POLITECNICO DI MILANO

Management Engineering Department

DIGITAL INNOVATION IN THE SPORT INDUSTRY: THE CASE OF ATHLETIC PERFORMANCE

Supervisor: Prof. Emanuele Lettieri

Co-advisors: Claudio Rorato

Sara Zagaria

Master Degree Thesis of:

Federico Iannella 841783

Andrea Morandini 858842

Academic year 2015/2016

Summary

Immages Summary

Chapter 1. The big picture

Chapter 2. Athletic Performance: a framework of analysis

Chapter 3. Methodology

Chapter 4. Case Studies

Chapter 5. Conclusions

Appendix

Abstract

Questo lavoro di tesi si prefigge l'obiettivo di indagare il contributo che le innovazioni tecnologiche digitali hanno apportato al settore sportivo delle performance atletiche. Grazie ad una classificazione delle più importanti tecnologie che stanno caratterizzando e rivoluzionando l'industria sportiva negli ultimi anni, viene predisposta una descrizione dettagliata del settore riguardo ad aspetti geografici, tecnologici, motivazionali, economici, oltre ad individuare i trend più importanti ed identificare le analogie e i tratti distintivi tra chi utilizza le innovazioni tecnologiche (atleti e teams) e chi invece le propone (vendors). L'analisi della letteratura ha permesso l'identificazione delle tecnologie come una delle principali fonti di innovazione del settore sportivo, ed è stata poi affiancata anche dallo studio degli attuali trend di mercato per ritrarre un quadro completo del ruolo dell'innovazione digitale nel settore. Sviluppando il modello dell'Osservatorio DigitalSport del Politecnico di Milano, sono state evidenziate 4 macro aree di implementazione dell'innovazione digitale: Athletic Performances, Sport Clubs, Fan Experience, Sport Institutions and Event Management. Il focus della ricerca è stato quindi poi verticalizzato su Athletic Performance, in quanto riconosciuta come area più proficua e dove le tecnologie digitali evidenziano un ruolo chiave. Dopo aver constatato l'assenza di un modello specifico in grado di gestire tale ambito di analisi, è stato proposto un modello originale focalizzato sulla classificazione delle diverse soluzioni digitali presenti in questa area. In questo modo si è potuta strutturare una struttura di ricerca per indagare il ruolo che le tecnologie assumono nel ambito delle performance atletiche, i benefici che portano, i trend futuri, il possibile impatto economico, i meccanismi di innesco, le barriere che le ostacolano, le differenze geografiche ed il ruolo che svolgono sulla motivazione dell'atleta. In particolare per approfondire alcuni di questi aspetti sono stati poi proposti 10 studi di caso, in cui gli aspetti rilevanti sono stati analizzati anche grazie al nuovo modello sviluppato. Il risultato di tale elaborazione è stato poi incrociato con le diverse funzioni d'uso evidenziate nella prima parte della tesi, rilevando inoltre i futuri trend e le azioni necessarie per raggiungere i possibili miglioramenti sia a livello tecnologico che a livello di esperienza d'uso per l'utente finale, in modo da fornire spunti interessanti che guidino la crescita di questo settore.

Abstract

This thesis aims to investigate the contribution that the digital technological innovations have brought to the athletic performance in the sport industry. Thanks to a classification of the most important technologies that are shaping and transforming the sports industry in recent years, a detailed description of the environment is carried out with regard to geographical, technological, motivational and economical aspects; as well as identify the most important trends and the similarities and the distinguishing features among those who use technological innovations (athletes and teams) and the vendor of the solutions. The analysis of the literature has allowed the identification of technology as a major source of innovation in the sports sector, and it was then also combined with the study of the current market trend to portray a complete picture of the role of innovation in the digital industry. Developing the model created by the Osservatorio DigitalSport of Politecnico di Milano, 4 major areas of implementation of digital innovation have been highlighted: Athletic Performances, Sport Clubs, Fan Experience, Sport Institutions and Event Management. The focus of the research was then deepened on Athletic Performance, as it was recognized as the most successful area where digital technologies show a key role. After having verified the absence of a specific model able to manage this area of analysis, it has been suggested an original model focused on the classification of different digital solutions in this area. In this way it was possible to structure a research structure to investigate the role that technologies assume in the sphere of athletic performance, the benefits they bring, future trends, the potential economic impact, the triggering mechanisms, the barriers that hinder them, the geographical differences and their role on the athlete's motivation. In particular to investigate some of these aspects, 10 case studies have been introduced, in which the relevant aspects were also analysed thanks to the new model developed. The result of this elaboration was then crossed with the different user functions identified in the first part of the thesis, highlighting also future trends and the actions needed to achieve improvements both technologically and in terms of user experience, to provide interesting insights to lead the growth of this sector.

Introduction

Improve yourself, run faster, hit harder, get there before your opponent. Talent, spirit of sacrifice, determination, self-sacrifice, all qualities that transform athletes into champions, and performances in records that remain in the annals. In sports, the athletic performances play the fundamental role.

It is in this area that, today more than ever, the digital innovation is at sport industry's disposal. Wearables, data tracking, video analysis, cognitive computing and AI are redefining the shape of this area. Gone are the days where step counting is considered 'data', athletes and coaches now want to exploit innovative solutions to their training program in order to set them apart. In last few years new professional profiles are born, as nowadays an analytics function is almost mandatory in every top-level sport Club. Advancements in this sports science data combined with advanced tools and technology will push the physical boundaries of athletes' bodies, allowing them to train, recover and move more efficiently.

But in order to fully exploit this change, we must first understand it. And here comes our thesis.

- What are the benefits, motivations and strengths related to their use of digital innovation to monitor athletic performance? What are the differences between pro-level athletes and amateur ones?
- Is it possible to understand the cognitive framework on the current and future use of technologies in this sector?
- Can we identify the main existing reference models?
- Are there in the industry several best practices to verify adherence to these models?
- Is necessary to develop a new rational framework along the lines of what has emerged from the research?

These are the questions that we set initially. The scope of analysis, however, is very innovative, and it is therefore necessary to define a precise path, and tackle it step by step as every race, to find the answer to our questions.

Our journey was thus developed as follows:

- The first step was to describe the Big Picture of digital innovation in the sport industry. Following the model suggested by the Osservatorio DigitalSport of Politecnico di Milano, we found out that in this area the role of digital innovation is divided into 4 main areas: Sport Clubs, Fan Experience, Sport Institution and Event Management, Athletic Performance. In this first part, we therefore wanted to provide an overview of the various ways in which the digital innovation is related to the first three macro-areas.
- An important step forward was to move our focus on the real core of our thesis: the athletic performance. The application of digital innovation to sport is integral to athlete development and performance and can be applied to sports science, performance analytics, coaching and training, rehabilitation and generally every discipline related to athletic performances measurement. Such richness of fields of application means also facing a complex and multifaceted topic: there are different needs of skills and abilities to be tested, different stakeholders for data measured, different technologies collecting those data and different diffusion for each technology.

In order to overcome this complexity, we developed a comprehensive model, which allowed us to categorise all the different digital innovations existing in the sphere of athletic performance highlighted in our research. At this point in our journey, however, we realized that in such an innovative and disruptive environment, to provide an effective description it was necessary to go one step further: we must provide a more detailed and defined assessment of the role of digital innovation with information not extractable from literature review.

- The following step was then to introduce in our thesis a new method of analysis: the Case Studies. Indeed, many operative topics can't be extrapolated by general inquiries, but rather are visible only gathering the opinion of whom works day by day in this industry: the vendor of digital solutions and the users of such solutions, the athletes. Through direct contact with their opinions, their experiences and their reflections, our work has been enriched in many ways: we understand how is configured the match of supply and demand within this sphere, highlighting its strengths and weaknesses. We were able to confirm the truthfulness of what said at the theoretical level, and in particular the validity of the developed model. We deepened the concepts emerged in the first part of the thesis, bringing out a more accurate figure regarding the underlying reasons for the choices made by the athletes, the various barriers still present in many aspects related to sports and the feeling coming directly from the protagonists of this industry.
- With the progress of our analysis, we also increased our awareness of what were the real key aspects at the root of our scope of research. Indeed, in other words, this race has finally brought us to reach our ultimate goal: the conclusions. Here, the results of our research were summarized through 10 research questions that we answered. Each of them shows a fundamental concept to fully understand the evolution of this environment, in order to have then the right tools to be able to make the most of it. The answer to our questions was already there, the real goal has been being able to find it.

Chapter 1.

The big picture

The goal of this first chapter is to provide an overview of the sports phenomenon, declined in various fields, in order to achieve a better understanding of the internal forces in this market.
The definition of sport, in terms of its contribution to economic growth, is the broad '*Vilnius definition'* [1], according to which sport includes all upstream industries that produce goods, services and works needed for sport, and the downstream industries in which sport has a significant input, like media, facilities, advertising, etc.
The sport industry is characterised by constant and rapid waves of innovation, which it is providing a heavy contribution to the upgrading of the industry, often in close collaboration with other industries (textiles, electronics, aerospace, etc.). Innovations have made sport technology a leader in several fields of applied science: textile technology, mechanics of human motion, new materials, sensors, actuators, human-oriented design, automation and others. In particular, our focus will be on digital innovation, which is providing a whole range of supports and drivers of change in this environment, and has gained the role of enhancer, being an important driver of productivity and competitiveness.
It will therefore be important to understand the contribution of digital and technological innovation in this industry, highlighting the pressures for growth and new business opportunities that have opened up, even considering some examples of particular importance related to the introduction of new technologies in different areas.

1.1 A new reference model

Studying different theories, there is not a model that reports this interpretation focusing on these parameters: the sport market from the viewpoint of digital innovation.
Today one of the few existing models related to the world of sport is the one developed by **ATKearney** [2], a relational financial-economic model, which on one hand gives us the idea of the power of this industry, but on the other still does not explain how the relations are changing through digital innovation.

---

[1] The Vilnius Definition is the statistical definition of sport agreed by the EU Working Group on Sport and Economics in 2007. It distinguishes between a statistical, a narrow and a broad definition of sport as follows:

- Statistical Definition: "Sporting activities", the only part of the sport sector having its own category.
- Narrow Definition: all activities which are inputs to sport (i.e. all goods and services which are necessary for doing sport) plus the Statistical Definition.
- Broad Definition: all activities which require sport as an input (i.e. all goods and services which are related to a sport activity but without being necessary for doing sport) plus the Narrow Definition.

[2] Leading global management consulting firm with offices in more than 40 countries

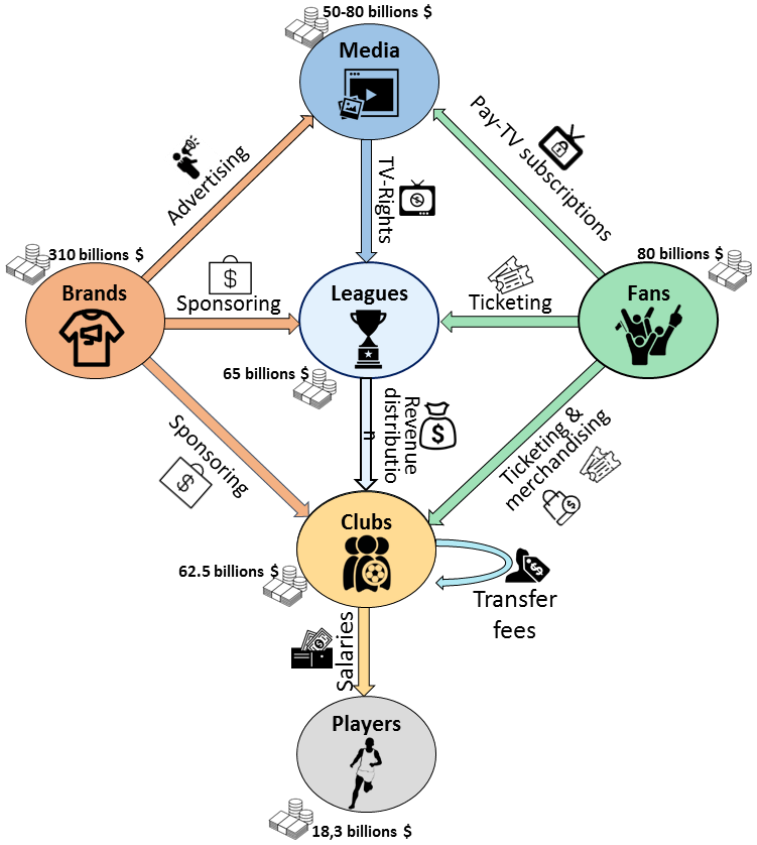


Figure 1. 1

The sports market comprises a number of sub-markets ranging from advertising and Pay TV subscriptions to ticketing and sponsoring. This model highlights the different relations that are set within the sports world, showing the major players involved in the valorisation and the different economic flows that are established between them.

We tried, through a careful analysis of the literature, to further specify the economic importance that these actors have on the system: in this way we have been able to **quantify** the total value of each player described in the ATKearney model, providing an even deeper understanding of the different weights that each sphere has on the total sport market. We additionally built a schema to remark the economic importance that this sector has assumed both globally and specifically within our national system:

Figure 1. 2

As we said before, these diagrams are useful because they make us understand the power and value of the sector, but at the same time their picture of the sport market is only partial because it does not consider the evolutionary lines on which these relationships, also on the level of value, may change. In particular, we want to investigate if there is a positive **relation between sport market growth and digital innovation**, since we realized that digital innovation within the sports world is impacting significantly and beginning gradually to spread among the sport fields, both the most popular and niche ones. We find it therefore necessary to introduce a new interpretation of this topic, mainly focused on the relationship between sports system and digital innovation as the enabler for the upgrading of the sector. Following what we said, we introduce a model based on 4 main macro-areas, derived from the analysis made by the Osservatorio DigitalSport.

This model is an **original model** as it emphasizes an aspect of this area that has not yet been analysed as a whole, since there are no literature models that depict how digital innovation works within sports industry, despite the digital innovation itself is often a subject of debate. It also helps us understanding how the industry is upgrading, where the update comes from and what are the main areas of innovation, all of which are not considered in the previous ATKearney model, that does not show how the value of innovation is generated and from where this value is resulting. This is extremely important in a sector with such a high significance, and that is also the reason why our model is conversely digital-based:

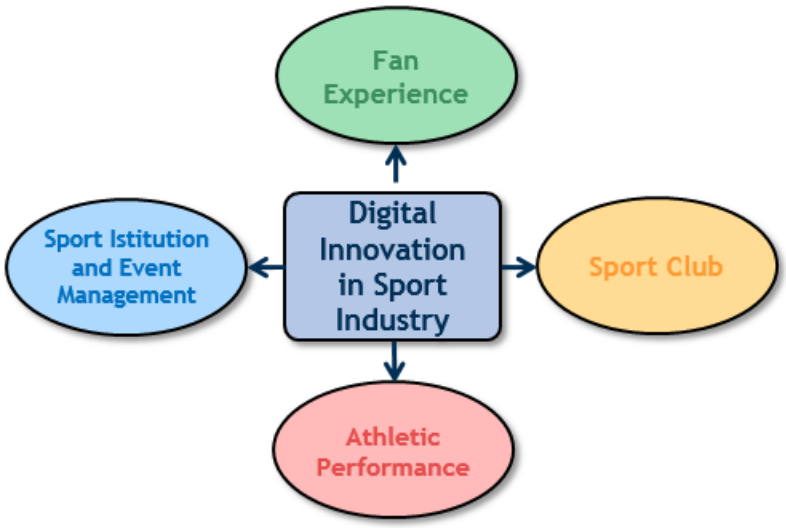


Figure 1. 3

The perspective of the model shown is based on the division of the analysis into **four** distinct **macro-areas**, that together are able to describe the whole big picture of the digital innovation in the sport industry. The classification criterion is defined through the identification of who are the end-users of the digital innovation:

- **Sport Club:** in this area we will analyse the role of digital innovation in the organization of the club, in particular focusing on the asset management of the athletes, the team staff and the employees.

- **Fan Experience**: the new digital technologies are transforming the world of fan experience, in particular by opening new business models regarding ticketing, media consumption and sponsorship. Moreover, the fan experience through technology is evolving into an expansion of the interaction of the fans with their teams and favourite players, contributing both to the raise of new ways of relationship and to stimulate the merchandising market.

- **Sport Institution and Event Management:** sports institutions, managers of sports facilities and sports organizers have had to interface with digital innovation, so as to manage the threats and capitalize on new opportunities in their respective fields. For instance, the "smart arenas" are one of the areas where the digital innovation has shown the strongest disruptive impact.

- **Athletic Performance:** the world of athletic performance has always been in a very strong relationship with technology, so it was heavily influenced by the digital innovation. The need for improvement in performance increase more and more: from this comes the desire to measure the ability of the athletes, to understand their limits, to optimize rehabilitative post-injury processes. That is the reason why this topic will be the main focus of our thesis, developed in the second chapter: we must remember that health and the preservation of the athletes is also the natural consequence of an economic interest. We will point out that athletes are a capital asset of companies and sponsors, who invest significant money on them.

This model is suitable to describe an emerging market which is beginning to extend the reach of management software adapted for sports organisations. Increasingly, developers are exploring and exploiting the vast potential of technologies and ICTs to create data driven value in several areas of sports management. Technology in this field functions in a number of ways: data acquisition/ management (big data), communication, online interaction, race monitoring, results display, access control and adapted software. Increased use of technology in sports management is due largely to the growing professionalization of sports firms and clubs, while the importance of sport broadcasting has contributed to improved monitoring and virtual representation of athletes. Technological advances have helped creating management and communication solutions which have become increasingly commonplace in many of today's sports-related fields. This phenomenon will be even stronger since sport is known as an early adopting market, which provides interesting cross-sectoral innovation opportunities to/from other markets. In recent years this resulted in the development of a cross-sectoral consumer goods innovations but also of cross-sectoral collaborations of technologies. Given their increasing use and further potential, it is fair to predict that sports management is going to demand this growing range of innovations and technology from different fields**: apps, Internet of Things, new models of cameras, augmented and virtual reality, software platforms.** In the next sections, we are going to give a general overview of each of the first three macro-areas, profiling also those areas with the specific killer innovation that are impacting in each field analysed, exploiting the possibilities given by the different technologies listed above.

Recap

- In the sport industry, a model showing the relation between sport market growth and digital innovation is still missing.
- We introduced a model based on 4 main macro-areas, derived from the analysis made by the Osservatorio DigitalSport.
- The new model is divided into Sport Clubs, Fan Experience, Sport Institution and Event Management and Athletic Performance.

Figure 1. 4

1.*2 Sport Club*

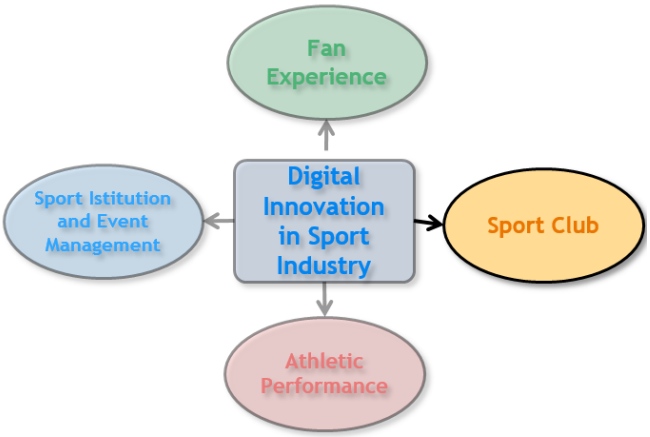


Figure 1. 5

In this section, we are going to give a general overview regarding the area of the Sport Club. We divided the following description into four parts, embracing all the different figures that characterize this first area. In particular, the element that we want to describe is the management of the different relationships between **individuals**, ie those who are the real protagonists within a club sport. For each part, a section of our analysis is focused on what typology of technology is impacting on that specific figure and the advantages related to its use:

- a first analysis regarding the relation between **athletes and coaches** inside a sport club, highlighting the support given by the new management platform developed specifically them;
- a second analysis on the current situation of the **employment** in sport clubs, focusing in particular on the new professional profiles that combine together athletic and technological knowledge;
- a third section on the **diffusion of physical activity** among the population, in order to outline the different personas interested in sport activities, and the new business opportunities enabled by digital technologies for sport centres;
- a final examination about the management of one of the most valuable sources of value for a Sport Club: the **sponsoring.**

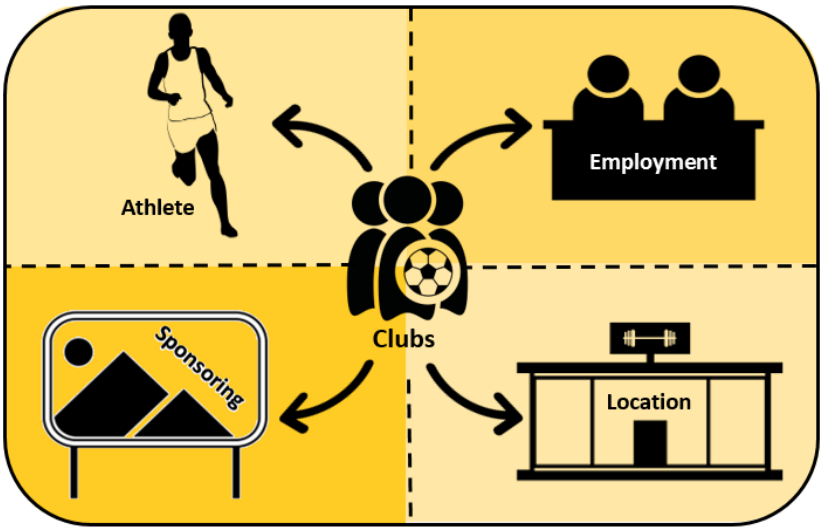


Figure 1. 6

1.2.1 Athletes and team management

In the analysis of literature and research about this topic, the global data are often absent or very uncertain and sometimes even contradictory between them.
Regarding the top 300 clubs3 in the world, we can calculate a global average that amounted to $ 54.9 million. These revenues originate 40% from sponsorship, 30% from marketing and merchandising, 20% from ticketing and 10% from player transfer. Analysing also the world of athletes as an economic player, considering only the professionals from the 333 more profitable clubs of 16 leagues, they amount to be about 9,731 with an average pay of $ 1.88 million, for a total of $ 18.3 billion.
To better understand what the key features within this area are, it is therefore necessary to narrow the field of analysis so as to obtain more data structured in depth. Therefore, we will now analyse in greater detail the situation at Italian level.
Referring to the Italian data collected by ISTAT in the 2015-2016 biennium regarding the inclination to practicing sports, the sports movement in Federations marks an overall increase in the number of registered athletes (+ 1.4%) and it is characterized by the growth of almost all categories of membership and the decrease in the number of sports clubs affiliations.

There are several factors that led to this increase:

- the introduction of new sports disciplines;
- the launch of new sports promotion campaigns to facilitate the knowledge and practice of their own sport;
- the increased visibility achieved through the organization of sporting events of high national and international level which have aroused interest in some sports and new passions;
- the continuation of the sports promotion projects in schools addressed to young people with the aim of involving them in playful, educational and recreational activities in sports and then bring them closer to the Federations;
- incentives and advantages provided for certain categories of membership and new forms of enrolment.

In addition to the athletes, even the number of coaches has witnessed a significant increase (+ 4.5%). These two trends are in some way linked together, since in recent years there has been a more stable and consolidated growth in the membership of the athletes when federations have **invested more on the training** of the supporting staff. The presence of skilled technicians, able to teach and to excite those who approach to a sport for the first time, can indeed make a difference.
The detail about aspect ratios recorded between the different components of the federal sports system (FSN and DSA), shows that a club in a year, on average, registers 72 athletes and can rely on a staff of 9 officers and 4 technicians. The ratio of technicians and athletes is equal to one for every 18, which suggests a high level of **complexity** in the management of internal processes to the club. In this context, the technological innovation has been able to bring significant benefits capable of **rationalizing** this complexity, in particular the management of the flow of information (data and communications) coming from the athletes (and broadly speaking from the whole sport organization) has been effectively improved through the introduction of **digital dashboards**, which unite all stakeholders in a social environment and makes all team data accessible and actionable. There are different forms of these platforms, but they are all usually built upon two different interfaces:

- the one **for directors and coaches**, that is a powerful management tool that provides a 360° view of their team, their athletes and their data. Through this tool they can easily monitor athlete readiness, assign training and manage schedules directly on athlete profiles, customize training sessions, evaluations

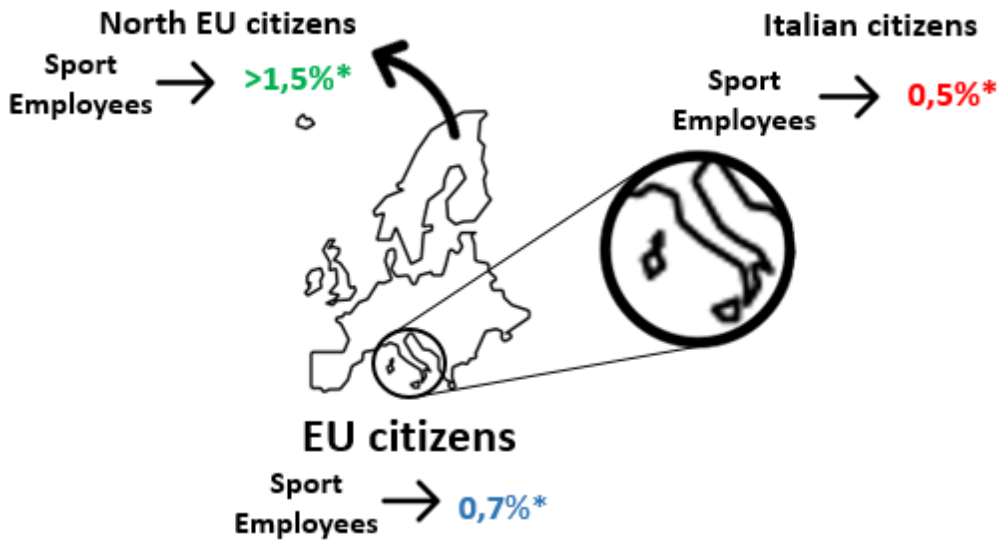
[3] Ordered by revenues

and performance tests to suit the needs of their staff and collect good data to make informed decisions;

- the one for **athletes**, which usually is a data dashboard that provides a constant connection to their team. Daily wellness journals, personal evaluations and test results inform athletes about their performance while training sessions, educational resources and dialogue from coaches help them improve.

In recent years we have witnessed a proliferation of offers relating to these software solutions, creating an offer able to meet all the existing demand levels: from the first complex and custom tailored software for professional teams the market has broaden its borders up to the simpler dashboards with basic functions and a cost accessible even for the most amateur clubs. This trend has been confirmed by a research[4] from Wintergreen Research, showing that in a $9 billion U.S. youth sports market the software for youth and amateur adult league teams at $389.4 represents 4.3% of the total spending. Moreover, as this is a nascent market, the expectations are to reach $5.9 billion by 2022. The paper highlight also the different revenues streams of those solutions: standard software licenses are common but often the package software generates revenue by taking a small percentage of the transactions that are run through the software by the teams; in addition, a third revenue model depends on an annual fee per registration. Market growth comes from increased benefits of organization: travel teams and tournaments are in vogue, so these require automated process in place, effective in making a team function smoothly, eliminating vast amounts of politics. Shared resource is always a problem, having automated management is better. Moreover, once one aspect of the team management is automated, there is demand to automate all the processes across the board leading to plenty of consolidation and acquisitions in this market. According to the author, this is the reason why vendors are making acquisitions to make their software able to provide a large set of capabilities, even if modules brought in from different companies and developers are difficult to integrate into a functioning platform. Most vendors offer premium features to make them available in high end web sites (including text messaging, team, and effective communications capability), while several software vendors provide web site design tools and others permit users to work with a graphics team to support building the appropriate design.

1.2.2 Employment Analysis



***percentage referred to the total value of the country employees**

Figure 1. 7

[4] Youth and Amateur Adult League Sports Software Market Shares, Strategies, and Forecasts, Worldwide, 2016 to 2022

The above figures show a stable situation, and it is interesting to note that the level of employment in the sports world has **not** been **affected by the cuts due to the economic crisis** in the four years from 2011 to 2014.

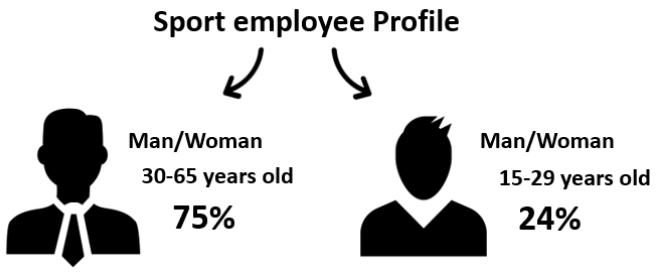


Figure 1. 8

We can also point out that in many countries the entire sports system is traditionally a system with priority to young workers. A result so evident is very peculiar, since in the calculation were considered not only the professions related to physical activity (although relative to other sectors, like the gym teacher of the school) but also those non-sports work in the practical meaning of the word, but belonging to the business of sport (for example to operators of fitness centres reception).

Digital innovations have had a major rone on the **new professional profiles** that have been developed in recent years, as investigated by the founder of first journal dedicated to sports statistics[5], Benjamin C. Alamar[6]. In his analysis[7], Alamar pointed out several points: first of all, the fact that a new figure of coach is born: athletes nowadays need someone who is able to incorporate technology into high performance training every day, combining his IT and statistical skills with his experience in sport in order to create practical features and provide **meaningful insights** into the masses of data in sport, developing practical software solutions that fit seamlessly into the culture of athletics.

Moreover, often more experienced coaches have transitioned into a business development role, where they can draw from personal coaching experience to assist coaches find the most valuable and practical solutions for the organization.

Finally, completely new positions have been added in almost every professional club organization. These are often roles that are linked to the new possibilities given by the new technologies aiming at analysing the incredible number of data that can be collected by a team. For instance, nowadays an **analytics and insights function** is almost mandatory in every top club, in order to develop and present business-impacting insights and measurement. These analyses can be also specialized on different topics, like fan and media engagement manager or match analyst and performance analyst.

1.2.3 Location dedicated to physical activity among population

To provide a more complete view of the role of digital technology on sport, we must now switch our field of analysis: if previously our subjects were sports clubs at a professional level, now we want to analyse the sport through more a more amateur and mainstream perspective, trying to identify what are the main features of those who practice physical activity among the population.

The most intriguing finding that highlights the unique characteristics of those who practice physical activity is the answer to the question "***Where?***".

To easily understand the results of the analysis that we have developed later, it is essential to clarify an important difference regarding the definitions of "sports facility" and "unconventional sports area". We define "**sports facility**" a single space that allows the practice of one or more sports activities. Often the basic sports facilities are aggregated into organic sportive installations, also known as "sports complex".

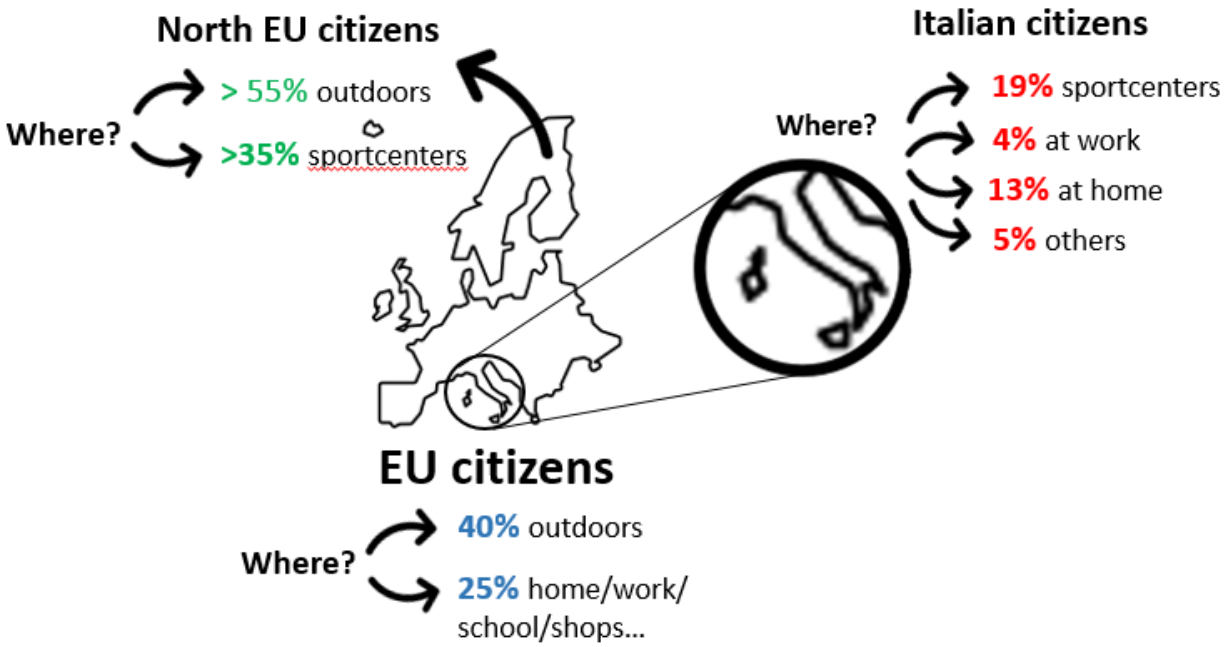
---

[5] The Journal of Quantitative Analysis in Sports.

[6] Founder of the Journal of Quantitative Analysis in Sports. He developed and teaches a class on sports analytics for managers at the University of San Francisco and has published numerous cutting edge studies on strategy and player evaluation. Today, he cochairs the sports statistics section of the International Statistics Institute and consults with several professional teams and businesses in sports analytics.

[7] Sports Analytics: A Guide for Coaches, Managers, and Other Decision Makers - Benjamin C. Alamar - Columbia University Press, 20 ago 2013

Generally, sports facilities are characterized by the following functional elements: spaces for sports activities, support services, technical facilities, spaces for the spectators. Then there are the "**unconventional sports areas**" that are areas and spaces, especially outdoors, not classified as technical spaces of sports activity but that, for the continuity of sports practice that takes place there and for the partial presence of sports equipment even if not homologated, become relevant in the study of sites for sports practice. This division, although seeming trivial, is extremely important in relation to what has emerged from the data coming from the Eurobarometer research.



[8]

Figure 1. 9

It is clear the prevalence of **informal settings** in the choice of the location, so it is normal to wonder why the places that have as primary aim to offer a location with specific system for sports activities are less effective in draw in citizens compared to a simple open-air space. This situation requires further analysis in order to try to explain the phenomenon: considering respondents by age group, there are important differences between the age group **15-24yo** (which in the analysis was the range with the lowest sedentary values) and the older age groups.

The situation delineated from these data is that in Europe fitness centres and sports centres are positioned in the market as the answer to the most **demanding customers**, so those who are young and work out regularly. Indeed, the use of health or fitness centres and sport clubs is greater among people who exercise or play sport on a regular basis that we saw being related again to the younger age. In addition, we should not underestimate a typical feature of fitness or sports centre, that is to offer its services in subscriptions and season ticket, and we can therefore assume that this type of contract acts as a pull phenomenon towards physical activity. The formal settings are therefore positioned on a **premium level of service**.

[8] Special Eurobarometer "Sport and physical activity" Research 2013/2014 in appendix A.2. Multiple answer possible. This is why the sum of the percentages referred to the different locations in higher than the percentage of people that practice sport in the different geographical areas.

- 41% of Europeans exercise or play sport at least once a week.
- 63% of North Europeans exercise or play sport at least once a week,
- 40% of Italian exercise or play sport at least once a week,

In this context, where Sport clubs and Health centres have to face the requests of a high-motivated and high-demanding group of customers, operators that fail to embrace digital technology risk falling behind those that continue to grow and expand to meet the expectations of their facility users.

As stated by David Stalkers[9], "*Technology has to be a major driver of growth for our sector, not a risk to be managed. It should be as easy to book exercise classes and other services, as-it-is to book a train ticket or hotel room*". This is exactly the concept on which some innovative software platforms, like Pay-as-U-gym, are working: enabling consumers to buy short-term passes at gyms nationwide for a discounted price. "*We offer a range of different access options including day passes, bundles and multi-site membership that gives people access to thousands of gyms across the country for a single monthly fee and no contract*," says Pay-as-U-gym co-founder Jamie Ward. "*Like Airbnb, Uber and Laundrapp, we provide customers with a way to find and use services they require on their own terms.*" In a sector that has a tradition of long memberships, Pay-as-U-gym is tapping in to the growing "pay-as-you-go" trend driven by consumers, particularly millennials. The company was able to recognize that the same digital revolution that has overwhelmed the tourism sector can give new business perspectives also in this market, reaching impressive results: today the gym marketplace has 400,000 registered users and 2,500 gyms nationwide, and in the first two years of life it has gone from under 300 participating gyms in early 2012 to almost 1200 in 2013 (adding about 100 new gyms every month). Considering there are about 6000 gyms in the UK that means that the London-based entrepreneurs in two years have already secured just under 20% of the national market (a growing £4 billion annual market). The most innovative fitness centres have already gone further, implementing a **Plan-Track-Reward loop** where the platform integrates with all main fitness 'wearable technology' applications such as Fitbit, Jawbone, Strava and Garmin. In this way, the club can reward members for being active inside and outside the centre, and give them the possibility to plan, track and be incentivized for the healthy lifestyle they are chasing.

1.2.4 Sponsorship

Mullin[10] defines sponsorship as "*consisting of all activities designed to meet the needs and wants of sport consumers through exchange processes. Sport marketing has developed two major thrusts: the marketing of sport products and services directly to consumers of sport, and the marketing of other consumer and industrial products or services through the use of sport promotions*".
Sport brand merchandising no longer means simply attaching a corporate name to a product. Rather, it has become a **triangle of association** between the team, the brand, and the passionate fan. They tend to be quite active in liking or following a brand on media because of its association with a team or a specific player, and 30% of fans who use media to connect with a sponsor later make a purchase because of the brand's association with the team orthe athlete. That's why sponsoring in social media is gaining a huge momentum: according to a study made by the Johan Cruyff Institute, Nike is paying up to $260,490 for just one message on Twitter from Cristiano Ronaldo sponsoring his latest boots. It's a situation of win-win for both the brand and the athlete: for Nike, it is still much more affordable than a television commercial and at the same time it guarantees a far-reaching coverage, while for the athlete it saves time and hassle. However, if the association doesn't feel authentic or comes on too strong, it can just as easily be a turnoff to fans.
Once a partnership deal is closed, the main differentiating factor is **activation**. In other words, can a brand tap into the emotional link between people and their favourite sports, teams, and players, while communicating its values and product offerings? Apparently, yes.
The global sports sponsorship market is worth an estimated $50 billion per year. Companies in all fields are turning to sport to drive awareness of their own products, with increasingly impressive results.

[9] CEO of UKactive
[10] (2007, p. 11)

The brands that succeed in this sector are those that select the right partner clubs, leagues, and athletes, and choose the right types of partnerships (official partners, suppliers, or stadium naming, to name a few options), based on their objectives. While geographical reach, price, and popularity are obvious components, the **values** that a certain sport carries are also crucial. For example, Nike's contract with Swiss tennis star Roger Federer is a natural fit, as the player brings his elegance, style, and success to a brand that seeks to embody those attributes. Sports sponsorship wields transformative power that is capable of driving exponential growth in brand awareness and affinity.

Red Bull GmbH[11] has enjoyed sporting success: ~~It~~ it owns the football teams Red Bull Salzburg (Austria) and RB Leipzig (Germany), and the Formula One teams Red Bull Racing and Scuderia Toro Rosso, and sponsors many extreme sports athletes including Gee Atherton, a British downhill mountain biker. The company's website links to a statement from Atherton saying he is "*never satisfied*" and "*always pushes higher*", values that are in line with Red Bull's focus on relentless energy. Such activities have helped to increase worldwide revenues from €4.25bn to €5.9bn over the past four years. Another example is Under Armour, the sports clothing and accessories brand, which is now the official match ball partner of the North American Soccer League and sponsors leading sports stars such as Tom Brady, the New England Patriots quarterback, and Jordan Spieth, the golfer who won Masters and the US Open last year.

"*The most successful sponsorships have a credible anchor based on a sport, team or audience need. They should be* ***easily communicated and understood*** *by the target audience.*" said Dan Zaltzman[12], "*A winning sports partnership will also have clearly defined objectives and success criteria for the rights-holder, sponsor, and fans. For the sponsor, the return on investment will always eventually come back to financial terms, even if the immediate benefits aren't linked to sales directly. You can be successful, if you're* ***smart****. Under Armour identified a number of up-and-coming athlete ambassadors who showed huge potential at a very early stage in their careers. This approach not only earmarked the company as experts 'on the inside' but also made the brand* ***more credible*** *with fans when those athletes finally made their names.*"

Recap

- *Sport clubs and trainers have to face an high level of complexity in the management of internal processes.*
- *New professional profiles are born, as nowadays an analytics function is almost mandatory in every top club.*
- *Sport clubs and Health centres have to face the requests of a high-motivated and high-demanding group of customers.*
- *Sponsoring has become a triangle of association between the team, the brand, and the passionate fan. Activation is the main differentiation factor.*

Figure 1. 10

[11] The Austrian company that produces the famous energy drink

[12] Director, Sponsorship & Consulting at Logan Sports Marketing

1.3 Sport Institutions and Event Management

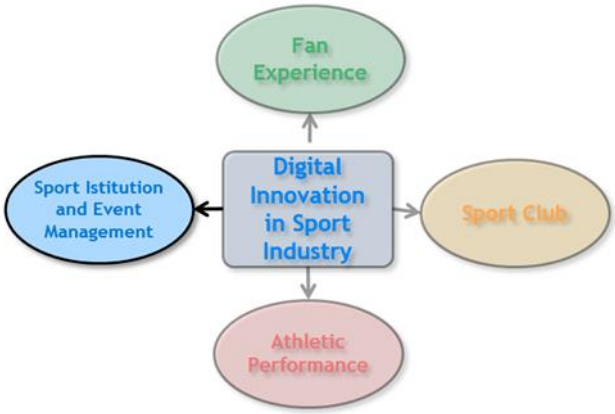


Figure 1. 11

In our third macro-area, our focus is describing the **organization** of three aspects in the sport industry: the structure of the different **governing entity** in this system and the cultural promotion related to their activities; the important role fulfilled by **officials** in each sporting environment; the organization and coordination of **sport events**, an area that usually plays a big role in the economic value of the sport sector; the **facilities management** and the new possibilities given by the smart-arena design.

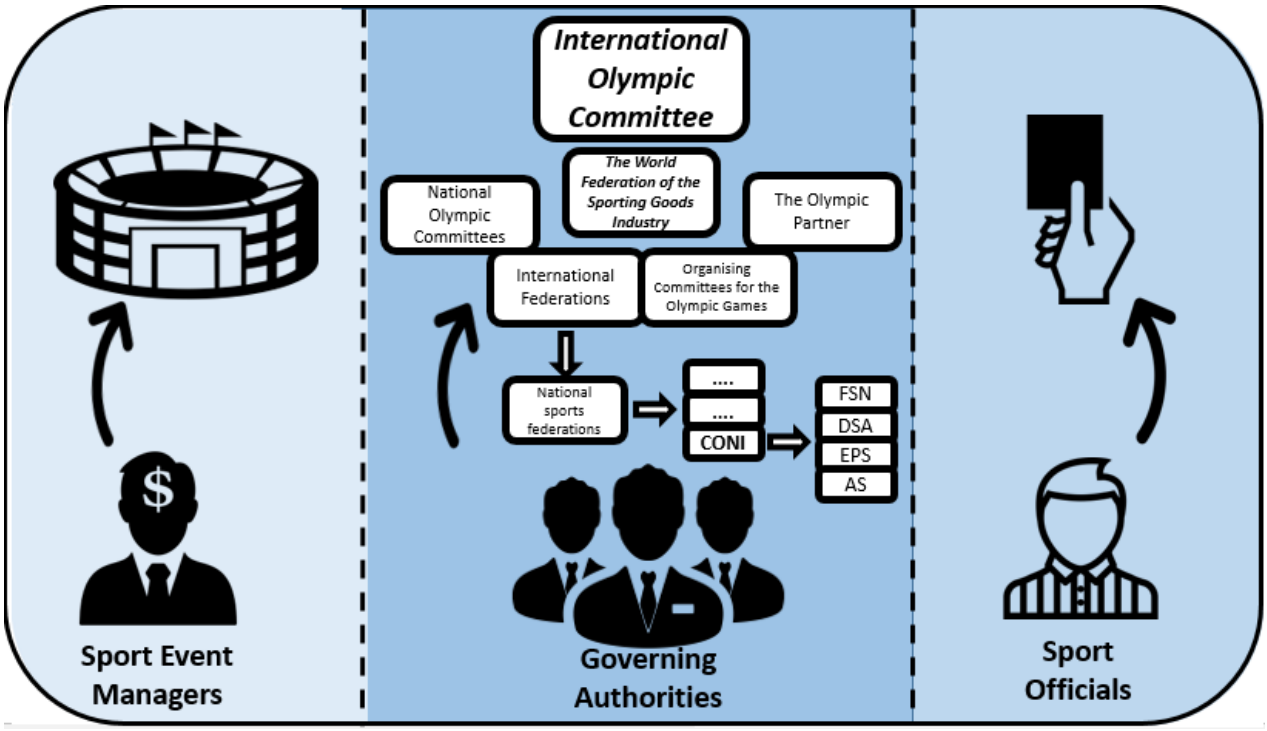


Figure 1. 12

1.3.1 Governing Authorities

There are several authorities worldwide responsible to the organization of the entire sports system (competitions, leagues, athletes, cultural promotion). They follow a hierarchical structure, divided as follows:

- ***International Olympic Committee*** (IOC): The IOC's role, as defined by the Olympic Charter, is mainly to support the organisation, development and coordination of sport and sports competitions, encouraging also initiatives blending sport with culture and education. It acts as a catalyst for collaboration between all parties of the Olympic family, including the National Olympic Committees (NOCs), the International Federations (IFs), the athletes, the Organising Committees for the Olympic Games (OCOGs), The Olympic Partner (TOP) programme sponsors and broadcast partners..
- ***The World Federation of the Sporting Goods Industry*** (WFSGI) is the world authoritative body for the sports industry officially recognized by the IOC as the industry representative within the Olympic Family: it is formed by sports and sports-inspired leisure brands, manufacturers, suppliers, retailers, national/regional federations, industry and trade associations and all sporting goods industry related businesses.
- For each sport on the Olympic Games programme, there is an ***International Federation*** (IF) that governs that sport on a global level. The IFs therefore play an essential role in the planning and delivery of the Olympic Movement and the Olympic Games, ensuring the promotion and growth of their sport around the world and the development of the athletes who practise it. As the governing bodies for their respective sports, the IFs administer their sports and are responsible for organising major international events, as well as the management of their events at the Olympic Games. IFs are also responsible for administering the national sports federations (NFs) that are affiliated to them.
- *The* ***National Olympic Committees*** (NOCs) are essential ambassadors of the Olympic Movement within their respective countries and territories, responsible for spreading the Olympic values at a national level, in partnership with the IOC and the International Sports Federations (IFs). Within their respective countries, the NOCs carry out many different functions – from the development of sport at all levels to the creation of educational programmes and the continued training of sports administrators – and ensure that all the programmes carried out at a national level conform to the principles of the Olympic Charter.

