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**Referential for technologies which track and improve the
performance of small rugby team athletes**

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Master Thesis

presented as partial requirement for obtaining the Master Degree in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
Universidade Nova de Lisboa

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Referential for technologies which track and improve the performance of small rugby team athletes

by

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Master Thesis presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

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ABSTRACT

This paper explores the potential of utilizing technology to track and enhance the performance of rugby athletes in smaller teams. The primary objective is to identify cost-effective and accessible technological solutions that can significantly improve training efficiency, monitor player performance, and provide actionable insights into athlete development. The research addresses the unique challenges faced by smaller rugby teams, including budgetary constraints and limited access to advanced resources, and offers practical recommendations for integrating technology into their training regimens.

The importance of technology in modern rugby training is highlighted through the examination of various tools such as video analysis, wearable devices, and GPS tracking systems. These technologies have revolutionized training methodologies by providing precise data on physical condition, performance metrics, and tactical execution. Video analysis allows for detailed review and critique of player performance, facilitating the identification of improvement areas and the development of targeted training strategies. Wearable devices, including heart rate monitors and GPS trackers, offer real-time insights into player movements, exertion levels, and overall fitness, enabling tailored training programs and effective recovery monitoring.

Despite the clear benefits, the paper emphasizes a significant knowledge gap in the use of technology among smaller rugby teams. Many teams lack awareness of the potential advantages and face difficulties integrating these tools effectively. Therefore, the paper calls for educational initiatives and resource allocation strategies to help smaller teams overcome these barriers and fully exploit technological advancements.

By following the recommended technological solutions presented, smaller rugby teams can leverage their training sessions to achieve substantial performance improvements. The integration of video analysis, wearable technology, and GPS tracking can transform training practices, making them more data-driven and efficient. Ultimately, this paper aims to empower smaller teams with the knowledge and tools necessary to enhance athlete performance, ensuring they remain competitive in the evolving landscape of rugby.

KEYWORDS

Rugby; Performance; Technologies; IOT's

Sustainable Development Goals (SDG):



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LIST OF ABBREVIATIONS AND ACRONYMS

DSR	Design Science Research
DSRM	Design Science Research Methodology
GPS	Global Positioning System
IMOS	Inertial Measurement Units
IS	Information Systems
IOT	Internet Of Things

1. INTRODUCTION

1.1. BACKGROUND AND PROBLEM IDENTIFICATION

In today's competitive and global sports world where every game is pushed to the limit both players and coaches in order to be in the edge of competitiveness, teams, coaches, sport scientists and trainers need to adapt their training programs and take the most advantage of the newest technologies and techniques available in the market. The science related to the performance of athletes has grown rapidly to meet the increasing demand for knowledge not just for player characteristics but also for game tactics (Kraak & Welman, 2014). Globalization has had a significant impact on the improvement of technology for tracking and improving the performance of athletes. With the increased movement of people, goods, and ideas across borders, there has been a greater exchange of information and a faster spread of new technologies. Which also includes the sports because gives the opportunity for every team having the same technology as the best and more technological teams in the world. (*Globalization Helps Spread Knowledge and Technology Across Borders*, 2018)

In rugby we can divide the position in two the forwards and the backs. The differences between these two groups are enormous not just in terms of roles but also on type of player both technical and physical. Also, inside of this two groups there is a really big diversity of roles which also leads to a big difference of technical and physical requirements both on and off-the-ball supporting activities. This means that each position has responsibilities that are both common and unique to other position which leads for both common and unique performance indicators (James et al., 2005). On the other hand, as a team sport the group performance inside the club is important especially in a sport like Rugby where all the positions are extremely important and with one less player in a team makes such a big difference.

According to Mike d. Hughes and Roger M. Bartlett (Hughes & Bartlett, 2002) the sports can be divided in three categories, net and wall games, invasion games, and striking and fielding games, each category subdivided in sub-categories. Within each category the performance indicators can change a lot once that the objectives of the games are not related at all, but on the other hand inside of the sub-categories it is possible to adapt the same indicator for the sub-categories of sports. For example, in Rugby and football they both belong to the category of invasion games but inside of this one they belong to the "try Scoring Games" and "Goal Striking Games" and in both we can re-use the same indicator to calculate the performance of not just the team but also from individual players.

The performance indicator is very important in the sports world and have different ways of usage, not just by the coaches to help developing their player's abilities but also for example to the social media when they present in their reports about the games all the statistics needed to make a better coverage of the previous and upcoming games. Further, for the

negotiations between clubs all the statistics and performance indicators of the athletes are a really important factor to take into consideration (Hughes & Bartlett, 2002).

A fully performance analysis should incorporate all the performance indicators, individual, team, opponent's and lastly the decision making. This last indicator has been identified as the most significant factor in elite performance specially for fast paced team invasion sports that is the case of Rugby. It is important to measure the own player's strengths and weaknesses from but also from the opposite team to train and prepare for future games. In order to make faster and more accurate decisions than the opponent team, expert decision makers use advance cues, a larger knowledge base, and superior anticipation. The most used and reliable method of performance analysis is the video-based simulation due to the several benefits that it includes like being cheap, injured players can participate and it can be individualized for each player. (Lorains et al., 2013)

There has already been a great development in this area because if a team wants to become a leader in their sports, they need to be always updated and in the edge of the development of the technology. But even though the use of analyses services has become increasingly accessible to rugby coaches and trainers, there is still a big path on the way so every team more specifically the smaller ones have access to the newest technologies and methods to measure the performance of the athletes (Kraak & Welman, 2014).

