crore-increase-from-last-year/articleshow/73839805.cms>
- Aschwanden, C. (2012, July). The Future of Cheating in Sports. *Smithsonian Magazine*. Retrieved December 20, 2020, from <https://www.smithsonianmag.com/science-nature/the-future-of-cheating-in-sports-138914769/>
- Ayodi, A. (2020, June 12). *AllAfrica*. Retrieved from <https://allafrica.com/stories/202006120227.html>
- Balmer, N., Pleasence, P., & Nevill, A. (2011). Evolution and Revolution: Gauging the impact of technological and technical innovation on Olympic performance. *Journal of Sport Sciences*, 30, 1075-1083.
- Beruwalage, V. (2019, April 24). *Does technology in sport undermine the role of on-field officials?* Retrieved from The Stand: <https://thestand-online.com/2019/04/24/does-technology-in-sport-undermine-the-role-of-on-field-officials/>
- Birthday Wiki. (2020, October 13). *Quick Facts Of Oscar Pistorius*. Retrieved from Birthday Wiki: <https://birthdaywiki.com/oscar-pistorius/quick-facts>
- Blake Leeper v. International Association of Athletics Federations, CAS 2020/A/6807 (The Court of Arbitration for Sports (CAS) October 23, 2020). Retrieved from https://www.tas-cas.org/fileadmin/user_upload/Award_6807__for_publication_.pdf
- Burgess, M. (2019, October 14,). *The incredible science behind Eliud Kipchoge's 1:59 marathon*. Retrieved from Wired UK: <https://www.wired.co.uk/article/eliud-kipchoge-ineos-159-marathon>
- Consenstein, I. (2016, February 29). *The technical side of doping*. Retrieved from The Varsity: <https://thevarsity.ca/2016/02/29/the-technical-side-of-doping/>
- Chua, J. (2013, June 18). *Sports Technology Blog*. Retrieved from <https://sportstechnologyblog.com/2013/06/18/safety-technology-in-sports/>
- Collins, H. (2010). The Philosophy of Umpiring and the Introduction of Decision-Aid Technology. *Journal of the Philosophy of Sport*, 37, 135-146.
- Dyer, B. (2015, September 18). The Controversy of Sports Technology: A Systematic Review. *SpringerPlus*, 4.
- Editorial Board. (2020, May 29). Government cuts sports budget heavily. *The Himalayan Times*. Retrieved from <https://thehimalayantimes.com/sports/government-cuts-sports-budget-heavily/>

- Mann, R. (2019, September 27). Budget Proposal for 2020 Cuts 49 Percent of Investment in Sports. *The Rio Times*.
- MEXT. (2020). FY2020 MEXT General Budget Highlights. Tokyo: Ministry of Education, Culture, Sports, Science and Technology.
- Mr. Oscar Pistorius v. International Association of Athletics Federation, CAS 2008/A/1480 (The Court of Arbitration for Sports (CAS) May 16, 2008). Retrieved from <http://www.austlii.edu.au/au/journals/ANZSportsLawJl/2008/7.pdf>
- Oli, P. (2019, June 17). A whopping Rs 5.26b budget proposed for South Asian Games. *The Kathmandu Post*. Retrieved from <https://kathmandupost.com/sports/2019/06/17/a-whopping-rs-526b-budget-proposed-for-south-asian-games>
- Oppermann, D. P. (2019, November 29). Retrieved from The Innovation Enterprise Ltd: <https://channels.theinnovationenterprise.com/articles/how-technology-is-changing-contact-sports>
- Pande, A. (2020, February 2). Retrieved from 4Play: <https://4play.in/stories/sports-budget-2020-olympic-year-khelo-india/>
- Research and Markets. (2019). Sports Technology Market by Technology (Device, Smart Stadium, Esports, Sports Analytics), Sports (Soccer, Baseball, Basketball, Ice Hockey, American Football/ Rugby, Tennis, Cricket, Golf, Esports), and Geography - Global Forecast to 2024. Markets and Markets.
- Rosandich, T. (2000). Sports Equipment and Technology. International Seminar for Sport and Social Inclusion. Sao Paulo, Brazil.
- Schindel, A. (2011, July 26). Retrieved from Bleacher Report: <https://bleacherreport.com/articles/773227-20-ways-technology-makes-sports-better>
- UNICEF. (2018). *Citizen' Guide To The 2018 Budget*. Mogadishu: The Budget Directorate, Federal Ministry of Finance. Retrieved from [https://www.unicef.org/esaro/Citizens_Budget_in_Somalia_\(2018\).pdf](https://www.unicef.org/esaro/Citizens_Budget_in_Somalia_(2018).pdf)
- Wood, L. (2019, May 14). Sports - \$614 Billion Global Market Opportunities & Strategies to 2022 ResearchAndMarkets.com. *Business Wire*. Retrieved from: <https://www.businesswire.com/news/home/20190514005472/en/Sports---614-Billion-Global-Market-Opportunities-Strategies-to-2022---ResearchAndMarkets.com>
- Wolbring, G. & Tynedal, J. (2013). Pistorius and the media: missed story angles. *Sports Technology*, 177-183.