<u>CONI</u>

The CONI (Comitato Olimpico Nazionale Italiano) is the Italian authorities governing the regulation and management of national sport activities (enactment of the IOC).
Being the Organisation that is responsible for the **maximum diffusion and management of sport** in the country, it has other essential functions like the organization of sport activities, health protection and spreading the sport culture in every age group in the population.
Having also the role of the **statutory body** responsible to relate to the IOC at national level, among its duties the CONI also include guaranteeing compliance with Olympic Charter and the IOC principles in its area of competence, and managing the resources needed for participation of the Italian delegation at the Olympic Games and other sporting events.

In turn, CONI is mainly based on four pillars: *Federazioni Sportive Nazionali* (FSN*), Enti di Promozione Sportiva* (EPS), *Discipline Sportive Associate* (DSA) and *Associazioni Benemerite* (AB).

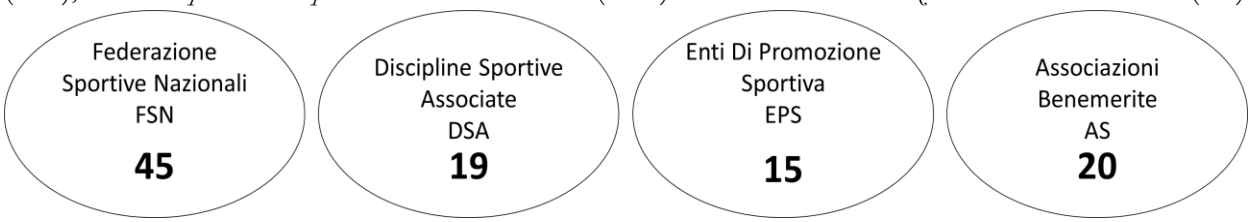


Figure 1. 13

These entities provide a capillary network in the territory and in fact create **the connection between demand and offer** of sports, through the provision services specifically related (training, workout, practice, competitions, etc.) and the transmission of the values of the sport.
The organizational model is therefore based on collaboration between public and private, that is, between the Italian Olympic Committee and the different bodies recognized by the Sports Organisation.
To get a clearer view of the tasks of each of them, we will analyze them individually:

FSN

Currently there are 45 Federations, covering sections of physical and sporting activities characterized by greater **competitive commitment** and based on approximately 72,000 cores, usually organized on a **territorial basis**. There are not two federations in the same category since they exercise a **monopoly** on the agonistic activity of a particular sport or sports area. Those who want to get at the highest levels of a sport can rely in toto to the federation that deals with the relative discipline: federations promote, perform and develop psycho-physical training of athletes in individual sports on a competitive and amateur level. They take care also of the technical preparation of sports technicians, as well as the establishment and organization of specific sport activities, either unprofessional and top-level. A Federation, therefore, is a kind of sport trusts that deals with a **vertical development** of all activities concerning a given discipline. These Federations are addressed to all those who want to play sports held in precise regulations and, most importantly, have the intention and ambition to compete at the highest levels of the chosen discipline.

EPS

The Enti di Promozione Sportiva are associations, often born as emanations of non-sports subjects, that, following a development process on the national territory, are recognized by CONI. There are currently recognized 15 entities whose task, as defined by the CONI, is the promotion and organization of physical and sports activities with **recreational and educational purposes**. Entities, therefore, promote and organize sports activities at amateur level and, while still considering a perspective of competing (even EPS organize leagues and tournaments), they are not intended to select the best athletes in order to direct them to the highest levels of a single discipline, but to **spread** as much as possible the practice of that discipline.

DSA

The Discipline Sportive Associate approved by CONI (currently 19) are substantially identical to the Federations and are involved in sports activities related to a discipline, through a vertical development that starts from the basic tasks up to the high levels. However, they are divided by the Federations for the following reasons:

- It is of type disciplines related primarily to **play-recreation activities** that do not give the immediate perception of sporting activities (such as chess or bridge).
- These are disciplines that, despite having a preponderant and immediately perceptible physical component, are still "young" and, more importantly, **are not yet recognized as an Olympic sport** (such as climbing or rafting).

1.3.2 Sport Officials

Sport officials (umpires, referees, judges) play a vital role in every sport, especially at the competitive level, as it is a role "**super-partes**" that is in charge of ensuring the **fairness** of the competition. Officials are nowadays expected to maintain higher professional standards than ever before. Over the years, referees have been the subject of coaches, players and fans complaints due to the subjective nature of officiating: despite continued training, sport officials are often at the mercy of their own perception of the contest in making accurate judgments. That's the reason why sports leagues and governing bodies should continually be looking to potential solutions and new technologies to **minimize incorrect calls**. Most common example of the technology being used is wireless communication technology with other officials: communication technology is used so that match officials can get more information when making a decision; in this way the main referee can seek the opinion from their assistants if he hadn't a good view of an incident and therefore make an informed decision. Furthermore, sanctioning bodies for many sports have implemented **video replay** to assist officiating personnel. The use of this technology has been implemented differently from sport to sport, especially in the form of the **Hawk-Eye** (named also "Challenge System" in volleyball and "Goal Line Technology" in football). It is a system able to visually track the trajectory of the ball and therefore catch its statistically most likely path as a moving image. The video is recorded through six or seven high-performance cameras, normally positioned on the underside of the stadium roof, which track the ball from different angles. The system then is able to triangulate and combine the images of the cameras to create a three-dimensional representation of the trajectory of the ball. Despite the fact that Hawk-Eye is not infallible (it is accurate within 5 millimetres), the system is generally trusted as a technological mean of adjudication. However, video replay has also some traditional problem to deal with: it is time consuming and affects the **rhythm of the game**, and sometimes is also inefficient due to limited vantage points from camera angles. This is the reason why in many sports, like basketball and baseball, the rules do not allow every play to be reviewed, or the number of replays permitted is limited. There are a lot of mixed feelings regarding video replay even from fans, who feel that it interrupts the flow of a match damaging the entertainment. Thus, many leagues are looking into new ways of implementing such technologies in order to solve these problems: for instance, the NBA and the NFL have introduced the **Replay Center**, a headquarter with referees staffed in to make decisions on certain replay situations and facilitate the on-the-court review. The Center is unique for the whole league, directly connected to all the arenas and active for all games: the aim is to help on-court referees to resume play faster, starting reviewing the play even before a challenge or replay review is initiated and communicating with them in order to determine the final decision. Some evaluation on the effectiveness of the system reported that the average review time was reduced by nearly 25%, giving an important support in maintaining the flow of the game.

1.3.3 Sport Events Managemen

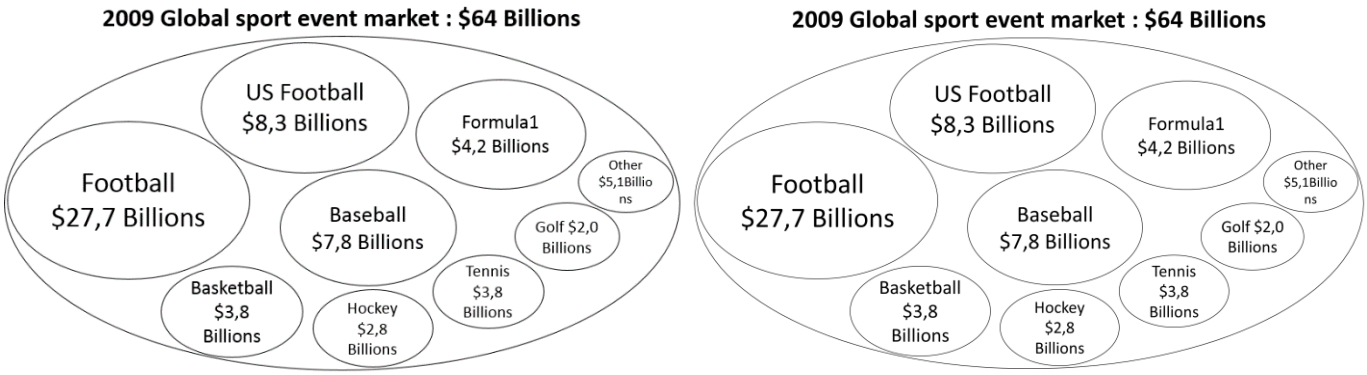


Figure 1. 14

EMEA = Europe, Meaddle East, Africa, US Sports = NFL ,MLB, NBA, NHL, NASCAR, NCAA

The sports events are of special importance within the world of sport, either because of the **great response from the fans** that they recall either due to the **strong economic impulses** that these events impress to their hosting sites.

The revenues related to the events are worth 11% of all the value that generates the sports industry, and in a typical sports cycle of four years the **growth** of sports events market has been estimated to be around 7%, which means a much higher growth than the usual GDP of a country. It is noteworthy that the absolute growth trend in revenues is recorded through all the years: this is therefore a particular feature and strengths in relation to an increasingly uncertain general economic situation. Applying a geographic division, we can analyse how the sports events industry has grown in both developing and developed countries: important was the growth in the *BRIC*[13] countries, who were able to enjoy the boost given by the great annual sporting events. It is no coincidence that most of world sports events of the last years were hosted by these countries: the 2008 Summer Olympics in China, the 2014 World Cup and 2016 Summer Olympics in Brazil, the 2014 Winter Olympics and 2018 World Cup in Russia. The activity in sports economy has obtained a **boost** from these events, as confirmed by the industry's impressive growth in relation to household spending: Russia's spending on sports rose more than 53 percent annually, China's rose by 20%, India's by 17% and Brazil's by 7%.

In this market, technological progress is happening rapidly, with innovative technologies gathering pace and adoption. Among the most widespread ones, there are:

- ***Live streaming***: It is a service that allows users to see live events through the web. The effectiveness and attractiveness of live streaming services depend on different features, like reliability of the connection, low latency streaming, an UI with a powerful interface and compatibility with different APIs in order to integrate with different applications. Many organisers see live streaming technology as an opportunity to build their overall audience, although some of them worry that this kind of service will impact on the number of potential customers who would have paid for a ticket.
- ***Omni-channel experiences***: it means that whatever medium a customer uses to interact with a brand, the experience is the same, but personalised to the strengths of that medium; this implies that all the data associated with that interaction is centralised, not stored within the separate channels. As organizers are not able to know how their attendees will try to interact with their event, it's important they have a great experience for each channel or medium they use.

[13] **BRIC** is a grouping acronym that refers to the countries of **B**razil, **R**ussia, **I**ndia and **C**hina, which are all deemed to be at a similar stage of newly advanced economic development.

- ***Real time Intelligence***: Business Intelligence and Analytics are a fundamental tool to make smart decisions about Big Data. Real Time Intelligence is a step forward, enabling to make decisions whenever during the event. For instance, a possible application could be during a crowded festival: if one gate is particularly busy, the organizer need to know this at the time, so he can shift staff over to help relieve the pressure.
- ***RFID***: standing for Radio-frequency Identification, it is a technology based on tag and reader. The tag can be read even if it is covered by the object or not visible and, unlike barcodes, RFID tags can be read hundreds at a time. With the reduction in cost of using RFID and increase in reliability, this is fast becoming a favourite way for organisers and exhibitors to interact with attendees and pass information, whether it's paying for drinks, tagging visitors or making entrance to events even easier and more reliable.

1.3.4 Facilities and Innovation: the rise of the smart arenas

Sport facilities and stadiums are one of the areas where the digital innovation has shown the strongest **disruptive impact**. As discussed in an article written by the Johan Cruyff Institute, sporting events had a maxim that worked very well to fill stadiums: there was nothing more authentic than experiencing the excitement at the playing field. But that was before the definitive explosion of the digital age: the new technologies and the resources of media players (aiming at monetizing their investments in media rights) have questioned this status quo. Further studies by telecom company Cisco and by sports demographer Rich Luker revealed two important trends over the last decade: 57% of sports fans now prefer to watch matches at home, with the largest decline in the 12 to 34 age bracket. Therefore, facilities managers had to stop seeing technology as a threat in order to ally themselves with it and fight for getting people off the couch. How they made this change? Treating each arena like a lab, where owners can try out new programs to find what's successful in deepening **engagement** and building new revenues. Some projects are exploring the use of drone technology to survey available parking spaces and even provide unique in-arena camera angles. During the 2016 Wimbledon tennis championships, cameras linked to IBM's *Watson* "machine-learning" platform have been monitoring fans facial expressions trying to work out what **emotions** they are displaying, in order to understand which player they are supporting just by reading their face. Moreover, the AI will be digesting millions of conversations on social media platforms and using natural language processing to identify common topics.
Another surprisingly underexplored avenue for engagement is **enhanced fan access** to athletes during events: these may include special fan invitations to pre-game warm-ups or post-game press conferences, or standing next to a player during the national anthem. Such enhancements are possible because the collection of **personal data** about fans would help teams match the experience that matters most with the right fans. Other franchises are looking for ways to capitalize on **mobile technology** to enhance the fan experience in their homes and as spectators in stadiums and arenas. 70% of fans bring a mobile device to the stadium or arena and expect to use it during a game there as well. That's why new arenas have Wi-Fi systems that function with a dense population of users, enabling mobile applications for check-in, ushering them to their seat, indicating shortest bathroom and concession lines, seat upgrade options (much like what has been done in the airline industry), cashless commerce, and in-seat wireless charging. This could mean one day scanning a ticket on customer's phone to enter the arena, which sends an alert to a service representative to let them know it's his birthday, so his favourite cocktail can be delivered to his seat.

In the luxury suites, technology further personalizes the event experience by allowing fans to customize their view of the live game or show below, or switch to other channels of premium HD content, by simply changing the channel through smartphones in conjunction with voice recognition service. In the future, fans will also be able to order concessions and team merchandise for delivery to the suites by using the touch screen on the phones.

And what about the **big centres and stadium**? Nowadays, the stadiums with the best technology in the world come from the United States. Levi's Stadium (NFL: San Francisco 49ers), the Barclay's Center (NBA: Brooklyn Nets and NFL: New York Islanders) and the AT&T Center (NBA: San Antonio Spurs) are a good example of what the best stadiums in the world need to have in order to fulfill that promise to offer fans an unforgettable experience and leave them wanting to repeat it. As stated before, connectivity and custom applications are essential in order to guarantee the interaction of the fans, and the three stadiums mentioned above have around 700 Wi-Fi hotspots that guarantee a fast, safe and good quality connection in order to exploit all the features of their specific app: watching video live and replays, ordering food from the seat, advertising offers by sector, delivering promotional contest or building live fan choreography (like sending a message to the fans' phone to make it vibrate and turn on flashlight) with a spectacular effect in the stands. These arenas are following the path that one successful facility is mapping: the Staples Centre in LA, one of the most famous US stadium and also the **world's most profitable** one, which earned more than $345M in 2014 in revenues. How did they managed to reach this achievement? Revenue growth has been driven through different strategies:

- the facility is not only seen as the home of sport, but it has expanded its range of use also hosting **other typologies of events**, like major concerts;
- the arena is relatively small in size but is home to four teams, which ensures 140 match days a year, one of the levers they exploited in order to obtain **premium seating revenue**;
- with constantly changing games, teams and events, one of the keys for Staples Center is the **flexibility of the technology**: the entire colour scheme, content and branding of the venue can be done with the push of a few buttons, and this is proving exceptionally valuable at the concessions stands where dynamic menu boards can easily be updated with new menu items and pricing;
- the arena can provide fans with an **immersive multimedia experience**, with an innovative digital video and content distribution system that centrally controls and delivers targeted high-definition video and highly relevant digital content to guests.

For the facility, the results coming from these new business models are impressive: the venue owner AEG inked a lifetime agreement for naming rights with Staples (the first of its kind for a major-market arena) valued 7.4 million$ a year. Ticket sales for all the events reached 281.000.000$, exploiting the premium level of services and, accordingly, prices. This huge success in terms of attendance affected also other revenues stream, as merchandise sales amounted to an estimated 24,100,00$ while concession sales and parking revenue were respectively 14,300,000$ and 18,400,000$. As stated by Todd Goldstein, president of AEG's Global Partnerships, "*By reinventing STAPLES Center with innovative technologies from industry leaders Verizon and Cisco, AEG is raising the bar for arenas when it comes to engaging fans and responding to consumer demands for real-time information that is uniquely tailored from event to event. In addition to better serving our customers, we're realizing unprecedented operational efficiencies that are helping to streamline venue management and deliver more value to our partners*".

Of course, the sport is no longer just the one played in the stadiums, since the urban parks and recreational areas (the one we referred to as "**unconventional sport areas**") have increasingly gained a dominant role in the facilities market.
According to the analysis developed by Sport Industry Directory for the 2015 edition of the international exhibition FSB[14], it is in this context that the new technologies may represent the true changing factor and bring the momentum also to a more mainstream level: for outdoor spaces, one of the most important branches of innovation concerns the external surfaces that can accommodate leisure and sports activities, like flooring that can be used for outdoor activities in the summer and become a skating rink for the winter months, or the latest innovations in the synthetic grass, with two-colors fibers, environmentally friendly materials, filling made of 100% recycled materials. For recreational parks, some manufacturers are also promoting new visual effects, bringing the virtual game in the real world, so that sport and physical activity can be tested on new levels.

Recap

- *Several authorities manage the entire sports system, with a hierarchical structure. CONI is the governing body for the maximum diffusion and the management of sport in Italy.*
- *New technologies are extremely interesting in giving potential solutions to help referees minimizing incorrect calls.*
- *Events generate the 11% of all the sports industry value, giving strong economic impulses and leveraging new digital solutions (live streaming, omni-channel experiences. real time Intelligence, RFID and more).*
- *Sport facilities and stadiums are one of the areas where the digital innovation has shown the strongest disruptive impact, deepening engagement and building new revenues.*

Figure 1. 15

[14] Fiera internazionale dell'impiantistica sportiva

1.4 Fan Experience

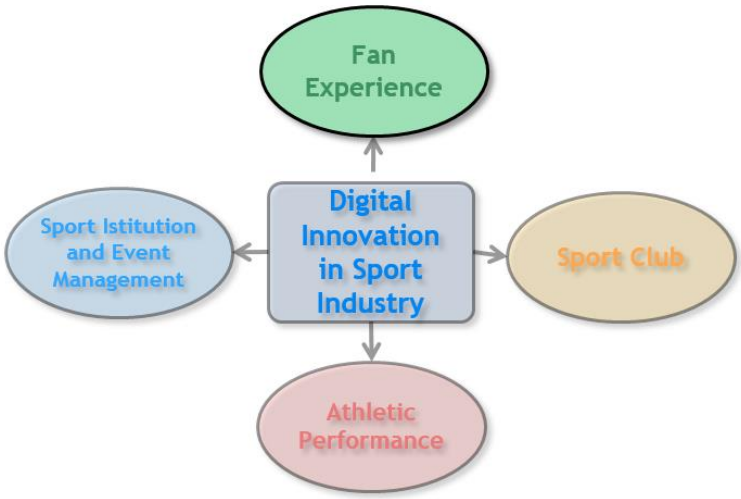


Figure 1. 16

The third macro-area of analysis concerns the fan experience. This area deserves a more detailed discussion, since it has been the area (along with Athletic Performances) where technological innovations have had a **higher disruptive impact** than ever before. For this reason, this area has been covered according to a division criterion that takes into account of the different killer-innovations and the related areas on which they have had an impact. We have combined this concept with the different steps in the typical **customer journey** of a fan: our choice was then to split the following macro-areas in paragraphs analysing different revenues streams related to an effective management of the fan base through each phase of its relationship with the sport industry:

- **Traditional media** and **Social media**
- **Ticketing**
- **Merchandising**
- For purpose of completeness, we included also **Arenas** in the following graphic. However, a deep analysis about smart arenas and new digital trends in sport events has already been developed in the previous paragraph.

For each of these areas we have therefore highlighted the **technological innovations** connected and some use examples that outlining the current situation and the new future trends.

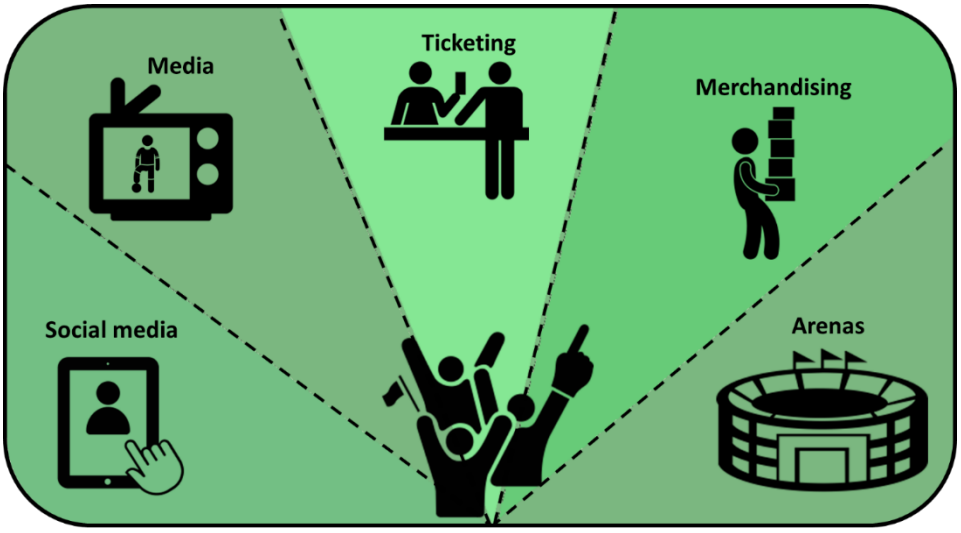


Figure 1. 17

As we said before, the digital innovation has deeply changed the different modalities of **interaction** of the world of sport with their fans. Before going into detail about this, we believe it is appropriate to clarify what is the true value that emerges for a club through a solid fan base. In the last years, a lot of tangible ways have been developed for fans to engage with the sports industry. By taking them beyond being a spectator, fans become **active participants** in shaping their social experience. The desire for **connectivity** is perhaps the most basic aspect of the human spirit and it's even more important when people come together to share a memorable experience about the same passion: this is what every fan ultimately desires.

That's why **social media** plays a larger role than ever in the lives of sports fans around the world, and here is where lies the value of fan interaction. But it can be hard to parse just how many fans use which networks and where the greatest opportunities for marketers are. IMG company[15] is the latest to try to **quantify** where sports fans hangout online and how they can be reached.

Catalyst's fourth annual fan engagement study surveyed 2,100 sports fans between the ages of 16 and 64. That group encompasses fans of the *NFL, MLB, NBA*, college football, college basketball and soccer, and its results can be seen in the infographic above.

These numbers provide a **fertile field for business promotions**: 7 out of 10 sports fans who Like or Follow a brand online say they're open to sharing brand content, buying goods or engaging with social posts. From this analysis, we can easily understand that nowadays is mandatory for a sport team or organization to have an **established diffusion** into the social media in order to strengthen their fan base.

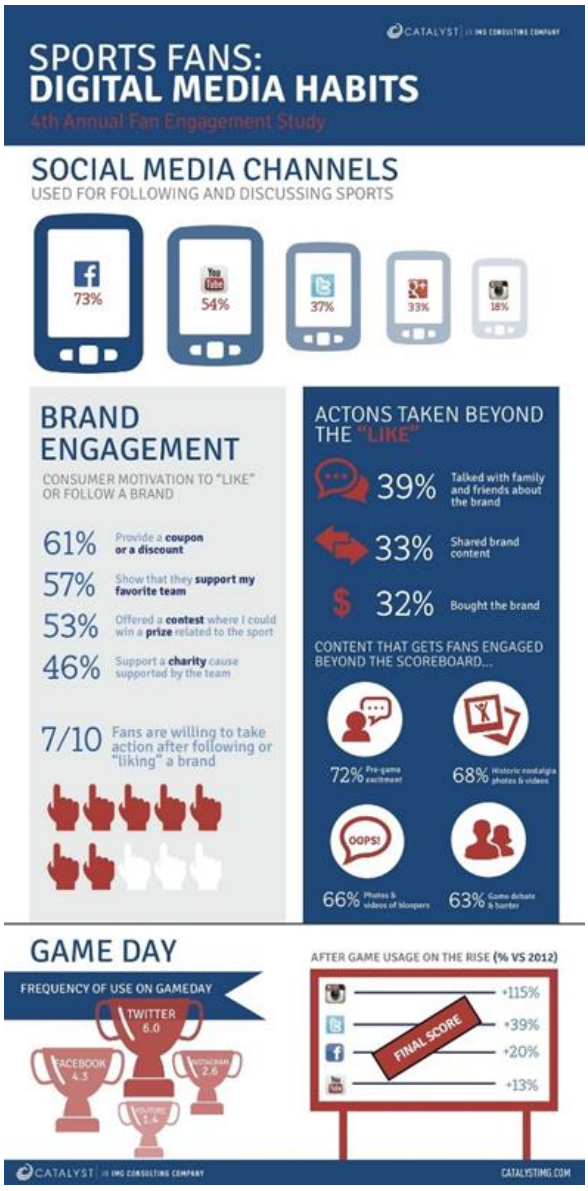


Figure 1. 18

Therefore, it is essential to run a deeper analysis into the relationship between social media and the sports world, in particular in terms of the various sports and their different diffusion that we have just analysed. The 2015 edition of the Global Sports Salary Survey[16] showed a particular ranking in order to define what were the "**biggest team**" in the world. Obviously the concept of 'biggest' itself is subject to different interpretations, and it is indeed interesting to note that they could of course use other metrics (like total club revenues, or international broadcast audience, or media mentions) but they decided to use **social media popularity** because it has the advantage of expressing a truly **global reach**.

Data confirm that football (soccer) is the real truly global game, especially European football teams. The supremacy of football on other sports worldwide is therefore evident, since the first 8 teams all come from this sport, and in particular from those which are de facto the two major leagues: the *Premier League* and the *Liga*, which take up respectively the first and second place in the ranking for **average number of followers per team**. Referring to this, it is interesting to note that in the *English Premier League* the *Manchester United* has a social media following (69M) that is larger than the entire population of the United Kingdom: this is a clear example of how these teams have been able to exploit to the perfection the possibilities offered by the media, going far

[15] Through an analysis made by a controlled company: Catalyst PR

[16] Produced annually by www.sportingintelligence.com

beyond the local fan base relative to their hometowns. Of particular interest is the case of Basketball: it is not a challenger to football in terms of the world's biggest global game, but it does have a claim to being a truly global sport despite the fact of being a typical US-sport. The **global appeal** of the *NBA* has been particularly supported by an **aggressive strategy on social media**: rather than rejecting the social media movement, Adam Silver[17] and the NBA have welcomed it transforming the landscape of the league entirely. While some other leagues have taken steps to eliminate this sort of content hijacking, Silver has decided to take his in the opposite direction, embracing the almost constant flood of NBA-themed memes and GIFs to Twitter and Facebook. They recognized the positive impact of fans posting copyrighted game footage and, instead of condemning their loyal followers, they **adapted to the change** and revolutionized the way we consume sports: NBA's social media footprint has made fans feel tapped into the personalities of each one of their favourite players and teams. Linking to superstars' personal accounts and different team pages with every post, not only do fans feel connected to the sport, but also to the lives of their favourite athletes and teams. Moreover, with access to the Internet, fans across the globe are now able to watch every player and any team without exception or geographical prejudice. This process can be seen as a **Globalization of the hometown team**.

At this point, it could be somehow surprising witnessing the new oncoming relation between a global audience and teams that, according to tradition in sport culture, have always been strongly related to the hometown where they belong to (particularly clear and noticeable in the classic conventionality of naming a team with the name of the city where it is located). Then why such an effort in reaching a global audience? Why it could be the key in exploiting the business potential of fan interaction? Because the **financing** of sports has some major features which makes it quite different from other types of marketing. Proximity to the stadium isn't a prerequisite for tapping new revenue streams: while catering to regular attendees and season-ticket holders is obviously valuable, there's **untapped potential** in fan bases that have no access to the stadium at all. Over half of fans from each major sports league in the US are "*displaced fans*," meaning they support teams that do not play in the state that they reside. Even the total cost fans spend on products can be split into direct and indirect, and one aspect is mostly evident in the case of major professional sports with high level of followers: revenues from **indirect costs** are somewhat greater than revenues from direct costs such as ticket sales (being the major source of revenue). Indirect revenues mean media contracts and sponsorship money, and the tendency to rely heavily on these indirect sources of income is quite notable on most professional sports as attempts are being made to obtain sponsorship agreements and vital media contracts in the sports industry. Indeed, it is important to notice that sponsorships accounted for 35% of sports event revenues in 2013, and media rights accounted for 35%, while ticketing was only 27% of revenues. A further analysis is therefore useful on these revenues streams.

1.4.1 New communication channels

Sports clubs and businesses are only beginning to appreciate the potential of the new social media trend we analysed: their challenge is to find ways of **measuring the value of social media**.
As we can see in the appendix table A.1, *Barcellona* has become the world's largest sports club on social media, and last year, it worked with sports marketing agency IMG to examine what value social media adds to its shirt sponsorship rights: "*We found there was an extraordinary amount of value that the shirt sponsor of Barcellona was receiving on social media, which wasn't really factored into the sponsorship*" says Rob Mason, managing director of IMG Consulting, "*Our work there told us that social media is the* ***next great frontier*** *for sports sponsorships. But sports rights holders need to understand their social media value, and sponsors need to know what they want from it*"

[17] Commissioner NBA

This is a point that has been highlighted also by Mark Lichtenhein[18], "*We now have a* ***dialogue with the fanbase****. We never had that before. We were just a business-to-business industry selling our content to broadcasters and rights to sponsors. This has been the biggest sea change for all sports rights holders in the past few years*".
So it's clear that there is so much **business potential**, but the challenge for businesses is to find ways of measuring the value social media offers, beyond simple page views and unique user data. "*Increasingly we are building social media benefits into sponsorship contracts but it's a mistake to measure it in a narrow vertical, saying that you have spent so much on Twitter and asking what you're getting back for that*" says again Mr Lichtenhein, "*You have to look more holistically in terms of how it adds* ***value to the brand****, its audience reach. An investment in digital media may come back through other revenue streams. The more popular your product is, the better rights values you can attract.*"
By engaging fans via social media, sports rights holders can open **new communication channels**. But right now, these are just potentialities waiting to be fully exploited: "*There is enormous potential in this area but brands need to be wary*," says Tim Crow[19], "*Rights holders are playing catch-up when it comes to integrating sponsors into their digital real estate and enabling sponsors to communicate meaningfully with fans.* ***Rights packages need to be re-booted for the social media area****, particularly in the area of exclusive content. And what's being offered to sponsors needs to focus less on selling price and impressions and much more on delivering engagement and value.*"

Media assets: Broadcasting and Consumption

Media sports assets are particularly **valuable assets**, and the raw media rights numbers themselves are impressive: TV rights and marketing deals for the 2014 World Cup brought roughly $4 billion in revenue for soccer regulator FIFA; in the United States, the NFL earns about $5 billion a year from its TV deals with four networks, and the Super Bowl XLVIII in February 2014 was the highest-rated program in U.S. history, even though the game was one of the least competitive in years.
What is incontestable is that media coverage has had an incalculably large impact on sport, but why media assets related in combination with sports are such a rich asset to be exploited? Because it's **live**. Only sport has one nation, and sometimes the world, watching the same thing at the same time: if you have a message, that's a potent messenger. A single sport 'live' TV broadcast can be shown in 'real time' and endlessly afterwards, and can be cut up and packaged in different ways. The sports print media, both newspapers and magazines, can help stimulate interest before the event and 'keep it alive' for a lengthy period afterwards, aided by the celebrity status of elite sportspeople.
Taking the example of the USA's NBC television network, we can briefly analyse what happened when NBC won the US TV rights to show to American audiences the 2000/2004/2008 Olympics Games (with escalating fees). Despite its capacity to sell subsidiary rights, the cost of rights and of producing TV coverage ensured that NBC would lose large sums of money on the deal. But this business decision has a **broader economic motive**: the huge audiences for the Olympics raise the network's overall ratings, meaning that it is in a **stronger position** to negotiate advertising rights across its year-round, all-genre programming. In an image-saturated age where 'branded sign-value' is paramount, being known as the Olympic network (with all the brand recognition and prestige that the label entails) gives an important competitive advantage in the media industry.
In such a profitable market in terms of brand awareness and recognition, the increase and experimentation with broadcast technologies and techniques is a key point. Many of these attempt to add to the viewer's **on screen experience**, bringing the viewer closer to the action: the most common choice is the "live app" (part of smart television range) which provides on-screen information relative to the particular sporting event being viewed, over and above that normally provided onscreen by the host broadcaster. This helps spectators as they can continue to watch the broadcast and not be distracted by sourcing any further game information from other

[18] The *PGA European Tour's* head of television, digital media and technology.
[19] CEO of Synergy, a sports marketing agency that advises sponsors on digital and social media strategy.

devices, such as their smart phone or tablet device. "*Personalization is key for 2017. As each viewer is more connected than ever before, it is now a priority to deliver personalized experiences by offering customized content, promotions and product offerings, recommendations, reminders and alerts; all specific to each viewer across all devices*"[20].
Moreover, many technologies have been developed directly on the playground: early examples of sports technology were the photo finish (1888) and the instant replay screen (1955). Also, one of the first innovation was the addition of microphones, an idea that nowadays has been improved with the use of cameras attached to the players' jerseys for a point-of-view perspective of the action during the game. The most innovative additions are realistic 3D analysis systems which allow 360 degree replays. Referring to 3D possibilities, the 3D television broadcast of sport is one of the biggest new technologies to have been largely discontinued, despite the initial interest: one US study reported by Nielsen in 2010 found 65% of respondents wanted to see sport broadcast in 3D, the most popular genre ahead of nature and animal programs (62%), and action and adventure (60%); however, this innovation never really took off, as much of the dissatisfaction for viewers was having to wear the additional glasses. This dissatisfaction for wearing additional equipments raises other interesting questions for the future of sports broadcasts, as 2015 was argued to be the year of **wearable technologies**. Much simpler examples of wearable technologies and sport include sport-specific watches that are able to link to a smart phone and provide the user with game updates direct to the watch face. In Australia, Foxtel has already experimented something more with wearable technology and sports broadcasts, with its *Alert Shirt*, described by its developers, Wearable Experiments (We:eX), as "*a fan jersey that uses wearable technology to take the experience into the physical world, allowing fans to feel what the players feel live as it happens during the game*". In this way, not only can you watch the game, you can now **feel** it. For sure there will be other interesting developments, as wearable technologies become a more common part of our daily lives.

1.4.2 Ticketing

Sporting event ticketing websites need to be appealing to every type of sports fan throughout the year. Despite the diverse audience, nowadays most ticket websites employ a mass market approach to website design. Savvy sports marketing websites need to be smartly designed for diverse sports fans: dynamic pricing and Artificial Intelligence (AI) are the innovations that are expected to transform in the coming years the way that fans spend and the way franchises profit.
Dynamic ticket pricing is already drastically expanding who attends games. The concept is relatively simple: instead of selling single game tickets at one price, the amount fluctuates based mainly on demand, but also on other factors like promotions offered by the team or the weather forecast. For instance, if the defending champs are visiting on what's predicted to be a sunny Saturday, the price might be higher than normal. With the floating price, teams can increase revenue off a ticket that might go unsold under a regular pricing scheme, as fans can pay what they want, as often as they want, sitting as close to the action as they can afford. The result is sold-out stadiums, with plenty of cheaper tickets available and an overall revenue increase of 7%; additionally, filling the seats at a stadium or arena benefits the home team and looks better on television.
AI ticketing takes this one step further: fans set their preferences, but they don't actually know which seats they will get until shortly before the game, as the ticketing system will try to maximize their **value for price**. The experience represented by your ticket can be customized in a variety of ways, because the new sales platforms have much more detailed data about their fanbase. If a fan wants to sit near Facebook friends, the system can do it. If a big group of people wants to go to the game together, they will no longer have to sit in the furthest section in order to sit close to each other. The system can handle also more complicated preferences, like who wants to be near other families or even who wants to go with the guys and actually meet single women. All the various reasons people have for wanting to attend the game can be isolated, packaged, and priced according to demand.

[20] Chris Wagner, Executive Vice President/co-founder, NeuLion

Recap

- *The value of fan interaction lies in social media, which play a larger role than ever in the lives of sports fans around the world.*
- *Leagues and clubs need to adapt to this change, in order to monetize the advantages of the globalization of the hometown team.*
- *In traditional media broadcasting, personalization and customised contents are the keys for the future.*
- *Ticketing has already embraced the opportunities given by digital technologies such as dynamic ticket pricing and AI ticketing.*

Figure 1. 19

1.5 Athletic Performances

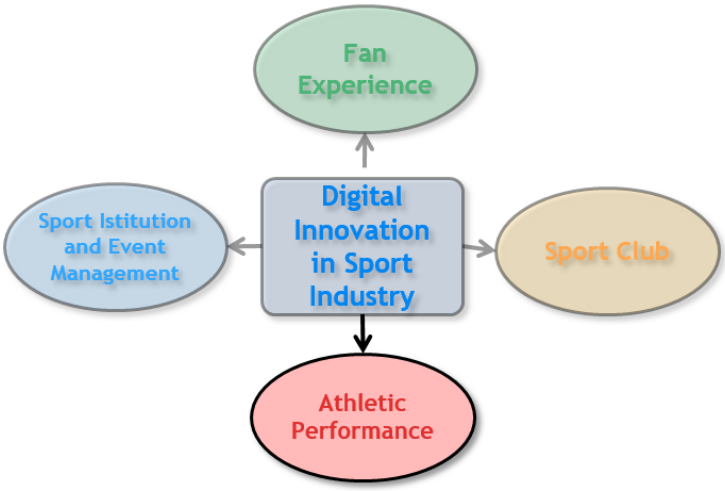


Figure 1. 20

At this point, we have seen that technology plays a particularly vital role in different thematic applications. The last macro-area we want to go deeper in details is Athletic Performances, on which we centered through a deeper analysis in the next Chapter. There are mainly **three reason** behind our choice of focusing on this specific macro area:

- **The historic connection between technologies and performances**. In this first chapter we saw that sport technology today acts as a catalyst for the growing global sports industry. But in the pre-digital age, the application of technologies in sport was heavily concentrated on a single topic: the performances; usually in terms of athlete testing (diagnostics) and improved sports equipment through better engineering and design. Over the years, sport has acquired high levels of professionalism and commercialisation, leading to a greater pressure to win. And it is this pressure that feeds the need for continued application and the search for new technologies that will assist the athlete in achieving even better results. From that point on, the technological and digital innovation has never stopped its run toward the improvement of the performances. It is difficult to imagine this trend changing in the future, given the relentless demands placed on athletes from competition, sponsors, trainers and the general public.

- **The increasing interest in innovation for future trends** in this specific field. There are many examples of technology playing a role in helping professional athletes or amateur active people to improve their success and participation levels. *"In 2017, you will continue to see a rise in sensors utilization across sports, but also a struggle to utilize the data to its fullest and distill down 'real' additional value for coaches and analysts*[21]*."*. Technology doubles in complexity every two years[22] and thus devices become increasingly smaller, lighter, more powerful and easier to use. Moreover, with recent convergence of technologies, many functions are fused into one single device. "*One of the biggest trends we will see in 2017 is consolidation. Consumers want to consolidate all of their tech into one comprehensive device/wearable, instead of 6 wearables for each function*[23]*"*.

[21] Brian Kaiser, Chief Technology Officer, Hudl
[22] Moore's law
[23] Davyeon Ross, Chief Operating Officer/co-founder, ShotTracker

Applications of these new possibilities allow for more effective training, simulation of game situations, management and tracking of athletes, accuracy of results, developing performance and preventing injuries. At the individual level, a major trend is toward real-time application of devices that provide athletes, coaches, and analysts with immediate feedback across a wide range of performance factors: for instance, "*AR will take athletes to another level of training and performance feedback*[24]" or "*Athletes will demand more than tracking from their fitness wearables. Steps, calories, heart rate - users might know what their body is doing 24/7, but there is a disconnect between having the data and knowing what to do with it. Turning trackable data into actionable recommendations will fundamentally change the relationship between coach, athlete and sports*[25]".

- **The Economic Impact**. In 2017, Sports Innovation Lab[26] has initiated its coverage on the technology companies that are working to quantify athlete performance, identifying this topic as a key area of industry disruption in the evolution of sports and fitness technology trends across thousands of global companies. Their initial research shows this is a dynamic market where massive investments are being made by sports apparel, electronics, wellness, and software companies, as stated in the figure.

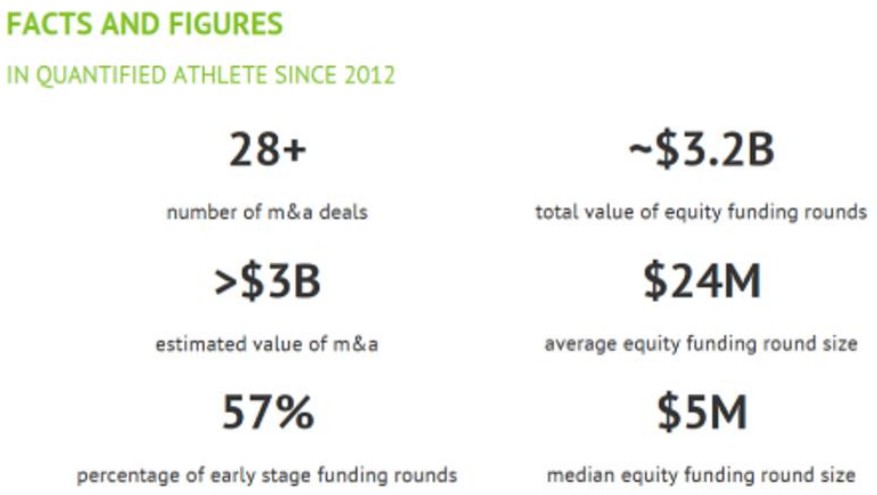


Figure 1. 21

[24] Rich Esposito, General Manager, Mobility Services, IBM
[25] Dan Giuliani, Chief Executive Officer/co-founder, Volt Athletics
[26] https://www.sportsilab.com/

Chapter 2.

Athletic Performance: a framework of analysis

It is possible, although not easy to provide, a framework of athletic performance. Jones and Howe[1] argue that "athletic performance is a delicate mix of natural, moral, and technical, aesthetic, psychological and physical capacities. A collection of contextually grounded intentional and unintentional actions or excellences that we praise and celebrate". The specific nature and amount of each ingredient is not fixed by a general formula and varies from sport to sport: tactical, open games like soccer require a different and broader range of ingredients than closed contests such as power lifting. Identifying the necessary and sufficient conditions of athletic performance is extremely difficult because of the mixed nature of the skills involved. In particular, the challenges in this environment address three different (but complementary) levels:

- The performance measurement is always characterized by **perishable insight**: information needs to be delivered quickly in order to effect decision making. If it takes too long, the opportunity for improving performance is lost or severely diminished. This is a particular arduous task, because so much of all sports involves being able to change and react very quickly.
- Today's competitive **coaching roles** are mired with seemingly incompatible skills and responsibilities: unique sport expertise, competitive landscape, ever-evolving training methodology, sports medicine, modern technology, mention organizational, logistics and equipment design are just a few of the key qualifications for a successful coach. Seeing how all the different athletes in team react to different workouts and different environments: some are more sprint based, some more endurance based athletes, some teams have a combination of both. The best method would be doing an effort, getting feedback, changing that effort, doing the next one and so on.
- Athletes who are training intensively walk a fine line between **peak performance** and **health issues**. Training too much (or too little) will inevitably result in disappointing performance, illnesses or injury. As demonstrated *in "The training—injury prevention paradox: should athletes be training smarter and harder?*[2]", while there is a relationship between high training loads and injury, the problem is not with training per se, but more likely the **inappropriate training** that is being prescribed. Excessive and rapid increases in training loads are likely responsible for a large proportion of non-contact, soft-tissue injuries.