1.2. OBJECTIVES

The goal of the paper would be constructing a set of recommendations that can be adopted by the Rugby clubs to improve the individual and group athlete's performance.

To achieve this goal, the following intermediate objectives were defined:

- Which type of technologies already exists to measure and improve the performance of the athletes and teams.
- Which is the roadmap for teams to purchase technologies
- Reasons why smaller teams do not use technologies as part of their training techniques.
- Build a referential with the technologies that can be used in training and where they can leverage the performance of rugby athletes.
- Validate the guidelines.

1.3. IMPORTANCE AND RELEVANCE

This thesis will be important and relevant for several reasons.

Firstly, the technology used in sports, more specifically in rugby, has become an increasingly relevant area of research. Rugby is a sport that is rapidly gaining popularity globally, which leads to a growing need for technology to track and improve the performance of athletes. The use of technology can help coaches and trainers to better understand the physical and mental demands of the sport, to guide the training programs to meet the demands.

Secondly, this thesis will provide new insights and understanding of the topic of how technology can be used to enhance the performance of rugby players and teams. My research will identify the most effective technologies and strategies that smaller teams can use to leverage the use of technology when training their athletes and identify potential limitations or challenges associated with their use.

Thirdly, it will have practical implications for various stakeholders. The findings of the research can be used by coaches, trainers, and sports organizations to improve their practices and make data-driven decisions to enhance the performance of their athletes. Additionally, it could inform public policy and inspire new products or services for the sports industry.

2. LITERATURE REVIEW

The foundation of any comprehensive literature review lies in the systematic exploration of relevant scholarly articles. On this part of my thesis, I navigated the vast expanse of academic knowledge using Google Scholar as my primary tool. I strategically employed keywords tailored to each topic I wanted to abord in this section. Through this deliberate and methodical approach, I was able to collect a series of articles that would provide nuanced insights and perspectives about my topic, laying a robust foundation for the discourse that follows. This introduction elucidates the meticulous process by which the articles comprising this literature review were meticulously selected, underscoring the rigorous methodology employed in its construction.

2.1. RUGBY

2.1.1. Game description

Rugby is a physically demanding and dynamic sport that has become increasingly popular worldwide, making a deeper understanding of the elements impacting player performance necessary. A critical analysis of the extant literature is essential to understanding the game's intricacies in this setting. This literature review explores the many facets of rugby, including the game's description, player needs, psychological perspectives, training tactics, and creative learning strategies, among others.

As Colomer et al. (2020) stated that a rigorous systematic evaluation has been conducted on performance analysis in rugby union. The research underscores the significance of comprehending the nuances of rugby player performance, establishing the foundation for complete evaluation and enhancement tactics. This is consistent with the understanding that rugby is a complicated sport that requires thorough analysis to improve performance effectively. Sato et al. (2023) noted that physical fitness assessments are essential for forecasting rugby players' ability to run at a high intensity. This emphasizes how important it is to evaluate each player individually to customize training plans and maximize the potential of athletes. It is essential to comprehend the unique requirements of the game to customize treatments that focus on key performance measures.

Additionally, Daly et al. (2021) clarified how players perceive their psychological risks, especially about concussions and injury risk. The qualitative analysis highlights the mental health issues faced by rugby players and highlights the necessity for comprehensive interventions that consider both physical and psychological well-being. This supports the idea that the needs of athletes go beyond only physical preparation. Rugby small-sided games show both Severe and long-term impacts of Constraint adaptation, as Zanin et al. (2021) discussed. The dynamic nature of rugby training and the potential advantages of implementing different limitations to improve skill development and overall team

performance is highlighted in this systematic review. This approach, which acknowledges the significance of team needs, adds to a more sophisticated comprehension of training approaches.

2.1.2. Rules

Understanding and effectively navigating rugby rules is a pivotal aspect for both players and coaches, as highlighted by Harbison (2019). The intricate nature of rugby rules, encompassing various facets of gameplay and player conduct, demands a comprehensive exploration to ensure adherence and practical implementation on the field. A solid grasp of these rules is fundamental for maintaining fairness and integrity in the game and achieving successful team performance. Harbison's work emphasizes the practical implications of rule comprehension in the context of player and team dynamics.

Kaluziński (2019) explored the connection between games and rules by adding a philosophical perspective. This study sheds insight on how rugby regulations are not only a set of principles but contribute to developing the dynamics and strategies inside the sport. Understanding the conceptual foundations of these regulations offers a more comprehensive framework for interpreting and implementing them in the dynamic game of rugby. Beyond the superficial level of rule conformity, Kaluziński's exploration enables a deeper reflection on the underlying concepts that regulate rugby. Within rugby rule performance indicators, Kraak & Welman (2014) points out ruck play as a crucial element during the 2010 Six Nations Championship. This study emphasizes the importance of comprehending particular game scenarios, like rucks, as performance markers. Examining these factors becomes essential for coaches and players who want to maximize their tactics and compliance with the regulations. Rugby gameplay is nuanced, as the study highlights the complex relationship between rule-specific performance measures and overall team success.