---

[1] (2005, p. 139)

[2] School of Exercise Science, Australian Catholic University, Brisbane, Queensland, Australia
School of Human Movement
Studies, University of Queensland, Brisbane, Queensland, Australia - Dr Tim J Gabbett,
Accepted 16 November 2015 Published Online First
12 January 2016

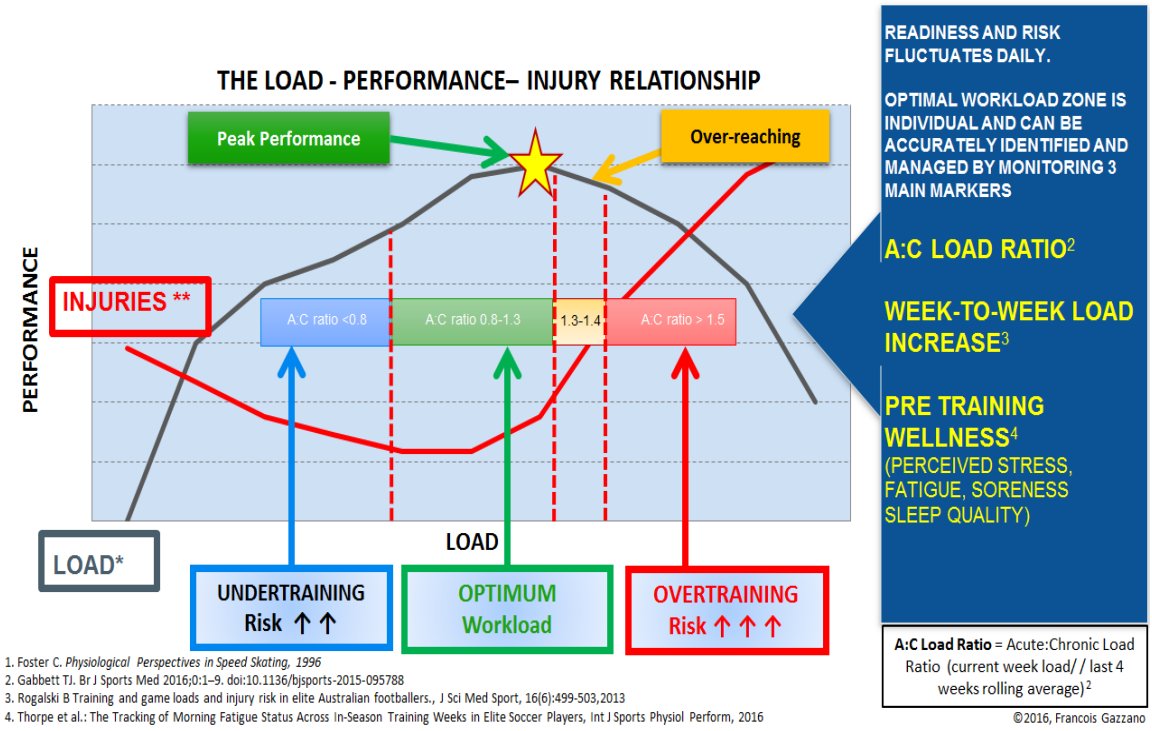


figure 2. 1

All the criticalities described above represent exactly where **digital innovation** can have a huge and extremely useful role: we have seen that in the context of sport, innovations are solutions to pre-identified problems or needs that are critical to the advancement of sport, in order to maximize the experiences and performances of individuals and teams. Consistent improvement in modern athletic performance has been greatly aided by continuous innovation in equipment, training, nutrition and sports clothing. But also digital technologies play a key role: for instance, the latest valuation highlight that sports coaching platform technology market (at $49 million in 2014) will be worth $864m by 2021. In particular, the application of digital innovation to elite sport is integral to athlete development and performance and can be applied to sports science, performance analytics, coaching and training, rehabilitation and generally every discipline related to athletic performances measurement.

Referring to what just said, we pointed out that the athletic performance, since it is a major ingredient in sport, is a complex and **multifaceted topic** that is neither easily specifiable nor measurable: there are different needs of **skills and abilities** to be tested, different **stakeholders for data measured**, different **technologies** collecting those data and different **diffusion** for each technology.
Since once again our topic is on the edge of digital innovation, in today's literature there is not a defined paradigm able to depict this set of characteristics. In order to overcome this complexity, we developed a **comprehensive model** able to categorise all the different digital innovations existing in the sphere of athletic performance.

This model is a ***spider-web chart*** built up on **four axis**. It classifies the different subjects following a precisely defined metric which aims at providing objectivity in the categorisation of the different solutions.
The axis are:

1. **Level of diffusion in the market**: on this axis we have indicated the level of diffusion (high or low) of the technological solution under investigation, splitting the market of athletic performance into amateur athletes (or sports-fitness lovers), and professional athletes. We have therefore identified four different values:
   - *High diffusion both at Amateur level & Pro level*: refers to products that have achieved a good diffusion in terms of sales but also of general knowledge in the whole community of athletes and fitness and wellness enthusiast.
   - *High diffusion only in the Competition sphere*: refers to products that have achieved a medium-high diffusion in a market that is represented by athletes and team which compete in championship or leagues, both at amateur or pro level. The main difference with the previous level is the fact that these consumers have the necessities related to the fact that they are actually competing against opponents, so their aim is not simply related to personal satisfaction.
   - *High diffusion only at Pro level of competition*: refers to products that are quite common only for teams or athletes that compete at the highest level of competition. This means that even if their potential market could be the same as for the previous level, their truly penetrated market is only represented by top players and teams.
   - *Low diffusion even at Pro level*: refers to product that are so innovative, expensive or complex, that only few teams, athletes or leagues in the world have been able to implement them.

2. **Stakeholders of the results of the analysis**: axis that identifies those individuals who have the skills, knowledge and the role suitable on one hand to enter data and to properly customize the system according to user preferences, on the other hand to understand properly the outputs from the technological solution. We want to clarify that this axis not therefore refers to individuals who are the subject of the measurement (as they are always the athletes or those who do physical activity) but it aims at differentiating the different actors which then will have the opportunity and ability to fruitfully use the data recorded or processed by the system. Even here, we have identified four values:
   - *Individual athlete*: the information coming from the technological system considered are basic information, related to a time range which often does not coincide with the duration of the single workout or match (for instance, they perform a daily or continuous monitoring), with a relatively simple interface that allows the input or the reading of data also to the athlete himself, without the need for a more experienced support.
   - *Athlete and Coaches*: the output of these systems is more complex and a more focused on a defined time (usually related to training sessions or games). In addition, during both the installation and customization of the service step and during the analysis of output data, skills are needed about the physical technique that require the knowledgebase of a coach. In addition, such systems can provide comparison services between different athletes or team performance measures and therefore they require a stakeholder who has an overall view on the performances of all athletes.
   - *Athlete, Coach and Medical Staff*: the information required as inputs and then given back elaborated as output by the system contain biomedical parameters with a complexity that requires the knowledge of the medical staff in order to be able to enter the required information and then interpret correctly the results provided and extrapolate valuable insights.
   - *Whole Team Staff*: they are systems which address the different professional figures present in a team. This because the information required as input concern not only strictly the direct observation on the field of athletic performance, but also data coming from the analysis of other parameters or athlete's specific behaviors which could then provide information to the analysis of athletic performance.

Even at the output level the results processed by these systems, while focusing on the athlete's physical performance, can generate valuable information not only for team staff closely related to the athletic performance, but also for individuals related to other functions (for instance related to management or marketing).

3. **Level of complexity of the analysis**: this axis provides a measure of the level of complexity and homogeneity / heterogeneity of the required input data of the system. The classification is also based on the use that the system is able to do on the data entered, ie the level of processing applied to the data from the system and the corresponding wideness of results provided, both in terms of number of insight and time spawn. As with the previous axis, the core values are four and are:
   - *Simple data gathering*: systems able to manage a simple format file of the input data, aiming at showing those data in a proper and user-friendly way. Usually the level of elaboration applied to data is low or absent, because of the simplicity of the solution or because data are already easily understandable by the stakeholder. The main goal of these systems is usually to provide a clear view on the series of data gathered during time.
   - *Data analysis on specific file format, to describe the situation*: systems able to handle all data of the same typology (for instance video files) which, however, often are not immediately readable for the end user. The system then uses its technological and computational capabilities to process these data, with the aim of picturing a description as complete and close as possible to reality.
   - *Data analysis on different file formats, to describe and provide insight on the situation*: here the system does not aim only to describe the situation as-is, but also to highlight any possible changes to the situation mapped, or to include in the description even parameters external to the situation actually examined. To do so, this typologies of systems are able to receive the input data even with very different formats from one another.
   - *Analysis on both technological and biomedical data to describe, provide insights and foresee future scenarios*: extremely complex solutions that require as input not only a very heterogeneous set of data formats but also the time series of such data. This to be able to apply internal models that can predict possible future developments of the situation and of the parameters examined.

4. **Technologies used**: axis which refers to the variety of technologies used both to run the system, either functional to that system to collect the necessary data. Consequently, depending on the technologies employed can also define the variety of file type/measurements provided. The four levels are:
   - *Basic Interface application*: applications that do not use specific technological solutions for data gathering. Consequently, also the computing platform on which they are implemented is streamlined and simple.
   - *App & IoT sensors*: solutions that are built upon the IoT sensors to derive the information that will then be entered and processed by the system.
   - *App, IoT & Cameras*: solutions that can develop synergies between IoT technologies + App and video playback technologies, usually in order to obtain more specific measurements and leverage the strengths of each technology to overcome the difficulties expressed by the other.
   - *Complex computation algorithm gathering data from app, IoT & Cameras*: solutions not only able to communicate with these different technologies, but also to match and synchronize data from all sources to provide an analysis more accurate and effective. For this reason the algorithms required for this analysis are often very complex and require customization based on the specific needs of stakeholders.

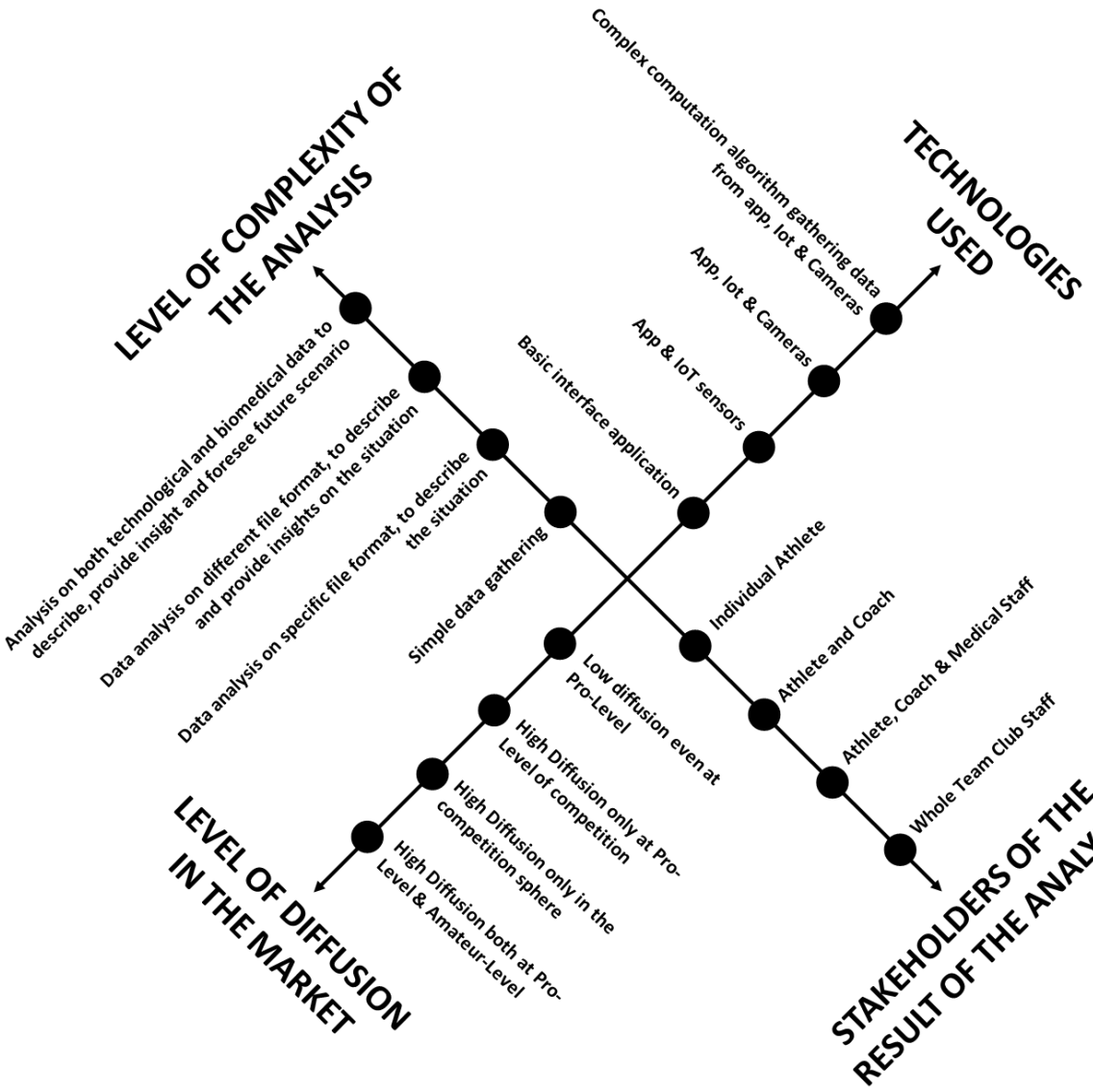


figure 2. 2

After defining the skeleton of our model, we have classified each of the technological solutions analyzed in the literature. We wanted to map the current state of digital innovation, highlighting the different clusters of innovative solutions in relation to service packages tied to well-defined areas:

- **Training and Fitness Apps**
- **Performance Trackers solutions**
- **Specific Gesture Analysis solutions**
- **Team Movement Analysis solutions**
- **Virtual Environments solutions**
- **Cognitive Computing and AI solutions**
- **Injury treatment solutions**
- **Talent Identification solutions**

The analysis of each solution was made by identifying the most suitable level on each axis, and then linking together the points found, thus forming the real *spider-web chart*:

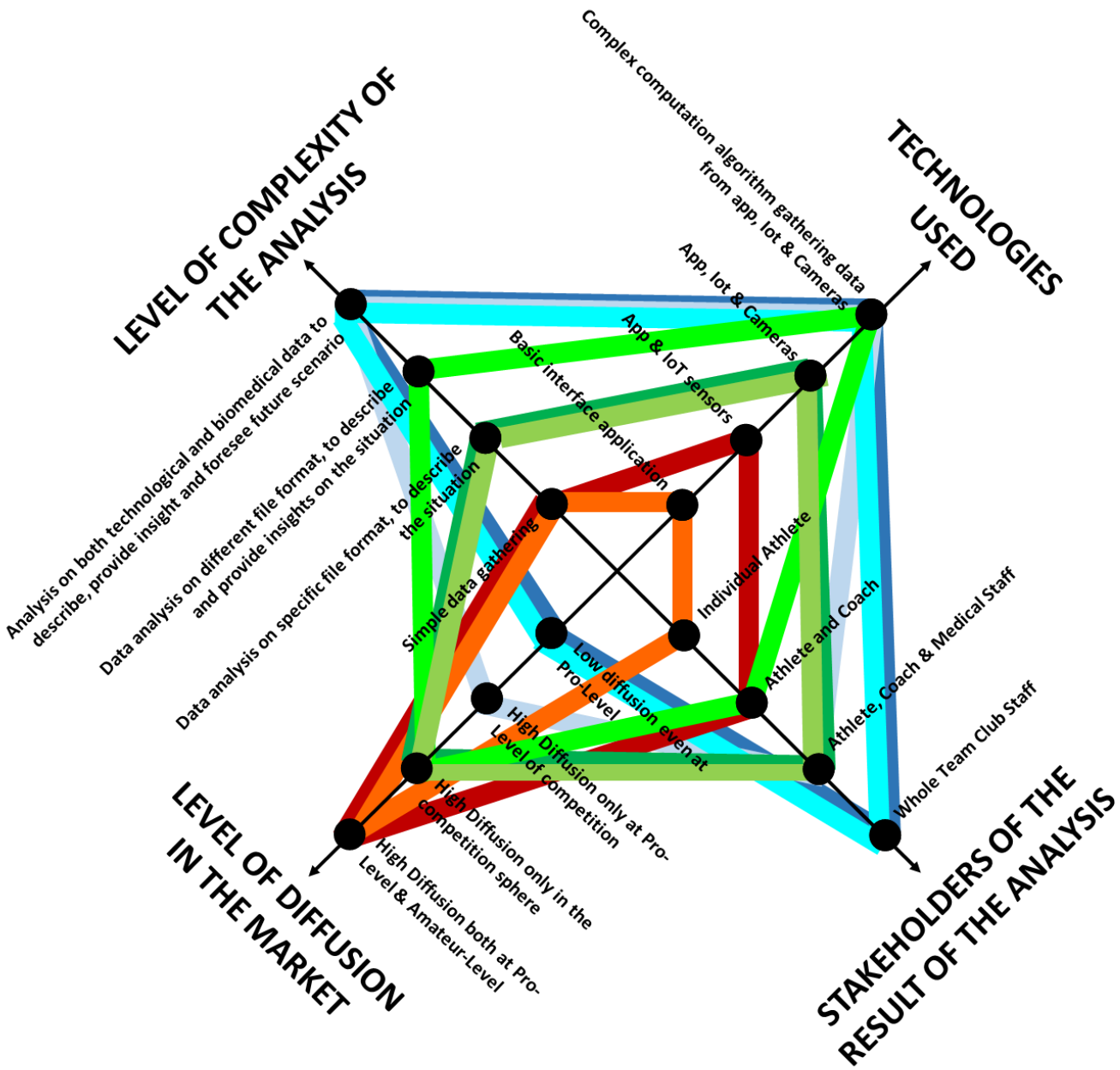


figure 2. 3

Through this model we are able to see that the different varieties of innovation solutions monitoring AP existing in the market nowadays can be splitted into three main areas:

- ***The established trend (red shade):*** solutions that have reached an high diffusion on the market, leveraging their simplicity and easiness of use.
- ***The full measure (green shade):*** solutions that can provide a valuable and complete view to different stakeholders, leveraging the use of different technologies.
- ***The last frontier (blue shade):*** solutions that are on the edge of digital innovation, providing a complex range of insight.

Our intent now is to go deeper into each of the solutions in these three areas. Each solution will be analysed in its specific paragraph, in order to explain their particular features and therefore explain the different values they have obtained in the graph.

The final paragraph is dedicated to Sport Equipments, a topic that conversely has drawn the attention of many studies, focused on different factors of this market. Therefore, we provided a recap and reprocessing of their findings.

2.1 The established trend

The first solution we are going to analyse is the most **widespread** one, since it has reached the mainstream diffusion leveraging its simplicity of use, installation and setup. For this reason, our dissertation starts with a focus on the market characteristics of this sector.
It could be useful to point out that, despite the lighter level of innovation of these solution, we should not underestimate their role on the whole sector: revealing in advance the results of our analysis, we can affirm that they have strongly contributed to the **diffusion** on a large scale of the culture of digital innovation in the athletic performances, often providing the **basis** for a further development of more complex solutions.

2.1.1 Training and Fitness App: the mHealth market

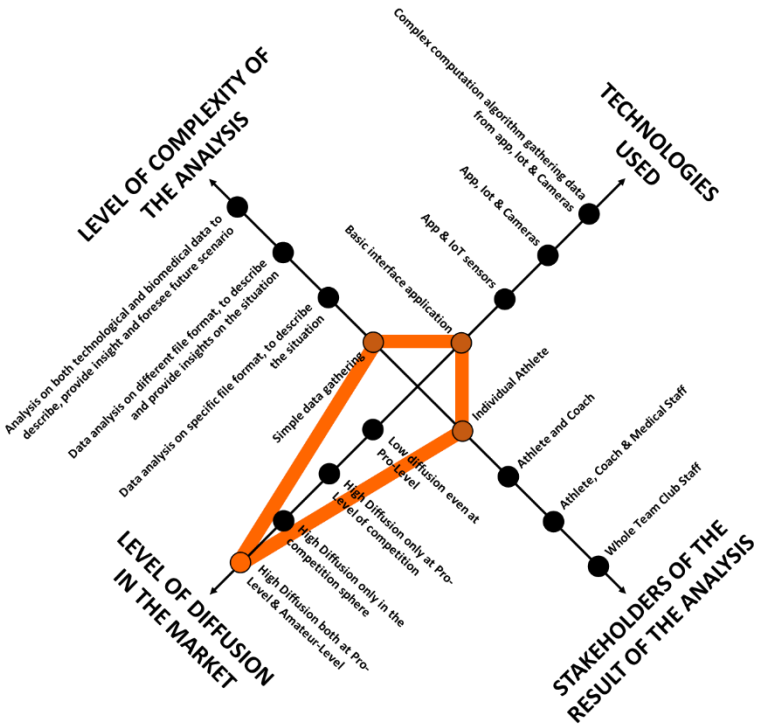


figure 2. 4

The **mHealth market** (which in literature refers both to the fitness sphere and the health sphere) according to a report by Research2guidance, is currently valued at $10B, and it will grow at a compound annual rate of 15% to reach $26 billion by 2017 and $31 billion by 2020.

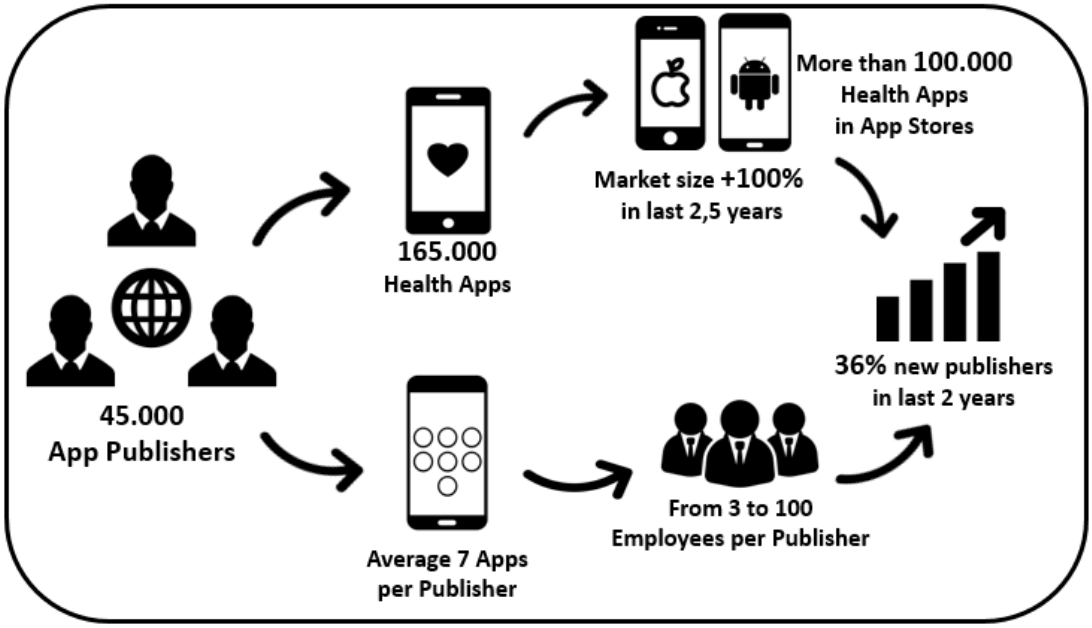


figure 2. 5

"*The mHealth market will step out of its niche in the next few years*," stated the managing director Ralf-Gordon Jahns[3]. "*mHealth app publishers will have to concentrate on selling high value health services and devices with the help of their apps in order to grow.*" Indeed, although the health app market has seen significant growth, the app developers are still trying to find effective **monetization strategies**.

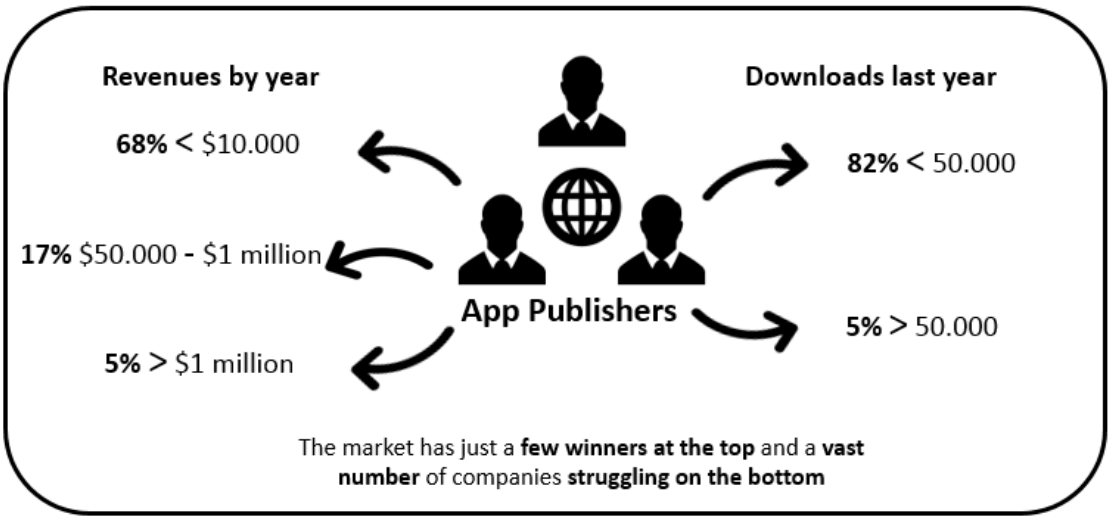


figure 2. 6

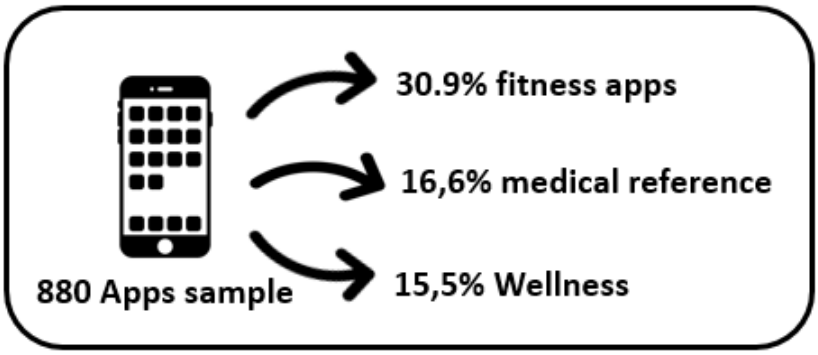
[3] Director of research2guidance

In spite of the great hype in the market that attracts new entrants, the majority of mHealth app publishers did not find the right business model to monetize from. In general, the mHealth market consists of the following **revenue streams**:

- App store download related revenues of the categories Health&Fitness and Medical, including **paid download** and **in-app purchase revenues**. Apps in the Medical sections of the app stores generate significantly fewer downloads than their counterparts in the Health&Fitness section. Despite lower download volumes, Medical apps generate more money than those in the Health&Fitness category, as revenues of Medical apps come predominantly from users paying to download the app.
- **advertisement revenues** that are related to app advertisement;
- mHealth **service revenues** that are linked to services delivered through the app. This mainly includes remote consultation and monitoring services but also a large variety of niche services;
- mHealth **device revenues** that relate to devices being sold in conjunction with an mHealth app.
- mHealth **transaction revenues** that come from selling drugs and sanitary products via an app.

As a we can see, companies have developed a variety of business models that move away from the traditional revenue streams, **transforming mHealth apps into tools to sell product and services**: one strategy that health app developers have found is to use the apps to sell connected devices, like activity trackers, wristbands and glucometers. This is the reason why total revenues of this market are not related to paid downloads (which will make up 9%), but from mobile health hardware and services (84%).

As stated in different marketing researches[4], the general **healthcare and fitness apps segment** (comprising fitness and nutrition apps, health tracking tools, and weight-loss apps) dominated the healthcare apps market with the largest share.



[5]

figure 2. 7

The high diffusion of this segment is mainly due to the increasing awareness on the benefits of maintaining healthy lifestyles, while apps are offering increasingly advanced and diversified features. Just to give some examples, the app designed for wellness and fitness allow the monitoring the parameters of different workouts outdoors or in the gym, to keep track of the diet, or to book yoga classes or massages in your fitness or wellness center.

Recently, apps that target women have also become very popular. However, it is interesting to notice that a plurality of app publishers [6](31%) target the chronically ill with their apps, followed by fitness-oriented people (28%) and doctors (14%).

[4] *Health and Fitness Apps* redatto da Flurry ; *Top 10 Global Spa & Wellness Trends 2014* redatta da Spafinder Wellness

[5] Sample analysis.

[6] From the analysis of the appstores for their report, as well as surveying 2,032 app publishers to make their predictions.

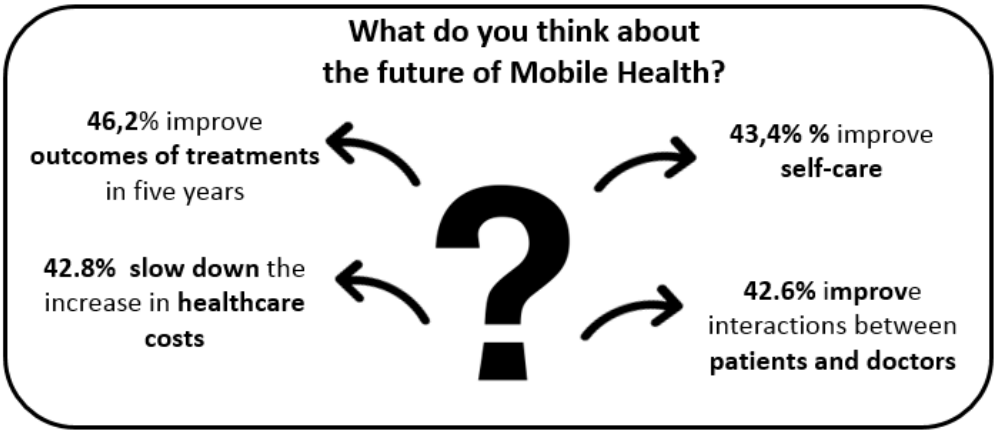


figure 2. 8

It is interesting to notice that, despite Android overall market dominance in the app market, IOS remained the leading platform for this market. IOS mHealth app publishers also spend most for paid app downloads and in-app purchase features and services: the average app store revenue per mHealth app for iOS is between $5,000 and $6,000, while for Android is half of that.

Chronologically, the first main drivers[7] for mobile health adoption have been:

- the increasing penetration of smartphones, tablets, and other **mobile platforms**;
- robust penetration of **3G and 4G networks** to provide uninterrupted health and fitness services;
- the increasing utilization of **connected medical devices** and mHealth apps in the management of chronic diseases to reduce the rising healthcare cost;
- rising focus on **patient-centric** healthcare delivery.

On the opposite, risk of data theft, stringent regulations by the FDA and EU, low guidance from physicians in selecting apps, and resistance from traditional healthcare providers in emerging countries are some of the threads that this market is showing.
One of the key point in the success of an app that has gained importance in the last period is the possibility to **connect** with different sensors, software or even other applications, hovering up to 30 integrations per app. It is a trend clearly explained by the fact that 71% of apps either connect or plan to connect to an API in order to import or export health data, and the health apps that connect to the most device APIs (MyFitnessPal, MapMyFitness, and EveryMove) are also the most successful ones.

These **synergies** have created several and different solutions designed for mobile, addressed both to end users and to those who manage a health or fitness club, with functions that can encourage the relationship between members and owners / operators. Not surprisingly, this segment has attracted investment from both the software giants like Apple (HealthKit), Google (GoogleFit), Samsung (SHealth), both traditional sporting players like Nike (Nike+) or Adidas (myCoach). In particular, we have highlighted two trends, opposed yet complementary: on one hand, users nowadays tend to **individualise** their sports practices, meaning that they now prefer competing against their own abilities (for instance, people use apps for timed trials or constantly try to improve the number of repetitions in a gym situation). In this sense, the data collected by the sensors are analysed by its app with a focus centred on the time series and the gradual and day-by-day improvement of their own achievements.

[7] http://www.marketsandmarkets.com/PressReleases/mhealth-apps-and-solutions.asp

On the other hand, the fact that these results are available for being **shared** on **social media** have also had a profound impact on the behaviour of sporty people: in fact, sharing their results on Facebook or apps like Strava, pushes people to train even harder in order to achieve better results. People get motivated and feel as a part of a virtual community, and gain the ability to benchmark their results with others. Not surprisingly, the main cause of the greater use of applications as part of the healthy lifestyle is directly linked to the rise of those defined by Flurry as ***Fitness Fanatics*** consumers, who use health and fitness app for a span three times higher than the average consumer.

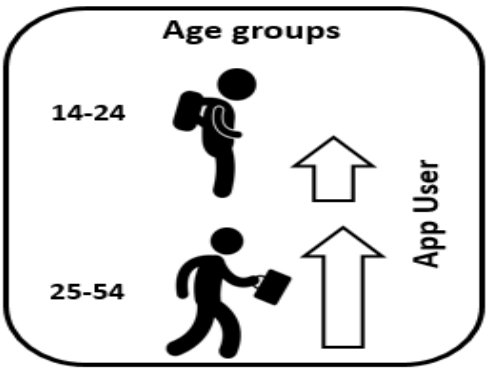


figure 2. 10

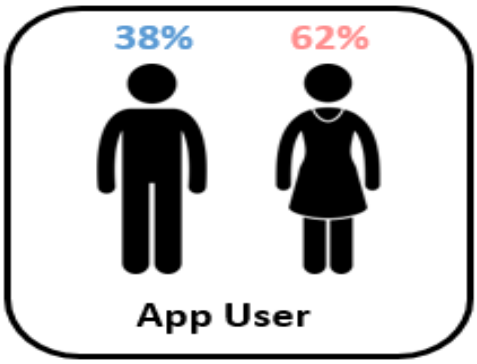


figure 2. 9

"*Will survive* - as stated in the study conducted by Spafinder Wellness - *those offers which will capture the imagination and confidence of users, as well as guaranteeing the essential functions. The determining factor in the evolution of wellness app will be twofold: make data collection as* ***simple*** *as possible and relate it with the group of peers (like the training partners) and with that of advisors (instructor, personal trainer, physiatrist etc.)*". For instance, the integration of MyFitnessPal with Facebook is a significant example: "*friends can support each other, appreciate and share the goals achieved and engage in competition within each other*", says the Flurry's study, "*This innovation has amplified the viral spread of these apps through the social network channel.*" The professional figures working in the areas concerned - fitness, sports, wellness, health - could add value and/or efficiency to their business and be more competitive, using or even developing an application for the mobile channel, with appropriate and original content, usefulness and simplicity.

2.1.2 Wearables: IoT-enabled performance measurement

"*Wearables will continue to be a game changer for coaching staffs, athletes, and fans. The ability to measure and track performance data and leverage analytics will ultimately empower teams to be more sophisticated about their game plan, athlete performance, and injury avoidance.*"

- Scott Mager, Principal Deloitte Digital

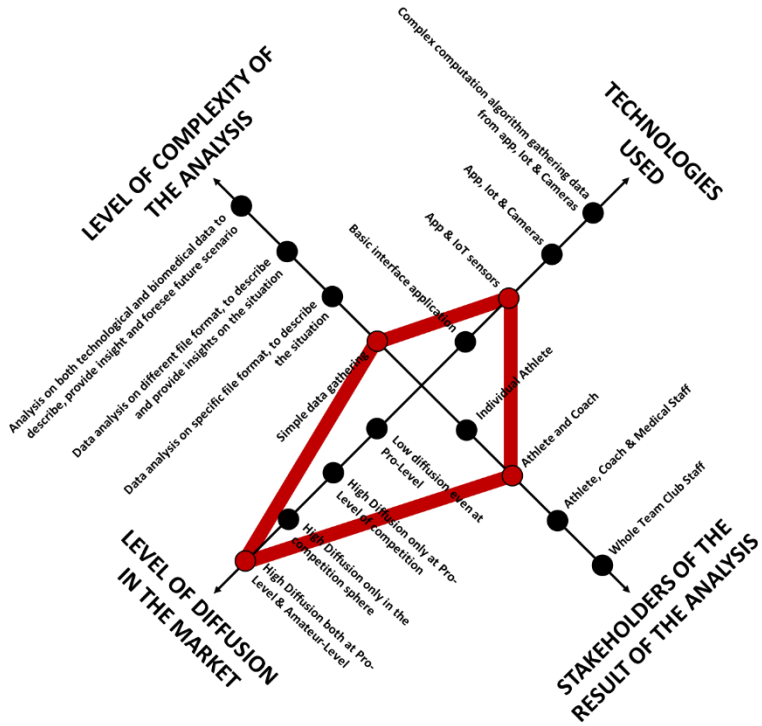


figure 2. 11

Leaders in advancing Internet of Things applications on athletic performance analysis have been able to understand something crucial: more than ever today's technology needs a comprehension of the human mind and body, as some of the performance indicators we are interested in are not yet fully understood and can't be measured directly. Athletes can mentally correlate their **perceived performance** (how fast they think they're going, how tired they think they feel) against their **actual performance** (based on real, instant data).
The **wearable solution** allows coaches and team staff to monitor player information such as motion, heart rate, and other useful health and performance metrics from **sensor-equipped vests** worn by players. This information, combined with player location and environmental data, are usually sent to a secure cloud-based analytics platform providing critical insights back to team staff via a dashboard. By informing better player interventions and improving game-time tactical decisions, the IoT solution helps provide significant **competitive advantage** to teams. In addition, user's interface can be designed to enable better overall management of player health, recovery, and injury avoidance, extending the benefits far beyond an individual game. The potentialities of this approach are so high that even a market leader like IBM has started different businesses in this area. For instance, they started a collaboration with the USA Cycling team through their Watson IoT service, in a project named "IBM jStart". Through their service, they are feeding information back to the cyclists immediately after a workout and real-time during a race through smart glasses. This data and real-time feedback "*improves the cyclists efficiency, guides them when to push more, and helps them avoid the dreaded "bonk" when your tank just runs out of fuel.*[8]"

[8] Rhonda Edwards, manager and writer for IBM Internet of Things blog.

Therefore, IBM recognized 10 key factors that are behind the competitive advantage of the IoT technology applied to athletic performances:

1) **Track power**: measuring the exact amount of power an athlete is putting out in real time, providing data in order to maximize the athlete's live performance.
2) **Understand energy levels**: allowing athletes to better-understand energy production and utilization in order to optimize training load and recovery, as there are metrics (like muscle oxygen) that have a uniqueness to the individual and can correlate to many physiological conditions.
3) **See matches burned**: essential high-performance product can fuse critical wearable technologies that include an innovative heads-up display and audio technologies.
4) **Analyze all times**: containers first convert the raw data into user-friendly messages, next they automatically send the messages in near real-time to a Watson IoT, for more immediate feedback and integration with other data feeds (power, heart rate etc.) to point out correlation and advanced analytics
5) **Derive value from the things**: with IoT analytics, team members can get a clear analytical picture of what they need to do to win. Watson IoT now allows them to read both structured and unstructured data to create a comprehensive view. If a player is overexerting themselves, the Watson IoT platform can notify them before an injury occurs or before they burn too many matches.
6) **Collaborate with the team**: listening to the coaching staff in the development of an effective service with a simple user-interface, bar charts and high readability.
7) **Spark insights**: the team will also be including the power of IBM Analytics to calculate metrics in real time. This will allow the team's coaches to monitor performance not only after the training session, but while it is still in progress (for instance, during each exchange the coaches will be able to see whether a match was burned).
8) 9) 10) **Collect and share IoT data / Go mobile / Store IoT data on the cloud**: the solution on the cloud remove the complexity of developing and managing mobile apps and allow teams to focus on the needs and demands of the dynamic mobile user: having relevant information at the right time with the ability to take immediate action. As this new training solution is mobile and cloud based and on the Watson IoT Platform, teams can practice anywhere and still benefit from the real time tracking, analysis and communication. Bringing together not only tools to connect the wearable devices but also the data and analytics services, providers can create personalized end-user experiences, drive progress, and cut costs with healthcare in the cloud. Using their mobile app, coaches can also access real-time training sessions at any time and from anywhere, enabling remote engagement when everyone can't be in the same place at the same time. This provides a lot of flexibility to pro-team that are constantly on the go.

Recap

- *The mHealth market is expected to growth significantly, exploiting different drivers.*
- *The key factor will be the development of synergies between app and devices, to make data collection as simple as possible.*
- *In particular, wearable devices will have a prominent role in the comprehension of athletes' own bodies.*

2.2 The full measure

At this point, we have understood that in today's sport training and performance analysis, nearly all performances are captured on video or through IoT sensors. Captured footage and sensor data are then viewed by expert coaches/analysts. Is in this field that the software platforms and applications play the biggest role, in a range that goes from reducing or avoiding time for manually annotate and label important performance indicators to gauge performance, to computer-assisted self-training systems for sports exercise, extracting tactic information next to regular semantic event detection, leveraging even virtual reality and on-body acceleration sensors to perform motion and force analysis.

2.2.1 Specific Gesture Analysis

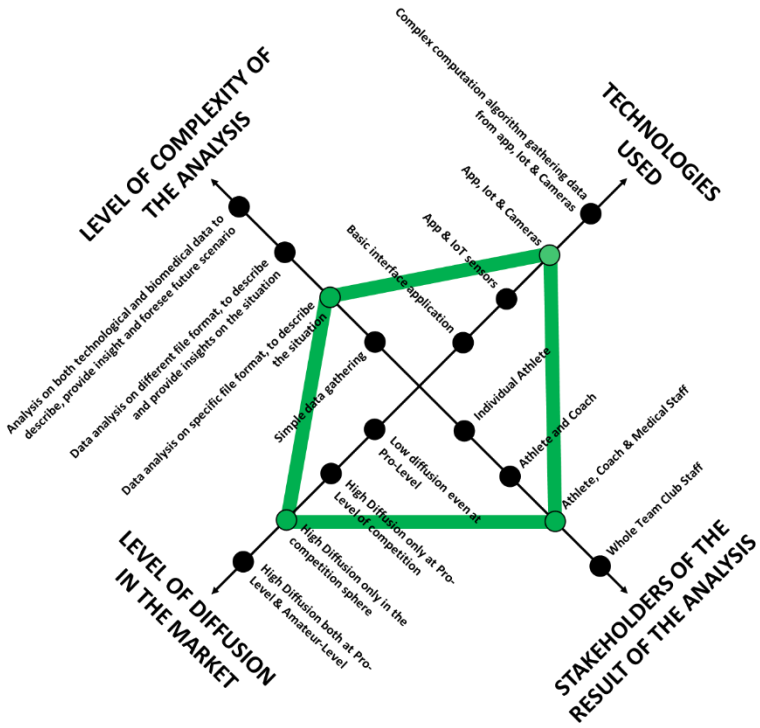


figure 2. 12

Motion Capture (MoCap) is defined as[9] "*the practice of dynamically recording the positions in 3D space of various pre-defined points on the body or an object*". Besides the general motion studies, biomechanics intends to measure the motion and relates it to the underlying musculoskeletal function. This provides information for the performance of a single athlete, but can also provide information about the health status of the individual regarding the musculoskeletal system. The whole model is known as the **biomechanical model**. The complexity behind these models is not just related to the methodology behind the analytics, but also to the technology applied: a very **wide range of technologies** for motion capture are available, hence the outcome differs significantly with each system. Optical tracking devices use multiple infrared-sensitive cameras to track the positions of '*markers*' attached to the target (to joints on the body, for example). '*Passive*' systems illuminate

[9] 2011 Joint Symposium on Computational Aesthetics (CAe), Non-Photorealistic Animation and Rendering (NPAR), and Sketch-Based Interfaces and Modeling (SBIM)
Edited By Tobias Isenberg, Paul Asente, John Collomosse and T. Metin Sezgin

the scene with infrared light and detect the positions of retroreflective markers. '*Active*' systems use infrared light-emitting diodes as markers, but are otherwise similar. Provided the positions of the cameras in the space are known (i.e., the system is calibrated) the 3D location of each marker can be recovered by analysing its position in each camera's image (at least two are required to recover 3D position of a marker). Often these systems work in conjunction with IoT sensors, but in this specific field of analysis they have some constraints: the non-functional requirements of the system are primarily related to its **wearability**: the system should be portable and wearable and easily used as part of the athlete' s normal training program. This limits the range of usable sensors, as they must be non-invasive and minimally influenced by physical and biological responses such as vibration and sweating. The system's size and weight must also be kept to a minimum, preventing any movement or performance restrictions. It should also have a sufficient power supply, at least for a full training session, while wearability also implies that the information between the athlete and the system's main control unit should be wirelessly transmitted.