In team sports, such as rugby, Lorains et al. (2013) emphasize the importance of performance analysis for decision-making, which adds to the larger picture. The study acknowledges that performance analysis encompasses more than individual skill sets; it also involves comprehending the dynamics of rule adherence and team decision-making dynamics. This aligns with the overarching objective of improving team performance through applying performance analysis insights. A more comprehensive understanding of the sport is possible by integrating rule-specific data into performance analysis, opening the door for focused enhancements in team tactics. The psychological requirements of rugby regulations are also extensively discussed in the literature, as studied by Kruijt & Grobbelaar (2019). Their research emphasizes the significance of mental health for top players by concentrating on the psychological requirements of international rugby sevens players. This broadens the conversation beyond the gameplay mechanics and highlights the necessity of considering the players' overall demands while adhering to the regulations. To create a safe and long-lasting

sports environment where players can flourish physically and intellectually while adhering to the game's laws, it becomes imperative to acknowledge the psychological components.

2.1.3. Athletes needs

In rugby, an athlete's needs cover a wide range, from psychological needs to physical well-being. The psychological demands of international rugby sevens have a significant impact on the requirements for the well-being of elite South African players, according to Kruijt & Grobbelaar (2019). The study explores international players' psychological difficulties, highlighting the need to treat psychological issues to protect athletes' overall health. Brazier et al. (2020) investigate elite male rugby athletes' anthropometric and physiological traits. This study offers insightful information about the physical characteristics that distinguish elite rugby players. Comprehending these anthropometric and physiological characteristics is crucial to customize training plans and interventions to rugby athletes' unique requirements and enhance performance.

A systematic review by Sella et al. (2019) examined female rugby sevens athletes' physical attributes, anthropometric traits, and match needs. This research emphasizes the necessity for a gender-specific comprehension of rugby's material requirements, considering the unique qualities and expectations put on female players. Attending female athletes' distinct requirements is imperative to promote diversity and enhance rugby performance. Pike's (2021) study explores inclusion, equity, and safety, focusing on transgender rugby players. This study acknowledges how rugby is changing and how important it is to address justice and inclusivity to satisfy players' varied demands. Establishing a culture that promotes rugby athletes' physical and mental well-being requires protecting the rights and well-being of every player.

Chen et al. (2021) adds to the body of knowledge by concentrating on safeguarding rugby players' and support personnel' health and well-being, particularly in times of global calamity like a pandemic. The study has an occupational safety and health viewpoint, stressing the significance of considering outside variables that affect athletes' health. This all-encompassing strategy fits the overarching idea of attending to athletes' needs outside the playing field. In competitive children's sports, Płoszaj et al. (2021) evaluate referees based on their ability to foster a positive environment and their response to rugby players' physical, mental, and social demands. Recognizing the referees as part of the rugby ecosystem, this work highlights the interdependence of many stakeholders in providing a safe and encouraging environment for athletes.

2.1.4. Teams needs

In rugby, the demands of the team are critical to success. Płoszaj et al. (2021) claim that referees uphold the law, foster a pleasant atmosphere, and attend to rugby players' physical, mental, and social needs, especially in competitive children's sports. This demonstrates how match officials encourage an atmosphere that safeguards the game and the player's health. Referees, coaches, and players collaborate to foster a positive and healthy team culture that reflects rugby's interdependence. Teixeira & Alves (2021) investigation of occupational therapy interventions offers crucial new information about low-cost assistive equipment for Wheelchair rugby. This study highlights the significance of inclusive practices within the rugby community and acknowledges the unique requirements of athletes with disabilities. Considering the individual needs of players from different backgrounds adds to the sport's general adaptability and inclusion. Rugby organizations may strengthen the sport's commitment to diversity and inclusivity by establishing an environment that is not only accessible but also supportive of athletes with diverse abilities. This can be achieved by considering these factors within the larger framework of team needs.

Moving beyond physical considerations, Ojio et al. (2021) investigate anxiety and depression symptoms among rugby top league players. Understanding athletes' psychological challenges are essential for teams to provide adequate support and resources. Mental health considerations become integral to team needs, emphasizing the holistic approach required for player well-being. By recognizing and addressing mental health, rugby teams can implement strategies to support their players on and off the field, fostering a culture of well-being and resilience.

Furthermore, Fazackerley et al. (2023) explore the perceptions of elite professional rugby league players and staff regarding the National Rugby League Annual Calendar. This mixed-methods study sheds light on the challenges and opportunities the annual calendar presents, providing insights into the scheduling complexities that teams navigate. Understanding these dynamics is crucial for effective planning and resource allocation within rugby organizations. The study emphasizes the need for teams to adapt to the evolving landscape of rugby, considering factors such as player workload and competition schedules to optimize performance and strategic planning. Assessing the impact of globalization on sports, including rugby, the study *Globalization Helps Spread Knowledge and Technology Across Borders* (2018) emphasizes the exchange of information and technology in the sports domain. This underscores the interconnectedness of rugby teams globally and the opportunities for knowledge transfer and technological advancements. In an era where information and technology are shared across borders, rugby teams can stay at the forefront of developments in the sport, enhancing their capabilities and contributing to rugby's overall growth and competitiveness on a global scale.

2.1.5. The stadium and the spectator experience

Rugby's stadium and spectator experience are essential components that significantly add to the sport's overall appeal and enjoyment. The ambiance of the stadium and the degree of participation from the fans enhance the thrill and emotion of rugby beyond what happens on the field. This section uses ideas from pertinent literature to examine various stadium and spectator experience factors thoroughly. The mood and involvement of sporting events are greatly enhanced by the stadium and the spectator experience, which are crucial components of the overall dynamics of the event. Tajima et al. (2020) claim that the Rugby World Cup 2019 in Japan offered a chance to investigate the field of spectator medicine at a global sporting mega event. Comprehending the health and welfare of attendees is imperative in guaranteeing a satisfactory and secure encounter, hence augmenting the general triumph of these occasions.