In addition to technologies that capture human and object motion, technology for eye and gaze tracking can also be used in the context of **sports training**: gaze behaviour can differ significantly between experts and novices (e. g. when tracking a ball), so **bad habits** and **unconscious actions** that can affect performance can also be identified by tracking an athlete's eyes during play. Additionally, the technique and analysis differs widely, depending on the methodology used. For example, animation needs a continuously and steady signal, but does not need a physiological precision of the individual. The latter would be essential for clinical science, where motion capture needs to be complemented with other systems, such as force measurements and electromyography. This is needed in order to not just measure motion, but to analyse and comprehend the reason for the motion. This is the reason why general motion analysis is usually applied in the field, while clinical motion analysis is more restricted to specialised laboratories which consist of complex technology and specialised professionals to handle it.

In the past two decades, MoCap systems have been developed that allow to track and record human motions at high **spatial and temporal resolutions**. Such applications require efficient methods and tools for the automatic analysis, synthesis and classification of motion capture data.

The main challenge in articulated body motion tracking is the large number of **degrees of freedom** (around 30) to be recovered. Researches have usually focused on two opposite approach: one approach is to introduce **constraints** from assumptions about motion trajectories or view restrictions, either labelling using markers or colour coding. The other approach is to relax constraints arising from articulation, and track limbs as if their motions were **independent**. In both cases, the analysis is challenging because of the technological and practical difficulties associated with the resolution and accuracy of 3D video analysis through **large volumes**. Since even an improvement of as little as one-hundredth of a second between two different movement could be significant to the gesture outcome, performance enhancement for elite athletes may involve technique adjustments that are beyond the capabilities of video-based systems and instead must rely on coach and athlete intuition. To solve this complexity, an innovative system called **fusion motion capture** (FMC) has been developed. It is able to capture 3D kinetics and kinematics overcoming the technological difficulties associated with athlete performance monitoring in an elite environment. FMC is a term that describes motion capture when several **different streams of data** are **fused** to measure athlete motion: inertial measurement units (IMU), global positioning system (GPS), pressure sensitive insoles and video measurements have been combined. The core of the FMC is the fusion of IMU and GPS data: IMU typically contains accelerometers, gyroscopes, magnetometers and a thermometer, and they track local orientation and acceleration of each limb segment of interest. GPS data are fused with local acceleration data to track the global trajectory of the athlete. In this way, the software is able to draw a **complete picture** of the gesture of the athlete, highlighting also the different vectorial forces and momentum of each part of the body during the activity. Moreover, the most advanced softwares also include an eye-mark recorder, a device for measuring a subject's point of visual focus and pupil diameter which is able to draw a precise single or dual eye movement measurement of lines of vision. Those data can then be synchronized with the motion capture systems, in order to view them in both real-time and post-processing.

2.2.2 Team Movement Analysis

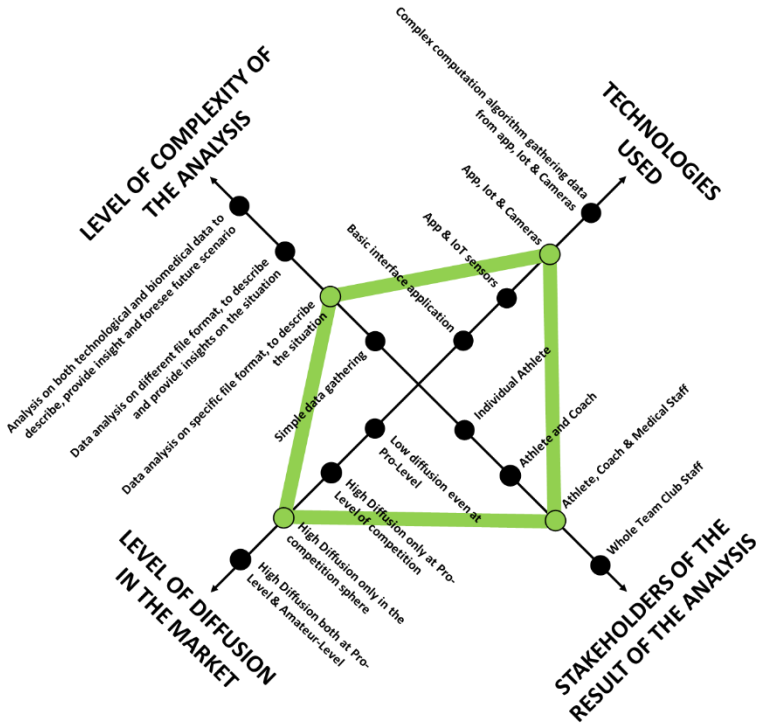


figure 2. 13

Both during training sessions and on gameday, efforts at player motion tracking **on the field** have traditionally involved a range of data collection techniques from live observation to post-event video analysis, where player movement patterns are manually recorded and categorized to determine performance effectiveness. This process is called **Notational Analysis**, and involves the subjective quantification of individual players' movements by an investigator, and the frequency and timing of particular movements are then related to their relative success. Obtaining accurate positional information about sports players is of interest to coaches and high-performance support teams because of the potential to relate performance to **tactics**, and to assist in the design of better training programmes. The complex nature of movement inherent to many physical activities also represents a significant hurdle to overcome: athletes tend to exhibit quick and agile movements, with many **unpredictable changes** in direction and frequent collisions with other players. Each of these characteristics of player behaviour violate the assumptions of smooth movement on which computer tracking algorithms are typically based. However, the increasing capacity of digital technology to collect, manage and organize video images has made it possible to enhance existing sport-specific analytical procedures: those are the **Automated Vision-Based Tracking Systems**, that consist of a variety of methods employed to analyse the motion of athletes during sports where the movements vary in duration, field position and surface, speed, direction technique and tactics. Unlike the manual visual tracking systems, automatic motion tracking does not require human operators to locate manually and continually record the position of the tracked object. There are plenty of potential applications of an automated motion detection system are offered, such as: planning tactics and strategies; measuring team organisation; providing meaningful kinematic feedback; and objective measures of intervention effectiveness in sports team, which could benefit coaches, players, and sports scientists.

- **Object tracking** is widely used in sports analysis. Balls and players are the subjects tracked most frequently, since significant events are mainly caused by ball-player and player-player interactions. Common tracking techniques include trajectory-based ball detection and analysis, physical model-based 3D trajectory reconstruction and 3D position estimation with multiple cameras.

The visual cues used for highlight detection are ball motion, playfield zone, players' positions and colours of uniforms: for instance, a model can utilize dominant colour ratio and motion intensity to map the structure of a specific sport videos, basing on the syntax and content characteristics of the videos themselves, since in a sport game the positions of cameras are usually fixed and the rules of presenting the game progress are similar in different channels. Other algorithms are able to exploit the marker lines on the field in order to determine the calibration parameters: they are based on a specialized court−line detector followed by a combinatorial optimization step to localize the court within the set of detected line segments and an iterative court−model tracking step. Exploiting these properties, the object tracking methods[10] are able to perform a classification based on mid-level representations, including motion vector field model, physics-based algorithm, colour tracking model and shot pace model.– With the statistical graph for ball movements, the coach is able to view the distribution of playing actions at a glance and to quickly comprehend where the players can have higher effectiveness.

- **Shot Classification**: as for object tracking strategies, many shot classification methods are proposed based on camera motion, colour information, texture information or face detection. Most of existing shot classification approaches follow also the same procedure, focusing on clustering by aggregating shots or key-frames with similar low-level features. Additionally, the shot classification scheme can employ a supervised learning process to perform a top-down video shot classification. This framework consists of three main steps: identify video shot classes for each sport; develop a common set of motion, color, shot length-related representations and supervised learning of the given sports video shots. Employing space analysis to map low-level features to mid-level semantic video shot attributes (such as player motion, camera motion patterns or court shape, etc) a match analyst can combine these mid-level shot characteristics and classify video shots into a small number of semantic predefined shot classes which are able to cover 90%–95% of broadcast sports video.
- **iCaCoT**: the concept of Interactive Camera-based Coaching and Training focuses on using interactive video navigation for coaching and training purposes. The concept leverages tiled streaming technology[11]: iCaCoT gives a trainer the possibility to zoom in on his trainee while she is training and to focus on specific areas, both spatially and temporally, using a smartphone or tablet. By pausing the video at key moments, trainer and trainee can focus on and discuss details of the performance. By placing multiple high resolution cameras around strategic positions, it is even possible for a trainer to view a moment from different angles. A research[12] showed that the most popular features are the slow motion functionality, the stepframe and the draw possibilities. More generally, iCaCoT scored high for experience, learnability, usability, quality of navigation and usefulness; a trend also reflected in evaluation of impact on teaching/learning ability and benefit for trainers and trainee. Additionally, trainers have indicated that they would further benefit from a method for comparing 2 athletes or 2 runs of the same athlete, so further research on tiled video streaming for the use in coaching and training should focus on this aspect.
- **3DRSBA**: it stands for 3D Remote Sports Biomechanics Analysis, and its aim is to establish remote biomechanical service for health screening of athletes. 'Remote' means that by combining existing high end 3D capture systems with modern tools in communication, such as high speed internet, cloud storage and the new 4G mobile network, biomechanical sport studies can be moved outside to the training side, without losing the scientific and medical support a motion laboratory can provide. This is an answer to one of the main obstacles of laboratory studies: the limited availability of biomechanically literate technical staff in addition to trainers.

[10] L.Y. Duan, M. Xu, Q. Tian, C.S. Xu, J.S. Jin, A unified framework for semantic shot classification in sports video, IEEE Trans. Multimedia 7 (2005) 1066–1083

[11] Dividing a video frame up into multiple tiles, where each tile contains a particular area of the video. This allows users to navigate freely through high-resolution video feeds while minimising the bandwidth required, by only streaming the part of the video the user is interested in.

[12] D'Acunto, Lucia et al. "iCaCoT - Interactive Camera-based Coaching and Training." WSICC@TVX (2015).

Currently, the professional education of such professionals is extensive and requires many years of experience; hence the availability of such experts is limited. Moreover, a full analysis session in the laboratory is an interruptive event in the already tight schedule of an elite athlete with a professional training plan and living. On the other hand, the laboratory approach delivers results of high technical quality, with carefully controlled parameters. Therefore, the possibility to combine the power of 3D motion capture in biomechanical laboratories with the necessities in sports analysis to provide reality-close surroundings in measuring is the real key factor that is driving the success of 3DRSBA systems.

Ending this section, we want to provide a practical example of the use of the Automated Vision-Based Tracking Systems a league which traditionally has always been particularly close to the analysis of statistical data, often pioneering best practices which then have spread in other sporting areas: the **NBA**. The 2013-2014 NBA season is the first for all teams to have SportVU tracking, a system of six cameras in each arena that measures the movements of the ball and every player on the court, generating an entire database of performance information, helping owners and coaches recruit players and executing game plans. Data are changing the way the game is played, shifting emphasis from how many total points a player scores to measures of player efficiency, productivity per touch, and defensive effectiveness. "It has been hard, historically, to quantify defense," said Brian Kopp[13], "Now we have four camera views helping you do that." In addition, the data have influenced the types of shots players take on the court. Of course "Analytics alone won't win you a title, said Sam Hinkie[14], "analytics is a tool to help those decision makers. With every team having the same deep information, the way to gain competitive advantage in the future will be finding an analytics technique or technology from another industry that can be applied to our sport in an innovative way." The NBA is one of the League where this phenomenon of '*technification*' is most noticeable and has been embraced by the entire association, but other projects are already in embryonic development in other associations[15].

[13] senior vice president of STATS, the company that developed SportVU player tracking

[14] Philadelphia 76ers general manager and president of basketball operations, an early advocate of basketball big data

[15] http://www.sporttechie.com/2016/10/27/sports/mlb/chicago-cubs-leverage-big-data-motion-capture-technology-in-2016-run/

2.2.3 Virtual Environments

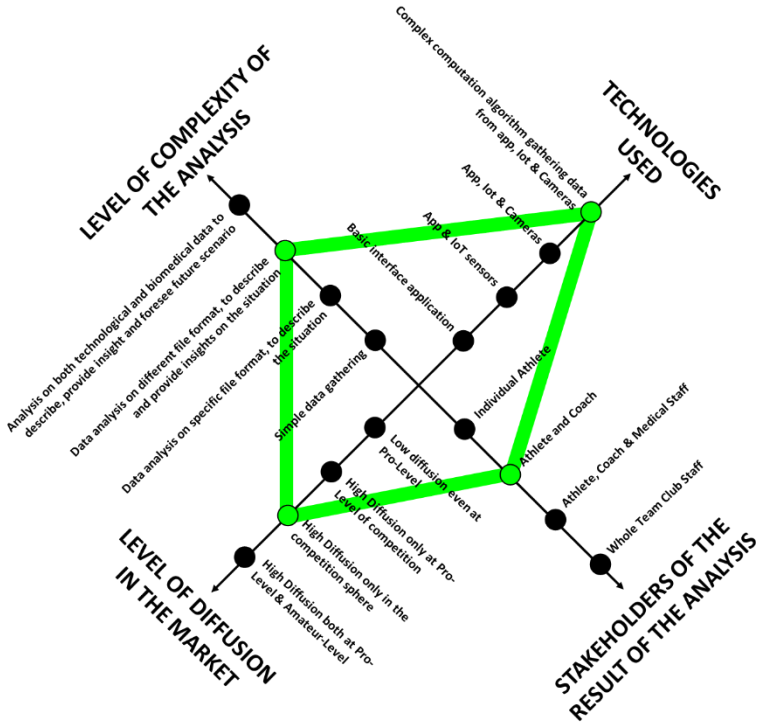


figure 2. 14

There is growing interest in utilising virtual environments (VEs) in the context of sports. The range of skills required across all different sports is very large and varied. A VE needs to provide realistic rendering of the sports scene, which requires an accurate physics model of a complex environment, real time response, and a natural user interface. The goal is to provide multiple scenarios to players at different levels of difficulty, providing them with improved skills that can be applied directly to the real sports arena.

In literature, a virtual environment (VE) is defined[16] as a **collection of technologies** that allow people to interact efficiently with 3D computer generated models in real time using their natural senses and skills. The main advantage of this technology is the possibility to go through exactly the same **view point** that an actor will have during the action. As such, a VE can be used in a variety of ways, including to provide the end user with an immersive experience for entertainment purposes, to explore and gain insight from data in an intuitive manner, and to train people at complex tasks in a safe, convenient, and/or effective environment. Sport performance is one area where there has recently been great interest in obtaining added value from a VE. For instance[17], *quarterbacks* can review the options and opportunities they missed by going through a play several times and reviewing each of their teammates' positions. In particular computer gaming, although designed primarily for entertainment, has led to the development of many useful tools and techniques that can be

[16] G. Burdea, P. Coiffet
Virtual Reality Technology
(2nd ed.)John Wiley & Sons, Inc, New York, NY, USA (2003) vol. 12 (6)

M. Slater, A. Steed, Y. Chrysanthou
Computer graphics and virtual environments: from realism to real-time
Addison-Wesley, Harlow (2002)

[17] As Chris Kluwe, NFL star and Minnesota Vikings punter, points out in this TED Talk

deployed in training applications. These range from hardware peripherals, to physics engines, to computer-graphics rendering algorithms.
The effectiveness of any VE used for training can reasonably be measured against a single and demanding criterion, as there is a desire to be able to improve sensorimotor skills (rather than just using a VE as a tool for strategy analysis): a VE needs to provide **realistic rendering** of the sports scene to achieve good perceptual fidelity, which requires an accurate physics model of a complex environment, real time response, and a natural user interface. This is because the technology has progressed so far that a comparison to reality is now the expectation, not the hope. That explains why virtual reality is a perfect step forward in the world of athletic training: since the mind has no way of distinguishing between a real situation and one generated by the technology, it is the ideal means of supplementing work to further athletes' skills and knowledge of the game.
An important general distinction can be made between the extent to which the sports VE should depict the appearance of the real world (**perceptual fidelity**) and the extent to which it should behave like the real world when a participant interacts with it (**functional fidelity**). The goal is to balance this trade-off, in order to provide multiple scenarios to players at different levels of difficulty, giving them improved skills that can be applied directly to the real sports arena.
There are a number of basic technological elements required to construct a sports VE, directly impacting on the costs associated with the VE: to give an idea, the projects that will be described range in cost from around €10,000 to well over €250,000 (if a CAVE system is used, for example).
The main technologies typically deployed are:

- **Display technologies**, often using stereoscopy. Examples range from Head Mounted Displays (HMDs) to large-screen Power Walls. Data projectors are the most common display type because they offer a larger field-of-view than a desktop monitor, giving a more immersive experience, while they are cheaper than a CAVE (Cave Automatic Virtual Environment) system which requires rear-projection for 4, 5 or 6 walls (including floor and ceiling).

- **Tracking technologies**, such as optical, magnetic, and inertial systems. Motion capture is a very common technology also in this field. In particular, real-time motion capture is used with VEs to capture the user's position and movement, to allow the 3D graphics to be rendered correctly, taking into account the current position of the player's head. Moreover, it allows the player to interact with the virtual world in an intuitive fashion, using natural movements (this could include using her body to control an avatar 'double' that is visible in the VE, and may be necessary when using an HMD). A further potential use of motion capture in sports VEs is to provide data for animation of virtual figures or objects. Pre-recorded motion capture is used in this way games to produce many variations of the same attacking or defensive moves that would otherwise be very time consuming to create if manually animating the characters. It is also potentially possible to create models of typical behaviour into which random variability in performance is introduced, that is essential when using VE for skill acquisition since all human motion contains inherent variability

- **Haptic technologies** for force and tactile feedback. These range from hand-held joystick devices, to large-scale pneumatic motion platforms. Haptic technology provides various forms of sensing movement with a means of interacting with their environment in terms of touch and to enhance their immersion into the VE. The majority of haptic devices currently available on the market are custom built, to allow the VE and haptic device to truly complement each other. In particular, vibrotactile devices hold great potential, due to their portability and flexibility: they can be used for providing both guidance stimuli and attentional stimuli in the training process through a sport VE where the need for concentrating one's attention to the environment prevents the efficient use of visual outputs. Audio output is another possibility: the sounds a system produces directly impact upon the feeling of presence experienced by a user, and the tone may provide important information for tasks such as judging how hard a ball has been hit with a bat, as stated in specific studies.

- **Software algorithms** for efficient rendering of 3D computer graphics and modelling, multi-user synchronisation, interfacing with the hardware devices, managing the VE in real time, and providing feedback and validation. There are a large variety of software packages available for VE creation and development, but more importantly, there are few systems using one package alone. Each package or suite has different benefits, and most systems use the best available package for the specific section of a project.

Despite recent technological advances in VEs and support for their use in training a variety of sport, it is still not clear how skills developed through practising in a VE transfer to real-world situations: a study[18] highlighted that the best learning experiences are those that most closely approximate the **movements** of the target skill and the **environmental conditions** of the target context (specificity of practice). These findings point to the importance of matching the VE as closely as possible with that of the real-world setting if transfer of learning is to be maximised. Thus, if VE learning is to be successful (as measured by retention and transfer in real-world situations) the VE environment should provide opportunities to obtain all essential information required for schema development, to a level that is as close to the real-world context as possible. If those requirements are meet, VE can be well-suited to train a range of motor control skills: better accuracy through repeatability in performing a particular task is the most addressed one, but also anticipation and decision making skills are also well suited for training in this environment, and the level of difficulty of the task can be increased over time. Secondly, the sports simulator system is able to monitor **psycho-physiological data**, linking them to the performance obtained, and adjust the simulated sports activity in response. This provides for an expansion and improvement in current psychological training programs for athletes.

Recap

- *A wide range of technologies for motion tracking are available nowadays, suitable for different user needs.*
- *They deal in different ways with the user experience, the degrees of freedom, the reliability and precision managed by the system.*
- *For the purposes of classification is therefore important to establish the measurement objectives, the technologies implemented and the system constraints.*

figure 2. 15

[18] F.M. Henry
Specificity vs. generality in learning motor skill
R. Brown, G.S. Kenyon (Eds.), Classical Studies on Physical Activity, Prentice Hall, Englewood Cliffs, NJ (1968), pp. 331–340
Matsuura H, Abe N, Tanaka K, Taki H. Constructing virtual air hockey game through the network. In: Proceedings of the 20th International Conference on Advanced Information Networking and Applications

2.3 The last frontier

In this paragraph are analysed three different themes:

- *Cognitive Computing and AI*
- *Injury treatment*
- *Talent Identification*

Although they may seem quite different one another, through our spider-web chart we pointed out that instead they do have strong analogies: first of all, they are built on extremely **innovative**, state-of-the-art technologies and IT knowledge, and therefore they are still in an **embryonal stage** of their diffusion. Secondly, even with specific focuses, they aim is to achieve a powerful insight through a better understanding of the many **biomechanical**, **physiological**, and **psychological** factors affecting the world of athletic performances.

2.3.1 Cognitive Computing and AI

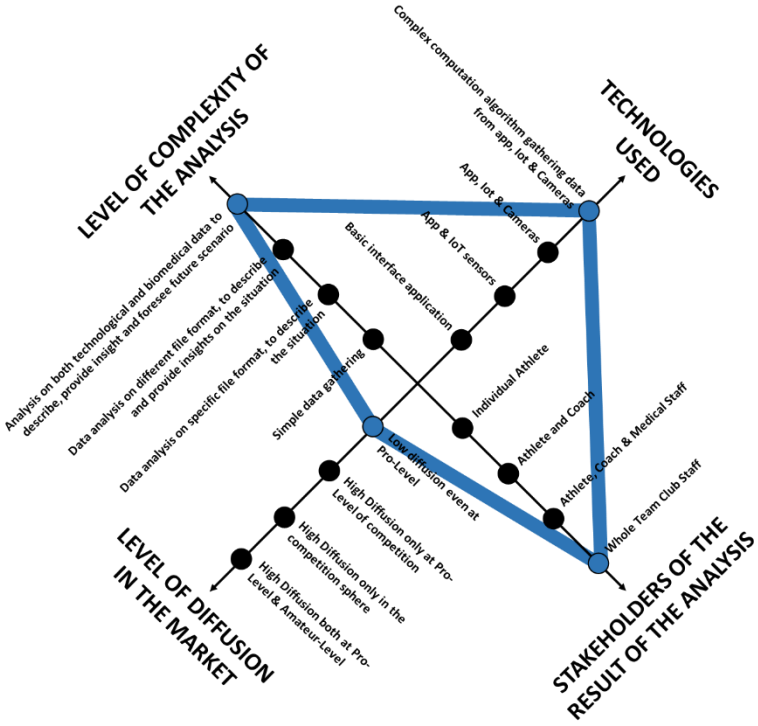


figure 2. 16

AI technologies are available as a growing portfolio of APIs for language, speech vision and data services that can be embedded into applications and solutions relevant to players' performances.
Additionally, Cognitive Computing is becoming one of the key factor to gather those data in input, and deliver as output powerful insights. Cognitive computing systems are basically applications that **understand reason and learn**: this means computers that actually learn from their experiences and that are actually taught. So their first need is to learn a base level of knowledge. This is the reason why usually those systems are paired with **predictive analytics technology**, able to mine incredibly large amount of data points to determine patterns and styles of the game.

This is exactly what IBM (world leader and at the vanguard in this technology development) has done to run its SlamTracker's "*Keys to the Match*" project: over 8 years of Grand Slam Tennis data (41 million data points) has been analysed, both competitors' historical head-to-head match-ups as well as statistics against comparable player styles, in order to determine what the data indicates each player must do to do well in the match.

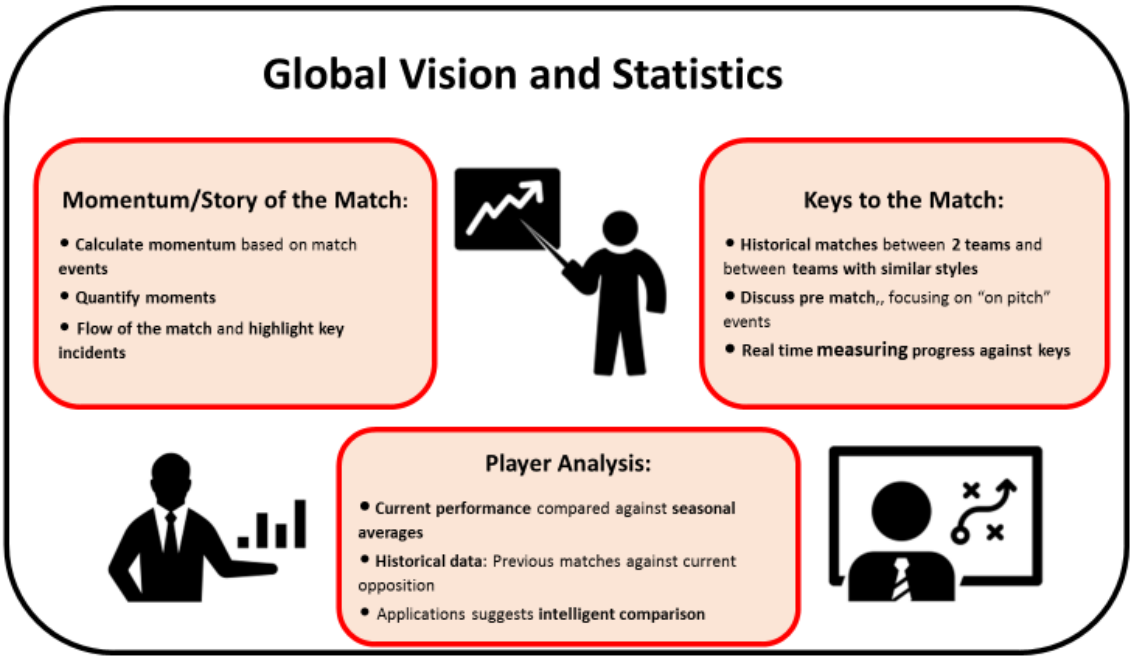


figure 2. 17

As stated in a Sport Illustrated's interview with IBM's Vice President of Global Sponsorships (Sports and Entertainment) and Client Programs, Noah Syken:

"*There is all this other information that can add powerful insights, so a system like Watson or cognitive computing can read and interpret all of the press conferences of players over the course of this year, last year or the past five years, and help general managers understand the mindset of that player. Is that player becoming more positive in how they talk to the press? Becoming more optimistic about their game and what is going to happen on the court? That is important for a GM to know. All that stuff can be brought together in a really simple, user-friendly interface*"

Another example is that to improve **prevention and safety** related to concussive and sub-concussive impacts in sports, a monitor can track the force and frequency of head impacts during play and delivers that information to the in real-time. From this data, a solution like IBM's Watson Personality Insights can analyse sentiments and infer social characteristics to better respond to user inquiries and help make more intelligent recommendations regarding head impact incidence, response, treatments and return to play decisions.

Some criticism has arisen about cognitive computing, in particular regarding cultural aspects in the juxtaposition of machine learning and human mindset. But there is a fundamental difference between these two aspects: while humans bring a **natural bias** to certain kinds of attributes (which colours how the human looks at the objective data), a cognitive system scours all of that data and define an **objective** frame on interpreting that data, and then present it in a very consumable way to a human: is this **combination of a human and a cognitive system** that can really lead to better outcomes. This is exactly one of the main advantages that has been recognized in the implementation of Watson system during the Golf Ryder Cup[19], where captains have to put their players in pairings. These captains could bring a certain bias to their pairings, but they have been helped by the cognitive system in order to have a more complete view on each of their teammates.

[19] Biennial men's golf competition between teams from Europe and the United States.

2.3.2 Injury treatment

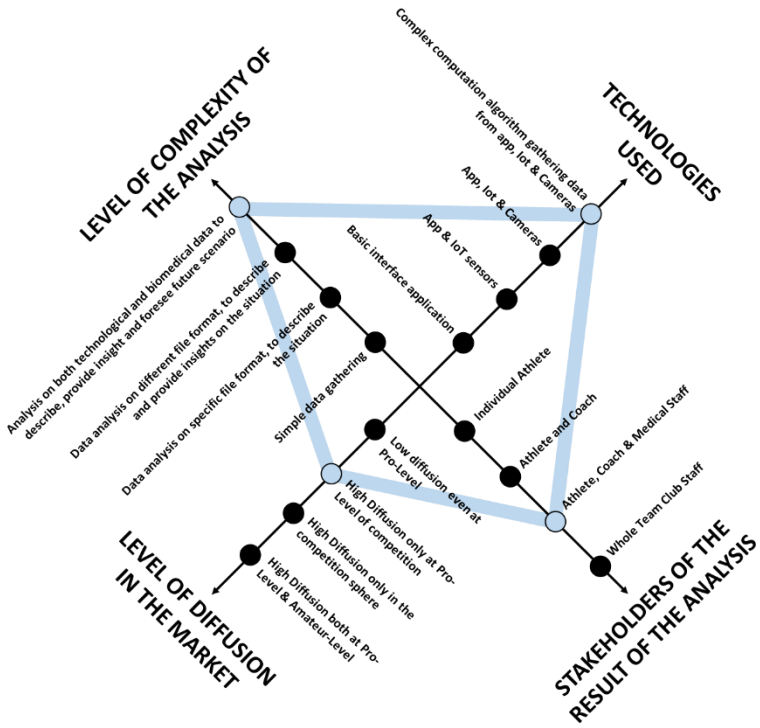


figure 2. 18

The weight of evidence supporting the benefits of physical activity (including both sport and active recreation) is substantial. However, there are also risk related to the contingency of an injury: as one of the most important topic contemplating both the sport and the medical field, different studies has been carried out in this segment. Generally speaking, Bahr[20] offers six criteria for physicians in order to understand the **seriousness** of a sports injury: nature of sports injuries, diagnosis, duration and nature of the treatment, sports time lost when injured, working or school time lost, permanent disability and cost of injury.

In response to this threads, it has been shown[21] that preseason training, warm up and cool down patterns, using protecting equipment and meeting safety standards are among the factors that reduce sports injuries significantly. However, one particular factor has widely been emphasized in sports injury prevention studies: **sports medicine** knowledge. Stevenson et al[22]. has found that the risk of injury was reduced by 32% if the participants had received a program designed by a professional. Additionally, sports medicine is of importance not only as preventive medicine but also for supplying special treatments and cures for specific sports injuries. Going deeper in our analysis, it is therefore mandatory to split our considerations in two areas: the impact of sport injuries in the professional segment and the impact on the whole collective level.
At a **pro-competitive level**, an athlete is seen also as one of the key **economic assets** of the team, and it is then clear that the occurrence of an injury can be seen as an economic risk leading to a reduction in the 'profitability' of the athlete. Bill Barnwell, managing editor at Football Outsiders[23], **has observed the impact on a NFL team of an injury of one of their players**: the injury rate of a team's offensive and defensive player year on year has respectively the 0.42 and 0.29 correlation with team success (where 1 is a perfect correlation and 0 is no correlation).

---

[20] Bahr R, Kannus P, Van Mechelen W. Epidemiology and prevention of sport injuries. In: Kjaer M, Krogsgaard M, Magnusson P, Engebretsen L, Roos H, Takala T, , editors. Textbook of sports medicine. Massachusetts: Blackwell; 2003. p. 299-314.

[21] Nys J. Physical activity, sport and health. In: Andreff W, Szymanski S, editors. Handbook on the economics of sport. Northampton: Edward Elgar Publishing; 2006. p. 141-53.

[22] Stevenson M, Finch C, Hamer P, Elliott B. The Western Australian sports injury study. Br J Sports Med 2003;37:380-1.

[23] Editor of the almanac American football statistics

And **the *quarterback*** is crucial: since NFL offence is designed intricately around his strengths and weaknesses, his **individual correlation is 0.3, twice that of any other position**. The same can be said for other sports like, for instance, volleyball, given the high importance of the *setter* in a team. Moreover, Barnwell explains also that for a superstar is about 6.75 times that of the observed impact of an injury to a reserve player. Finally, a huge 26% of a team's win rate from year to year can be chalked up to a change in injury rate. It is therefore clear why organisations are striving to incorporate **stats-based economic insights** into their approach to injury. Additionally, the way professionals are treated when they are injured differs from the way ordinary people are treated: Simon Kemp[24] stated that "*We're dealing with people whose priorities are very different from the man on the street. While I might advise an amateur to try conservative treatment, which will still let him lead a pretty active life, professionals can't get by with that. Moreover, they're used to injury*".

Regarding the whole **public citizenry**, the situation is quite different: problems arise in assessing the true 'cost' of sports injuries because not enough is known about the social and personal cost (mental wellbeing) of sports injury, so the available evidence concentrates on the clinical and remedial costs of injury treatment and recovery. The immediate and long-term '**costs**' of sports related injuries results mainly from health care costs for treatment, but are also related to insurances costs, time and productivity lost and equipment and program costs for rehabilitation and prevention.

Countries need timely data on what injuries occur, to whom and how often, to indicate which sports people and injury types should be prioritised for prevention. They also need robust information about what caused those injuries to fully understand how to prevent them and identify effective preventive solutions, for instance considering the '*Training-Injury Prevention Paradox*'[25] model: a phenomenon whereby athletes accustomed to high training loads have fewer injuries than athletes training at lower workloads, based on evidence that non-contact injuries are not caused by training per se, but more likely by an inappropriate training program.

Inappropriate training programs and need of timely insight from data are exactly the key points on which the digital innovation is having the highest role. In fact, in the Health and Rehabilitation field, technology has always played a prominent role: new devices for rehab are presented to physical therapist almost monthly, with different approach for different problems. In particular, as stated by Bager & Engebretsen, prevention[26] can be broken up into three broad categories of primary, secondary, and tertiary prevention, and these different areas rely on different kind of technological tools.

The 3D motion capture technology and augmented reality are often the main enabler for 3D dynamic movement analysis and diagnostics, which are the most effective tools for **Primary prevention**, which involves the *avoidance of injury*. As we have seen in the previous paragraph, AR allows the user to use real objects to interact with computer-generated environments: these solutions are able to use both cameras and body-sensors (to capture in real time all of their movements of the athletes) and elements of computer vision and machine learning-based algorithms to automatically analyse full-body dynamic movement parameters. This analysis allows trainers and coaches to score jumping and landing patterns, pelvic and trunk stabilization, symmetry of motion, dynamic balance and more. Then, forcing the athlete to execute specific movements through augmented reality, the training staffs can provide appropriate **corrective training** to the athlete in real time, while doctors and physical therapists are able to watch for injury-causing techniques, body alignment and patterns, in order to enhance their injury prediction analysis. Equipment don't have to be extremely expensive or bulky, and all data and 3D videos are stored on the cloud to be viewed on desktop or mobile devices in real time: in this way these sensors limit the need for all the players and staff involved to be in the same location, which makes the whole process much **less invasive** for athletes.

Secondary prevention involves an *early diagnosis and treatments* that should be acquired once an injury has occurred, while **tertiary prevention** is solely focused on the *rehabilitation* to reduce and correct an existing disability resulting from the traumatic event. Different typologies wearable physiological and motion sensors are implemented, linked together by a signals collector for collecting and synchronizing the received signals and a wearable processor for generating alerts and assisting with the athlete' s interaction with the system.

---

[24] Head of sports medicine at the Rugby Football Union in England

[25] Described in the paper: Gabbett T, British Journal of Sports Medicine, published online (12 January 2016)..

[26] Bager, Roald; Engebretsen, Lars (2009). Sports Injury Prevention. Chichester, UK; Hoboken, NJ: Wiley-Blackwell.

With this architecture, the system is able to collect different **input parameters**:

- **Electrocardiogram**, for monitoring heart rate (HR) and heart rate variability (HRV)
- **Blood pressure**: measured before and after the training session to detect if a hypertensive athlete needs special attention
- **Respiratory effort**: measured with respiration transducers usually in the form of a belt worn on the athlete's chest, for monitoring breath rate (BR, an indirect indicator of oxygen uptake and of the aerobic capacity, which can also detect disorders like exercise-induced bronchospasm).
- **Joint angles**: measured with electro-goniometers, for detecting differences in movement patterns between the injured and healthy zone and for quantifying gait adaptations and alterations in the injured part of the body.
- **Temperature**: often two temperature probes, one at the site of injury and one on the contralateral site, for an indirect indication of the improvement of the injury, especially in more severe injuries and major operations.
- **Pain**: a pain assessment for the injury made by the athlete through personal pain descriptions (i.e. "none", "occasional", "always present", "bearable-unbearable"). Alternative assessment for pain can be made through the visual analog scale (VAS), where pain is numerically classified by the subject, from 0 to 10, to reflect the discomfort experienced during activity. Ten refers to maximum pain and zero to none or minimal pain.
- **Performance measurement** during the athlete effort to control the monitoring conditions.

In these situations usually **multi-method robotic machine** are involved. They interact with the end-user by measuring, controlling and adapting the exercise in real time using a variety of ways. In physical conditioning as well as in functional recovery, traditional workout resistances like elastics, water or weights, have often had some limits for athletes and patients (for instance, the same load at different angles of workout might represent a threat to a recently injured joint). By combining an electric motor with data collected by sensors, these machines allow patients to have total control over the resistance used in each phase of the movement, in order to customize rehab sessions and easily test and measure patients' progresses. Moreover, the mechanical capabilities of these system can be combined with biomedical concepts: for example the process of **bio-mimicry**, which is designed to simulate intense physical exercise, leaving the body filled with lactic acid. Because the build-up of lactic acid is so high, the brain receives very strong feedback to release growth hormones to repair damaged tissue, and this can translate into faster recoveries, while reduced exercise time would minimize the chance for re-injury. Fast recovery time means not losing cardiovascular fitness and being able to return to the game on the same physical level as they were before, which is a huge boost to any injured player.

In an attempt to treat musculoskeletal type injuries along with trying to improve physical performance after a period of rest forced by an injury, athletes are prescribed exercise programmes by appropriately trained specialists. This method usually means that athletes are shown how to perform each exercise in the clinic following examination, but they often have no way of knowing if their technique is correct while they are performing their home exercise programme. Here is exactly where IoT changes again the paradigm: systems nowadays utilise a number of inertial motion tracking sensors, usually incorporated in a wearable body suit, which allow a wireless connection to a computer. Using a specific software programme, the athlete can be instructed and analysed as he performs the individually tailored exercise programme, recording the time and performance level of each exercise completed. Moreover, a clinician can later review the athletes progress and subsequently alter the exercise programme if they see **improvements or corrections** needed. The motion capture suit with sensors embedded in the garment has the purpose of tracking the movement of body segments. Data come from inertial-based sensors, small lightweight sensors which detect 3D orientation using two accelerometers, a magnetometer and a gyroscope. Sensors are usually located on both left and right shank, thigh, forearm and upper arm along with one on the left side of the trunk, to gather a complete view of the whole body.

2.3.3 Talent Identification Solutions

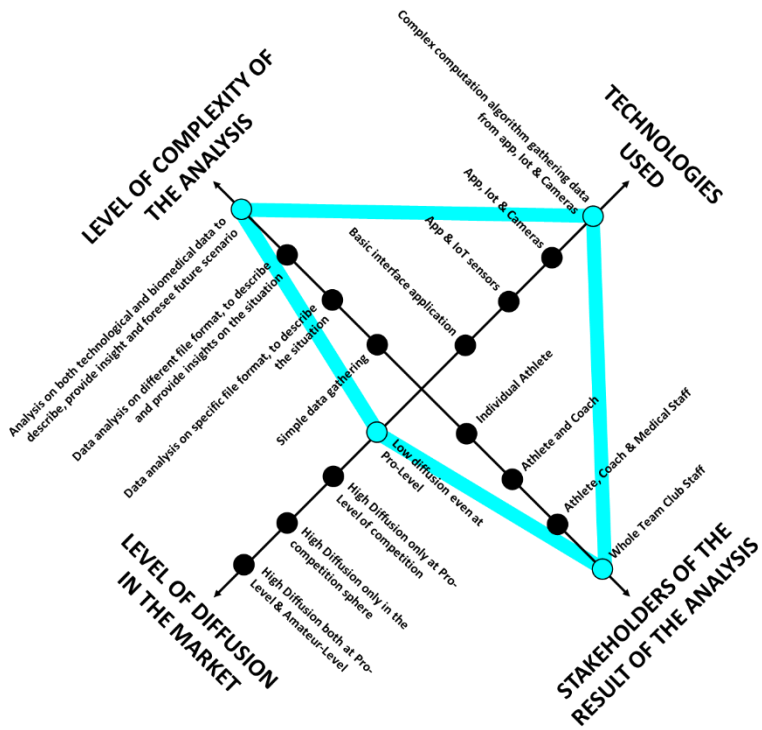


figure 2. 19

Talent identification (TID), as its name suggests, is the discovery or observation of factors or characteristics an athlete may possesses that can influence success in a specific sport.
TID can be deliberately integrated into a sport's system, as part of the athlete developmental pathway. Those systems are **multidimensional**, incorporating relevant factors from physical, psychological, skill development, and socio-cultural domains; as well as system and environmental factors and intuitive assessment. This is why it is a complex and dynamic process, in which there are multiple layers, and the complex interaction among all success variables presents a number of challenges when developing a talent identification model. Success at the elite level of sport performance stems from a combination of many factors, which are influenced by socio-cultural and politico-economic conditions as well as individual performance factors. **Intrinsic factors** (e.g., body type and rate of maturation, aptitude, adaptation to training, motivation, and psychological skills) as well as **extrinsic factors** (e.g., environment, access and opportunities, sports systems, coaches, family, etc.) work in synchrony to determine an athlete's success, so both genetic and environmental influences must be acknowledged.

A number of different approaches have been used to implement TID, from Physiological and Skill Models to Psychological Models. However, in this field innovation has had a particularly disruptive effect, introducing a new model based on new possibilities given by biotechnologies: the **Genetic Markers Model**. The physical and physiological potential of an individual is influenced (not completely defined) by an individual genetic makeup. Many of the traits that contribute to sports performance, like endurance capacity or muscle power, are linked to single or multiple genetic expressions or variants. There have been different attempts to identify specific genes that influence performance and then use that knowledge to identify potential sporting talent, but they have obtained mixed results. This may be the consequence of the very complex interactions between **talent identification domains** (physical, physiological, psychological, socio-cultural, etc.) and **talent development factors** (coaching, training quality and quantity, opportunities, facilities, etc.). Research has been directed toward identifying genetic markers that fit models predicting the likelihood of having significant traits associated with individual sports. In this way, gene testing might help not only in tailoring training programs for individual athletes, but also helping to identify athletes who are prone to particular sport-related injuries. For example, one of the most innovative study in this field is "*New genetic model for predicting phenotype traits in sports*[27]". The aim of this study was to construct a genetic model with a new algorithm for predicting athletic-performance variability based on genetic variations. The findings of this study suggest that a new model may be used to build a genotype score specific for a single key factor that is unique to each sport. Another recent study, "*Predicting elite endurance athlete status: A genome-wide exploration*[28]", has followed the same path: the authors believe they have identified markers that can discriminate between the low responders and the high responder for max VO2 trainability, defining and optimising a panel of genomic predictors of elite endurance athlete status. These kind of researches offer the potential to identify genomic markers.

Recap

- *This area relies on extremely innovative, state-of-the-art technologies and IT knowledge.*
- *The aim is to expand the scope of analysis, also including biomechanical, physiological, and psychological factors.*
- *The most innovative feature of these solutions is the ability not only to analyze a complex system of present interactions, but also to predict the evolution of such system.*

figure 2. 20

[27] Massidda M, Scorcu M and Calo C, International Journal of Sports Physiology and Performance, Volume 9 (2014).

[28] Bouchar C, Rankinen T, Sarzynski M and Wolfarth B, Prince Faisal Bin Fahad International Prize for Arab Sport Development Researchers (2014).