In their investigation of the changing nature of the match-day experience in multi-purpose stadiums, Richards et al. (2022) highlight the evolving carnival connected to sporting events. The study emphasizes how crucial it is to reinvent and recreate match-day knowledge to satisfy changing fan expectations. This is consistent with the understanding that the spectator experience is dynamic and susceptible to ongoing changes in the general culture and society. The "Stats on-site" concept is presented by Lo et al. (2022), emphasizing the sports fan experience through contextual visualizations. The subject of this study is integrating real-time data and visualizations to improve spectator engagement and game comprehension. This aligns with the current technology movement to enhance the spectator experience at sporting venues.

By examining placemaking in the peripheral, particularly during the Japan 2019 Rugby World Cup, Hayes (2023) adds to the body of literature. The study sheds insight on the physical and experiential factors that affect spectator engagement and stresses using limonoid environments for host advertising and experience building. Creating experiences that viewers will find memorable and significant requires an understanding of the relationship between space and experience. Additionally, Templeton et al. (2020) enlighten on the difficulties brought about by the COVID-19 pandemic, particularly emphasizing returning to athletic events in the UK. The paper examines spectators' perspectives at pilot competitions, discussing the special conditions and safety precautions. This gives the literature a contemporary edge by emphasizing the necessity of flexibility and resilience in handling the viewing experience in unexpected situations.

2.2. TECHNOLOGIES IN SPORT

2.2.1. Overview

Incorporating technology into sports has undergone a transformative evolution, reshaping how athletes perform, coaches strategize, and games are analysed. Mali & Dey (2020) characterize this integration as a significant paradigm shift, signifying a strategic move towards optimizing training, performance, and safety in the ever-evolving landscape of modern sports. Peffers et al. (2007) propose a robust framework, the Design Science Research Methodology for Information Systems Research, providing a structured and systematic approach to developing innovative solutions.

A noteworthy application of technology in sports is evident in collision-intensive games like rugby, where player safety and performance optimization are paramount. Naughton et al. (2020) conducted a comprehensive review, meta-analysis, and critical analysis to quantify the collision dose in Rugby League. The study offers valuable insights into the physical toll on players, shedding light on the intricate relationship between the intensity of collisions and player workload. Such quantification is a foundation for coaches and medical staff to tailor training regimens, manage player workloads effectively, and mitigate the risk of injuries.

Turning attention to the technical proficiency in fundamental aspects of rugby, Hollander et al. (2021) embarked on a systematic scoping review focusing on tackle and ruck techniques in rugby union and rugby league. This research delves into the nuanced intricacies of these core elements, providing a comprehensive understanding of the technical aspects that drive player performance. By exploring the nuances of player techniques, coaches gain valuable insights for refining training programs and enhancing the skill sets of their players. This aligns seamlessly with the overarching objective of leveraging technology to optimize and elevate the technical facets of gameplay.

Biomechanics, a crucial facet of sports science, takes centre stage in the study by Edwards et al. (2021). The researchers explore the realm of 3D biomechanics, explicitly focusing on rugby tackle techniques. Through a systematic review, the study dissects the biomechanical intricacies of tackles, offering a nuanced perspective beyond the surface level. This understanding of biomechanics contributes to the theoretical underpinnings of sports science and lays the groundwork for practical applications in rugby research and coaching.

The study by Powell et al. (2021) focuses on wearable technology's application in rugby union for digital sports-related concussion evaluation. Wearable technology is another critical component of technological integration in sports. With real-time data that surpasses standard monitoring techniques, wearables have become indispensable instruments. Wearables provide a means of quickly diagnosing and treating concussions in rugby games, where player safety is paramount. This real-time data helps with ongoing efforts to improve player safety and well-being and is a diagnostic tool.

The studies above underscore technological advancements' dynamic and multifaceted nature in the expansive landscape of sports technology. From quantifying collision doses to dissecting the technical proficiency in gameplay and delving into the intricacies of biomechanics, technology is not merely a facilitator but a catalyst for innovation and progress in sports science. The fusion of technology and sports science extends far beyond the individual athlete, permeating the broader ecosystem of coaching, sports medicine, and performance analysis. With insights from collision dose quantification and technical proficiency studies, coaches can tailor training programs to individual player needs, maximizing performance potential while minimizing the risk of injuries.

Moreover, the advancements in wearable technology, as exemplified in the study on digital sports-related concussion assessment (Powell et al., 2021), contribute to a paradigm shift in how sports-related injuries are diagnosed and managed. Real-time data from wearables not only facilitates quicker and more accurate concussion assessments but also informs ongoing research and development in the field of sports medicine. Sports technologies, particularly in Rugby is changing the game and how we view sports science. Technology integration drives innovation, research, and sports evolution. The studies show how technology becomes an essential collaborator in pursuing excellence, safety, and a better knowledge of sports performance dynamics.

2.2.2. Areas

There is a lot of interest in applying wearable technology in sports. Seçkin et al. (2023) offer a thorough analysis, exploring the ideas, difficulties, and possibilities related to wearable technology in sports. Smartwatches and fitness trackers are only two examples of wearable technology that have proven crucial for tracking athletes' performance and advancing the use of data in training and health care.

Workload monitoring has become a key component in team sports in improving athletic performance. In a scoping review on the "workload a-WEAR-ness," Benson et al. (2020) emphasized wearable technology to measure and examine athletes' physical demands during practice and competition. This field investigates how coaches and sports professionals may make educated judgments to maximize players' training loads and avoid injuries using real-time data from wearable devices.

Bădescu et al. (2022) narrative review from 2022 examines the connection between technology and sport. This more comprehensive viewpoint includes a range of technology-based interventions in sports-related domains, such as fan interaction and training approaches. The review highlights the disruptive impact of technological innovations on the sports environment and identifies the connectivity between sport and technology.

The nexus between sports and surveillance technologies is an essential issue in the larger context of sports technology. In their investigation of this topic, Jones et al. (2022) discuss the problems and ramifications of monitoring technologies in sports. This field examines the moral and privacy issues surrounding using technology to track athletes, fans, and events. It poses problems about how to strike a balance between innovation and protecting people's rights.

Husain et al. (2021) examine electric drive technology trends in sports within a larger technological framework. Although not directly related to wearable technology, this field is essential because it clarifies the larger technical environment that affects sports, such as the advancement of electric cars and their possible effects on infrastructure and sporting events.

Sharp et al. (2022) explore the prospects and challenges in mental health promotion in sports. Although it has nothing to do with wearable technology, this field is essential to comprehending athletes' overall well-being. The study examines the difficulties men encounter when talking about mental health and emphasizes how technology may help create environments and solutions that are supportive of mental health in sports.

2.2.3. Types of technologies

Integrating multiple technologies has become crucial in sports, delivering varied solutions that cater to some aspects of athlete performance and training. Modern technology, as defined by Mali & Dey (2020) has substantially altered sports performance, and one central area within this landscape is wearable technology. Wearable gadgets, particularly fitness trackers and smartwatches, have emerged as vital instruments for real-time monitoring of athletes' physiological characteristics. These gadgets provide insights into critical variables such as heart rate, sleep habits, and activity levels, offering coaches and athletes valuable information for enhancing training programs and maintaining general health.

Performance analysis technologies, as explored by Lorains et al. (2013), constitute another critical category that has reshaped the landscape of team sports, including rugby. Video-based performance analysis systems have become integral for coaches seeking to dissect players' movements, decision-making processes, and overall performance during matches and training sessions. The detailed insights from performance analysis contribute to a nuanced understanding of player dynamics, facilitating informed decision-making in refining strategies and enhancing individual and team performance.

Biomechanics technology is essential for deciphering the subtleties of player movements and methods, especially in contact sports like rugby, as described by Edwards et al. (2021). A detailed analysis of players' trends is made possible by 3D biomechanics technology, which provides a thorough grasp of the biomechanical components of actions like

tackles. This kind of technology helps to maximize player performance, reduce the danger of injury, and determine the best tactics.

Naughton et al. (2020) have highlighted the importance of collision monitoring technology in rugby. These technologies aim to shed light on the frequency and severity of such incidents by measuring the amount of physical contact during rugby matches. This data is crucial for controlling players' workloads, reducing the chance of injuries, and maximizing recuperation tactics in a sport where physicality is critical.

Furthermore, as highlighted by Peffers et al. (2007), sports analytics technologies are an advanced class of instruments that utilize complex statistical models and data analytics capabilities. Coaches and analysts can gain deep insights into player performance, team dynamics, and strategic considerations by using integrated sports analytics, making comprehending massive datasets easier. Teams' approach to performance optimization has changed dramatically due to this evidence-based decision-making process, making training programs and game strategies much more successful.

2.2.4. Technologies for rugby

Technology integration in rugby has increased dramatically to improve player performance and the game. Naughton et al. (2020) state that the collision dosage in rugby league has been measured using systematic reviews, meta-analyses, and critical analyses. This entails a thorough examination of the physical demands on players throughout games, offering insightful information about how collisions affect player performance and well-being. Hollander et al. (2021) carried out a comprehensive scoping review on tackle and ruck technical proficiency in rugby league and rugby union in 2021. The study sheds light on the nuances of these crucial game elements by examining the technical aspects of tackling and rucking in both rugby codes. Comprehending technical proficiency is essential for creating training plans and techniques that minimize injuries.

Furthermore, Edwards et al. (2021) add to the body of work that examines the three-dimensional biomechanics of rugby tackle tactics. Their systematic review, which explores the biomechanical components of tackling, guides future rugby research practice. This gives researchers and coaches a starting point for improving tackle mechanics and lowering injury risks. An encompassing perspective on contemporary technologies and athletic performance is offered by Mali & Dey (2020). This synopsis highlights the broader uses of technology in sports, such as rugby. It sets the groundwork for a more thorough investigation of technologies to monitor and enhance athletic performance. Rugby has seen a rise in the use of wearable electronics, as noted by Powell et al. (2021). The rugby union's multimodal digital sports-related concussion diagnostic methodology, which uses wearables, demonstrates how cutting-edge monitoring technologies can improve player welfare and injury control. A thorough analysis of wearable technology in sports is provided by Seçkin et al. (2023), who

also discuss potential problems and prospects. This analysis helps to clarify the various uses of wearables in sports, such as keeping an eye on players' health and performance—a vital function in rugby.