2.4 Sport equipment

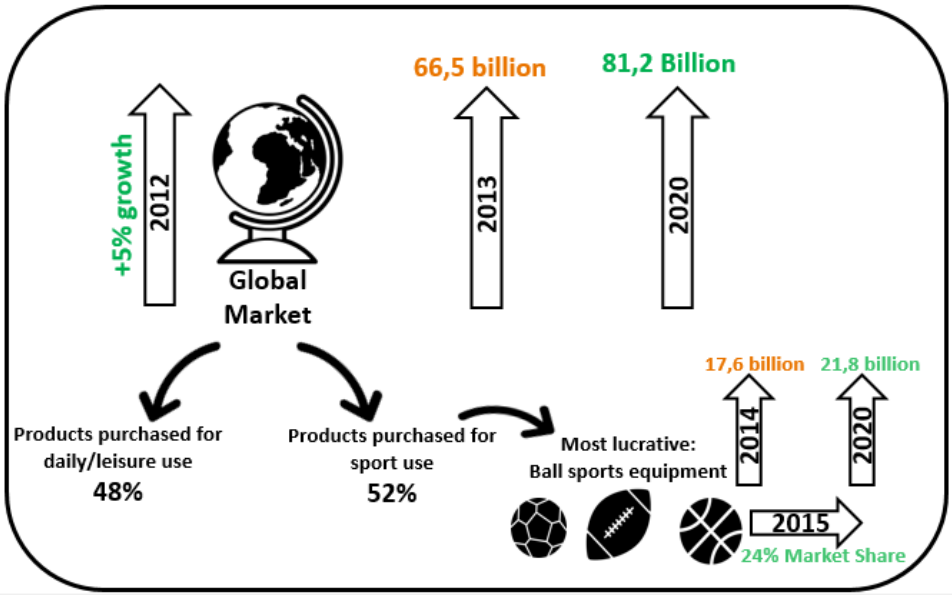


figure 2. 21

There are many studies on the sport equipment market[29]. Their results in terms of actual and expected future revenue are depicted in the graphs above. These studies highlight different factors that likely will impact stronger to fuel growth of the sports equipment market in the near future: **product improvement** through R&D activities and an emergence of **e-commerce** are two of the most important new trends. Even the increased awareness of a **healthy lifestyle** is a key driver for the growth of this market: the need for a salutary living coupled with rising health issues such as obesity has created a clear demand for fitness-related sports equipment. People are increasingly becoming **health conscious**. Consequently, a greater number of people engage in one or the other sporting activity to remain fit and healthy. It is interesting to point out that around 35% of the American adults were considered to be obese during 2014, according to Organisation for Economic Co-operation and Development (OECD), and this for instance is strongly linked to the geographical characterisation of this sector: North America is the major market for sports equipment (accounting for around 38% of the market share during 2015 and is expected to reach a revenue of around US $ 31 billion by the end of 2020), followed by Europe and Asia Pacific, which however is expected to be the fastest growing market for sports equipment in the near future.

Another peculiar characteristic of sport equipment market is the fact that **speciality and sports shops** accounted for 46% of the market share during 2015: the convenience provided by this distribution channel and its ability to stock popular brands have been driving the growth of these stores. Moreover, they provide consumers with numerous discounts on the equipment driving their popularity further.

The larger companies and leader brand names (like Adidas, Amer Sports, Jarden, Mizuno, Nike and Under Armour) cover part of this market, investing huge marketing budgets in branding their name and image. However, these big companies account for only half of the turnover of the market, allowing the rest of it to be exploitable by high functional products and services for the sportsmen and sportswomen: in fact, production of the wide range of **specialised sports equipment** in the various EU countries is controlled by a large number of small manufacturers. Between their customers, the rising demand is for lightweight sports equipment:

[29] Global Market Study on Sports Equipment: Ball Sports to be the largest segment by 2020
GLOBAL SPORTS EQUIPMENT MARKET 2016-2020
Global Sports Estimate Report 2012

they help consumers yield high performance due to their excellent stiffness and high strength. Moreover, they also give full control to the user over the equipment and provide them with a high level of flexibility. Carbon fibre is emerging as a popular replacement for traditional metal, wood, and steel in modern sports equipment. This part of the market provides many challenges for European SMEs, where proximity to customers and understanding of their wishes is the key factor to success. Why? Because this market is an **early adopting** and global market in which on one hand there is the huge volume of production of relatively simple labour-intensive sports goods (bulk products, produced mainly in the Far East and in Eastern Europe) but on the other hand this market is also related to more intelligent and functional products that are open to the introduction of new technologies:

- Use of Smart materials
- New design and creativity methods
- Customised production techniques
- Integration of ICT
- Internet of Things and added services

These intelligent and functional products are partly produced in Europe and partly in the Far East, and seem to be a very challenging investment area for European industry.
Two of the most encouraging technologies for sport products, among the ones listed above, are the 3D printing technique and the IoT applied to sport equipment:

- Over the last years **3D Printing** has developed into a common technology in the design process and rapid prototyping and for aerodynamic optimisation in sports products, and companies are now adapting 3D printing techniques also for wearables, shoes, and components. Clear benefits for 3D printing are related to the possibility to produce parts of different geometry within the same batch, or even create objects with complicated internal features. Moreover, functional specifications and fitting (size) can be served with a better personalisation: manufacturers and retailers constantly need to estimate demands in terms of consumer preferences (such as colour and style) as well as function and sizing since the vast majority of sporting goods are designed to meet the requirements of a large group of people. The fact that every customer is different and desires individualised products and services poses many opportunities for this innovation: an athlete's safety, for instance, will benefit from individualised protective gear. 3D printing will also enable the redesign of products for simplification to meet the required skills of a specific target group, such as amateurs, children or certain patient groups.
- Along with health-care and wellness, sports represent one of the most rapidly growing areas of personal and consumer-oriented Internet of Things technologies (IoT). These **sensors** can be easily found **in sports equipment**, such as baseball bats, tennis rackets and basketballs. They have become more common, smaller and cheaper to manufacture, despite being able to measure a huge variety of data like speed, acceleration, direction, balance, distance, altitude, and stress levels. The most innovative products are also able to combine IoT technology with VR: the Airwave by Oakley is a crucial successful example of how these two technologies can be effectively mixed together. It is equipped with a built-in HUD, integrated GPS, Bluetooth, an accelerometer, barometer and gyro sensor, all of which allows the goggles to display key indicators such as speed, time, location, distance, altitude, jump airtime and vertical descent. All information are shown in a small screen on the bottom right quadrant of the goggle's frame, which is perceived by the eye as a 14-inch screen viewed from five feet away.

Moreover, we said that sport is known as an early adopting market, which provides interesting cross-sectoral innovation opportunities to/from other markets. In recent years this resulted in the development of a cross-sectoral consumer goods platform (with e.g. textiles, clothing…) but also of cross-sectoral collaborations with other technical platforms (such as textiles, clothing, mechanical equipment and electronics). In this context, production of **sustainable sports equipment** is becoming increasingly important, with the creation of sport

products with sustainable design principles aims at meeting environmental challenges: In the last decade leading sports apparel brands, including Nike or Adidas, have advertised the use of sustainable manufacturing practices and recycled materials. On this topic, the sportswear industry's focus on merging ecologically sensitive innovation with higher performance has initiated a change that is making sustainable apparel mainstream.
There are two other main factors that team up with these new trends (intelligent products and sustainable products) in defining the quality of a sport equipment: fashion and comfort.
The combination of sport and **fashion** in the mass-market is more widespread than ever, which is why style and design in sports goods are just as important as functionality for the majority of market segments. This is why sports fashion is a fast-growing segment that is set to continue expanding in the coming years, and in this case, technology in aesthetic is an integral part of the design that focuses on the sensation and the emotion that the product evokes.
The need for **comfort** in sports practice can be seen to a large extent in all categories and disciplines but, in particular, higher levels are needed in sports demanding intense and extended efforts and sports demanding protection against the weather. Comfort plays an important role also during sport practice. Different studies show evidence that comfort can affect performance[30], in particular it has been observed that more comfortable clothing allows greater freedom of movement, while a garment or equipment that causes discomfort can lead to alterations in the sport technique increasing the risk of injury[31].
We must point out that the search for comfort and wellness is not exclusive to athletes as they are important factors for every consumer of sports goods, on which it has a great influence both during sports practice and in the buying decision: comfort has been identified as one of the most important attributes in the purchasing decision[32] as well as in their satisfaction before and after purchasing[33]. So even if a product has positive functional aspects and increases the performance of the athlete, it will not be bought unless it is comfortable. It is therefore necessary to research the comfort in any sports equipment, and that will be the key to its mass diffusion and success.
There are many examples of how changes to equipment have impacted upon a sport at all levels, improving the speed of the game, its strategy, and the relationship between athlete and the equipment. In tennis where in the past 30 years racquet technology has evolved in design and materials have changed, and the newest developments incorporate sensors in the racquet handle to give the player and coach immediate feedback about particular shots. Participant safety is also enhanced through the development of certain sporting equipment, such as helmets and body protection which are used in cricket, NFL, boxing and ice hockey to help prevent and mitigate injuries.

Focus on the Italian situation: The 'Made in Italy'

Focusing now on data from our Country, we can affirm that the sporting goods industry contributes significantly to the affirmation of the concept of '*Made in Italy*', fully expressing the values of quality, technological innovation, style and design, characteristics of Italian **principles of excellence** that do recognize and appreciate our products in the world.

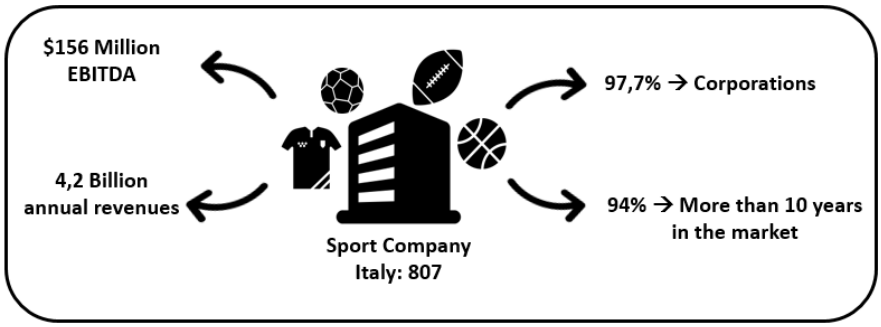


figure 2. 22

[30] (Luo et al, 2009; Mills et al., 2010; Mullet, 1996)
[31] (Cheung et al., 2003; Kinchington et al, 2012)
[32] (Blackwell et al., 2006; Kaplan and Okur, 2008)
[33] (Chae et al., 2006)

The Italian production has a great tradition with **high-end** brands and models, where **quality** and **exclusivity** guarantee greater stability of demand. Indeed, according to the official financial statement data, **Italian sports companies have recorded a substantial stability even during the past period of economic recession**: the sales volumes were generally kept constant, with a minimal growth which, compared to other sectors substantially declining, is a positive signal.
Italian exports of sporting goods, in 2012, amounted to € 770 million, of which 60.3% to EU countries. The main markets for Made in Italy sporting goods therefore remain mainly European ones. Next, the first non-European market is the United States. High consumer potential markets are China, India, Russia and all other countries with a rapid economic growth as the Emirates and South Africa that at this moment, yet don't represent significant volumes for our products, even though we are registering a slow but steady growth of exports in these emerging markets. It is therefore important to provide a further boost to this sector, as pointed out by Luca Businaro - President Assosport, in the analysis on sporting goods market carried out by his association, "*Considering fact that the consumption of sporting goods in Italy is equivalent to 25 billion euro, our industry occupies a prominent place in the national economic system and therefore must rely on a guaranteed future*."

Recap

- *The market for sports equipment shows peculiar features: specialized manufacturers, early adopter customers and massive influence of technologies.*
- *Despite the focus remains mainly on athletic performance, this field is also influenced by other factors such as sustainability, fashionable products or the need of comfortable items.*
- *In Italy it is important to emphasize this sector, which has shown a strong stability built upon the high standards of the made in Italy.*

figure 2. 23

Chapter 3.

Methodology

The structure of the Thesis will follow a precise path which has been shaped in order to build a complete and exhaustive research.

3.1 Objectives of the Research

The aim of this thesis is to perform an investigation on the potentiality and the role of the technologies that today impact on the sport sector, with a scope centred on the athletic performances field.
We identified that the sport industry is characterised by constant and rapid waves of innovation, and thus the decision to deeply investigate the trigger mechanisms of digital innovation in the sports world. In particular, we specified our analysis on the athletic performance, mainly with the goal of identify in greater detail the best practices, the benefits arising from its use and possible motivations and resistances of potential end-users (professional athletes and amateur).
In this regard, the present work aims to achieve the following objectives:

- identify the main existing reference models;
- provide a cognitive framework on the current and future use of technologies in the scope defined;
- select a few best practices to verify adherence to the identified models;
- assess the benefits, motivations and strengths related to their use (professional and amateur athletes);
- propose a rational modeling along the lines of what has emerged from the research.

Once we identified the main objectives, we defined a precise logical scheme which guided the research.

3.2 Methodology

Thesis has been structured following a specific path, described in the figure above:

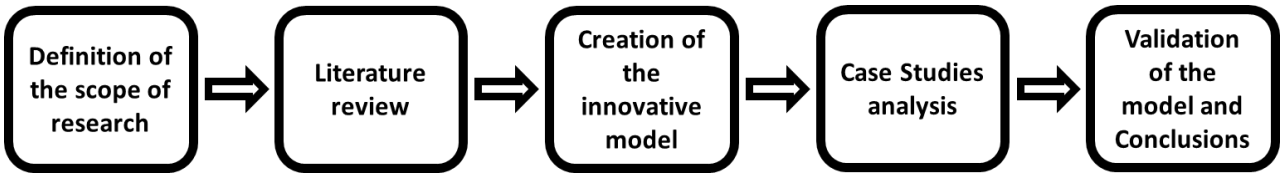


Figure 3. 1

The logical process started after the Introduction Chapter, where we described the industry, introduced the Digital Innovation as one of the main trend and identified Athletic Performances as the most important field of innovation, before going in a deeper analysis. At the end of each paragraph, we have highlighted a Recap box, so as to emphasize more clearly what were the key points to what outlined above.
In the first chapter our goal was then to provide an overview of the sports phenomenon, declined in various fields, in order to achieve a better understanding of the internal forces in this market. In particular, our focus was set on its relation with the digital innovation, highlighting its effect of dynamic force and its role of enhancer. For this reason, we have introduced an original model based on 4 main macro-areas, derived from the analysis made by the Osservatorio DigitalSport, that was at the foundation of our thesis in understanding how the industry is upgrading, where the update comes from and what are the main areas of innovation.
In the second chapter, our focus has moved to Athletic Performance. This second chapter was useful to develop a taxonomy of existing digital innovations in Athletic Performance in order to identify the state of the art of the technology implemented, their diffusion and their main areas of use. To accomplish this analysis, we have developed an innovative framework. Moreover, in order to validate our new framework and to further identify prospects for the future , we developed 10 case study: they have been a direct source in understanding what is the added value that digital innovation produces in the Athletic Performance, providing also examples supporting the hypothesis that thanks to digital innovation there is a boost in this field. In this chapter we even set up a comparison between the different realities analysed.
Final results of both analyses of literature and Case Studies are the inputs for the final Conclusions.
In the next sections, we will exhibit the methodologies used to develop Literature Review, Database and Case Studies.

3.2.1 Literature Review

In order to build our own awareness about the theme and at the same time develop a sufficient knowledge of the industry, we analysed both literature and scientific papers together with articles and news regarding the latest trends or technological development in the sport industry business.
We examined scientific literature contents published starting from 2008. To keep trace of our investigation, we built a working sheet, where we catalogued scientific articles according to different dimensions: field of research, date, subject areas, title, authors, journal, keywords and notes. In writing our thesis, the most important literature documents and papers were from:

- findings by Osservatorio DigitalSport of Politecnico di Milano
- Google Scholar
- ATKearney
- Eurobarometer Researches
- CONI's report: "*I numeri dello Sport*"

We considered also articles or news where innovation in such industry was highlighted, paying attention on deepening the established directions of analysis. In this way, we have been able to gather up-to-date insights about the market and its continuously evolving relation with digital innovation topics. The main sources for such news and articles were:

- Sport Techie
- Clearinghouse for Sport
- IBM Newsroom Blog

Moreover, particularly regarding the description of the different technologies and solutions shown in the second chapter, we analysed different patents available on Google scholar, going then deeper on the literature specified as a support in the bibliography, to extrapolate the theoretical basis on which these innovations relied.

With the aim of providing a reliable and comprehensive structure to both our first two chapters, our work was focused initially on the search thorough literature of models able to:

- Explain the relationship between the different areas of the sports industry and digital innovation
- Provide the classification rules of the technologies in the field of Athletic Performance to then outline a comprehensive and readable overview of such solutions.

Being our scope of research particularly innovative and unexplored, we did not find the suitable models that would have met these two needs. For this reason, we have included in our thesis two original models (one per chapter) whose layout is described hereinafter.

3.2.2 The Osservatorio DigitalSport's Model

This model was developed by the Osservatorio DigitalSport with the goal of defining four macro areas, in which we can classify the different interactions of digital innovation with the sports industry:

- Sport Club
- Fan Experience
- Sport Institutions and Event Management
- Athletic Performance

This model is an original framework as it is built on the distinction of the different actors who can exploit the utility of the digital innovation in the sport market, providing a precious base through which we can show how the value of innovation is generated, from where this value is resulting and analyse the role of the various digital innovations on the four main actors that characterize the sports industry. Additionally, we have mapped the different needs of each actor highlighting how the sports industry is evolving in response to such requirements.

3.2.3 The spider-web chart Model

The Spider-web chart model was created with two objectives:

- to classify the different digital innovation solutions available today in the sports sector
- to identify the various areas showing similar patterns in regards to the different scores on the axes

This model is built up on **four axes**, classifying the different subjects following the metric here described:

- **Level of complexion of the analysis**: provides a classification based on the intricacy of the process of elaboration of data carried out by the technology, and on the following capability of results to understand the current situation and even to foresee future patterns.
- **Technologies used**: a classification based on the different technologies exploited by the innovation. It goes from basic applications to systems making use of different sensors synergies and up to complex computational algorithms.
- **Stakeholders of the results**: a classification based on who are the individuals directly interested in the output of the analysis developed by the digital innovation system.
- **Level of diffusion**: a classification based on the degree of spread of this kind of innovation, referring to how widespread is that specific solution among the sport market.

3.2.4 Case Studies

The problem

The aim of Case Studies has been to find information not extractable from literature review. The main problem that emerges when analysing the information available on different articles or paper is indeed to provide a more detailed and defined assessment of the role of digital innovation. Actually it is difficult to understand all the mechanisms behind the choice of a particular technology over another, or the reasons for the adoption of a digital-based support for clubs, teams or individual athletes, also in relation to the possible presence of cultural barriers in this sector which boasts a very strong tradition.

On one hand, our aim was to figure out what were the enablers for success of a given digital innovation in sport, while on the other hand we wanted to understand if it is possible to digital innovation more accessible, encouraging its use even to the low-level teams or to amateur athletes.

This was possible also through the choice of international respondents, thus able to bring out a comparison between the Italian culture and the one they have found abroad.

Case studies have followed the CASE STUDY METHODOLOGY (Michela Arnaboldi, Management Engineering Department, 2016).

Objectives

Our case studies have been developed with three main purposes:

1. Confirm the truthfulness of what said at the theoretical level, and in particular the validity of the developed model. We have seen if there were confirmations of assumptions and considerations that we took in the previous chapters. In order to verify that the theory emerged from our model proved not only to be true, but also robust.

2. Define more clearly what was the value added by technological innovation to athletic performance. In this aspect, it was for us of particular concern to investigate whether the offers proposed by vendors (and then their conception of added value from their technology) were actually suitable for the needs of different athletes (then by listening to their opinions, their beliefs and their hopes regarding what they would like the technology to do for them).

3. Verticalization: the case studies have proved to be necessary to find more news that can refine those already emerged from the literature. In the first part of our thesis we applied a widespread and global perspective, while through the interviews we were able to bring out a more accurate figure. In particular, we have analyzed the underlying reasons for the choices made by the athletes in relation to the management of their athletic performance through digital solutions, the various barriers still present in many aspects related to sports, and the feeling coming directly from the protagonists of this industry.

Framework of Analysis

Since many operative topics can't be extrapolated by general inquiries, but rather are visible only gathering the opinion of whom works day by day in this industry through an adaptive approach, our framework of the analysis was heavily influenced by the two different actors we addressed:

- **Vendor**, which we investigated on their relation with the athletes (trying to understand if and how they are able to satisfy sportsmen needs), on their technologies (gathering the pro and cons of the technology they chose and the possibilities for future innovations) and on their vision on the market (opportunities and threads on their field, different cultural approaches they faced and previsions for future paths). Aiming at these goals, it was extremely important for us to contact vendors with different business models (from startup to international companies) and with a different expertise in the market.

- **Athletes**, to whom we asked their personal experience, the cultural background in their sport and their specific needs as athletes. Moreover, taking into consideration their level of knowledge about digital technology, we investigated their opinions on digital innovation today, on the role it can have on their performances, discussing about what they have been missing until now and what is still missing. Again, aiming at these goals, it was extremely important for us to contact sportsmen coming from different sports, even exploiting the possibility to have athletes of different ages (and so different training opportunities).

Methodology

1) Deciding unit of analysis

We opted for a Multiple-Case design: the analysis and the comparison of several cases in which we applied the same unit of analysis. The choice of this typology was driven by two fundamental reasons:

- Multiple cases are able to provide more robust results and compelling arguments
- Heterogeneity: different cases are representative of different pattern of behaviors, different achievements, etc.

2) Selecting cases

When selecting the cases we wanted to develop, we applied an empirical sampling but with a clear set of propositions, in order to grab three different situations:

- Successful cases, that are those case that could be seen as the most representative or typical instances of the digital technology taken into consideration.
- Cases on the edge of digital innovation
- "what if" cases, meaning gathering the opinion of pro-level athletes about the difficulties they have encountered during their carrier in relation to the measurement of their performances, in order to understand with them if nowadays digital opportunities could fill this gap.

3) Collecting data

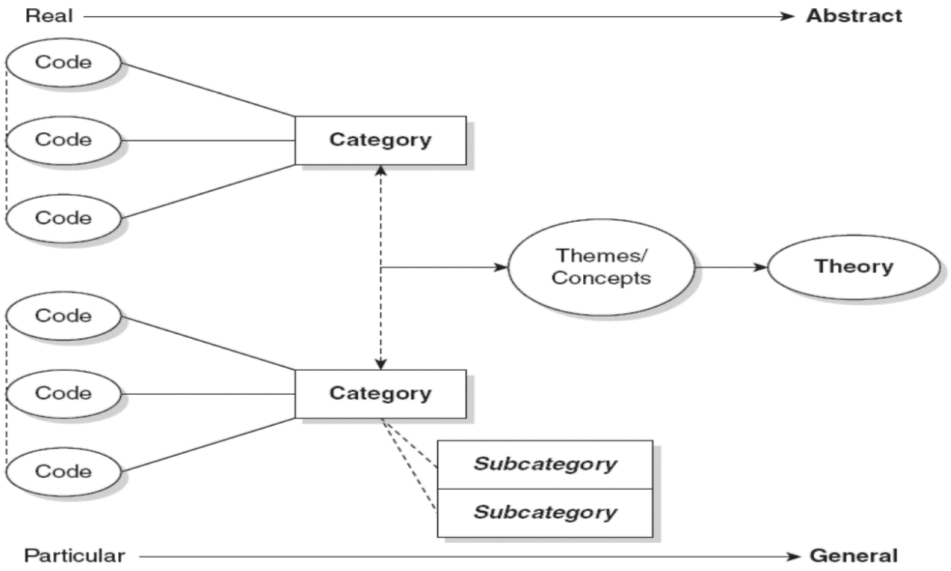
We used multiple source of evidence:

- Official Documents
- Internal documents
- Phone interviews
- Face to face Interviews
- Observation

In details, we developed semistandardized interviews: we implemented a number of predetermined, structured, open-ended questions in order to know interviewed's world by asking them to answer referring to their experiences. At the same time the interviewers were also permitted to probe beyond the answers to their prepared questions, giving them the possibility to talk, as we believe that also spontaneous deviations are important.

4) Analysing data

We applied a triangulation of the interviews with other data gathered from the literature and other web sources. In particular, we examined in depth the key concept revealed during the coding[1] phase, carried out with an inductive approach, as shown in the figure above.



5) Interpreting the findings

For the interpretation of the results, we applied our model of the web spider chart in each case considered. We therefore developed a matrix for comparative purposes, filled using the spider web chart from previous analysis. The matrix consists of several rows that refer to use-functions in relation to the intercepted digital innovations, and 10 columns dedicated to each of the analysed cases. In this way the obtained representation is effective as it provides a visual comparison of all the case studies.

[1] Coding is the analytic process of examining data line by line or paragraph by paragraph (whatever is your style) for significant events, experiences, feelings, and so on, that are then denoted as concepts (Strauss & Corbin, 1998)

Chapter 4.

Case Studies

4.1 Introduction

Following the flow described in the methodological note, in this chapter we have compiled the information gathered during the development of our Case Studies.

The path we followed is: identification of the Cases → identification of user functions (existing and potential) → construction of a matrix.

The chapter is therefore structured as follows: there are initially presented one by one all the studied Cases, developed through a layout that follows a standard pattern. We then built the matrix based on the user functions we have highlighted, the characteristics of which are described below.

List of vendors addressed:

- **Fitbit:** vendor producing smart trackers.
- **AthleteMonitoring:** digital platform provider for analysis of athlete's data
- **SkiLLGo:** startup that is thinking about an innovative way to monitor physical data of football players and their collection through a digital platform.
- **STATS:** vendor that provides statistical analysis of a sport match.
- **Wyscout:** well established Startup that provides throw its platform all the video of football matches and data obtainable by them.

List of athletes addressed:

- **MOXOFF:** Vendor that provides video analysis made by complicated algorithms and give information by its platform.
- **Unet Yamamay Busto Arsizio:** Italian women's volleyball society located in Busto Arsizio.
- **Avide Mondonico:** Albinoleffe's footballplayer.
- **Alessandro Gnecchi:** athlete of the Italian Canoeing National Team.
- **Mauro Pra Floriani:** athlete of the Italian Canoeing National Team.
- **Mauro Crenna:** athlete of the Italian Canoeing National Team.
- **Marco Culiersi:** kickboxing world champion.

We focused our questions on certain areas of particular interest to give a structured view of the concepts that would later arise during our interviews:

VENDOR:	ATHLETES:
Introductory questions: **COMPANY PROFILE.**	The **TECHNOLOGY** used.
Features of their **OFFER.**	The **SIGNIFICANT PERFORMANCE INDICATORS** he gathers from this technology.
BENEFITS AND CRITICAL ASPECTS of their product/service.	**BENEFITS AND CRITICAL ASPECTS** observed.
The **RELATIONSHIP** they have established **WITH** their **CUSTOMERS** and **MARKET.**	How the team handles **THE MANAGEMENT OF THE DATA ANALYSIS.**
Future **EVOLUTION OF THE INDUSTRY** and expected trends.	**THE IMPACT OF DIGITAL INNOVATION ON IMPROVING PERFORMANCE** they came upon.

Among all the user functions identified in Chapter 2, through a careful analysis we pointed out the ones addressed by the technologies that we faced: to map the results obtained through our case studies, we have therefore highlighted in particular these 7 functions:

- **Wellness monitoring** (stress, sleep, athlete's physical state)
- **Nutrition**
- **Workload management** (indications for training, schedule)
- **Physical activity** (physiological parameters, aerobic parameters, load parameters, dynamic parameters)
- **Tactical-technical analysis**
- **Injury tracking**
- **Scouting report**

Every vendor or athlete focuses on one or more functions. Our final analysis is aimed at understanding the diffusion of the functions, what vendors are now offering and what athletes use or require; also analysing where the technology producers are moving and their future improvement.

The most interesting patterns emerged from our analysis of the case studies, the model we applied, and a more general analysis of technological innovation within the sport were the topic subsequently deepened and reprocessed through a further interview, together with an experienced figure in the sports industry world: **Antonio La Torre**, professor of methods and didactics of sports activities at the Scuola di Scienze Motorie of Unversità di Milano.

The matrix:

On the columns we have positioned the case analysed, while the rows contain the user functions. In each given cell, intersection of a specific row and a specific column, we have put our spider-web model (developed in the second chapter) built on the technology provided/used by the different companies/athletes and that impacts on the relative user function.

The structure of the spider-web model is the same as the previous chapter, with the same axes 4: level of complexity of the analysis, technologies used, level of diffusion in the market and the stakeholders of the result of the analysis. In compiling the charts we have kept the same colour convention (red shade, green shade, blue shade), so we could colour charts with the colour of the group that was more similar in shape. The lighter dashes instead indicate the situation to-be: they have been added to indicate the cases in which the company already has a clear idea of the future development, or the real needs of the athletes who has not been satisfied yet.

In addition to considering mainly the information that emerge from the model, analysing the rows one by one we can draw some preliminary considerations, looking at the amount of graphics present, their structure and distribution of the dashes. For example, if the line has many empty cells means that the user function is not widespread, while if it is present in almost all the boxes means that it is well established in the market. Similarly by analysing each column we can understand if the vendor offer is specific to a single function or instead covers a larger number of targets, while for the athlete we understand if he monitors his athletic performance with a wide or close range of technologies.

Similarly by analysing the dotted lines we can understand if the vendor offers an even developing product or whether a offer is already mature; as well as for the athlete having many dotted lines means not having access to many digital innovations, while many continuous lines indicate that the athlete has already mature tools for the analysis of his athletic performance.

Finally, through the dotted lines we can have a first look at how and what will be the future, seeing what the athletes will require and how the vendor would like to modify its offer.

4.2 Vendors

Lorena Landini, Marketing Manager Italy
Technologies used: Wearables (wristband fitness tracker), Platform **Market size**: Global, top market: USA. In Europe: UK, France and Germany
Business offer: focused on the monitoring of athletic performance for wellness

"A wellness platform with customized advices, simple and immediate … is the way through which we want to give everyone the opportunity to improve their wellbeing"

COMPANY PROFILE

Corporate history: Fitbit was founded in 2007 in San Francisco (USA). After several years of growth in the US it began to expand into other countries and then lands in Europe.
Fitbit has started as a producer of tracker to monitor physical activity focused primarily on the sport. He has since evolved its business in response to a very competitive market, through which the company turned more toward the topic of health and wellness.

Mission: Develop a range of products as smart companions, worn on the wrist, with the aim of monitoring the user's own health through customised tips. Hence not only a simple tracker for sports performance, but a motivational companion for the user, addressed to everybody.

ANALYSIS

THE OFFER

- **Performance, training, strategy, health and rehab**? Performance, Health and Rehab
- **Sport**: Healthy living, wellness and fitness
- **Where you place it**: Wrist.
- **Monitoring time**: 24/7 monitoring of some parameters, selective tracking for other parameters (depends on the product)
- **Report analysis**:
  - **What is tracked**: Steps, distance, calories burnt, sleep quality, activities done, heart rate (even the heart rate at rest, one of the essential parameters through which you can measure a person health condition); VO2 max estimation; stress monitoring (through the 'relax' function).
  - **Report**: A user-friendly platform of well-being, able to record various parameters such as physical activity, sleep, nutrition (within the app you can upload the foods eaten, through a preloaded database). Customized recommendations for healthy living based on personal information, indications for training and basic workout (suitable for everyone).
  - **Stakeholder of the analysis**: The offer is addressed to a very large market, consisting of all ages, regardless of gender or level (beginner or pro). Everyone has different health objectives and therefore the company's goal is to have a product able to cover all of them. Constantly growing users (2014: 15 million, 2015: 38 million, today: 60 million) and the wearable brand that sells the most to women.

KEY ASPECTS

• **Distinctive features:**
- Suitability according to the users needs.
- Support in setting actually achievable goals based on historical user data.
- Coaching and advices (customised on user characteristics) to achieve this objective, notifying even the small daily results or failures.
- Sharing personal achievements in the community (largest community of activity and health fitness in the world), comparison with data of other users, and support of friends.
- Motivation and encouragement, through small steps. It starts from the person, but may decline over time: this is why the app every day customizes the promptings and suggestions on personal objectives and results, even through challenges with the community (function adventure, that immerses the user in a challenge with himself to get nice awards).

• **Understandability of data**: The device collects a lot of data, but the results are translated by the application to make reading simple and immediate. The goal is to give a clear and understandable view to anyone, including providing parameters that are calculated through a comparison with the community.

• **Competitive advantage of this solution over competitors:**
- Proven stability and product quality. Exceptional punctuality in the monitoring of the heartbeat (minimum gap from medical devices).
- The application is the core of the offer, provides added value and differentiate from the competition: gathers in one place the various performance monitoring tabs.
- Wide and active community, brand awareness.
- Active listening with the consumer: willingness to answer quickly to requests and feedback coming from the market. Very advanced and timely customer support system when answering questions.

RELATIONSHIP WITH CUSTOMERS/MARKET

• **Approach to the market**: Great importance given to R&D. Key defining what will become a trend: intercept and answer to the requests coming from the market. Market driven approach to innovation: the level of technological features of the tracker is defined mostly by these trends that are identified. Research is made at both global level and through the analysis of regional markets in which the company operates.

• **Customers distribution, replicability the solution on wide range**: Pyramidal customers segmentation:
- Wide base: everyday fitness. Non-continuous or light physical activity.
- Middle segment: active. People who make the most of their training on a continuous basis, very active life (gym or sports), but the aim is still the personal enjoyment and improvement of their own health.
- The tip of the pyramid: fitness performance. Much more limited group of consumers who want high performance. They train very often and use devices to monitor their results and to improve them (Fitbit addresses this segment with premium services).

There is also the Corporate program addressed to companies: the firm that adheres has the option to purchase devices at a discounted price and accesses to a portal, with the aim of encouraging its employees to healthy living and reduce employee illness rates.

• **Differences within different markets, channels exploited**: Globally there is a return to healthyhabits, in terms of activities and care for their health. The mission and the products are therefore the same at a worldwide level, what changes is the communication activity based on the most relevant users in each market. For instance in Germany the users prefer a device that provides accurate information, in France instead it is important the awareness, so they use the tracker with an approach bound to have a better knowledge of themselves and reach their own wellbeing.
In Italy, the buying power is not very high (even for subscriptions to the gym), so outdoor physical activities are widespread. Then there are different concepts of wellness: in the North there is a greater propensity for physical activity and sport, while in the Center and South well-being is tied to the cuisine and to eat healthy.

• **Difficulties encountered in the market:** Most users like to enjoy other aspects, such as the stylishness of their outfit, yet they require constant and continuous monitoring: demand for appreciable products also on a fashion viewpoint.
Some more experienced users often use several third-party applications, having a more advanced and specific knowledge of different apps, thus choosing the most suitable for their habits.

• **Competitors**:
- In the activity trackers segment, Fitbit is the market leader.
- Many brand deal with that part of the market (limited) more interested in measuring the sport performance: high end competitors like Samsung and Garmin, with products that have a very high quality and a high level of innovation.
- In the lower end of the market there is Cellular Line, which offers cheaper products with basic functionality, lower reliability in measurement and robustness, lower technical characteristics and a lower refinement in design.
- There are also apps that the company sees as partial competitors (Runtastic or MyFitnessPal) because they do not provide the same comprehensive view on data as they are more specialized in certain areas or specific training sessions.

EVOLUTION OF THE INDUSTRY

• **How the demand has changed, future trends**: Growth in the awareness of users: evolution in understanding what a tracker is and what it should do. Hence in this direction future trends involve an integration of as much functionality as possible inside the wrist device, combining functions that nowadays belong to other devices, up to the concept of smartwatch (better display, touch screen) and closer integration between the tracker, the app and the smartphone. New features of the tracker required by the market: GPS, water-resistant devices, more automated tracking of sports and expansion of the activities tracked. Integrations and partnerships with doctors and hospitals, to get more and more towards the concept of digital health.

Athlete Monitoring - FITSTATS
François Gazzano, Founder & CEO at FITSTATS Technologies Inc.
Technologies used: Platform
Market size: Global
Business offer: 40% full system, 40% workload management and train monitoring, 20% other features

"A good workload management: athletes are happy. And when they are happy they are also healthier and they train harder. And they get better performances. These are our results."

COMPANY PROFILE

Corporate history: Born in 2000. In 2004, they were the first company in the world to release a web- based athlete monitoring system. In 2008, the first one to create web-based skill and fitness assessment and reporting system. In 2015, mobile app. Nowadays, they are growing quickly, with more and more people using it.

Mission: To make quality workload management athlete monitoring systems, accessible to every coach. Our products aim at reducing injuries and improve performances of athletes by helping them training better.

ANALYSIS

THE OFFER

• **Performance, training, strategy, health and rehab**? All of them.
• **Sport**: A high number of different sports in different sport, leveraging on the modularity and customisation of the solution.
• **Where you place it**: Digital platform.
• **Monitoring time**: Post-training or post-competition, everyday monitoring of injuries and athlete situation.
• **Report analysis**:
- **What is tracked**: The analysis of the platform is based upon both statistical and mathematical analysis on data, and on the feedbacks and qualitative report provided by the athletes themselves. This have a particularly high importance in the measurement of wellness (level of fatigue, quality of sleep, subjective measurement). The quality of training is based on qualitative and quantitative analysis as well, with objective measurement (e.g. distance run) and subjective reports (level of involvement in the session).
- **Report**: Four different modules in the application. The core system is the workload management, which also tracks data useful for injury prevention. Wellness monitoring: from athletes feedbacks the coach can understand their readiness to the training session. Training monitoring: post-training or post-competition, gaining feedbacks and metrics. Injury tracking: to track the situation end evolution in time of your injury. Survey module: a solution to provide the questionnaires to athletes.
- **Stakeholder of the analysis**: Their customers usually are focused on performances but also on athletes well-being. Usually they have a high expertise in the sector, looking for the right tools to gather conclusions. The system is modular, so clients can request only a single module of the application. Typically, the teams at pro level take the full application. School coaches are usually less experienced and more focused on fitness testing and wellness monitoring. In general, the most requested modules are the survey module and the workload management (post- training evaluation).

KEY ASPECTS

• **Distinctive features**:
- Improve the workload of the athletes means to improve their motivation and their effort during the workout.
- Develop and measure the optimal workload for the competition day.
- Feedbacks from athletes to coaches, in order to take into consideration their input and build a mutual trust relationship.
- Fitness assessment, where the athlete can track also his skills or the results of his competition and carry out an evaluation of his results so far.
- Possibility to catch the first signals of injury and start prevention.

• **Understandability of data**: Only fancy numbers or data are not valuable if you are not able to translate them into a significant insight for the coach. Software can help you understanding data and taking action. Technology to be valuable needs to give sense to the data, in order to allow coaches to take action.

• **Competitive advantage of this solution over competitors**:
- Modularity allows a higher customisation on customer requests.
- Data and analysis can exploit the combination of different modules.
- This solution uses the same high level of algorithms and analysis, but with a more affordable price for different level of teams.
- A single solution to handle the complexity of a lot of different athletes with different needs for each of them.
- Wide spectrum of customers (even geographically), from which gather feedback in order to improve the system.

RELATIONSHIP WITH CUSTOMERS/MARKET

• **Approach to the market**: The decision of the market came from the fact that the founder was a strength and conditioning coach (at international level) and has gained a lot of experience and knowledge. The idea for this product was born from the field, as a personal need: from the start it gave extremely positive results. Usually to gain knowledge on sport performances, coaches had to rely on papers and then process on their own the information.
The technology helps giving models to monitor the risk factors during an athlete training, lowering the complexity in the management of a large team of athletes. Coaches can understand immediately what needs their attention and what needs to be fixed.

• **Customers distribution, replicability the solution on wide range**: The software should be not so expensive in order to reach a wider customer base. Addition of features requested by the market: clients provide feedbacks on the system, and also the number of new features request is important to understand the successfulness of the company.

• **Differences within different markets, channels exploited:** Directly in every market to promote their software. Diffusion of education in this field, promoting news and theory behind the sport science. Coaches education is extremely important.
Markets are very different, also in terms of culture. There are countries with informed and active national institutes on sport. Australia and Canada are two of the most advanced countries.
In Europe and in Italy usually there is a good level of coaches education, but this approach is still new. Even in the US there is a more traditional approach (with a mentality more closed on the coach's own ideas). But there are growing possibilities, especially with Universities.
The possibilities of customisation of the system can face the geographical complexity.

• **Difficulties encountered in the market:** It is difficult to teach coaches the importance of data, because they are too focused on their own arguments. Also new coaches sometimes want to have a more traditional approach to be sure to maintain their job, and the software requires an investment. For this reason is better to refers on higher level of management in the sport club.
Also a structural difficulty in sport is that even if the coaching staff is working well, results during the competition could be not directly related and not so positive.
Another difficulty is the high motivation of the athletes: they try to push their performances to the limit even when they would benefit more from a period of resting (to avoid injuries).
A lot of effectiveness of digital innovation depends on the approach of the coach facing it

• **Competitors:** The first in this market, but competition has increased. New players are usually sophisticate systems, complete but expensive, for few top clubs in the world.
Other software from competitors use simpler formula. One of the main competitor in this case is Excel, as culturally is diffused between coaches, especially in the US (but it lacks the analysis of data).

EVOLUTION OF THE INDUSTRY

• **How the demand has changed, future trends:** Demand growing. Growing range of clients: not only professional teams but also sport institutes, federations and high schools.
Request were to streamline the user experience in the training flow.
The needs are always the same: adapting the workload basing on freshness and readiness to maximize results and avoid overtraining.
Future development: automatically synchronize data from wearable devices; improvement in measuring the objective work done during the workout, being able to match data with the specific moment during the training session.

SkiLLGo
The Sport Evolution

Samuele Celeri, Co-Founder
Technologies used: Wearables (Zephyr military sensor), Web Platform
Market size: Global
Business offer: Still in development and testing phase

"Easiness in reading data means time saving and time saving means money earned"

COMPANY PROFILE

Corporate history: SkiLLGo is a startup founded in 2016 that provides innovative services for those who work in the world of sport. It is a company of professional people with considerable expertise in several fields, such as, for example, the selection and development of athletes, mainly footballers, and sports medicine. SkiLLGo was born initially only for scouting, but then analyzing the market they noticed how the data owned by the teams are often incomplete, and so there was the possibility for the development of an offer.

Mission: To provide innovative support to the world of sport as well as to add value to each athlete's performance and potential, through informed solutions for the creation of a sportsman's profile, both in terms of his/her athletic ability and tactical skills.

ANALYSIS

THE OFFER

- **Performance, training, strategy, health and rehab?** All.
- **Sport:** For now only football as the most popular sport, but it can be applied to any type of sport.
- **Where you wear it:** On the side through a special elastic band.
- **Monitoring time:** Real time during training session and matches.
- **Report analysis:**
  - **What is tracked:** The sensor works monitoring physiological parameters (such as heart rate, breathing rate, activity level, posture, core temperature), aerobic parameters (such as VO2, AT limits, acceleration), load parameters (heart load, physiological load, HRV, stress) or dynamic parameters (such as, vertical jump, explosiveness). In addition it is equipped with three-axis accelerometer that calculates the acceleration, the speed of the foot to the ground, the impact that it receives and many other.
    The system can also measure the reaction time to get the statistics in order to assess the athlete's presence in different zones of the field, the distance covered, the speed, the time/distance ratio, accelerations, decelerations and many more tactical elements.
  - **Report:** All data is stored within a platform, which processes the data and provides useful information to the company and to the players. This also in the area of injury prevention and rehabilitation.
  - **Stakeholder of the analysis:** Coach, trainer, medical staff and athletes.

KEY ASPECTS

• **Distinctive features:**
- A simple and individual, customizable report. It provides the physiological, aerobic and kinetic parameters.
- Real time analysis is necessary in order to provide an initial quantitative evaluation and to verify the intensity level of an athlete's effort during a training session.
- Ability to combine a report with each video, to evaluate an athlete's efficiency and to draw an accurate picture of the athlete's performance.
- Personal profile for each athlete and compare his/her parametric levels to benchmarks or to check difficult moments such as fatigue, suffering from heat, overload or underload, anaerobic levels.
- Athlete's CV: comparison of several sessions of the same athlete (e.g. to track his/her trend during each training session, to set a goal for improvement, to spot the main areas that need improvement and to understand the best way to get it), comparison of different athletes.
- For coaches: the opportunity to observe a very wide selection of athletes with detailed and objective information about the physiological and tactical performance of each one of them.

• **Understandability of data:** It is crucial for the player and the coach to not have a myriad of data that are confusing. So the online platform presents data that are organized and analysed so as to provide a direct output of information understandable and practical.

• **Competitive advantage of this solution over competitors:**
- Talent scouting: the platform is able to provide an overview of the player, and at the same time highlight which of its parameters can be improved.
- Platform through which analyse the historical data and to provide clear and understandable information without the intervention of data analyst. It allows athletes to record also collected data with third-party devices to have no limitations with any new technology in the market.
- The data is available in real time because they do not use either Bluetooth or Wi-Fi, but a system of military derivation that communicates much more precisely up to 400 meters away, ensuring a cleaner signal.
- Understanding the psycho-physical state of the player: might avoid certain types of injuries and therefore allow the company to save these costs.
- Accuracy of data: 1% error (while data of some GPS are incorrect up to 20/30%).

RELATIONSHIP WITH CUSTOMERS/MARKET

• **Approach to the market:** The idea had by SkiLLGo was put into effect thanks to new technologies that are being developed in recent years. The staff is composed of former players, who have encountered these needs during their careers.

• **Customers distribution, replicability the solution on wide range:** The solution could be diffused for any sport and any sports club.

• **Marketing:** Channel used, penetration of the market: decision to start from the football world and especially from Serie A as it is a very strong market economically. Decision made also because of the fact that SkiLLGo does not own technology and has many costs involved. The market so far has responded very well. To penetrate the market, they are thinking about taking advantage of the contacts already collected by Wyscout and combine the services that these two realities offer.

• **Differences within different markets, channels exploited:** The product is still under development and in the testing phase.