Using wearable technology, Benson et al. 2020_ conducted a scoping review on workload awareness in team sports. The study highlights how crucial workload monitoring is to maximizing training and performance in team sports like rugby. This supports the idea that optimizing player potential and preventing injuries require controlling and modifying workload. Bădescu et al. (2022) provide a narrative review of the relationship between sport and technology in a more general setting. This extensive synopsis offers valuable perspectives on the past and present developments in the interplay between sports and technology, paving the way for a more in-depth investigation of particular technologies in rugby.

2.2.5. Challenges and Opportunities

Rugby technology integration has many advantages, but it also has drawbacks and potential. The nexus between sport and surveillance technology is explored by Jones et al. (2022). The study examines the effects of monitoring technologies in sports, bringing up moral issues and emphasizing the need to balance privacy rights and performance improvement. The electric drive technology developments, obstacles, and prospects for upcoming electric vehicles are discussed by Husain et al. (2021). Although unrelated to rugby, the study draws a link by highlighting the necessity of adjusting to technological trends and tackling obstacles in the way of further developments. This aligns with the opportunities and difficulties of using new technologies in the sports industry, particularly rugby.

Morley (2020) explores challenges and opportunities in magnetospheric space weather prediction. Although not directly linked to rugby technology, the study underscores the broader theme of navigating challenges and leveraging opportunities in a technologically driven context. This broader perspective informs the discussion of challenges and opportunities in the technological landscape of rugby.

Sharp et al. (2022)_ conducted a focus group study exploring challenges and opportunities for men's mental health promotion. While not directly related to sports technology, the study addresses challenges, and opportunities differently, emphasizing the importance of considering broader societal implications when integrating technology into various domains, including sports.

While the current literature provides valuable insights into integrating technology in rugby and its multifaceted impact on player performance and safety, notable gaps warrant further exploration. One significant gap lies in the limited attention given to the long-term effects and sustainability of technology interventions in rugby. Most studies focus on immediate benefits and applications, but more research should investigate these

technologies' extended consequences, potential drawbacks, and adaptability over time. Future research should address wearable devices' durability and evolving efficacy, biomechanics technologies, and performance analysis tools in rugby's dynamic and physically demanding context.

Moreover, a distinct gap exists in understanding the psychological aspects of athletes' interaction with technology in rugby. While studies touch upon the physical and tactical dimensions, more research needs to explore how athletes perceive and respond to the increasing integration of technology into their training and performance environments. Investigating athletes' attitudes, motivations, and potential stressors related to technology use can offer crucial insights for optimizing the design and implementation of these tools. Understanding the human-technology interaction in rugby is pivotal for ensuring that technological advancements align with athletes' needs and contribute positively to their overall well-being.

3. METHODOLOGY

The methodology used in this study is Design Science Research (DSR). The decision was based on the goal to develop an artifact that will help the rugby coaches and teams to achieve the maximum value able to take out of all Technologies to track and improve the athlete's performance.

The output of the DSR method may not be a tangible item, but it can still be considered as part of the conceptual category of applications, which encompasses design theories, models, methods, principles and technological rules according to The Australian National University et al. (2013). In this paper it is also emphasized that the abstract knowledge produced through the DSR process can eventually be converted into a physical solution, making the DSR methodology a valid choice.

3.1. DESIGN SCIENCE RESEARCH (DSR)

The DSR Knowledge Contribution Framework proposed on the paper The Australian National University et al. (2013) categorizes the type of research to be conducted based on two axes: the maturity of the solution and the maturity of the application domain as it is presented in the following graph.

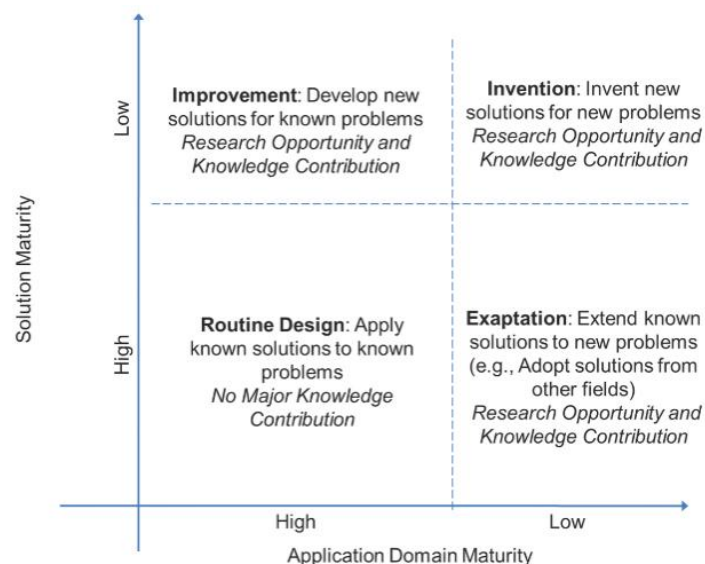


Figure 1 – Framework maturity (The Australian National University et al., 2013)

This study can be classified as routine design once that the goal is to collect all the technologies available to track and improve the performance of rugby athletes existing in a market. Which will help the coaches and the teams to get access to it and make better decisions on which gadgets to use when training the athletes.

According to Peffers et al. (2007) Design Science Research Methodology (DSRM) is crucial for the progress of Information Systems (IS) research once that it provides a systematic and rigorous approach for developing new solutions and evaluating their effectiveness. DSRM emphasizes the creation of new and valuable artifacts, such as information systems, that have a positive impact on organizations and society. The authors also note that DSRM provides a structured approach for IS researchers to design, develop, and evaluate new IS solutions in a rigorous and repeatable manner. This structured approach leads to an increase in the quality and relevance of IS research, as well as the potential for IS research to have a significant impact on organizations and society. The authors conclude that DSRM is a valuable and necessary approach for IS researchers to create new and useful information systems that solve real-world problems.

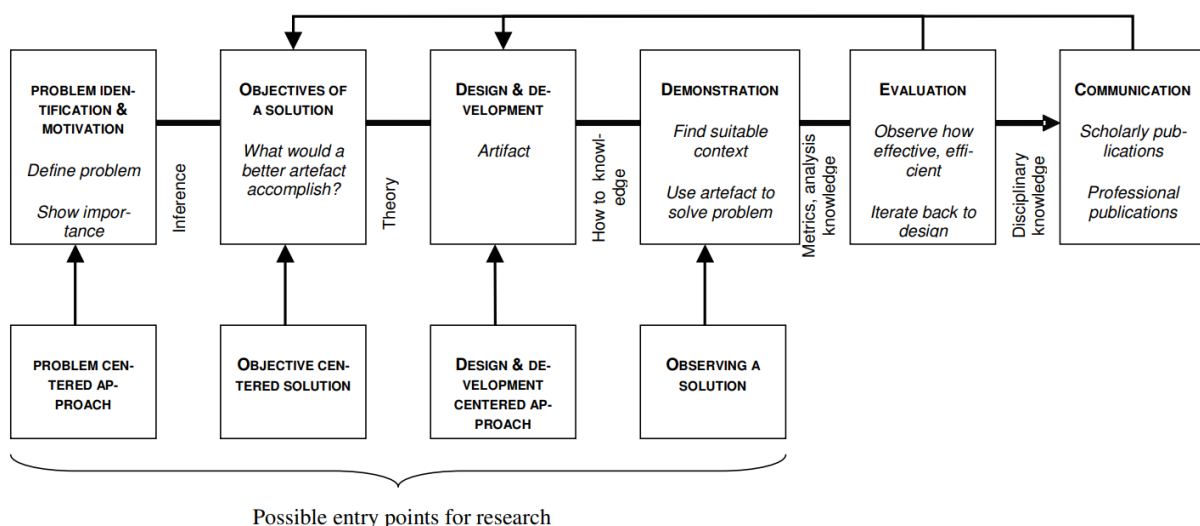


Figure 2 – Design Science Research Process (Peffers et al., 2007)

To provide a structured and systematic approach for IS researches, Peffers et al. (2007), presented in this paper six stages of the Design Science Methodology: Identify problem and motivation (to outline a detailed and complex problem in a clear manner, highlighting its significance and the worth of the proposed solution, using a thorough understanding of the current situation and the significance of resolving it); Define objectives (the goals of a solution can be logically deduced from the problem description and classified as either numerical or descriptive based on the nature of the problem and solution being presented); Design and development (developing an implementable solution that consists of various elements, such as models, methods, and designs, while also defining its functions and structure);

Demonstration (the effectiveness of the solution in resolving the problem is shown through practical testing, simulations, real-life examples, evidence, or other relevant methods); Evaluation (when evaluating how the solution helps address the problem, considering the type of problem and solution, its functionality should be compared to the established goals, determining if improvements are necessary and requiring a return to the Design and Development phase, or if it is feasible to move on to the next stage of evaluation); and Communication (The information regarding the problem, its significance, the design of the solution, and its effectiveness is effectively communicated to researchers and relevant stakeholders) (figure 2).

For Hevner & Chatterjee, (2010) in order to gain the Key insights of a design search project the Relevance Cycle, the Design Cycle and the Rigor Cycle need to be present as it is shown in the figure (3).

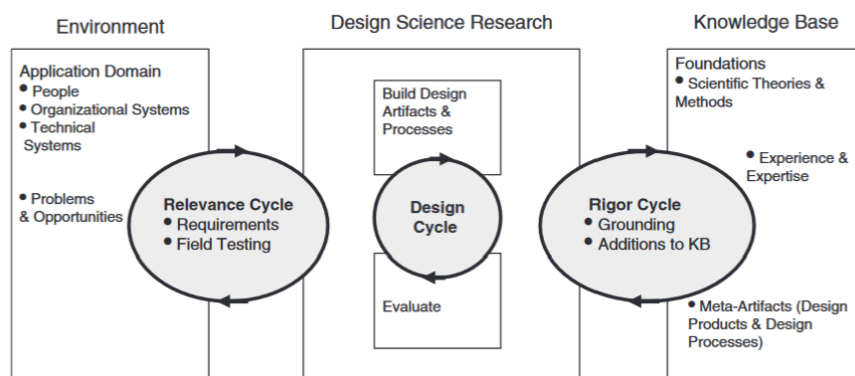


Figure 3 – DSR cycle (Hevner & Chatterjee, 2010)

3.2. RESEARCH STRATEGY

Based on the DSR methodology, the research strategy to develop the present study is:

Identify problem and motivation:

The literature review will explore the topic by delving into a comprehensive investigation of rugby sport and the existing technologies within sports, particularly focusing on the rugby discipline.

Define objectives:

The intended creation aims to offer a framework for rugby clubs of all sizes, aiding them in selecting suitable technologies for monitoring and enhancing player performance. It is anticipated that this initiative will have a positive impact on players, as their performance is expected to significantly improve.