• **Difficulties encountered in the market:**

- Lack of a comprehensive data collection system within teams. They currently only implement tight compartments (the fitness trainer, video cutter, who collects data, etc.) and do not communicate with each other, putting together the data only at the end.
- Often the workouts are not personalized and is likely to give the player a load of training too low or, even worse, too high, which then leads to a psycho-physical decline or injuries.
- Lack of regulation on the use of technology during official matches.

• **Competitors:** The main competitors will be the GPS manufacturers both in the technological development and because of the fact that they already have contacts with various teams. SkiLLGo can not answer only with the supplied tool, as it is not the producer of technology. The strength will be the platform which can give an advantage as it is extremely original and innovative.

EVOLUTION OF THE INDUSTRY

• **Competitors**: How the demand has changed, future trends: Today this service is still under development. There is a great interest and, if approached together with Wyscout, it will ensure comprehensive monitoring of any parameter required by the customer.
Applications will also be able to reduce the rate of injury through proper management and analysis of data collected, taking into account the devaluation of the injured player.
Implementation of statistics to understand how every single player responded to a particular training load at the moment. There is still an important part of sports medicine knowledge needed to develop this: for this reason they contacted a large center in Italy that provides advices in this area.
Spreading the idea that an adequate training plan and the player's overview in every moment of the event, both pre and post match, can lead to a reduction in accidents.
They will develop indicators that show the club the real impact both at the level of performance and at the level of savings generated.

STATS

Tommaso Refini, Business Development Manager Italy
Technologies used: App, IoT, Cameras
Market size: Global
Business offer: 40-50% Athletic Performance (steady), 30-35% Training (growing), 10-15% Health & Rehab

"Data give you the answers but they should also give you the questions: they should push you to try to interpret and understand.

Over the years, I realized that technology is very useful to create conditions such that good professionals can catch the flow of information"

COMPANY PROFILE

Corporate history: STATS traditionally has a focus on sports and media market. In spring 2015 the company acquires Prozone which instead focused on the monitoring of athletic performance for professional clubs. STATS has a widespread presence all over the world and a high experience in the industry.

Mission: allow coaches, athletes and technical staff to monitor all the activities of their team and their performances, both during the day and with a long-term perspective.

ANALYSIS

THE OFFER

• **Performance, training, strategy, health and rehab?** Athletic Performance, Training and Strategy. Managed directly (data collection), and then providing in-depth analysis for staff.
Health and Rehab: the company offers support (providing information) to the customers internal medical staff.
• **Sport:** Several sports targeted worldwide, in the interview we deepened the theme related to football.
• **Where you place it:** Data gathering leverages both the video analysis and the tracking system.
• **Monitoring time:** During matches and training sessions.
• **Report analysis:**
- **What is tracked** (referring to football): Physical data (the range of information related to athletic performance) and statistical data to recreate a game from the tactical-technical point of view: the "ball event", players involved, movements without the ball, passages, degree of difficulty of the move and other more advanced information than the traditional reporting.
- **Report**: Video analysis. Training session analysis: depends on the context of the sport club, the field in which they train and the quality of its infrastructure (the goal is to reproduce the same measurement carried out during the match). Data and parameters monitored and supplied both live and after the game, analysed and corrected. Very good level of reliability, with certifications that confirm that the data is reliable and thus also the subsequent analysis is trusted. The live data is very slightly more inaccurate (within about 95% accuracy anyway) and is then corrected during the subsequent analysis.
- **Stakeholder of the analysis:** Fitness coach, main coach and technical assistant, data analyst. Available an app to browse the video data, which can be installed into the smartphone of any athlete of the team, so that staff can share relevant information.

KEY ASPECTS

• **Distinctive features:**
- The technology has created the conditions to monitor, providing access to information previously unknown, so that the athlete can then use it and treasure it for his own learning.
- Obtain information necessary for the improvement and training, game and result optimization.
- Extracting of summarizing information to help you understand what is being done effectively and what is wrong.
- Provide suggestions to coaches for the design of new improvements.
- Exploiting the best available technologies which however are able to provide a rich and readable content.

• **Understandability of data:** Software increasingly dynamic and user friendly, even for beginners. Customization: choose the parameters shown create your own screen, set visualization thresholds or control variables. The problem then remains in the interpretation of the results, so in general would be more effective if the team has the figure of the data analyst.

• **Competitive advantage of this solution on competitors:**
- Global company:
- Larger data volume than local companies.
- Ability to collect data with the same systems, necessary for the efficient and effective comparison of the data.
- Learning economies, large and diversified knowledge, background of adaptability to different situations (e.g. in data collection with unsuitable infrastructure), problem solving, ability to meet different needs.
- Influence the market, pushing one technology over another.
- International useful data on foreign teams for international competitions.
- Scouting department able to gather data from players around the world.
- Relations with many teams to improve the product and introduce new features

RELATIONSHIP WITH CUSTOMERS/MARKET

• **Approach to the market:** In the product development phase, you must know how to intercept the needs of the market, to be able to anticipate some trends.
Information sharing within the company. They discuss both the requests/feedback from the staff around the world and the solutions from the technical department (with a specific knowledge on new technology trends). Ability to develop cross-sports products.
Feedback from other nations, to compare the different situations and have different pictures of the same sport.

• **Customers distribution, replicability the solution on wide range:** Dynamic products that meet different markets. Economies of scale in offering the same product in other markets.
There are nonetheless difficulties related to the typicality of each sport, technical training or infrastructure level (the most obvious is outdoor / indoor). Each team then works in a different way (e.g. in Serie A there are not two teams that use the same product customization) then the offer must be personalized and dynamic. This is also valid in the medical area where every athlete has his needs.

• **Differences within different markets, channels exploited:**
It is important to include the right skills the world of sports. For this reason, they collaborate with Universities to share knowledge on this innovative sector.
Each market has its own personality, so the company needs to access it with a local focus:

- The Anglo-Saxon countries are ahead, more familiar and more aware, based on objectivity and on results over the long term (daily monitoring – they consider the game event only as a moment of confirmation) so even the club structure has a scientific department.
- Emerging countries such as Middle East: no strong sport tradition but they want to emulate and follow successful models.
- Latin countries have a very strong emotional component. The result of the game influences a lot the arguments and the preparation itself has a short term view. In Italy, a traditional problem was the infrastructure, although investments are now growing. Also Italy is missing the culture of the analysis of data (e.g. specific coach in the staff) especially evident in the lower leagues (in Italy a technical coach often does not even have a specified office, while in England the standard is a technical staff of 10 people).

Differences between sports: Interpretation: some sports have simpler codifications, and series of well defined events. Comprehensive and credible image of what was the match. In football it is difficult to encode some choices because it is a mix of objective aspects (the ball moved forward) with subjective aspects, interpretation and game strategy of each coach (defensive or aggressive). More emphasis on the monitoring of athletic-physical performance, objectively measurable.

• **Difficulties encountered in the market:**

- In Italy the problem is cultural: the evaluation of staff quality of work depends on the outcome of the game. No long-term reasoning, different approach to daily work.
- Missing a specific coach for data analysis, and therefore they lack the ability to study the parameters which give the capacity to explore new ways of reading the output.
- Some athletes are not interested in deepening the data on their performance, considering their subjective opinion more valuable.

• **Competitors:** Different typologies of competitors, in different nationalities and different sports, differing from country to country. The answer is a business strategy focused interpretation of the needs from sport to sport, from country to country, both in the media market and in the athletic performance market.

EVOLUTION OF THE INDUSTRY

• **How the demand has changed, future trends:** Software customization requests, which are an incentive for the company. Balance between technology push and market-driven approach: tendentially 50/50%, then depending on the characteristics of the market there becomes unbalanced to 70/30% or 30/70% resolution of technical issues relating to fit (and invasiveness) of the sensors or in the signal noise.
Boost in the to increase interest and awareness of the potential of this sector, especially in the generational shift. Data are already considered reliable, this is a barrier already overcome. The optimal data quality is a minimum requirement of the market, the real differentiating factor will be the time element: deepening and data sharing to save time, because of more and more games close together and therefore with tighter work schedules (data already available in the morning the day after the competition or live data).

wyscout

Matteo Campodonico, Wyscout founder and CEO
Technologies used: Cameras, Web Platform
Market size: Global
Business offer: Performance analysis, focus on the field of strategy and tactics.

"Wyscout, changing the way football works."

COMPANY PROFILE

Wyscout was founded in Chiavari (Liguria) in 2004. In 2016 it was the first startup to join Wylab, the first sports tech incubator in Italy. Wyscout has its headquarters in Chiavari and offices in London and Shanghai with a staff of more than 90 people. The company supports 800+ professional football clubs, 700 football agents and the major federations, being used in more than 90 countries and international competitions.

ANALYSIS

THE OFFER

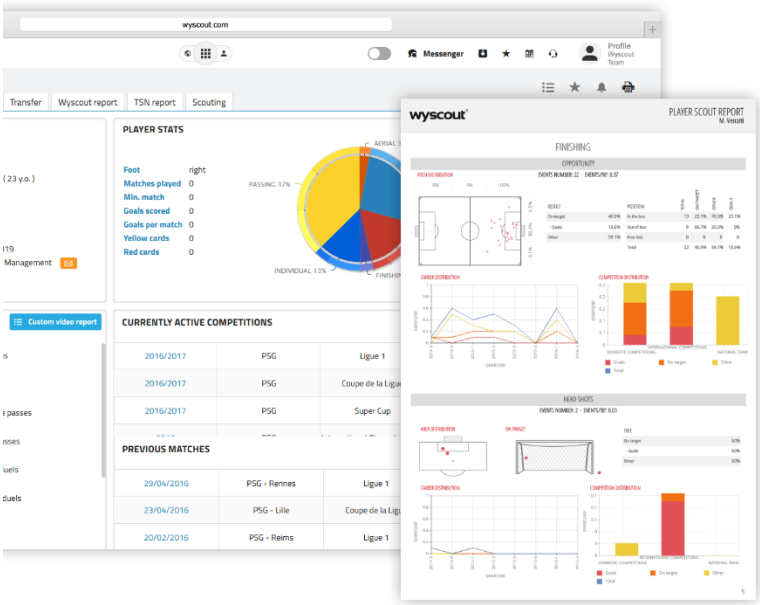


Figure 4.1

- **Performance, training, strategy, health and rehab?** Strategy, training, performance.
- **Sport:** Football.
- **Where you place it:** Web platform. It only needs videos of the match from the pitch.
- **Monitoring time:** Videos taken during the game.

- **Report analysis:**
  - **What is tracked:** It contains videos of the analysed match tagged action by action so as to be filtered by typology. For example, the user can choose to view only assists, goals, corners, goalkeeper saves, acceleration for each of the players or the entire team. But also performance statistics, technical data and players' transfer details.
  - **Report:** a platform containing up to 1500 new games analysed every week, from more than 200 championships in 80 countries and with 400,000 player profiles. It is the most widely used tool in the professional world for the analysis of the game, scouting for new talent and management of players' transfers. In addition to videos, performance statistics and technical data, the team can download a full report analysis with graphic supports. Wyscout is also the global largest community of football professionals, who through the web platform can get in touch and send each other messages.. The matches and the data are loaded on the platform a few hours after the live event so that those who use them can access the data before the next game or training session.
  - **Stakeholder of the analysis:** Each team has a data analyst who works on this data and looks for information that is visible from the video, or from the countless statistics and data provided. Generally it is used by the technical staff, the team managers, the sport agents, the referees, the players and the scouts, from the most important championship to semi-professionals ones, to youth leagues. Wyscout is also used by the editorial offices and TVs, to prepare pre and post game analysis and extract the data and market insights.

KEY ASPECTS

- **Distinctive features:**
  - Since Wyscout has decided to offer its web platform, the way of doing scouting and analysis of football data has changed radically. From that moment on, anyone who has access can watch to all the championships and could see every player and every action from anywhere, overcoming geographical and budget limits.
  - Wyscout has implemented more and more video coverage up to create a comprehensive archive available at any time
  - Wyscout users also avail of an editing tool to create customized analysis and reports, both in terms of individual games, players' actions or particular time during the game
  - Coaches, analysts and head scouts can share videos and data with their technical staff in a private way. In addition, the internal messaging allows them to get into direct contact with the representatives of the teams and sport agents

- **Understandability of data:** Wyscout provides a huge amount of data that could be easy to analyze (such as video) and more complex (e.g. different game statistics). The platform does not provide a service of analysis of data and statistics itself, as the information must be extracted by various companies who use the service. Wyscout provides a range of very specific data that needs to be analysed by the various teams to transform them into useful insights.

- **Competitive advantage of this solution on competitors:**
  - Before Wyscout there were statistics and data processing companies, while less attention was devoted to the video for contest indexing.
  - High barriers to new entrants, due to the high assets required.
  - Huge database of games, worldwide.
  - Each and every specific moment of each game is decoded.
  - Some leagues even offer Wyscout to all Clubs to invest in their training.

RELATIONSHIP WITH CUSTOMERS/MARKET

• **Approach to the market:** This project was born from the passion for the game, since when one of the founders used to play football, his coach used to show him video to analyse how others players were managing penality shots, or the offside etc… but obviously there were technological limitations. After understanding, however, the high utility of this type of approach, the idea that lies behind Wyscout was developed. Now the company bases its success on the number of partners, importance of customers, market penetration and the amount of players / games / leagues analysed.

• **Customers distribution, replicability the solution on wide range:** Wyscout collects data from any match anywhere in the world and played by any player at any level.

• **Differences within different markets, channels exploited:**
- To penetrate the market, the company relied on the demonstrating the effectiveness of its product. Great spread came with word of mouth and because of the fact that the clubs did not want to lag behind those already using Wyscout.
- The talent scouting is approached differently by different leagues. If for some clubs was crucial to view the South American players, for others the talent scouting was to take place in Eastern Europe.
- Italy lacks many aspects, not only regarding the technological field but also related to the more closed-mentality than other countries (e.g. England).

• **Difficulties encountered in the market:** It was difficult in the beginning to win the first customers because they did not understand the importance and the advantages that this solution could bring.

• **Competitors:** There are many companies that provide video match analysis but none of them has successfully established itself so firmly in the market or has such a wide database of games.

EVOLUTION OF THE INDUSTRY

• **How the demand has changed, future trends:** The growth of technology in recent years has allowed the development of products that until a few years ago were unthinkable. Initially Wyscout was intended to coaches and technical staff for the preparation of the game. The match analysis was used by scouts, sports managers and agents as a tool to see new players. The football world was rather backward from a technological point of view: the most common practice in scouting was that sport agents or the players themselves sent to the team managers of the Club the DVD with their highlights. It was a very limited approach, with partial information and which required an internal data center that very few Clubs could afford.
The initial idea has evolved many times over the years and today the firm's boundaries often change. This is because Wyscout offers services based on technology and always wants to look to the next step, wondering how to provide a better service. For example, minimizing human intervention required to analyze the video, looking more and more to make it automatic and mechanized. Or increase further the talent center trying to incorporate more and more players, both of different levels and ages.

Ottavio Crivaro, CEO Moxoff spa **Technologies used:** App and platform
Market size: Italian and European
Business offer: two subjects for two different needs: game strategy and technical gesture

"The world of data is coming now to the world of sport. At the heart of the sport there is the passion… and technology is useful both to train the talent and the passion"

COMPANY PROFILE

Corporate history:
Moxoff was founded in 2010 as a spin off of the Mathematics Department of the Politecnico di Milano. The business model is based on the ability to develop a concrete and effective transfer of technology and know-how between the world of research and the world of companies. The idea to implement Moxoff 's work to the world of sport has taken place in 2014, through a meeting with Mauro Berruto (former coach of Italian Male Volley Team). In November, 2016 it was created a startup, Math&Sport, which brought together these activities related to the field sports, and Wylab recognized as one of the best startups regarding the potential level of market.

Mission: Moxoff leverages its modelling, simulation, optimization and intelligence capabilities, to extract valuable insights from data. This then allows the company to build mathematical models and algorithms into easily user friendly software for end users.

ANALYSIS

THE OFFER: Virtual Coach – SeTTEX

- **Performance, training, strategy, health and rehab?** Training & Strategy.
- **Sport:** Adaptable to different sports, born with Volleyball (SeTTEX).
- **Where you place it:** Application on the tablet, touch system.
- **Monitoring time:** Before and during the match.
- **Report analysis:**
  - **What is tracked:** The coach through the app indicates the opponent's tactic, and the app pro- vides an indication of what is the best tactic that should be used to counter the other team (even if the opponent is adjusting its behaviour).
  - **Report:** The real-time algorithm through countless variety of data available is able to report dominant scenarios and dominant tactics to provide practical guidance on what should be done. The algorithm also monitors in real time the difference between a tactic model reconstructed by studying the opponent and what the opponent is actually doing in that specific game.
  - **Stakeholder of the analysis:** Athletes, Coach and Tactical Staff.

THE OFFER: MOViDA (Movement's Optimization, through Video and Data Analysis)
• **Performance, training, strategy, health and rehab?** Athletic Performance.
• **Sport:** Adaptable to different sports (Tennis, Volley, Golf, Soccer).
• **Where you place it:** Digital platform. It is compatible with every action camera, and it doesn't require bulky sensors but just simple markers.
• **Monitoring time:** During training session.
• **Report analysis:**
- **What is tracked:** Tracking of some points of interest identified on the body of the players: data on specific points of the body are automatically extracted from the video footage of the movements of the players during training session.
- **Report:** It is the true value of the analysis. Video processing algorithms extract data, then they are used through statistical and mathematical models. The gesture is described as a set of curves on the three axis, which represent the movement of the different parts of the body and of the ball, and the functional analysis of these data allows to obtain information that is not directly detectable on the field, such as speed and acceleration. The system also examines the gesture through many repetitions of the same athlete to analyse its variability and effectiveness.
- **Stakeholder of the analysis:** Athletes and coaches.

KEY ASPECTS

• **Distinctive features**
- Objective measurement, not only the gesture but also the outcome of the gesture itself
- Data monitored over time, to study the regularity of the gesture.
- Analysis of the specific gesture of each athlete. The goal is not to map the ideal movement, but to analyze the effectiveness of each athlete with his personal gesture.
- Validation through test and real cases.
- The algorithm is self training and evolves over time.
- High adaptability of the solution, no special technological configuration required.
- Unobtrusive, it does not affect the natural execution of the movement.
- Ability to analyze the gesture made in the natural environment, not in the lab. Possibility of outdoor and indoor application.

• **Understandability of data:** The athletes and the coaching staff require objective data but expressed through comprehensible indicators, to communicate better. For this they provide quantitative information, accurate and synthetic.

• **Competitive advantage of this solution on competitors:**
- The value comes mostly from being able to draw out information from the data.
- Minimally invasive during natural execution of gestures, using colored marker which can also be used during the game.
- Advanced statistical techniques, high mathematical expertise.
- Ability to analyze hundreds or thousands of videos.

RELATIONSHIP WITH CUSTOMERS/MARKET

• **Approach to the market**
The literature provides a point of departure. Study of market trends. Relationship with indirect stakeholder, eg incubators (wylab) or contests in the sector.
Approach directed to the measurement of capacity and potential of an athlete, just as in other industrial sectors it is normal to investigate about the performance measurement and the trend over time of a machinery. Top-down approach: the strongest teams and their federations are the first early adopters of technologies, to gain an edge over competition. The difficulty is to deal with higher levels of management, that do not always understand the difference between the various services offered.

• **Customers distribution, replicability the solution on wide range:** The startup Math&Sports was born for this: it is possible to offer the product in a simpler and appealing version even to semi-professional user, who would otherwise struggle to understand the service. In this way instead they grow his interest in the service, they build loyalty and there are opportunities for up-selling or cross-selling.

• **Differences within different markets, channels exploited:** Much depends on the specific staff with which you collaborate. Some sports such as athletics have a lot of literature, although they are not very common sports. The analysis of technical movements instead is less suitable to all sports where there is physical contact, because there are many variables that affect the technical gesture. Often there are also events less easily classifiable therefore less trackable and predictable. In some sports there is also a cultural problem: when you think that the technical gesture is due to the fantasy and skill of the player and is therefore related only to the talent.
In some countries is rooted the concept that sport like any other discipline can be measured, managed, optimized, predicted. The product can be adapted to different situations: it does not change the basic concept, i.e. to highlight the significant information of the events that occur during the game.

• **Difficulties encountered in the market:** The companies are unaware of the value of data, or can not handle this value. Difficult to show the value of data. The sport is going now through that transition that some industries witnessed years ago. In sports, the product is the athlete but basically they face development plans that are little quantitative yet very qualitative and based on sensations. Often the focus is on specific ideas of the coach. Considering the lowering of prices of technology solutions, often the clubs buy services that even other teams use, but without knowing how to exploit it. They do it for fear of being left behind but they don't actually base their decisions on data. The coaches do not always accept the fact that the talent should be trained and then measured day by day. There are also resistances from talented players or talent scout.

• **Competitors:** The market will become very crowded, new entrants, new specialized companies. Both on technologies but mainly on how to use them. Stats is definitely very strong, however, they have been focusing on the statistics area. Other competitors offer only video analysis solution to analyze the single gesture. And quite often the competition is merely in terms of marketing, commercial, and visibility.

EVOLUTION OF THE INDUSTRY

• **How the demand has changed, future trends:** The technology has become pervasive, not only for pro teams, the cost has been lowered. The biggest problem is still handling a large volume of data, obtained also thanks to the deployment of IoT technologies (where now the investments are still concentrates). The problem is then how to analyze them effectively and in real time, to counter the opponent.
A different culture is growing: now companies begin to hire software engineers and analysts: each coach has a new request, to extend the range of analysis. The industry is also in a transition phase in which there should be an activity of education and fertilization made by institutions to facilitate change.

4.3 Teams and Athletes

Unet Yamamay Busto Arsizio (UYBA)

Enzo Barbaro, CEO, Marketing & Team Manager of Unendo Yamamay Busto Arsizio

"The club is interested in everything that is related to the world of sport innovation, both in digital and in medical or scientific area"

Marco Mencarelli, Head Volleyball Coach
Technology used: Strobe Glasses, Virtual Video Training

"The long-term monitoring is the key"

Alessandro Mattiroli, fitness coach
Technology used: Beast

"Having only the data is useless, they must be processed and analysed to be exploited."

Tommaso Barbato, Scoutman and Video Analyst
Technology used: DataVolley

"Technology is critical to understand what the human mind can not perceive from the single event

TECHNOLOGY 1: Virtual Video Training

• **Performance, training, strategy, health and rehab?** Performance, training, health and rehab.
• **How it works**: Platform consisting of a touchscreen monitor (55 inches) and a frame equipped with different sensors: camera, infrared and laser.
A sensor analyses the eye movement of the athlete during exercise (speed and direction). This platform computes specific athlete's performance through a series of exercises, which can be repeated at different speeds in order to adapt better to different athletes and levels of preparation:

Figure 4.2

1) Exercise that helps coordination: the screen shows the dots one at a time to be touched by the athlete, these dots appear randomly in different parts of the screen.

2) Exercise that helps exercising the rotary perception: the screen shows different dots of three different colours that rotate around a central point of the screen at different distances. This training is useful to train the visual perception at different points depending on whether the stimulus is central or external.

Figure 4.3

Figure 4.4

3) Exercise that helps to train the prediction of the position: the screen shows the dots that start from the centre and move randomly towards the edges of the screen, the athlete must click on the screen not where the ball was, but where she thinks it's moving, so anticipating the movement.

• **Where you place it:** in front of the athlete.
• **Monitoring time:** during specific training session, not on the field.
• **Report analysis:**
  - **What is tracked:** reaction times, increased visual and perceptive ability, eye movement, analysis of the movement of the body.
  - **Data provided:** The system is able to figure out in which of the four quadrants the athlete has had more difficulty and in which one instead she was stronger.
  - **Report:** The coach can decide training sessions targeted to enhance the athlete's performance. The medical staff uses the data collected as a prevention of the second injury: this is because after an injury in the athletes sets an unconscious mechanism which causes the athlete to load abnormally other parts of the body, and this helps them to assess this load and bring it into line. Results are also shown graphically
  - **Stakeholder of the analysis:** Athlete, Coach and Medical Staff.
  - **When the report is analysed:** in real time using special sounds the athlete knows if her touches are correct or wrong, while the final statistics are available after a number of exercises.

TECHNOLOGY 2: Strobe Glasses

Figure 4.5

• **Performance, training, strategy, health and rehab?** Training, performance.
• **How it works:** glasses with LCD screen that creates a fragmented image, so it is possible to reduce frames of movement perceived by the athlete.
• **Where you wear it:** like a pair of normal glasses.
• **Monitoring time:** only during specific workouts.

• **Report analysis:**
- **What is tracked:** No physical report is provided from this technology, only feedbacks from the coach.
- **Data provided:** The athlete is able to train her own brain to improve coding the short-term memory in order to accurately predict the trajectory of the ball.
- **Stakeholder of the analysis:** Athlete and Coach.
- **When the report is analysed:** During some of their weekly training sessions.

TECHNOLOGY 3: Beast Fitness Tracker

Figure 4.6

• **Performance, training, strategy, health and rehab?** Performance, training.
• **How it works:** This system is equipped with three accelerometers, three gyroscopes and three magnetometers that monitor the athlete's movements during training.
• **Where you wear it:** Wrist.
• **Monitoring time:** During workout.
• **Report analysis:**

• **Report analysis:**
- **What is tracked:** The device is able through an algorithm to detect speed and power of execution of each repetition, basing on the movement executed.
- **Data provided:** Speed and intensity of the workout
- **Report:** The device connects to an app on the smartphone of the coach, who can monitor in real time the training parameters and in this way determine the load that the athlete must use at that particular time.
- **Stakeholder of the analysis:** Athlete and Coach.
- **When the report is analysed:** Athletes are tracked during each workout in the gym and the data are displayed in real time and collected later in a database.

TECHNOLOGY 4: DataVolley by DataProject

Figure 4.7

• **Performance, training, strategy, health and rehab?** Training, Strategy.
• **How it works:** This software is able to record every time an athlete hits the ball, and gives the opportunity to the data analyst to include objective assessments of the effectiveness of the play based on video analysis. Each club worldwide analyses the video of their own team and once they have entered all data, but they also share data with all other teams. Sharing data is not compulsory, as instead the video exchange is, but many years by now they also automatically share data collected in order to help each other, as they are still objective data available from videos.

• **Where you place it:** During the game, the data analyst collects statistical data evaluation, connecting them to the video automatically and he sends them live streamed to the bench.
• **Monitoring time:** All matches.
• **Report analysis:**
- **What is tracked:** In each match it is monitored every time the ball is touched and all the objective data related to the touch, connected to that action, as the trajectory of the ball and the assignment or not of the point.
  Detailed analysis on the fundamentals of a player or team during several sets, the whole game or even her career. Detailed Analysis and specifications regarding field section, the stopwatch, the player, the team, the game, the trajectory of the ball, the areas of the court or the effectiveness after hitting the ball.
  The collected data can be exploited to study the performance of the athletes and their evolution over time, in order to prepare exercises aimed at improving performance.
  Through the platform, you can watch live streaming video and the replay of the last 5 points.
  Save and review videos of the most important points. You can share useful information for the game strategy with coaches and statistics with journalists and television.
- **Report:** Video analysis, not to miss single details of the game and match the statistics with the visual feedback. Data regarding the efficacy and distributions of the various attacks based on the area in which they are done, the rotation, the quality of reception or more.
  Retrospective Analysis of a set or a whole match looking at the provided charts and always keeping an eye on the deviation from the score of the game that is indicated by different colors.
  Simplified report with no numerical data chart pattern for athletes.
- **Stakeholder of the analysis:** Athletes and Staff.
- **When the report is analysed**: Some statistics and replays are available in streaming with a few seconds delay, while the full report is available after each game and after a careful work of the data analyst, who is able, however, to enter the necessary data already during the game.

SIGNIFICANT PERFORMANCE INDICATORS

• **What is derived from the output:**
- Visual perception of athletes and their reactivity.
- Proper workload to be submitted to the athlete, adapted to its psychophysical state in that specific moment.
- Effectiveness and efficiency of actions during the game.
- Statistical data on the current game and a database coaches can refer to.

KEY ASPECTS

• **Usefulness observed:**
- Increased perception and prediction on the movement of the ball thanks to the use of strobe glasses and virtual video training. This allows an increase of the visual capacity and consequent increase in performance, predictive capabilities and reaction.
- Ability to calibrate the workload based on the result provided by Beats device, adapting it to the type of training: strength, endurance, etc. The athlete does not always present the same psychophysical and neuromuscular conditions, so her performance may change from day to day. This may depend on her workload in previous days, by her mental condition, or other factors that can not be measured directly from their coach. Using this device the coach is able to suggest to the athlete the exact workout with the right workload. To do that the coach considers, as fundamental parameter of training, the speed of execution, so knowing the speed at which the athlete is doing some repetition, he can calibrate the load, increasing it if the athlete executes it at a too high speed, or decrease it if there is a drop in this rate. This factor is very important because it allows to train the correct group of muscles in the same way, even if the athlete is tired or unmotivated.

- The coach, adjusting the load of the athlete, does not overload her preventing possible injury or conversely, in the case of a load too light and therefore not functional, he can increase it to make it more effective.
- Ability to prevent some injuries before they occur, by monitoring performance with the Beast device or through the ability to recover in the best way by using the virtual video training.
- Through DataVolley is possible to have statistics that help preparation for the game by studying the opponent, to have a real time monitoring during the game to allow to choose the best strategies and to have a full report after the game so they can improve and implement corrective measures for the following matches.

• **Critical issues:**
- Minor companies, presenting limited budgets, fail to obtain highly precise technology, although these can provide great results.
- Athletes are not always interested in the information generated from the data collected, that sometimes are not even consulted.
- Technologies are able to provide many data, but not to give direct information. That's why coaches need to spend much of their time analyzing data and processing them through complicated Excel tables.
- Some technologies such as Beast provide data but do not have a certificate of how effective they are. Moreover, sometimes they will encounter difficulties in linking the match statistics with data collected in the field because exercises are not standard.
- DataVolley software needs to enter manually more than 2000 codes for each match (great deal of time).
- Inability to record an evaluation of technical movements within the software because the data analyst can only enter objective data.
- Inability to use DataVolley for minor companies because there are no videos available at low levels.
- Inability to store high-quality video because of computational and storage problems.

• **Psychological implications:** The athlete, during monitored workouts in the gym, can see in real time when she has a physical decline and therefore this pushes her to improve in the next iteration.

• **Resistances to the use:**
- Not all athletes are excited about these technologies and sometimes they think they are useless.
- Some technologies such as strobe glasses are delicate and can not be used in full-time training or game simulations.
- Some technologies that would be useful, such as a heart rate monitor, can not be used because they would hinder the movements of the players and would be dangerous during their movement into the match and training.

MANAGEMENT OF THE DATA ANALYSIS

• **Who manages the data tracking:** The club, on the advice of the coach that is more interested in the innovations field, usually also the one that introduces the technologies.

• **Figure within the team delegated to data analysis: Each technology that provides data is supported by one of the coaches that acts as a data analyst and transforms all data into useful information.**

• **Understandability of data:** Collected data are not directly readable by athletes but need external figures that analyze and transform them into information.

• **Importance of data communication between different staff members:** Data are exchanged between athletes, coaches, and medical staff within the team and sometimes with other teams.

ROLE OF DIGITAL INNOVATION ON IMPROVING PERFORMANCE

• **Effects:** Surely, from what was stated by the various members of the staff, all these technologies have a positive impact on the end result of the various matches, although it is difficult to give an actual percentage of how powerful it is. As it has been pointed out, even considering only a reasonable 5% of impact, this is reflected on the outcome of a set in about 1-2 point, and considering the score with which the matches usually ends, many of them could be completely twisted.

• **Needs still not satisfied, possible new ideas for new technologies:** There is a technological problem coming from the fact that there are software that, using complicated algorithms, can detect from the video the position of the ball and thus may help staff to put in many data automatically during the match analysis with DataVolley. The problem is that all tested software do not work during the match because of the background of the video, that is no longer monochromatic as in the tests, but it has a lot of variations due to the movement of fans or objects in the background.

Davide Mondonico

Age: 19
Sport: Football Player
Club: Albinoleffe, third year at pro level **Palmares**: "Pallone d'Oro 2014" Allievi Nazionale
Technologies used: IoT,Cameras

"I'm never weary of the time I spend on the football field. I could stay there all day long."

BIO

- 10 years in the youth sector of A.C. Milan.
- 2 years in the A.C. Milan Under19 youth team.
- Several training sessions with A.C. Milan first team.
- This year is the first year in Lega Pro, in the Albinoleffe first team.

ANALYSIS

TECHNOLOGY 1: GPS (Global Position System)

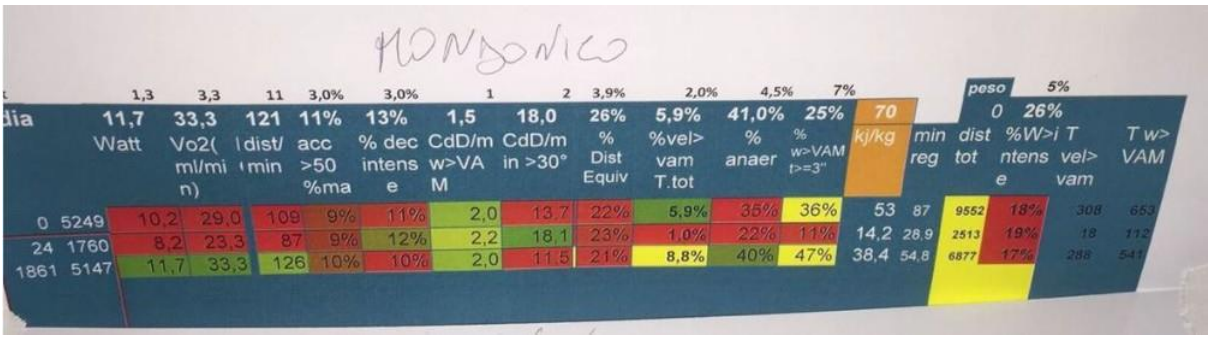


Figure 4.8

• **Performance, training, strategy, health and rehab?** Performance, training.
• **How it works**: The GPS receiver locates 4 or more satellites, calculates the distance from each of the satellites and with the data received is able to calculate its position in time.
• **Where you wear it**: In an undershirt with a pocket on the back.
• **Monitoring time**: During training session.

• **Report analysis**:
- **What is tracked**: Players' movements, kilometers traveled, twists and turns, intensity of play, recovery times.
- **Data provided**: It shows indicators such as output power, volume of oxygen consumed per minute, average speed, acceleration, intensity of play and others. If a workout is done with a specific aim (e.g. strength or endurance) it will be evaluated, among all parameters, only those relating to that particular aim.
- **Report**: Specific tables with indicators of performance to be achieved, the value of which is customized and varies from athlete to athlete according to his physical characteristics. The report also shows the results of the indicators compared with a theoretical value that the player is expected to reach; the value will be highlighted in red if it differs negatively from the desired value, or an increasingly green colour as much as it is near or beyond the required value.

- **Stakeholder of the analysis**: Mainly the fitness coach, but also the main coach and the players after explaining them the meaning of the data and how to read the report.
- **When the report is analysed**: Only after the training session and occasionally during the game. Periodically, every Thursday, the trainer shows the tables to athletes.

TECHNOLOGY 2: Drone

• **Performance, training, strategy, health and rehab?** Strategy.
• **How it works:** Each athlete has a dedicated drone, which film the whole training session that will be analysed by the fitness coach and the main coach.
• **Where you place it**: Flying over the football field.
• **Monitoring time:** During training session.

• **Report analysis:**
- **What is tracked**: It monitors the entire workout of each player through aerial shots.
- **Data provided:** Visual feedback, useful to show the players their mistakes on a technical-tactical level.
- **Report:** Video which will be analysed. It shows a game situation, without providing numerical values.
- **Stakeholder of the analysis**: Video helpful to the coach to better analyze the movement of the players with a more suitable point of view.
- **When the report is analysed:** Video available in real time, but used at the end of the training session.

TECHNOLOGY 3: Wearable

• **Performance, training, strategy, health and rehab?** Performance, Training
• **How it works**: Elastic band or bracelet that can monitor the heartbeat and send wireless data to the connected device. The bracelet is also capable of monitoring the movements.
• **Where you wear it**: Chest/wrist.
• **Monitoring time**: During training session.

• **Report analysis**:
- **What is tracked**: Heartbeat, calorie calculation (based on cardio activities), recovery time.
- **Data provided**: It provides a general description of the athlete's physical state. On this it will be built the calculation of the values of each indicator for subsequent workouts of each athlete. For this reason, this technology is used at the beginning of the season, during mid-season and sometimes at the end of season.
- **Report**: Technical data available for download from the device
- **Stakeholder of the analysis**: Fitness coach
- **When the report is analysed**: Also in real time, but the true value emerges through analysis repeated 2-3 times during the year.

SIGNIFICANT PERFORMANCE INDICATORS

• **What is derived from the output**: Monitoring of performance in order to have under control the physical state of each athlete, see their results and improvements over the course of the season.
Video Analysis to analyze the team's play patterns and the technical movements of the individual athlete.

KEY ASPECTS

• **Usefulness observed**: Easiness of use, fit, completeness, accuracy and objectivity of the results.

• **Critical issues**: Very often the results are not easy to read as they are very technical, so they require a detailed study and an explanation by the fitness coach. The technologies are not exploited to prevent injuries and manage rehabilitation, as the medical staff does not consider these data collected by players.

• **Psychological implications**: Having one or more devices that are monitoring, the athlete is pushed to always give his best in every occasion, also for fear of not being up to what is required by the coach. In addition, the ability to see at the end of the match the values written in green (and thus reflect the standard values accomplished) gives a sense of satisfaction to the athlete; while the values written in red (not enough) make the athlete aware of what needs to be improved and give an incentive for getting better. Over time these improvements helps to be motivated and to train with tenacity.

• **Resistances to the use**: No resistance to the use of technology during his career, even if the athlete has repeatedly emphasized the fact that it is fundamental that they do not impede the movements during training.

MANAGEMENT OF THE DATA ANALYSIS

• **Who manages the data tracking**: It is the club that provides the fitness coach the means to better see how the footballers work and train. The training sessions are structured in preparation for the game, and in particular from these data the coach is able to know the physical condition of the players, to find out in advance who will be able to hold the full 90 minutes and who will need a substitution.
• **Figure within the team delegated to data analysis**: Fitness coach for data analysis, main coach for the video analysis.
• **Understandability of data:** Technical data not easily comprehensible, until through a specific education.
• **Importance of data communication between different staff members**: The technical trainers always talk with the coach, sharing the information they have collected through the analysis of data.

ROLE OF DIGITAL INNOVATION ON IMPROVING PERFORMANCE

• **Effects**:
- More objective data available to the coach, that help him in the decision making on a technical- tactical level.
- Stimulation of the athlete, involvement and encouragement in giving his best.
- The athlete has found that the more they give him available technologies (and therefore more information), the better.
- The information is also useful to compare objectively with other players who have the same role; in more they provide an objective evaluation of the athlete commitment during his training sessions, increasing, in case of positive results, the possibility of career of the player.

• **Needs still not satisfied, possible new ideas for new technologies**: Athletes are not the figure in charge of the selection of which technologies to use, but it is a decision made by the fitness trainer, the staff and the society that imposes some of them.
At high levels are implemented the most accurate and comprehensive technologies that at lower levels are not used. He would have used technologies to support performance even when he was younger, but he would have seen them as a game, not as a serious commitment.
Shortage of data at a tactical level, compared to those at the technical level. The athletes would like to have statistical analysis at the end of training (e.g. the % of successful / bad passes), all data already recorded during the game thanks to the WhyScout application (used by all teams and deepened in our Case Study). These data would be useful to know which side of their skills improve at first.

Alessandro Gnecchi

Age: 24
Sport: Canoeing
Club: Canottieri Lecco
Years at pro-level: 7
Palmares:
- 4 medals during World University Championships -Montemor 2016
- 13° during k1-200m World Championships Under23 – 2015
- 2° k4-200 World University Championships - Minsk 2014
- Italian team in 6 World Championships and 2 European Championships
- Many Italian titles

Technologies used: heart rate monitor, GPS, Catapult, Video Analysis.

"If a tool allows you to monitor your own parameter, then it should be used"

Mauro Pra Floriani

Age: 30
Sport: Canoeing **Club**: Fiamme Oro
Years at pro-level: 13
Palmares:
- Silver Medal during Mediterranean Games - Mersin 2013
- Silver Medal World University Championships - Minsk 2014
- Italian team in 8 World Championships and 8 European Championships
- 11 times Italian champion

Technologies used: heart rate monitor, GPS, Catapult, Video Analysis.

"The more the feedback is immediate, the more it is useful"

Mauro Crenna

Age: 25
Sport: Canoeing **Club**: Fiamme Gialle
Years at pro-level: 6
Palmares:
- Competed in the men's K-2 200 metres event at the 2016 Summer Olympics.
- Gold medal during World Cup 2016
- Silver medal during World Cup 2014
- Silver and bronze medal during Mediterranean Games - Mersin 2013
- 16 Italian titles

Technologies used: heart rate monitor, GPS, Catapult, Video Analysis.

"What is not measurable is not improvable"

TECHNOLOGY 1: Heart rate monitor

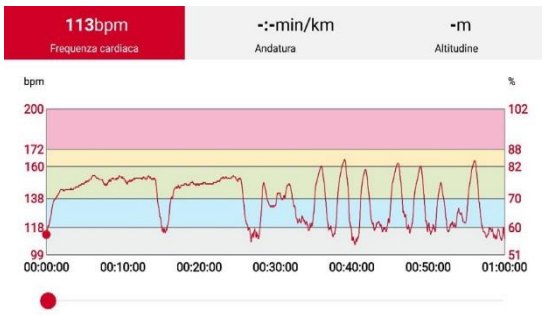


Figure 4.9

• **Performance, training, strategy, health and rehab?** Performance, training, health and rehab.
• **How it works**: Thanks to a simple sensor, it transmits electromagnetic signals which will be properly encoded and processed by a receiverwatch.
• **Where you wear it**: Under the chest.
• **Monitoring time**: During training session.

• **Report analysis**:
- **What is tracked**: Heart rate.
- **Data provided**: It provides the number of heart beats so that the athletes can keep it monitored during workouts. Extremely precise and reliable.
- **Report**: Shows the value on a connected device and saves the past data.
- **Stakeholder of the analysis**: Athlete and Team Staff.
- **When the report is analysed**: In real time, during every training session.

TECHNOLOGY 2: GPS

Figure 4.10

• **Performance, training, strategy, health and rehab?** Performance, training.
• **How it works**: The GPS receiver locates 4 or more satellites, calculates the distance from each of the satellites and with the data received is able to calculate its position in time.
• **Where you place it**: On the canoe.
• **Monitoring time**: During training session.

• **Report analysis**:
- **What is tracked**: Athlete's position at different time intervals.
- **Data provided**: It provides the canoe speed at different time intervals. Excellent for long workouts, but inaccurate in short bursts due to the instrument's response time.
- **Report**: Shows the value on a connected device and saves the past data.
- **Stakeholder of the analysis**: Athlete and coach.
- **When the report is analysed**: In real time, during every training session.

TECHNOLOGY 3: Catapult

FICK Federazione Italiana Canoa Kayak — VELOCITÀ

Settore Kayak D.T. Loddo Stefano

Analisi Prestazionale con Sistema Catapult

Dott. Stefano Vando Referente Tecnologico FICK

Canoa	Tempo	Distanza	Gara	Luogo	Atleta	Data	Colpi	Frequenza	Lefficacia	Max vel	Dist mt	Avg Vel	m/s	P.load	Roll(deg)	Pitch(deg)	Yaw(deg)
K2	33.13	200	Test	Mantova	Gnec/Crenn	29/4/2016	86	155.75	25.81	6.75	100	21.73	6.04	0.16	7.02	-1.28	-14.05

Distance	Time	Time Track	AvVel m/s	AvStkRate	StrokeTrack	StrokeTot	Lefficacia	P.load	m^2/cycle*s
0	0.00	0.00	0.00	0.00	0	0	0	0	0
50	9.69	9.69	5.16	155.17	25	25	17.08	0.13	1.30%
100	17.10	7.41	6.75	164.50	20	45	22.46	0.08	1.20%
150	24.95	7.85	6.36	161.75	22	67	24.59	0.07	1.17%
198.15	33.12	8.17	5.89	154.73	19	86	25.37	0.07	1.38%

Annotazioni di gara /allenamento	
Vento nodi:	
Temperatura esterna °C:	
Temperatura acqua °C:	Circa 16°

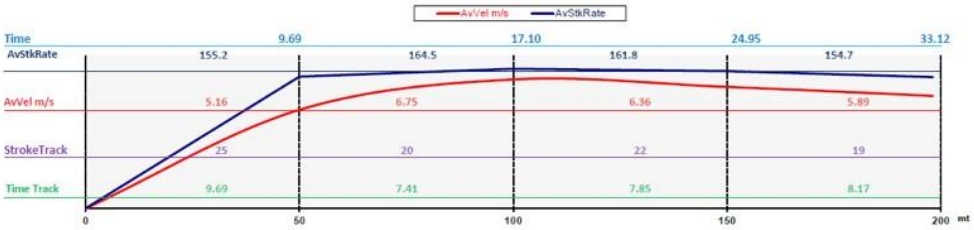


Figure 4.11

• **Performance, training, strategy, health and rehab?** Performance, training,
• **How it works**: Similar to a GPS but with an accelerometer inside. This device receives the signal up to 30 times faster (referring to Hertz) of a traditional GPS.
• **Where you place it**: On the canoe.
• **Monitoring time**: during training session.

• **Report analysis**:
- **What is tracked**: Athlete's position at different time intervals.
- **Data provided**: It provides the canoe speed.
- **Report**: Shows the value on a PC on shore via WI-FI connection.
- **Stakeholder of the analysis**: Only the coach.
- **When the report is analysed**: Real-time (PC required), staying within range of the Wi-Fi, otherwise after the training session. Used only in some workouts.

TECHNOLOGY 4: Smart Tracker (Polar)

Figure 4.12

- **Performance, training, strategy, health and rehab?** Training, Health and Rehab.
- **How it works:** Wristband that monitors the athlete's parameters using a gyroscope and a GPS.
- **Where you wear it:** On the wrist.
- **Monitoring time:** During the whole day.

• **Report analysis:**
- **What is tracked**: It monitors calories burned and sleep quality. During the workout it is more accurate because it is connected to the HR strip.
- **Data provided**: It collects data gathered during the day and thanks to the connection with the HR strip, it creates a searchable database comparison from day to day. Plus it provides specific technical guidance on breathing. It shows on the smartphone app all these data, processing them and providing information to the individual athlete (through graphs, tables, etc.).
- **Report**: Visual report through the app.
- **Stakeholder of the analysis**: Athlete.
- **When the report is analysed**: In real time, every day.

TECHNOLOGY 5: Video Analysis

Figure 4.13

- **Performance, training, strategy, health and rehab?** Training and strategy.
- **How it works:** Shooting of training and competitions.
- **Where you place it:** On the canoe, on shore.
- **Monitoring time:** Only specific training session.

- **Report analysis:**
  - **What is tracked:** Gesture analysis.
  - **Data provided:** Shows the athlete's movement during the workout.
  - **Report:** Visual, useful to the coach to give feedback on the athlete's technique.
  - **Stakeholder of the analysis:** Coach and Team Staff.
  - **When the report is analysed:** Real time.

SIGNIFICANT PERFORMANCE INDICATORS

- **What is derived from the output:**
  - **Heart rate:** After a threshold test, the athletes find the number of pulses during which their muscles produce the maximum amount of lactic acid that the body can dispose. This individual limit is then used by the coaches to customize the different training session.
  - **Velocity:** Fundamental as a key component for competition, which last from 30 seconds to 3 minutes and half. Used especially for short shots workouts (10/15 seconds) where the heartbeat does not have time to increase and thus is not a reliable measure.
  - **Improvement horizon:** During the whole season.
  - **Power output:** Objective value as a basis for the training evaluation, as it is not influenced by external characteristics athlete (such as the presence of wind or particular water conditions).

KEY ASPECTS

- **Usefulness observed:** The technology allows the athlete to improve and provides objective data that show such improvement. More technology is sensitive, the better the athlete's feedback. Ability to comprehend and monitor the exercise, also understanding how to split it in terms of use of energy and tactical changes. The estimated impact of technology on improving performance is currently around 1% (which is a high value considering that a podium in a race usually involves milliseconds). If the providers will manage to overcome the critical issue, it could reach up to 5-10%.

- **Critical issues:**
  - Monitoring only during training session, while athletes would like an overview of the whole day in order to establish the quality of recovery.
  - The heart strip cannot be replaced by a simple wristband as during the workout the display of the latter is not visible by the athlete and it troubles in monitoring the HR because of rapid and repeated movements.
  - The GPS is not precise enough to monitor short shots. Excellent for long itinerary, but not very precise for short path due to the instrument's response time (7/8 seconds delay). For this reason is also used the Catapult, which can provide much more precise data, but its measurements are not visible in real time by the athlete.

- The Catapult is very complicated and requires technical knowledge both to use it and to read data. As it calculates the speed variations so much faster, is able to provide precise data even on short shots, and in particular it can monitor every single stroke.
- The athlete cannot have an accurate feedback on his performance in training, as most of the monitoring is based on velocity, which depends on the slip of the boat over the water and is therefore influenced by external factors (rain, wind, currents, water density).
- The athlete needs the explanation of data collected (this had never happened until two years ago).
- The velocity does not provide information on technique, energy consumption and other parameters useful for training.

• **Psychological implications:** The immediate feedback is useful as it allows the athletes to immediately understand their mistakes and what they can improve. The possibility to obtain objective data allows various athletes to confront each other, and this generates a stimulus to the personal improvement.
Seeing, however, the negative data despite their commitment may have an adverse psychological response (although the positive impact is still greater than the negative one).

• **Resistances to the use:** There are experimental technologies that are being developed but are cumbersome: for example a new project not yet commercialized is developing sensors to put on the paddle to monitor the power of the strokes, However, this sensor has an excessive weight that the athlete can not bear during the whole workout without recording a distorted performance.
The heartbeat sensor is activated by moisture that allows users to record the pulses of the body, so if dried at times does not monitor some beats. Not used outside the training session.
The thermal shirts might become positively charged through rubbing and sometimes interfere with the signal.

MANAGEMENT OF THE DATA ANALYSIS

• **Who manages the data tracking:** First athletes as they need to monitor their parameters, but also required by the team since last year.

• **Figure within the team delegated to data analysis:** Qualified technician

• **Understandability of data:** The output of recent years is almost zero for the single athlete, because it still is not clear how these data can provide a complete athlete mapping, highlighting what he can improve and what he can't. This would be a task of the whole staff rather than a single coach. Often there are experimental tests for data collection (from university or company), without them being explained to the athlete and thus useless for him.

• **Importance of data communication between different staff members:** The data collected from both technician and athletes are often analysed to determine from time to time the training program of each individual athlete, and to customize it according to his physical condition.
90% of the coaches, especially foreign ones, make the collection and analysis of data the winning strategy. In Italy these aspects are considered to a lesser extent, although in the last year they seem to have started a positive trend with the new team staff.

ROLE OF DIGITAL INNOVATION ON IMPROVING PERFORMANCE

• **Effects:** More than one technology and thus more data you have available the better it is for the athlete, because he can improve on different aspects.

• **Needs still not satisfied:**

- Monitoring the heart rate during the whole day.
- A device that makes it possible to monitor the velocity with a high precision (such as the Catapult), but at the same time shows it in real-time (such as GPS).
- To have available a program that analyzes data collected from the Catapult and turns them into readable information by the athlete.
- Having a tool that provides real-time power output (watts) in order to have a specific data (upon which to base the training program) that cannot be influenced by external agents.
- A tool to detect the number of strokes per minute.
- A system that monitors and records the heart beats in the resting phase in an automatic way.

• **Possible new ideas for new technologies:**

- Adapt sensors, existing and already used in cycling, which detect the Watt produced. It would be useful to have even in the gym instruments able to calculate the power output in watts.
- Ensure that the data collected are then translated, aimed at a very specific purpose and explained to the athlete. For example, a system that compares the power and the strokes so as to have a parameter unaffected by external factors that the athlete can use as a basis for his improvement.
- A system which monitors the technical gesture. It would be useful to have at the end of the workout a percentage of the strokes made with the right technique (rotation, movement to get into the water, movement of the legs, etc.).
- Make user friendly technologies for a real time comparison with teammates during practice, both on land and on water. Current ones require slow and cumbersome processes.
- Ability to understand the moment when the boat reaches the maximum speed and thus change my paddling technique (no longer aimed at increasing the velocity but to maintain it constant and efficient). It's something that sprinters already do in the athletic field: they have technologies that allow them to understand when they reach the maximum speed in the initial phase of the run, in such a way as to change technical gesture to try to maintain the speed and the effort optimized during the rest of the race.

Marco Culiersi

Sport: Kick Boxing, Semi Contact
Club: Super Team (S.Vitttore Olona)
Years at pro level: 30
Palmares:
- 6 World Titles,
- 6 European Titles,
- 9 World Cup,
- 13 European Cup,
- 29 Italian Titles

Technologies used: -

"Is not the technology itself, not the wristband that when you put it on, it gives you a motivation that you did not have before: the effectiveness of the wearable depends on who wears it. I'd wear the technology because I am motivated, I love this sport and I want to improve."

BIO

He started practicing kickboxing (semi-contact) at age 17. Immediately he started official matches because he had the right temperament. The second year he became Italian champion, and then he reached the title of world champion. From 1992 until 2004 he never lost a match and he filled his own palmares with several titles. Then in his career he have competed in different typologies of matches and tournament, from regional level to the European level.

ANALYSIS

TECHNOLOGY

The athlete unfortunately could not take advantage of any technology during his workouts because years ago there was still no suitable technology to monitor its performance. Talking with him, however, he expressed to us his belief that current technology would be useful for its improvement and that with their use he likely would have racked up more results. So our goal with this case study was to understand the opinion of a high-level athlete about how technologies would have impacted in his sport, if today has caught on among younger athletes and what is the contribution that they can generate.

SIGNIFICANT PERFORMANCE INDICATORS

• **What was monitored:** To train the athlete relied on exercises and workouts indicated by his master, whose feedback was almost always subjective as he did not collect any performance data. The only objectively measurable improvements were those related to the time, that is those that could be timed. For example, the running training or the number of fists / techniques executed in a specified time interval. For everything else he had just indications on how to structure his training, but nothing that would tell him if he was performing in the optimal and correct way.

KEY ASPECTS

• **Potential benefits provided by technologies:**
- Monitor your physical condition.
- Monitor your own workouts with real-time feedback and ability to create workouts that reflect the physical condition of the single athlete.
- Analysis of technical movements.
- Objective data which show the rate of improvement.
- Ability to train aspects that previously could not be monitored in an objective manner as output power, single shot speed, etc...
- Ability to prevent certain accidents before they occur.

• **Critical issues of training without technologies:**
- Training is not based on individual physical standards, and then, not being personalized, it is not optimal for everybody. For instance recovery time, diet, level of intensity etc.
- Inability to have a workout and performance history at your fingertips.
- The need for a training partner to help you to be motivated and who controls the execution of your techniques.
- The fitness coach feedback was provided monthly and not daily, communication difficulties.
- Only the single athlete knew his own limits, and they were still subjective, so sometimes exceeding these limits could mean getting injured.

• **Psychological Implications:** Having at their fingertips many values and information of their own performances would help the athletes to give their best, even reducing the stress (factor that affects most of all on the performance of an athlete). In addition having objective data that can be compared between different athletes means that can be indirectly established a sort of competition in which everyone is pushed to give his best. It is a fact however that the technology increases the motivation of those who have much, but it is not able to provide motivation for those who already has none. This is because is exactly the motivation that drives you to monitor certain parameters to be able to improve.

• **Resistance to the use:** It is important that during matches the technology does not get in the way or hinder the athletes. During the workout it would be possible to use more invasive and cumbersome technologies to improve certain parameters of the athlete (although as stated then it is subjective and varies from athlete to athlete). Hardly bracelets with sensors would create trouble as the athlete already wears boxing gloves and as well as sometimes during the workout he uses ankle or wristbands with additional weights. Also during international competitions the athlete is equipped with an electronic bracelet as a pass, and he has to wear it even during matches.

MANAGEMENT OF THE DATA ANALYSIS

• N**owadays teams or athletes use these technologies?** Today the teams do not impose the use of any kind of technology and the few athletes that use them have had a stimulus and a motivation to improvement that came from their inner values.

• **Understandability of data:** It would be difficult for the athlete to have much technical data to analyze because most of the time he doesn't have the time to analyse them. It would require an external figure (as a Data Analyst) to analyse the data and give information, or programs that provide directly output in a clear and understandable language.

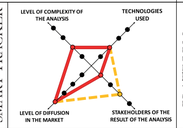
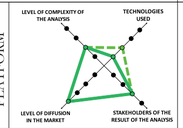
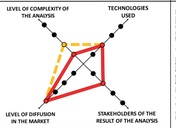
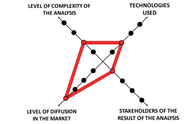
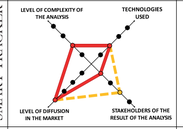
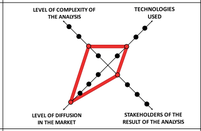
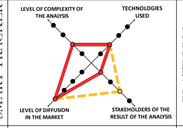
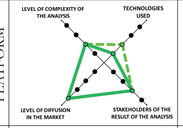
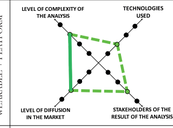
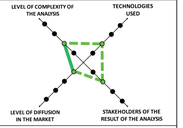
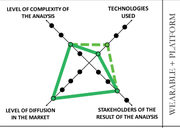
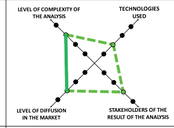
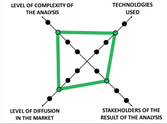
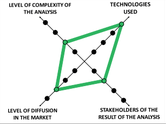
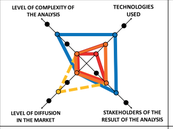
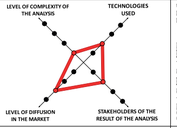
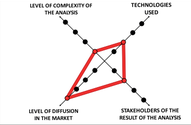
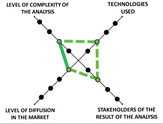
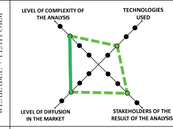
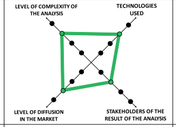
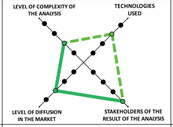
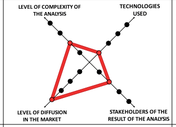
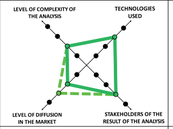
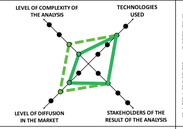
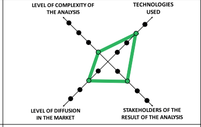
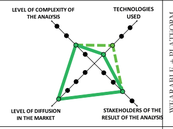
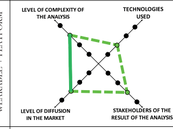
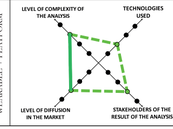
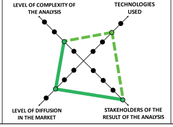
• **Importance of data communication between different staff members:** It would be important that before developing a training program, the coach or athletic trainer analyse the data collected by the athlete and the medical staff in order to decide a list of customized workouts.

ROLE OF DIGITAL INNOVATION ON IMPROVING PERFORMANCE

• **Effects:** The positive impact of these technologies could be real, but it is only at a theoretical level because until now digital innovation is not widespread in this sport. The use of technology would be crucial for high level athletes, where it is now hard to improve as you have reached the top of the fitness and tactic condition. Have something to dig deep and give accurate information on what needs to be improved would be of great help.

• **Possible new ideas for new technologies:**

- It would be essential a technology that monitors the speed of the of the athlete fists and the rapidity of such hits and that it is able to give a real-time feedback showing any strength declines or a possible unbalance between shots from the left or the right arm.
- Some gestures and techniques are similar to fencing, then you could develop similar technologies with sensors that measure the impact, but that are less bulky to not limit the athlete's movements.

	fitbit	AthleteMonitoring	SkiLLGo The Sport Evolution	STATS	wyscout	MOX OFF MATHEMATICS FOR INNOVATION	LYBA		MONDONICO	CANOEISTS	CULIERSI
Wellness monitoring (stress, sleep, athlete's physical state)	SMART TRACKER 	PLATFORM 							WEARABLE 	SMART TRACKER 	
Nutrition	SMART TRACKER 									SMART TRACKER 	
Workload management (indications for training, schedule)	SMART TRACKER 	PLATFORM 	WEARABLE + PLATFORM 								SUPPORTUNITY RESEARCH 
Physical activity (physiological parameters, aerobic parameters, load parameters, dynamic parameters)		PLATFORM 	WEARABLE + PLATFORM 	STATISTICAL ANALYSIS 		MOVIDA 	BLUE + STRONG GLASS + VIDEO 		GPS 	HEART RATE + GPS 	SUPPORTUNITY RESEARCH 
Tactical-technical analysis			WEARABLE + PLATFORM 	STATISTICAL ANALYSIS 	PLATFORM 	SETTEX 	DATA VOLLEY 		GPS + DRONE 	CATAPULT + VIDEO 	
Injury tracking		PLATFORM 	WEARABLE + PLATFORM 								
Scouting report			WEARABLE + PLATFORM 		PLATFORM 						

4.4 Analysis of the concepts identified

Here are some of the most important concepts that emerged from a careful reading of our Cases and the information highlighted by our matrix:

- The **Wellness Monitoring** function is monitored by technologies widespread among both amateur and professional sportsmen. Future trends indicate a possible diffusion in most cases not only between athletes and staff but also up to the medical staff, while increasing the easiness of reading the data in order to be clearer to the athletes themselves.

- The **Nutrition** function comes as natural additions to wellness monitoring. Through our market analysis (Chapter 2), we showed that it is a very common function especially between amateurs; through our Cases instead we understand why it has not the same relevance between specialized vendors and top athletes: they are used to have a diet to follow defined by the team and do not need digital technologies that take into account the calories consumed or the monitoring of eventual unbalanced diet. This has been specifically confirmed by the three canoeist respondents, who did not seek this function despite having it available within the technologies they use. The nutrition function will then expand in the future on the stakeholder of the analysis, in order to incorporate also the medical staff, but always on a broad market tied to the amateur level.

- **Workload Management** is the third user function by diffusion identified after the first two listed above, as it affects both pro and amateur athletes. From the graphs in the table we can see that it is a fundamental point upon which many companies base their offer, which want to expand in the future both trying to incorporate the medical staff and incorporating other technology solutions to widen their data in order to better structure this function.

- **Physical Activity** comes as the more mature function both in terms of vendors and market or athletes interested. The level of the proposed solutions is now well developed and allows simultaneously processing data from different technologies (apps, and video IoT). Even those who are behind in this area have already planned for a future integration with other technologies to remain competitive.

- Also the **Tactical-Technical Analysis** function is highly developed and present in almost every case study. The market analysed is quite satisfied although there are paths of development, increasing the number of technologies used or trying to spread it over a wider market.

- Regarding the **Injury Tracking** function, all the graphs represent a hatched area towards App & IoT: this means that the way in which the data will be collected will gain extreme importance in the future, focusing on automation features and simultaneously enlarged compatibility (in fact we have already pointed out that the smart tracker belong to the class of technologies already more popular on the market). This feature highlight still much room for development and a market segment still poorly crowded by non-specific vendor, which could, however, create a new value stream by integrating the best available data (the athlete physical condition) with his physical or mental condition examined by doctors in order to have a direct feedback.

- The **Scout Report** function, as well as the Injury Tracking, is one of the functions less diffused, probably because of its intricacy. The graphics often dashed indicate that in this case the companies are investing on this function for the future. In particular vendors are aiming to get more and more technology cooperating within each other in order to always improve the analysis.

- Among vendors offering a service with **digital platform and wearable**, on the axis of the complexity of data we have seen that our case studies (being best in class cases) now no longer stop at simple data gathering, as they always provide a higher level of complexity, while also providing additional information.

- Even **professional athletes** may use technologies (such as the wristband) already widespread in the amateur market, which therefore demonstrate to be nonetheless useful and with a satisfactory precision level.

- Among **professional athletes** there is a widespread demand for a more comprehensive monitoring of their parameters, both in terms of time and in terms of insights about their data. Moreover, often the athlete shows a great interest in understanding the data collected autonomously, leveraging also the fact that often the boost towards technological innovation is highly appreciated.

- A possible **axe of spider-web chart** to be added is the one that indicates the data reading difficulties / the user friendliness of data or of the insight if it is reported. In fact, the data reading and comprehension in terms of how to use them to improve athletic performance was one of the most critical stage for all athletes and coaches interviewed.

- As can be seen from the matrix, each vendor / athlete proposes / uses a technology or technologies that, combined together, impacting on a specific function in clear and unambiguous manner. In addition, athletes who use more separate technologies do it to cover different user functions. It is, however, an exception the **UYBA** team. While respecting this rule regarding technical-tactical analysis, they are a special case regarding the physical activities function, using three technologies (Strobe glasses, Virtual Video Training and Beast Smart Tracker) that impact on this area. The final graph is just the overlapping of the different graphs resulting from these 3 technologies. Such management is very interesting and might just be the result of the high interests of the society in the field of technologies to improve the physical performance of athletes, looking for a complete and diversified mapping. There are thus possibilities to try to fill the lack of a comprehensive technology, leveraging different solutions in the same field but with different specializations.

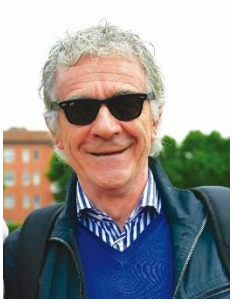
- Importantly, the importance of using technologies that monitor athletic performance is evident when you compare the current situation with the situation of even just a few years ago: thanks to our interview with **Marco Culiersi (kickboxing)** is easy to realize that even the simplest and widespread measurements nowadays actually provide a very heavy advantage. As shown in this specific case, however, this advantage depends largely on the motivation that the athlete must have in using these technologies.

- The possibilities of **cross-development** of technologies between different sports are extremely interesting. This is also evident by the interest shown by each athlete analysed when informed about the opportunities provided by technological solutions of other sports.

- However some of the problems often involve the need to adapt to your own sports a technology not created specifically for that area: for example **canoeists** use technologies born in other sports, trying to fit them to their own needs. Actuality they have in mind a precise and important parameter (the power output in watts) that they would like to monitor, but no technology in the market allows this. This is an example of how there is a need for more detailed analysis by vendors on the real needs of the market, also working closely with teams and athletes, to understand what are the parameters that can make a difference in each sport.

The most interesting patterns emerged from our analysis of the case studies above, the model we applied, and a more general analysis of technological innovation within the sport were the topic subsequently deepened and reprocessed through our final interview with Antonio La Torre.

Antonio la Torre



- Professor of methods and didactics of sports activities at the Scuola di Scienze Motorie of Unversità di Milano.
- He studies the theory-methodology of training and methods of evaluation of motor skills. He also coached top athletes (eg Ivano Brugnetti, Olympic Champion).
- He is also a senior lecturer for the World Federation of Athletics. He has written 70 scientific publications and over 300 informative articles, technical etc...

"Just like the talent, the technology has to be trained"

ANALYSIS

• **Reflections on digital innovation in the sports industry:** The world of high-level sport has met sports science systematically by no more than 30 years, so to talk about the real connection between research community with technological innovation and sport, we must refer to the past 30 years.
Across the world there is now so much technological and digital innovation, but it is presented in a confused way, meaning that so many players are proposing to the sports industry, but while some sportsmen look at these things with a little of suspicion, others are adopting them " all-in ". The real competition is to understand where the intelligent resources are, the real benefit for the transition to digitization has yet to be made. Some notable examples are the Australian one or the English one, where the sports federations have decided to invest heavily in sports: in these cases there has been a strong scientific technological innovation applied to sport, with an important part due to digital innovation. This step, however, is still lacking in many countries, including Italy, because there is still mistrust by coaches and federations are often linked to policy and are slow in the transition from the old world to a new world. Yet there are many clubs trying to appropriate of the same technology used by those teams who have exploited the major results, only to imitate them, and this means that they do not fully seize the real added value that can give the technology (which, in most cases, it is endeavored incorrectly or is not used at all). On the other hand there is also the problem concerning the way that companies and startups describe themselves, since they stand out as salesmen, but they do not actually understand how new products can help teams and athletes. They should therefore be less aggressive commercially, to develop a more rational flow of resources.
These issues are also reflected even at the amateur level: even here there is the digital innovation in the materials, shoes, wearable, GPS, computers, softwares etc .. but the passage that is always missing is not exploiting it to the full potentialities, falling in love only with the electronic gadgetry. This is also the fault of the vendor companies, which should offer the technology by providing expertise to process the data and draw useful information. The message that should be avoided is that technology makes your life better without you having to do anything, when in fact the active protagonist is you: the technology must be an aid, not a substitute.

Motivation: Scientifically what is discussed now is that the structural limits of the human body are not the thing that differentiate who comes first and who is second, but it is a bio-psycho-social approach that considers the motivational intensity. This feature may explain (considering physiological, technical and classic motivational equality) what is triggered in the athlete's body to allow him to give his 101%. The transition that is missing is understanding that the technological innovation really helps the athlete to improve and to force this motivation, and therefore at high levels, where athletes are obsessed with the pursuit of excellence, it can give a great contribution. We must consider that in many disciplines measurable the difference between the first and eighth place is less than 0.5%.

For the amateur world instead the message should be: "get moving right, get moving intelligently and rationally in order to do more with quality".

• **Geographical differences**: Worldwide, especially at English level, there is the long-term work culture, that organize the improvement planning a long-term workload, while the game is just a moment of validation. However, in Italy there the culture of the single event, so the talent of the staff team depends on the outcome of the game. This problem can only be solved in practice, when it will be understood that some teams who adopt certain technologies and are more open mentally then are the same ones that get the best results in the championships or competitions.

• **Benefits and critical issues in athletic performance:** Technology has already had a positive impact, especially for team sports, as far as training and strategy, and in part also on athletic performance, where, however, can still do a lot in the injury prevention sphere. The latter is a field still open where there are many information still missing. The key characters that push these technologies into the club are coaches, but also their closer trainers (especially fitness trainer). Even athletes are interested in innovations and often begins from them the need for these technologies. A criticality is the fact that it is difficult to give an objective measure of improvement due to the effective use of a given technology.

• **Data analysis:** data analysis can be carried out by an external staff, by a coach or trainer, or in some cases can be made by the same technology through the interface. But the sporting event as far as you can rationalize it, always has a human intervention factor that is crucial. There is need of human intervention that examines fatigue, physical and psychological state of the athlete and is able to customize the workout in accordance with these aspects.

• **Impact on athletic performance:** Give a percentage estimation is complicated because it definitely depends on sports, as athletes can not control external factors. At pro level the percentage estimated would be low, which in any case would lead to great results given the high level of competition. At amateur level instead it would be much higher and would depend very well on the use of technology. In general, if one gets used to leverage technology in an intelligent manner would have a minimal increase of 5-10% of its performance.

• **Future vision:** Vendors must be less aggressive in the presentation of their product/service and must validate their product, which is not always made, even investing and relying on Universities or Research Centers reliable and approved. This is difficult because many of these technologies are presented by startups, and this would go against their nature. Validation is not required by the market but by the end users because at pro-level the precision of the instruments used is critical. The center of decisions should be the actor who uses technology. Company should ask themselves what are the characteristics of the sport, so that then the coaches could have a help from such innovations to save time and effort. The technological output needs to be created to be read by the coach and athlete together, because the higher up at the pro-level the more the coach becomes almost a consultant, especially for the management of data. In general the coach is interested in the psycho-physical condition of the athletes, in such a way that he can manage to optimize their time and may have the ability to give each athlete a targeted workout and with an adequate workload. No need then to give him a lot of data but to turn them into readable information, intelligible, usable and immediate.

Chapter 5.

Conclusions

As our thesis's title highlights, our scope of investigation concerns the role of digital innovative solutions in measuring athletic performance in the sports world.

In details, the aims of our research were to:

1. Provide a cognitive framework on the current and future use of technologies in the scope defined.
2. Assess the benefits, motivations and strengths related to their use.
3. Identify the main existing reference models.
4. Select a few best practices to verify adherence to the identified models and refine the benefits found.
5. Propose a rational modelling for what has emerged from the research.

The first step to achieve this goal was to develop an accurate investigation of the literature. Through this analysis, we immediately identified one of the fundamental aspects of our research process: in the sport industry, **a model showing the relation between digital innovation and sport industry (and especially its growth) is still missing**. To make up this loss we introduced a model derived from the analysis made by the Osservatorio DigitalSport. This new model is divided into 4 main macro areas: *Sport Clubs, Fan Experience, Sport Institution and Event Management* and ***Athletic Performance***. This model has proven incredibly useful and necessary to identify and map the constant and rapid waves of innovation hitting the sport industry. In relation to what emerged from this framework, we decided the to concentrate our research work on athletic performance, highlighting several reasons that make the athletic performance the main area of interest when it comes to digital innovation. Our goal was then to see if in particular two of these reasons had arisen:

- **What are the benefits, reasons and strengths related to the implementation of digital technologies?**
- **Did we come across the expected future trends of innovation?**

Again, our scope of analysis has been extremely innovative: despite the great interest in digital innovation within this area, in literature no model has been developed yet able to map the many technological solutions that have been created to answer to specific needs.

We have therefore decided to propose a rational modelling on what emerged from the research. Reflecting on this, we pointed out that the athletic performance, since it is a major ingredient in sport, is a complex and multifaceted topic that is neither easily specifiable nor measurable: there are different needs of **skills and abilities** to be tested, different **stakeholders for data measured**, different **technologies** collecting those data and different **diffusion** for each technology.

We have therefore created a spider-web chart model, developed on these four areas, each one mapped on a specific axis: *Level of complexion of the analysis , Technologies used, Stakeholders of the results, Level of diffusion of the technology*.

This model has proved vital in the next phase of our research: the analysis of Case Studies. As already highlighted in the methodological note, the choice of introducing Case Studies as a mode of investigation was driven by the necessity to collect information not directly extractable from literature review:

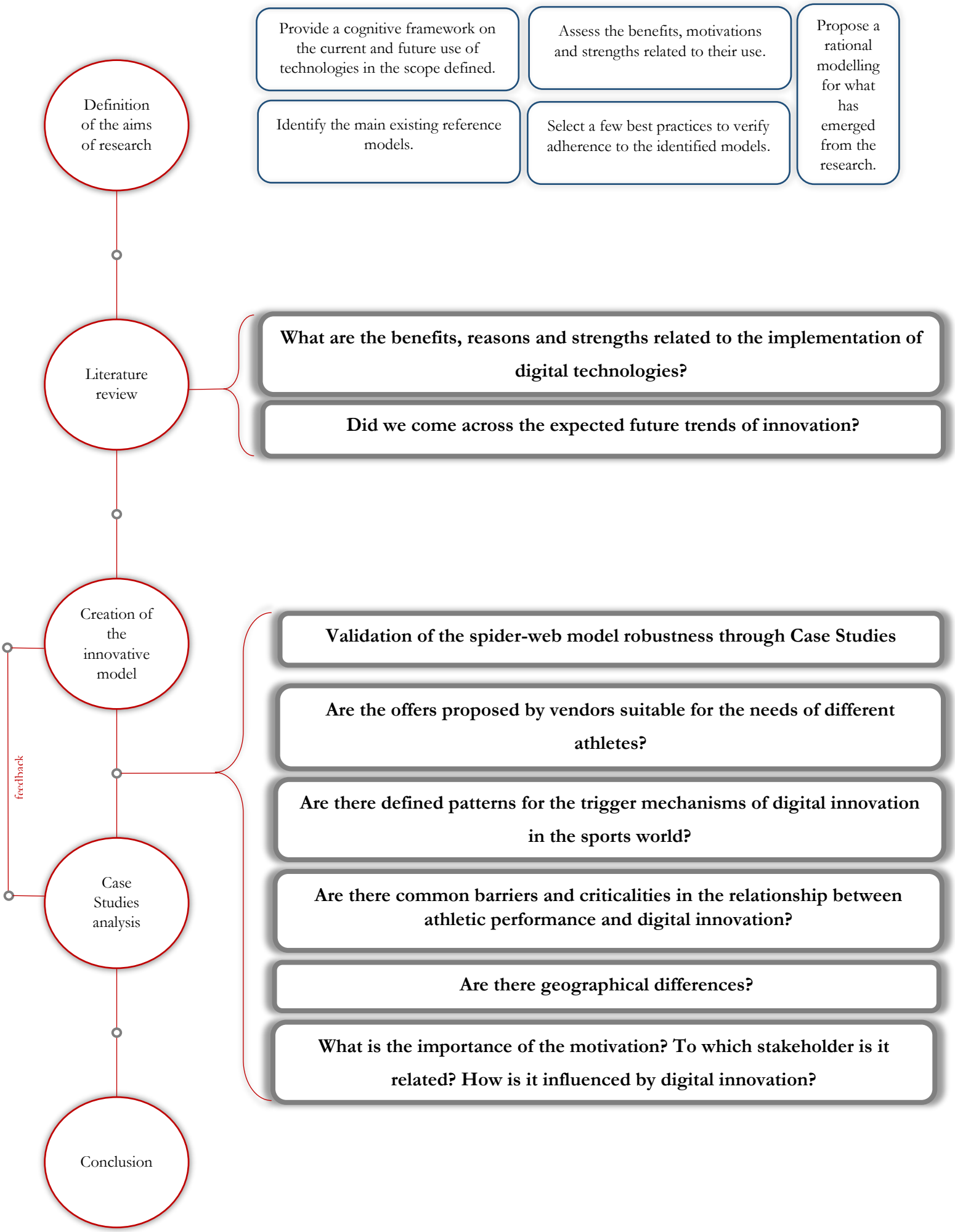
- **Are the offers proposed by vendors suitable for the needs of different athletes?**
- **Are there defined patterns for the trigger mechanisms of digital innovation in the sports world?**
- **Are there common barriers and criticalities in the relationship between athletic performance and digital innovation?**

The relationship between our model and the case studies is double and closely connected: the spider web was crucial for the analysis of each case, to highlight the similarities / differences with what we studied in the first two chapters and to answer research questions listed above. Simultaneously, however, the expertise coming from the Case Studies has been critical to a comprehensive validation of our model.

- **Validation of the spider-web model robustness through Case Studies**

The choice of vendors and athletes interviewed was indeed not casual: professional sports teams and professional athletes are driving this market sector, being early adopters of technologies, as they have the most to gain from athletic performance improvements in order to gain that edge over their competitors to stay in the game. This is the reason why for our case studies we focused on top vendors from the market and top level athletes and teams as user-representative. Performing this choice, we were sure to collect information that were really valuable.
During this analysis are thus revealed some fundamental common topic to all Cases studied, from which we extracted the underlying questions of major importance in order to define more clearly what was the value added by technological innovation to athletic performance and investigate the feeling coming directly from the protagonists of this industry:

- **Are there geographical differences?**
- **What is the importance of the motivation? To which stakeholder is it related? How is it influenced by digital innovation?**


Definition of the aims of research
Provide a cognitive framework on the current and future use of technologies in the scope defined.
Assess the benefits, motivations and strengths related to their use.
Propose a rational modelling for what has emerged from the research.
Identify the main existing reference models.
Select a few best practices to verify adherence to the identified models.
Literature review
What are the benefits, reasons and strengths related to the implementation of digital technologies?
Did we come across the expected future trends of innovation?
Creation of the innovative model
Validation of the spider-web model robustness through Case Studies
Are the offers proposed by vendors suitable for the needs of different athletes?
Are there defined patterns for the trigger mechanisms of digital innovation in the sports world?
Are there common barriers and criticalities in the relationship between athletic performance and digital innovation?
Are there geographical differences?
What is the importance of the motivation? To which stakeholder is it related? How is it influenced by digital innovation?
feedback
Case Studies analysis
Conclusion

5.1 Findings

What are the benefits, reasons and strengths related to the implementation of digital technologies?

Throughout all the previous chapters many strengths and benefits related to the implementation of digital technologies in athletic performance have emerged. We now want to summarize them in a clear and effective way:

- The technology helps to monitor those values that would not be visible to the human eye. In particular in the field of injury prevention is extremely useful to monitor fatigue and physical stress, i.e. all those biological parameters that require specific equipment to be measured. Even during the training session these parameters are very useful, since they can provide insight on the effectiveness of training and to calibrate the workload in an optimal manner for each athlete.
- the quality of coaching athletes and coaching teams is better with the introduction of some automated processes. The availability of strategic and tactic modules provides coaches with many distinct possibilities for strategic manoeuvring. The real value added by technology in this case is the ability to analyse an extremely large volume of data to point out hidden patterns and trends that could be the base upon which a good coach can build his successful gameplan.
- The best solutions are often fully customizable. This is because as we saw the athletic performances are an area that depends a lot on particular needs or specific requests to adapt the product to the characteristics of each athlete or style of training of each coach. Having a product tailored on you own specific needs, therefore, it means to increase the feeling with the technology and the value of the user experience.
- platforms offer information integration and distribution of results within the whole coaching staff, in order to share among the team all the useful data and providing a comprehensive big picture. So a single technological solution can simultaneously reach all the staff of the team including the player who can analyze his data and see his physical condition, the coach who can handle the workloads of the entire team and the medical staff that monitors the recovery of injuries and players' health.

Provide an approximation of how these benefits impact on the final result is particularly difficult. However, as confirmed by Professor La Torre, technology has already demonstrated to have a big role on athletic performances: at pro level the percentage estimated would be low, which in any case would lead to great results given the high level of competition. At amateur level instead it would be much higher and would depend very well on the use of technology. In general, if one gets used to leverage technology in an intelligent manner would have a minimal increase of 5-10% of its performance.
What has just been said, however, depends greatly on the how the digital innovation is used within the athlete sporting life: exemplary in this case what evidenced by canoeists, who stated that a possible intelligent use of technologies could improve their performance by 5-10%, while at the moment they only found an improvement of 1% at most, due to the fact that there are many critical issues that should be solved.
Addressing these critical issue was in fact one of the main scope of our thesis.

Did we come across the expected future trends of innovation?

When introducing our focus on athletic performance at the end of Chapter 1, we quoted some sentences[1] of prominent personalities among companies in the sports world. We bring them back here now to understand whether through our analysis we were able to intercept these trends:

"*In 2017, you will continue to see a rise in sensors utilization across sports...*" the examination of our Cases revealed that now sensors are a fundamental part in implementing the digital innovation within athletic performance. In particular, the monitoring of physical activity is the most widespread user function, and is now the standard among the analysed vendor (remember they are best in class) and among respondents athletes, regardless of the sport. So considering that these players are the ones who drive the technological choices of the market, we can confirm that the curve of adoption of these technologies is now growing even at lower competition levels.

"*…but also a struggle to utilize the data to its fullest and distill down 'real' additional value for coaches and analysts*." "*Users might know what their body is doing 24/7, but there is a disconnect between having the data and knowing what to do with it. Turning trackable data into actionable recommendations will fundamentally change the relationship between coach, athlete and sports*" In these sentences it is just summed up one of the main problems both highlighted in our analysis of the market and within the Cases: a criticality is the fact that it is difficult to give an objective measure of improvement due to the effective use of a given technology.

The importance of data quality is critical because on the goodness of the data base then depends the goodness of the analysis itself. But this is a concept already very clear among both vendors and athletes, and the services offered / used can provide data measured effectively and with low error rates. The real problem, however, lies in the next step:

- For vendors it is difficult to prove the quality of the analysis built on the data collected. Why? Because it is difficult to provide an objective or numerical demonstration of the benefit that the athlete gets in having available the data and then analysis itself. Without this validation, for a vendor will be difficult to convince of the value (including economic value) of its system.
- For teams and athletes the difficulty is to have large volumes of data processed into readable information, intelligible, usable and immediate. In part because it is again difficult to establish how these insights are effective in achieving the improvement sought, in part because not all vendors are able to provide insight calibrated on each specific sport. In some cases, the product still has a strong IT component and it is not designed for the user. The coach should not be an IT specialist but should have only a few more technological rudiments in order to use the vendor's solution. Moreover, some sports have simpler codifications, while others have a mix of objective aspects with subjective aspects, like interpretation or in-game strategy.

For this, we can confirm that our analysis revealed that one of the real focal points on which could and should evolve the relationship between vendors and athletes is precisely a joint collaborative effort to reach an effective understanding of insight that emerges from the data.

[1] Brian Kaiser, Chief Technology Officer, Hudl
Davyeon Ross, Chief Operating Officer/co-founder, ShotTracker
Rich Esposito, General Manager, Mobility Services, IBM
Dan Giuliani, Chief Executive Officer/co-founder, Volt Athletics

One of the biggest trends we will see in 2017 is consolidation. Consumers want to consolidate all of their tech into one comprehensive device/wearable, instead of 6 wearables for each function". "*Athletes will demand more than tracking from their fitness wearables. Steps, calories, heart rate…"* We had specific cases also related to this trend: in particular Fitbit showed to have already anticipated this trend, now starting the development of new devices able to bring additional features compared to basic fitness tracker. This problem has proved to be particularly noticeable among the athletes' Cases: indeed very often the athlete should be equipped with different technologies in order to monitor different function. In addition, some technologies used by the athlete were able to cover only part of the specific needs for a given function: exemplary the Case of the canoeists, who are forced to use two position measurement systems (GPS and Catapult) to overcome the technical limitations that each of the two technologies presents.

We can therefore not only confirm this quotation but broaden its scope of application: the market will not only try to bring together all the technologies in a single device, but it also will seek to consolidate the measurement of a function in a single technological system able to exploit in a systemic way all the individual technologies of which it is composed.

Moreover during our analysis in the first two chapters of the thesis, we have highlighted that the economic interest in this area was justified by many positive trends: for example, the Italian sports companies were able to record a substantial stability even during the past period of economic recession. Moreover, also the Sports Innovation Lab research pointed out that le athletic performances are a key area of industry disruption in the evolution of sports and fitness technology trends across thousands of global companies, highlighting that this is a dynamic market where massive investments are being made by sports apparel, electronics, wellness, and software companies.

Through the Cases analysed, we could add more nuances to what just summarized: first, we figured out that companies and athletes are still in a stage of introduction with the use of technology, and they are not yet able to give a quantitative assessment of how effectively the introduction of technologies in athletic performance could contribute to increasing the economic value of the sport club. However what was confirmed by everyone, both athletes, clubs and vendor, is that the use of these technologies is having an increasingly important role on performance improvement and, economically speaking, this will be reflected in the future not only on greater economic revenue due to higher sports results of both teams and individual athletes, but it could well lead to a gain related to a significant savings that the technology can create. The startup SkiLLGo has already anticipated this trend and want to make this one one of the strongest points when it will enter the market: indeed within heath and rehab, having a system that can help prevent accidents, or to be able to decrease recovery time, can be a key feature as it directly impacts on financial capital of the club. This factor, which can then be expanded to all of user features that we found, is of fundamental importance, especially at high levels, where economic flows are very high and therefore be able to have even a small percentage of improvement in the management of accidents, would result in a substantial amounts of money savings.

Through carefully analysing our model, we can have an accurate view of the major trends in the future, referring to each of the axes. We can understand how the market is evolving, what is still missing to athletes or what they would like to have in the future and how vendors will answer. In general there are many cases in which future trends confirm to evolve all at the same moment and in others it happens that already established solutions are then introduced even by runner-up (this fact is demonstrated by seeing how in some cases all the solutions converge towards the most advanced one).

Are the offers proposed by vendors suitable for the needs of different athletes?

The teams and athletes know what their needs are and how to fulfil them. If we analyse the summarizing matrix in the chapter 4, we can see how the charts sometimes exhibit a different shape than that which would theoretically be most appropriate for that particular technological solution. To facilitate this reading, we can use the colours we defined in chapter two as markers of a specific technological solution: For example if you look at the graphs of the function injury tracking, we would expect a blue shade (which would highlight typical characteristics of **Injury treatment solutions)** while the charts mapped in the matrix have a green colour as the group of **Full Measure** (Specific Gesture Analysis solutions, Team Movement Analysis solutions, and Virtual Environments solutions): this gap shows that are not being used specialized injury tracking technologies, but the clubs and athletes manage the injury tracking through indirect assessments that can be detected with other systems, but obviously they do not have the characteristics perfectly overlapping with those more specific of Injury Treatment.
This can be explained as an attempt by the clubs to adapt technologies (born for specific features) to additional features they would like to monitor, but for which they do not have the right technology. Make use of substitute technologies obviously has a negative impact on the effectiveness, and it is also for this reason that we have highlighted the wide margins for improvement in the measurement of certain functions (such as the talent scouting or injury tracking).
About this research question, the UYBA case is particularly important due to its slightly different approach in the use of technology. In all cases studied, all players have defined the user functions on which they want to work: each of the respondents found a specific technology, or the sum of technologies to manage each of the different functions. UYBA is the only case in which however the technologies used for the management of physical activity are more than one, each with a different graphic representation on our model. It was already happened in other cases to have 2 technologies that acted on the same function, but they were used simultaneously in order to have a more complete picture, and therefore resulted in a single overall graph (Mondonico GPS + Drone, Canoeist heart rate + GPS, …). UYBA is the only case in which the graph of the physical activity function is the result the overlapping of 3 different graphs, each dealing with a different technology. The fact that the team uses 3 different technologies, in 3 different workouts and that these act on a single user function is the demonstration of the importance given to technology by the coaching staff, which is interested in having a vision extremely detailed and comprehensive of physical activity, so deep that none of the technologies at its disposal succeeds alone to offer a satisfactory framework. UYBA has then opted for the use of 3 different devices which together give the big picture required.
We have therefore just described the opposite situation to what analysed talking about the trend of consolidation of the technologies into a single device. If on the one hand some customers would then monitor a single aspect of a user function, and then require an integrated solution, on the other hand some customers decide to adopt more technologies to map different aspects within the single use function.
A final area of analysis concerns the possibility of the repeatability of certain solutions initially designed and intended for a sport, to expand on different sports. For example, the respondent Marco Culiersi found that between his sport (kickboxing) and fencing there are similarities that could led to introduce technology designed and intended only to fencing, also in kick boxing (are an example of such technologies the various sensors that detect the moment of the jab). Even the case studies on canoeists revealed a potential synergy with the world of cycling. Some of the sensors applied to racing bike, such as sensors that monitor the power delivery, could be adapted and designed for the world of the canoe as it is a sport with cyclical movements too.

These findings therefore show that the offers proposed by vendors are able to reach a good level of suitability to athletes' needs, although there are many areas for further development to close even more the gap between offer and demand.

A very important factor that emerged from the analysis of our case study is the importance given to the difficulty in reading and understanding data provided. In fact more than one athlete has encountered difficulty reading the final data, or in an attempt to understand how does it works. Most of them have indeed found that once tracked the workout and after having collected the data, they do not know how to use them to better improve their performances and sometimes nobody, including the technology provider, is able to explain him how to read these data. This phenomenon has been crucial for the athletes of the Italian national canoeing team, who evidenced that they have collected data for years, but the utility that they have reported from having these data is almost zero, just because nobody taught them how to exploit these data. They have immediately understood, however, the potential of such data, and the factor that prompted them to improvise themselves ad data analyst it is just to try to exploit these information gathered. The same difficulty of trying to extract useful information from data was found at the same time, not only by the Albinoleffe's football player Davide Mondonico, who would like to have information more clear and readable, but also from Unet Yamamay Busto Arsizio, whose coaches have highlighted the difficulties encountered in the data analysis. They are forced to create and process complex Excel tables in which they handle this mass data; something that involves a great effort and a lot of time to shows results.

During our interview with Antonio La Torre[2], he confirmed that the technological output needs to be created to be read by the coach and athlete together, because the higher up at the pro-level the more the coach becomes almost a consultant, especially for the management of data.

The real key issue is not to give the athlete a lot of data but to turn them into readable information, intelligible, usable and immediate

This critical factor has already been solved at amateur level by Fitbit, which has precisely one of its strengths in ease of communication with the user and clarity of the information provided, but at a pro level is lagging behind (due to the more complex analyses to be performed), even if it is moving in this direction, as shown for example by Moxoff and Skillgo. These two companies expressed a desire to provide less physical data and deliver a customizable product that always extracts more information from the analysis of such data, since each team works in a different way. Even Athlete Monitoring is focused on customization of its offer, for example by giving particular importance to feedbacks provided by customers on the system, in order to build a product tailored on market needs.

[2] Professor of methods and didactics of sports activities at the Scuola di Scienze Motorie, Unversità di Milano

Are there defined patterns for the trigger mechanisms of digital innovation in the sports world?

This research question is one of the most critical points in the relationship between vendors, athletes and sports clubs. Theoretically, as showed by Antonio la Torre, the centre of decisions should be the actor who uses technology, and this should led to companies investigating on the measurement that athletes and coaches consider as the most important during their training session and during matches.
This witness is only a confirmation of what has already emerged from interviews with athletes, who have repeatedly said they are not 100% satisfied with the data supplied both in terms of reading difficulties and of completeness. The problem that emerges, however, is related to the fact that the management of digital technologies is often a managed process at the highest hierarchical level within a sports club, also in relation to the heavy investment that often require these technologies and a focus for improvement on the long run. In this way, however, you create a break, since the vendors to propose their ideas are often forced to negotiate not with the coach or the coaching staff, but with the administrative staff of the company. So then the risks are twofold:

- On one hand, the company's managers do not always have an expertise such as to clearly understand the advantages offered by adopting technologies, and therefore fail to give the correct importance (in economic terms too) to the solutions proposed by vendors. Moreover, even if there is a strong interest by top management, it is not sure then there is also the ability to be able to understand what technology and therefore what offer is the most suitable for the team needs.
- On the other hand, vendors have therefore had to adapt their marketing activities towards this target, often thereby losing the opportunity to establish a direct relationship with the coaching staff which, as highlighted by our model, is often the real stakeholder analysis.

The demonstration of how this last point is important can be found again in the Case Studies: some of the major success stories (Moxoff with Berruto or UYBA) were able to exploit the presence of an "inspired" coach, ie able to understand the importance of these technological innovations and at the same time be able to share / impose their own vision with the rest of the organization, so as to establish the digital culture at every level. It is therefore necessary this figure that plays the role of promoter of the digital innovation within the sports club.
But we must not forget that this industry is now in a transition phase: the technology is becoming pervasive (not only for pro-teams) and the costs has been lowered. Also a different culture is growing: now companies begin to hire software engineers and analysts and to trust their request. Great importance in this change is given to successful cases, ie those teams that were able to first understand the digital value of innovation, to set a true digital project and to involve all relevant stakeholders. In this industry mutual imitation is very strong, so when the other teams have seen that the most successful teams had started these digital projects, often has triggered a process of imitation for which all other opponents team acquired the same technologies, embracing the same innovative vision. Obviously it is useless to adopt technologies without actually knowing how to exploit their added value: that's why all vendors and interviewed athletes agree considering essential an activity of education and fertilization made by institutions to facilitate change.

Are there common barriers and criticalities in the relationship between athletic performance and digital innovation?

When addressing some of our research questions, some criticalities have already emerged, especially in the relationship between the stakeholders of the analysis (coaches and athletes) and the digital solutions vendor. But there are other barriers and criticalities that are not related to this field. They depend in fact on the intrinsic characteristics of athletic performance and the culture rooted in this area:

- First, there are physical and design problems: it is clear that the technologies used should be as precise as possible and still not be a nuisance to the athlete during the execution of the technical gesture. It is important that during matches or training session the technology does not get in the way or hinder the athletes. During some specific workouts it would be possible to use more invasive and cumbersome technologies to improve certain parameters of the athlete (even if this is subjective and varies from athlete to athlete). However, in many sports where there are a lot of physical contacts or tumbles on the ground, it is not possible to wear invasive tools that would break or hurt the athlete. Related to this, one of the things pointed out from the canoe case, is that there are experimental technologies that are being developed but are cumbersome or they do not work properly because they were thought for most common sports and sometimes do not fit perfectly in other sports.
- Then there is a strong cultural issue: the technical gesture is thought to be something related mostly to the talent of a player, to his creativity, fantasy and innate skills. So it's hard to convince both that technology can quantify these parameters and even help the athlete to improve them. This culture is evident in athletes but mostly among coaches, as many of the analysed vendors have reported that it is difficult to teach coaches the importance of data, because they are too focused on their own arguments and on their own ideas. And when a lot of effectiveness of digital innovation depends on the approach of the coach facing it, this comes up as a big problem. They do not always accept the fact that the talent should be trained and then measured day by day, a vision shared by some athletes who are not interested in deepening the data on their performance, considering their subjective opinion more valuable.
  In general the concept is that the sport is also “heart" and not just "head" and then they face thoughts that are little quantitative yet very qualitative and based on sensations.
- One more strong criticality concerns the structure itself of a sports club: teams can not handle the value coming from data. Often there is a lack of a comprehensive data collection system within the club. They currently only implement tight compartments (the fitness trainer, video cutter, who collects data, etc.) and do not communicate with each other, sharing together the data only at the end. Sometimes they miss a specific coach for data analysis, and therefore they lack the ability to study the parameters which give the capacity to explore new ways of reading the output.

Are there geographical differences?

Our investigations have shown that different countries in the world have very different mindset. The most advanced countries, both as revealed by the literature and according to the opinions of our respondents, are the anglosasson countries, particularly England and Australia. Here there is a more open-minded, interested in exploring and trying to understand how this world of digital innovations can contribute to sports development. They are more familiar and more aware, based on objectivity and on results over the long term (daily monitoring – they consider the game event only as a moment of confirmation). A demonstration of this is the fact that every sports club, both at the pro level either in the lower leagues, has a scientific department. As well expressed by Professor La Torre, this new approach to technology is still very recent, born from strong national boost with the will to improve the sport results of their Olympic representatives.

Precisely this trend was found even in emerging countries such as Middle East, which have no strong sport tradition but want to emulate and follow the Anglo-Saxon successful models.

Unfortunately, in Italy we are far behind in this field.

Generally, Latin countries have a very strong emotional component. The result of the game influences a lot the arguments and the preparation itself has a short term view. This is the "culture of the single event", so the talent of the staff team depends on the outcome of the game. In particular then in our country, despite a good level of coaches education, there is still a closed mindset by many coaches who do not see the potential that may emerge by using in the correct and intelligent way the new technologies. The international vendors we interviewed have encountered the problem that in Italy (as in some other European countries) some coaches see the athletic performances as a philosophy, an abstract science that depends on the experience and intuition of a good coach. Something that on the contrary is absolutely not common in some countries, where instead is rooted the concept that sport like any other discipline can be measured, managed, optimized, predicted.

This problem can only be solved in practice, when it will be understood that some teams who adopt certain technologies and are more open mentally then are the same ones that get the best results in the championships or competitions.

However starting from last years, even our market is witnessing growing possibilities, with investments growing in infrastructures and especially with Universities and Research Centres that can help to overcome this geographical complexity and dive to discover this new word that is the Digital innovation.

Geographical differences impact then also at the amateur level: for example Fitbit found geographic differences also due to the customs, culture and economic differences among different countries. For instance in Germany the users prefer a device that provides accurate information, in France instead it is important the awareness, so they use the tracker with an approach bound to have a better knowledge of themselves and reach their own wellbeing. In Italy the buying power is not very high (even for subscriptions to the gym), so outdoor physical activities are widespread.

The answer that vendors must prepare to handle these geographical differences is the customization: Athlete Monitoring and STATS , with a broad vision on the global market, they realized immediately that each market has its own personality, so the company needs to access it with a local focus. The product can be adapted to different cultures and traditions, without changing the basic concept, i.e. to highlight the significant information of the events that occur during the game.

What is the importance of the motivation? To which stakeholder is it related? How is it influenced by digital innovation?

A crucial element of the sport practice turns out to be the motivation. In the absence of motivation it is difficult for people to approach sporting activity or maintaining their constant commitment to sport. The initial motivation must arise from the athlete, then it can be "coached" but must always arise from the athlete. In our study we found that the technologies and coaching staff help to increase the determination and motivation that pushes the athletes to improve and give the best of themselves. Without motivation it is impossible to obtain the desired results, but sometimes only motivation is not enough and it is here that we have seen the role of technology. Over the years, sport has acquired high levels of professionalism and commercialisation, leading to a greater pressure to win. And it is this pressure that feeds the need for new technologies that will assist the athlete in achieving even better results. We saw that the structural limits of the human body are not the thing that differentiate who comes first and who is second, but it is a bio-psycho-social approach that considers the motivational intensity. The transition that is missing is understanding that the technological innovation really helps the athlete to improve and to force this motivation, and therefore at high levels, where athletes are obsessed with the pursuit of excellence, it can give a great contribution. As already said the motivation mostly may depend on their coach, society or teams, that can help the athlete to grow, even through technologies, to increase his desire to improve. It is important that this process is built at a young age, so that having one or more monitoring devices, the athlete is pushed to always give his best in every occasion, also for fear of not being up to what is required by the coach. Over time these improvements helps to be motivated and to train with tenacity. In this field, the technology allows the athlete to improve and provides objective data that show such improvement: the immediate feedback is useful as it allows the athletes to immediately understand their mistakes and what they can improve. Moreover, the possibility to obtain objective data allows various athletes to confront each other, and this generates a stimulus to the personal improvement. The latter concept is also important at the amateur level: the motivation is the key and those vendor (like Fitbit) that are aiming to that market, must base their own idea on helping people to be motivated and train constantly to keep fit. Motivation and encouragement start from the person, but may decline over time: this is why amateur sportsmen need customized suggestions on personal objectives and results, even through challenges with the community.
To end the answer to this question, we report what well expressed by the athlete Marco Culiersi: "*It is a fact that the technology increases the motivation of those who have much, but it is not able to provide motivation for those who already has none. This is because is exactly the motivation that drives you to monitor certain parameters to be able to improve. Is not the technology itself, not the wristband that when you put it on, it gives you a motivation that you did not have before: the effectiveness of the wearable depends on who wears it. I'd wear the technology because I am motivated, I love this sport and I want to improve.*"

Validation of the spider-web model robustness through Case Studies

In the realization of our model we relied on the enormous amount of information that we have drawn from the literature and actual industry analysis. Hence this model was initially drawn only in theoretical terms and then went on to validate it through several case studies that we have compiled. The reasons why we believe that the model is valid are more than one: during our work we have not had any difficulty in mapping all the technologies used by the athletes or provided by vendors. Each technology was perfectly suitable with the model and found her place easily within it. In addition, the axes on which we have built our model are based on objective classifications and choices defined uniquely. This point is crucial so that a model is clear and defined, without allowing a subjective reading that could be interpreted in different ways by different readers. We have created a standard and the same method of analysis for all, which can be used in several research projects without the danger of incurring subjective classifications or rating based on interpretation.
The model presented is considered valid also for the fact that highlights the differences of each technology solution in a clear, effective and readable way. When we mapped a solution that should be part of an area defined by a specific shade (red, green or blue) actually the model detects it as belonging to that specific areaIn addition, however, it is able to map out possible future developments in order to bring out any differences to other solutions already mapped or towards new solutions. This was of great help and has allowed us to read from the output information that before drawing up the model were not clear, because hidden inside a large amount of information and therefore difficult to highlight.
We is also received a final validation by Professor La Torre, who after the presentation of this model has confirmed its completeness and importance of the choice of those specific axes.
It was also important to find ways to cross the model with the different user functions that we mapped in our Case Study: These functions have made it possible to be able to create a matrix among the existing analysis and a third dimension focused on fully understand the unique characteristics of the area of athletic performance.

5.2 Finish Line

After exposing what have been the findings related to our research questions, we wanted to develop a synthetic speech, able to bring out the real added value of our thesis, in response to our main objective highlighted even in the title of our thesis: what are the characteristics of digital innovation applied to athletic performance?

We then divided this main question in the 7 areas related to our 7 research question, mapping them in the chart below. In this way we were able to highlight the impact of each area with respect to the purpose of our analysis (Y-axis), and therefore the importance of solving at first the heaviest variables to answer our main question.

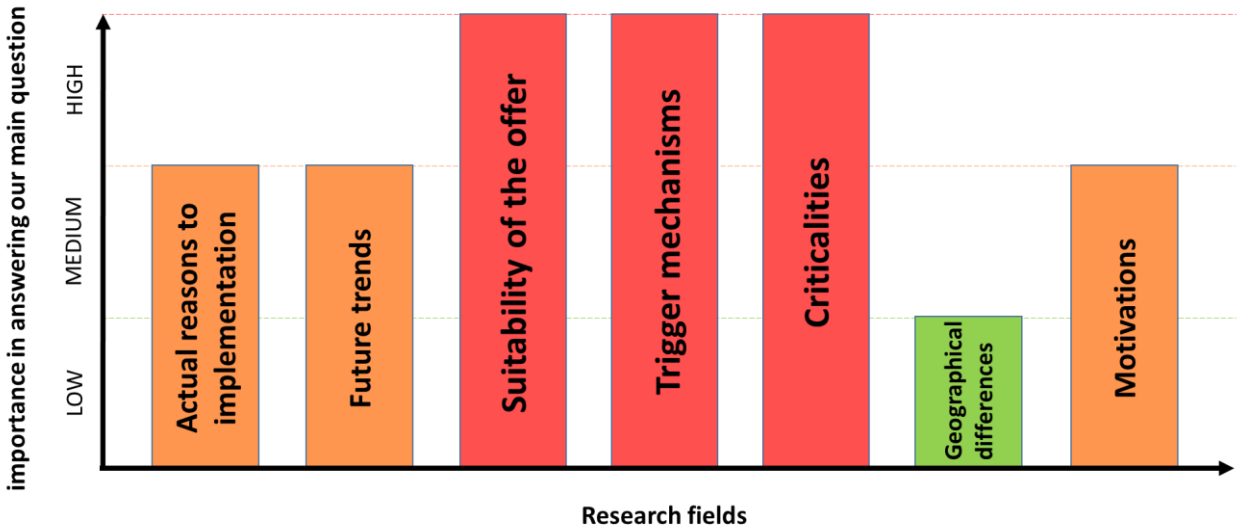


Figure 5. 1

From the graph we can see that not all fields have the same weight, as there are some that have more importance than others. We want now to rationalize them, explaining why we attributed the weight shown in the graph.

Actual reason to implementation: value given: 2 (medium): we assigned this score because nowadays the market has already clearly identified what is the key value added by digital innovation to the monitoring of athletic performance. The improvement can no longer be on the identification of these reasons, but must now focus on improving the tools, that means an effort focused on improving the quality of products.

Future trends: value given: 2 (medium): we wanted to give an average weight to this item because the future trends highlighted have different levels of importance. In fact the two trends related to diffusion of sensors and consolidation do not impact significantly as they relate to the technological evolution that already has a defined path. Instead, the key future trends, and the one toward which all vendors are moving, is precisely to make potential customers aware of the value behind their offer and then quantify the impact of digital innovation on the user's athletic performance. This concept has proven to be crucial in the analysis of the literature and even in the Case Studies.

Suitability of the offer: value given: **3** (high): this factor is important because the use of a technology is mainly based on how much this can help in improving athletic performance of each athlete, who often has the specific characteristics and needs for his body. Also the other

most common stakeholder of the analysis, the coaches, often have personal training styles very different from each other. Not to mention the differences in the needs of each sport and level of competition. For this reason, the suitability is extremely important in our chart.

Trigger mechanisms: value given: **3** (high): very often is the determining factor that allows the introduction of digital innovations, or on the contrary, it denies a possible use. Often it depends on highly motivated stakeholders who impose and manage to adopt the technology within the company, helping to make them understand the potential of innovation. Another factor to remember is the process of imitation so if an athlete / winning organization uses special innovative solutions, it is often imitated by its competitors.

Criticalities: value given: **3** (high): it is important to know what are the criticalities at the product design level to know how to invest in technology and innovative solutions. The other two highlighted criticalities (cultural problem and lacks in the organization structure) refers to a still immature mentality and to the low awareness of the usefulness of these technologies. For this reason it would be important to spread and teach the data culture, to make them understand how important it is in achieving their objectives, because a structure that gives the correct importance to the objective data is needed to overcome the belief that some of the sporting aspects are not measurable and depend only on subjective factors. hence spread the mentality that behind a strategy or a winning player sometimes hides an intelligent technology.

Geographical differencies: value given: **1** (low): we attributed a low importance because in general the sport, albeit very popular and practiced all over the world, does not present major barriers that are only due to territorial aspects. In fact there are no geographical differences related to the type product or the inability to use it. The only real barrier is the cultural one, but that often is reflected at the local level (such as the differences between Anglo-Saxon and Latin culture), generating the propensity or the resentment toward the use of innovative digital technologies. However, we also found that there are vendors who know how to manage this diversity in order to advertise the product in the correct manner, emphasizing each time different characteristics.

Motivation: value given: **2** (medium): It has an average impact because on one hand it is a fundamental requirement to enable the application of digital innovation. This is because from what we have analyzed, technology alone can not create the motivation but it can only be a catalyst for arises from the end user. On the other hand, however, we found that often in the market the motivation is already evident, especially at the highest levels of competition, and thus offers a fertile ground for the introduction of digital innovation.

Following this vertical analysis, focused to highlight the importance that each research question has individually compared to our research area, we wanted to introduce a new direction analysis: understand the correlations that arise between the various research question. It is indeed important to understand how the 7 areas are connected each other, because in this way we can understand on which functions to act in order to then influence the others.

The fundamental tool we used to carry out this last reading was our spider web-chart model, which has proved very useful in highlighting graphically the synergies that we want to explain:

1. **Actual reason of implementation and future trends**
   Especially in the case studies, our model shows clearly both the current solutions available in the as-is situation and the main fututre trends of each solution. In this way we were able to see that all the analyzed Cases already cover the current technological standard, and they are already in action to broaden their offering and manage the most important future trend, turning trackable data into actionable recommendation. So thanks to the model we understand that the actual

reasons of implementation are already an acquired parameter, and the most critical factors is already shifting towards the future trends we highlighted: it will no longer be sufficient for a vendor to provide its solutions, even if at the state of the art, because the user focus is now switching on its ability to explain the goodness of its solution to an increasingly higher number of stakeholders, managing an increasingly higher complexity of the analysis coming from different technologies and sensors.

2. **Actual reason of implementation and suitability**
   Crossing some chart mapped through our model with the user function that the athlete would like to monitor, we often noticed how the graph mapped to the web spiders do not correspond perfectly with the chart instead highlighted at a theoretical level for that specific user function (and in fact we have seen some graphic form and colour contrasting with what is defined in Chapter 2). Again the relationship with suitability is very strong, because sometimes athletes use products not perfectly suitable for the purpose that they would like to achieve but which are the most suitable available on the market. Again therefore, act on trying to prepare suitable solutions for the needs of final users would also refine the actual reason of implementation of the stakeholders involved.
3. **Criticalities and suitability**
   Another fundamental point that emerges from our model. Indeed, we have already shown that the criticalities mainly concern the fact that the chart mapped in the spider-web of athletes (ie what they would want to measure) does not always coincide perfectly with the chart of the offer vendors. Through the model, however, we can see that the offer of the vendor is developing in the right directions for the athletes, thus showing significant progress in suitability of their systems. For this reason, the more vendors and athletes mapped graphics will be similar, the more the suitability will gain importance diminishing the importance of the criticalities, which gradually will be solved.
4. **Trigger mechanism and suitability**
   Again we can find a key aspect: the fact that vendors are trying to adapt their offer to the market preferences, focusing a lot on customization, will have a strong impact even on the trigger mechanism of adoption. In fact, nowadays some vendors offer their products by focusing very strongly on some features that not found the interest of the athletes, risking to be aggressive and exposing the wrong message. This means that athletes sometimes do not see some other features of the service that instead could be extremely useful for them, and therefore do not push their clubs towards the adoption of digital technologies. With increasing of the offer suitability, however, it will make it easier for vendors to leverage on the right features for user, and they will then also exploit their support to convince the sports club to accept the digital innovation.

Thanks to the analysis of these correlations between the research question, made possible thanks to our model, we hence easily understood which is the true key aspect: **it is a process**, where the key factor is the **suitability**. Understand the importance of suitability and invest on this concept within the digital innovation in athletic performance therefore means having the ability to act indirectly on other important field, and then multiply the results of the efforts.
The suitability is therefore the key to give the boost needed nowadays to the digital innovation in order to enhance its role in the athletic performance.

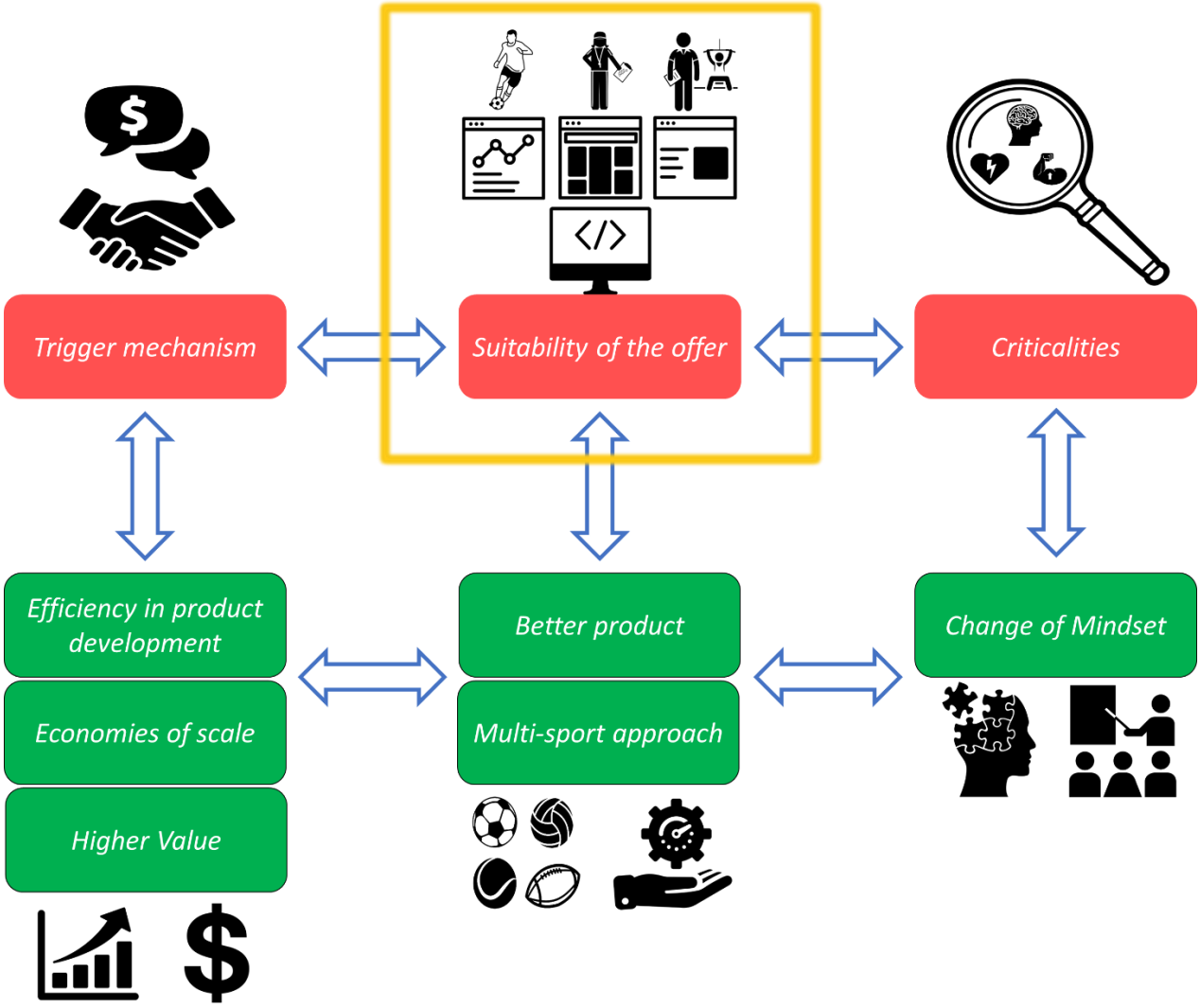


Figure 5.2

5.3 Limits of the research and further improvements

5.3.1 Validation of our hypothesis

Our main tools to define the importance of each research field were the literature review and the drafted Case Studies. Even our interview with Antonio La Torre has brought many useful concepts to define the graph. In particular, we reworked this information when we defined the level (high, medium or low) of impact of each research field. Our assumptions regarding these choices are therefore methodologically justified.
However, these concepts could then be discussed in more detail with further analysis and through additional validation, for example by identifying the opinions of other experts in the field or by organizing focus groups able to gather together several points of view on each field. The research possibilities are therefore still very wide.

5.3.2 Adding a fifth axis to the model

As we have already highlighted within our conclusions, in sports and fitness technology the real deal is not about what data can be shown, it is how meaningful the data are in terms of improving athletic performance or managing overall personal fitness. Vendors have realized that people need interpretation of data collected by the team, letting the coach communicate a coherent strategy. Having understood how important this concept is in the world of athletic performance, we believe that we could consider the idea of adding a fifth axis to our model, describing the complexity of the output provided by the system, thus providing a proxy of the readability and comprehensibility of insight emerging from its data analysis. The difficulty in this case would be to structure the axis so that it reflects the characteristics of the other four in the spider-web chart: objectivity, measurability, generalizability and hierarchical structure.

5.3.3 Developing a deeper analysis in the Health and Rehab area

Throughout our analysis, we have often emphasized the special features related to the Health and Rehab sphere. But we have realized that this sector deserves often a much deeper analysis, especially considering the fact that there is a close relation (also economic) between the inactivity of an athlete due to an injury and its value for the team.

In conclusion we would like to elaborate this very important concept, which is that there is evidence of how technology can have an important role on athletic performance of the user, as well as clubs know that using certain technologies can increase the performance of their athletes. The factor that mainly slows the use of these technologies is precisely the question of investment/money. Companies sometimes hardly see the investment in new technologies as an effective project, because who manages the budget is too tied to the costs and can not see the real reason why you should invest in digital innovation. The missing link is right on the value for the team, where now the main asset, especially at high levels, are players. Through the use of technology and monitoring these players, the team would help them grow and protect them from injury. This would not only increase their value, thereby increasing the value for the club, but it could also prevent their devaluation by preventing some injuries, which are really the main factor, hence leading again to significant savings for the clubIn addition an athlete who is in excellent condition and has trained in the most proper way has more chance of success and victory, and this would be great deal for the team either in monetary terms and in terms of image. This factor is not yet clear on the market, and yet there is a closed-mindset due to the fact that even if there is an awareness of the potential of technology, it is a rising trend in recent years and has not yet been established, nor the stakeholders have understood yet how to exploit it.

Overall, the technology must be accepted and effectively utilized in sports without forgetting its principles, its values and its objectives. It must therefore be an effective way to achieve excellence.

Appendix

A.1

Summary of social media by league

RANK IN SOCIAL MEDIA	LEAGUE	TOTAL (M)	AVG PER TEAM (M)
1	EPL	229	11.5
MOST SOCIAL	MAN UTD	68.7	
LEAST SOCIAL	CARDIFF	0.6	
RATIO TOP TO BOTTOM		116.4	
2	LA LIGA	217.6	10.9
MOST SOCIAL	BARCELONA	97.2	
LEAST SOCIAL	GETAFE	0.04	
RATIO TOP TO BOTTOM		2,430	
3	IPL	58	7.3
MOST SOCIAL	CHENNAI SUPER KINGS	12.1	
LEAST SOCIAL	DELHI DAREDEVILS	2.9	
RATIO TOP TO BOTTOM		4.2	
4	NBA	150	5.0
MOST SOCIAL	LA LAKERS	25.3	
LEAST SOCIAL	MILWAUKEE BUCKS	1.3	
RATIO TOP TO BOTTOM		19.5	
5	SERIE A	66	3.3
MOST SOCIAL	MILAN	26.5	
LEAST SOCIAL	LIVORNO	0.004	
RATIO TOP TO BOTTOM		6,625	
6	NFL	100.5	3.1
MOST SOCIAL	DALLAS COWBOYS	9.2	
LEAST SOCIAL	JACKSONVILLE JAGUARS	0.7	
RATIO TOP TO BOTTOM		13.1	
7	BUNDESLIGA	55	3.1
MOST SOCIAL	BAYERN MUNICH	30.2	
LEAST SOCIAL	EINTRACHT BRAUNSCHWEIG	0.2	
RATIO TOP TO BOTTOM		158.9	
8	MLB	63.1	2.1
MOST SOCIAL	NEW YORK YANKEES	9.6	
LEAST SOCIAL	MIAMI MARLINS	0.7	
RATIO TOP TO BOTTOM		13.7	
9	LIGUE 1	37.5	1.9
MOST SOCIAL	PARIS SAINT-GERMAIN	20.3	
LEAST SOCIAL	VALENCIENNES	0.17	
RATIO TOP TO BOTTOM		119.4	

Figure A 1

A.2

QD7 Earlier you said you engage in sport or other physical activity, vigorous or not. Where do you engage in sport or physical activity?

	In a park, outdoors, etc.	At home	On the way between home and school, work or shops	At a health or fitness centre	At work	At a sport club	At a sport centre	At school or university	Elsewhere (SPONTANEOUS)	Don't know
EU28	40%	36%	25%	15%	13%	13%	9%	5%	4%	4%
BE	32%	38%	29%	11%	13%	17%	9%	6%	5%	4%
BG	25%	52%	21%	12%	10%	5%	4%	6%	5%	4%
CZ	42%	46%	25%	17%	19%	11%	11%	5%	1%	1%
DK	50%	39%	29%	26%	18%	22%	7%	7%	3%	3%
DE	42%	46%	27%	16%	15%	21%	5%	4%	2%	2%
EE	47%	41%	24%	12%	20%	14%	7%	7%	3%	3%
IE	44%	27%	14%	16%	7%	18%	7%	5%	6%	2%
EL	33%	31%	41%	20%	10%	8%	5%	3%	4%	0%
ES	51%	14%	31%	19%	6%	9%	11%	2%	4%	1%
FR	42%	27%	16%	5%	16%	17%	7%	5%	5%	4%
HR	30%	44%	23%	9%	10%	8%	7%	3%	4%	5%
IT	36%	13%	23%	15%	4%	7%	19%	4%	5%	2%
CY	33%	36%	30%	22%	11%	5%	4%	7%	5%	0%
LV	42%	49%	34%	6%	26%	6%	8%	8%	1%	2%
LT	28%	63%	29%	2%	19%	12%	3%	8%	5%	3%
LU	36%	35%	11%	14%	11%	16%	9%	7%	4%	3%
HU	16%	51%	29%	6%	13%	5%	3%	5%	3%	5%
MT	29%	19%	36%	12%	7%	11%	9%	5%	7%	1%
AT	54%	43%	30%	19%	10%	12%	5%	5%	9%	1%
NL	37%	35%	29%	16%	13%	23%	10%	6%	5%	2%
PL	35%	37%	24%	9%	7%	5%	6%	7%	3%	8%
PT	44%	14%	25%	17%	5%	7%	3%	4%	5%	2%
RO	19%	53%	24%	5%	9%	3%	2%	6%	4%	16%
SI	60%	54%	24%	6%	9%	9%	8%	4%	4%	1%
SK	36%	54%	36%	13%	18%	8%	5%	7%	3%	2%
FI	72%	43%	47%	27%	15%	7%	12%	5%	5%	1%
SE	55%	46%	38%	40%	16%	12%	6%	6%	3%	1%
UK	38%	40%	22%	21%	18%	11%	9%	4%	6%	4%

Highest percentage per country *Lowest percentage per country*

Highest percentage per item Lowest percentage per item

QD7 Earlier you said you engage in sport or other physical activity, vigorous or not. Where do you engage in sport or physical activity?

	In a park, outdoors, etc.		At home	On the way between home and school, work or shops		At a health or fitness centre		At work		At a sport club		At a sport centre		At school or university	
	EB80.2 Nov. - Dec. 2013	Diff. 2013-2009		EB80.2 Nov. - Dec. 2013	Diff. 2013-2009	EB80.2 Nov. - Dec. 2013	Diff. 2013-2009	EB80.2 Nov. - Dec. 2013	Diff. 2013-2009	EB80.2 Nov. - Dec. 2013	Diff. 2013-2009	EB80.2 Nov. - Dec. 2013	Diff. 2013-2009	EB80.2 Nov. - Dec. 2013	Diff. 2013-2009
EU28	40%	-8	36%	25%	-6	15%	+4	13%	+5	13%	+2	8%	=	5%	+1
EL	33%	+6	31%	41%	-22	20%	+7	10%	-4	8%	+6	5%	=	3%	=
PT	44%	+5	14%	25%	-11	17%	+5	5%	-6	7%	+1	3%	-2	4%	-1
SE	55%	+4	46%	38%	+13	40%	+9	16%	+9	12%	+5	6%	-6	6%	+3
IE	44%	+1	27%	14%	-11	16%	=	7%	+1	18%	+2	7%	-1	5%	+1
MT	29%	+1	19%	36%	-13	12%	+5	7%	+3	11%	+7	9%	+4	5%	+1
UK	38%	-1	40%	22%	-6	21%	+7	18%	+9	11%	+1	9%	=	4%	+1
ES	51%	-2	14%	31%	-20	19%	+8	6%	+1	9%	+6	11%	+2	2%	-1
NL	37%	-3	35%	29%	-3	16%	-1	13%	+4	23%	-2	10%	=	6%	+1
IT	36%	-4	13%	23%	+2	15%	-2	4%	+3	7%	+4	19%	+4	4%	=
FI	72%	-4	43%	47%	+15	27%	+8	15%	+7	7%	-6	12%	-1	5%	+1
BE	32%	-6	38%	29%	=	11%	+4	13%	+5	17%	+2	9%	=	6%	+2
CY	33%	-6	36%	30%	-2	22%	=	11%	+3	5%	-1	4%	-1	7%	-1
LT	28%	-7	63%	29%	-6	2%	-1	19%	+8	12%	+8	3%	-1	8%	-1
PL	35%	-8	37%	24%	-13	9%	+6	7%	+2	5%	-1	6%	+1	7%	+1
LV	42%	-9	49%	34%	+7	6%	+2	26%	+16	6%	+1	8%	+3	8%	-2
SK	36%	-9	54%	36%	-5	13%	-2	18%	+9	8%	+2	5%	+1	7%	=
FR	42%	-10	27%	16%	-10	5%	+3	16%	+3	17%	=	7%	+1	5%	+2
AT	54%	-10	43%	30%	+6	19%	+6	10%	+2	12%	-3	5%	-1	5%	=
RO	19%	-10	53%	24%	=	6%	+2	9%	+3	3%	=	2%	-1	6%	=
DK	50%	-14	39%	29%	-3	26%	+6	18%	+3	22%	+4	7%	-1	7%	+2
LU	36%	-15	35%	11%	-5	14%	+6	11%	+2	16%	=	9%	+1	7%	+1
CZ	42%	-16	46%	25%	-11	17%	+4	19%	+10	11%	+5	11%	+4	5%	-1
DE	42%	-18	46%	27%	=	16%	+4	15%	+8	21%	+2	5%	=	4%	-1
BG	25%	-20	52%	21%	-6	12%	+1	10%	-9	5%	+2	4%	+1	6%	-1
EE	47%	-20	41%	24%	-3	12%	+7	20%	+6	14%	+5	7%	-1	7%	=
HU	16%	-20	51%	29%	-13	6%	+4	13%	+1	5%	+2	3%	-1	5%	-1
SI	60%	-23	54%	24%	-7	6%	+1	9%	-2	9%	+2	8%	-1	4%	-3
HR	30%	*	44%	23%	*	9%	*	10%	*	8%	*	7%	*	3%	*

Figure A 2

Bibliografy

Alberta Gimnastics (2012). Suggested Coach to Participation Ratio

Anzaldo D. (2015). Wearable sports technology – market landscape and cumpute SoC trends – International SoC Design Conference

ARCADA (2011).The Significance of Sponsorship as a Marketing Tool in Sport Events

ATKearney (2011). The Sport Market

ATKearney (2014). Winning in the Business of Sports

Atos company (2012). Expertise sport

Atos Company (2012). Reinventing your digital experience with small solutions for sport.

Auitel (2015). Sintesi annuale

Bager, Roald; Engebretsen, Lars (2009). Sports Injury Prevention. Chichester, UK; Hoboken, NJ: Wiley-Blackwell.

Banca Nazionale del Lavoro Gruppo BNL Paribas (2013). Focus settimanale del Servizio Studi BNL

Brett Hutchins,David Rowe (2013). Digital Media Sport: Technology, Power and Culture in the Network Society

Chambers et al. (2015) - The Use of Wearable Micro sensors to Quantify Sport-Specific Movements

CHI (2015). Contextual Influences on the Use and Non-Use of Digital Technology While Exercising at the Gym

Cil (2014). SCORECARD– National Conference on Business of Sports" organized by the CII.C08

Coni (2012) censimento nazionale impianti sportivi. Istruzioni per l'attività di rilevazione. V1.3

Coni (2006). I numeri dello sport italiano

Coni (2008). Primo rapporto Sport & Società

Coni (2012). Il libro bianco dello sport italiano

Coni (2013). Bilancio di Sostenibilità

Coni (2013). Bilancio di sostenibilità

Coni (2014). I numeri dello sport

Coni (2014). Lo sport in Italia

Coni (2015). I Numeri dello Sport

Coni (2015). I numeri dello sport

Coni(2007). La diffusione dello sport in Europa

Deloitte (2016). Annual Review of Football Finance 2016

Deloitte (2016). Top of the table Football Money Leagues

ELSEVIER (2014). Sport and social media research: A review

England Athletich (2017). Stratecic Facility Plan

Eurobarometer (2010). Sport and Physical Activity Report

Eurobarometer (2014). Sport and Physical Activity Report

Gazzetta dello sport (2006). Sport più praticati in Italia: il calcio è ora secondo.

International Olympic Committee (2015). IOC Annual Report

Istat (2007). L pratica sportiva in Italia

Istat (2011). Il non profit nello sport

Istat (2013). 11 Famiglie ed aspetti sociali vari

Istat (2014). 8 Cultura e tempo libero

Istat (2015). Italia in cifre

Keith Davids (2014).Complex Systems in Sport

McGraw –Hill Education – Open University Press (2004). Sport Culture and the Media

NPD Group (2008). Global Sport Market Size Estimate

NPD Group (2012). Sport market Report

Peter O'Donoghue (2015). An Introduction to Performance Analysis of Sport
SpEa (2012). Study of the Contribution of Sport to Economic Growth and Employment in EU

Sport Techie (2016). RESULT Sports Makes Teams Smarter About Their Social Media Presence

Sportintelligence (2015). Global Sport Salaries Survey

Tim J Gabbett (2016). The training—injury prevention paradox: should athletes be training smarter *and* harder?

Università degli Studi – Facoltà di Scienze Motorie – Bruno Ruscello (2012).

Università degli Studi – Facoltà di Scienze Motorie – Enrico Arcelli (2013). Teoria dell'allenamento - Classificazione degli sport

Università degli studi Milano Bicocca (2012). Facoltà di Sociologia – Mercato dei Diritti Televisivi dei grandi Eventi Sportivi.

Università degli studi Milano Bicocca (2013). EXSPORT: Cultura, Sport, e Turismo in campo"

Università di Pisa – Luca Pappalardo (2016). The harsh rule of the goals: data-driven performance indicators for football teams

University of Texas at Arlington – Jin-Woo Kin (2014).The sport event sponsorship: en event study

WHO international CES (2015). Guide to health, fitness and sport technology exhibits at the 2015 international CES

World Heath Organization (2015). Make physical activity a part of daily life during all stages of life

Sitography

http://business.financialpost.com/fp-tech-desk/high-tech-sports-pros-seek-edge-over-rivals-with-wearables?

http://futureof.org/sports-2015/payments-ticketing/

http://ieeexplore.ieee.org/abstract/document/

http://investor.analog.com/releasedetail.cfm?releaseid=970186

http://johancruyffinstitute.com/en/blog-en/the-athlete-as-a-social-media-marketing-product

http://s3.amazonaws.com/academia.edu.documents

http://spectrum.ieee.org/the-human-os/biomedical/devices/rocky-start-to-wearables-in-professional-sports

http://sportperformancecentres.org

http://swordhealth.com/#/

http://tech.co/virtual-augmented-reality-sports-2016-10

http://www.athletemonitoring.com/

http://www.ausopen.com/en_AU/slamtracker/

http://www.biometricupdate.com/201410/professional-sports-teams-and-athletes-driving-wearable-technology

http://www.catapultsports.com/system/

http://www.digitalistmag.com/industries/sports-and-entertainment

http://www.experimedia.eu/2014/02/25/3drsba/

http://www.hollywoodreporter.com/news/how-las-staples-center-earns-719857

http://www.marketsandmarkets.com/PressReleases/mhealth-apps-and-solutions.asp

http://www.mobihealthnews.com/48413/prediction-health-app-market-to-top-31b-by-2020-driven-by-hardware-sales

http://www.reportsnreports.com/reports/

http://www.sciencedirect.com/science/article/pii/S0097849312000957

http://www.si.com/tech-media/2016/08/01/ibms-cognitive-computing-system-watson-sports-industry

http://www.skill-go.com/

http://www.sporttechie.com

http://www.ted.com/search?q=wearable

http://www.tevak.org/pdf/dergi/2013/pdfsno2/24_2_108_111.pdf

https://marketreportscenter.com/reports/347625/youth-and-amateur-adult-league-sports-software-market-shares-strategies-and-forecasts-worldwide-2016-to-2022ttps://wyscout.com/

http://www.moxoff.com/

http://www.mathandsport.com/

https://newsroom.cisco.com/press-release-content?articleId=514376

https://pdfs.semanticscholar.org/d254/f168aa679ff7bd3fb2e4e1e61d65ab204f03.pdf

https://research2guidance.com/wp-content/uploads/2016/10/PREVIEW-mHealth-App-Market-Sizing-2015-20201-1.pdf

https://www.cisco.com/c/dam/assets/global/IT/local_offices/case_history/pdf/Ciscocasestudy-FISA-ita.pdf

https://www.clearinghouseforsport.gov.au/knowledge_base/high_performance_sport/

https://www.eventbrite.co.uk/blog/10-event-technology-trends-you-need-to-know-in-2016-ds00/

https://www.fitbit.com/home

https://www.ft.com/content/b2ad8488-a323-11de-ba74-00144feabdc0

https://www.google.com/patents/US6757572

https://www.gsb.stanford.edu/insights/five-key-trends-are-driving-business-sports

https://www.gsb.stanford.edu/insights/five-key-trends-are-driving-business-sports

https://www.ibm.com/blogs/internet-of-things/iot-sport-infographic/

https://www.stats.com/

https://www-01.ibm.com/events/wwe

https://www-935.ibm.com/services/sports/#team

www.elsevier.com