Design and development:

Within the thesis demonstration, I will present two matrices detailing technologies aimed at monitoring and enhancing the performance of rugby athletes. The first matrix will outline currently existing technologies, while the second will propose recommendations for future technological advancements based on the literature review.

Evaluation:

For this project, it was determined that the most effective method to assess the performance, reliability, usability, and utility of the artifact was through the implementation of a questionnaire comprising various inquiries pertaining to rugby technologies and athlete performance.

Communication:

The presentation of this thesis will serve as the platform to introduce the proposed technological solution to the public, including rugby club management seeking to enhance athlete performance. It will also target the market of sports technology solutions, with a particular focus on software developers, technology companies, and consulting firms involved in improving and tracking athlete performance in rugby. This communication is expected to outline the capabilities of the technology, its potential benefits for rugby athletes and clubs, as well as any limitations in its development and implementation. Additionally, it will propose avenues for future research in the field of sports technology, particularly in relation to rugby.

4. REFERENTIAL FOR UTILIZATION OF TECHNOLOGIES TO IMPROVE THE PERFORMANCE OF RUGBY PLAYERS

4.1. ASSUMPTIONS

By integrating technological solutions, rugby teams gain access to a wealth of specific player metrics. For instance, wearable devices can track an athlete's heart rate, distance covered, and acceleration throughout a match, providing valuable data on fatigue levels and overall physical exertion. GPS tracking enables coaches to analyse player movement patterns on the field, identifying areas for improvement in positioning and spatial awareness. Additionally, video analysis software allows teams to dissect attacking plays frame by frame, pinpointing moments of brilliance and areas needing refinement. This synergy between athleticism and technology marks a paradigm shift in rugby strategy, offering unparalleled insights and a decisive edge on the field.

Video

Utilizing video footage to enhance and track the performance of rugby players offers a comprehensive approach to analysis and development. As highlighted in various studies, including Islam (2020) and Jacobsson et al. (2023) integrating drones into video capture processes presents unique advantages for teams sports like football but the same capabilities can be integrated in rugby.

Video footage serves as a fundamental tool for performance analysis in rugby, enabling coaches and analysts to review player actions, team formations, and strategic interactions during training sessions and matches. By recording from multiple angles, including aerial perspectives facilitated by drones, teams can capture a holistic view of player movements and tactical dynamics on the field. This detailed analysis allows for the identification of strengths, weaknesses, and areas for improvement at both individual and team levels.

One significant advantage of using drones to capture video footage lies in their ability to provide aerial perspectives and dynamic tracking capabilities. Drones equipped with high-resolution cameras can capture footage from various vantage points, offering comprehensive coverage of the field and players' actions. This aerial viewpoint enables coaches to analyse player positioning, spatial awareness, and movement patterns in greater detail, leading to more informed coaching decisions and strategic adjustments.

Additionally, drones equipped with depth camera-based motion capture systems offer advanced capabilities for sports performance analysis. These systems utilize 3D imaging technology to track player movements with precision, providing accurate data on velocity, acceleration, and biomechanical parameters. By overlaying this data onto video footage,

coaches can gain insights into player kinetics, joint angles, and dynamic interactions, facilitating targeted interventions to improve technique and reduce injury risks.

Moreover, drones enhance the efficiency and effectiveness of video analysis processes in rugby. With their agile manoeuvrability and remote operation capabilities, drones can capture footage from multiple angles and perspectives with minimal disruption to training sessions or matches. This streamlined approach to video capture allows coaches and analysts to focus on extracting actionable insights and delivering timely feedback to players, ultimately enhancing learning and performance outcomes.

Wearable technologies

Wearable technology presents a promising avenue for enhancing and tracking the performance of rugby players, as highlighted in the paper Seçkin et al. (2023). These advanced devices offer a range of benefits tailored to the dynamic demands of rugby.

One key advantage of wearable technology in rugby lies in its ability to provide real-time data on player metrics such as heart rate, speed, distance covered, and acceleration. By equipping players with wearable devices during training sessions and matches, coaches and sports scientists can gain insights into players' physiological responses and physical exertion levels. This data enables personalized training programs, optimized recovery strategies, and informed decisions regarding player workload management.

Moreover, wearable technology allows for the monitoring of biomechanical parameters and movement patterns, offering valuable insights into player technique and injury risk. For instance, inertial measurement units (IMUs) embedded in wearable devices can track players' body movements and detect deviations from optimal biomechanics, signaling potential injury risks or areas for technique refinement. By identifying these factors early on, coaches and medical staff can implement targeted interventions to prevent injuries and optimize player performance.

Additionally, wearable technology facilitates performance analysis and feedback loops, enabling coaches to provide immediate insights and corrections to players during training sessions and matches. For example, smart shirts equipped with sensors can detect players' body positioning and posture, allowing coaches to provide real-time feedback on alignment and movement mechanics. This instantaneous feedback fosters skill acquisition, accelerates learning, and enhances player development over time.

Furthermore, wearable technology promotes data-driven decision-making and strategic planning in rugby. By aggregating and analyzing data collected from wearable devices, coaches and analysts can identify trends, patterns, and performance indicators at both individual and team levels. This holistic understanding enables evidence-based decision-making regarding

player selection, game tactics, and training program design, ultimately leading to improved performance outcomes on the field.

GPS

Incorporating Global Positioning Systems (GPS) into rugby offers a wealth of opportunities to enhance player performance and meticulously track key metrics, as expounded upon in the paper Cummins et al. (2013). This thorough examination underscores the profound impact GPS technology can have on optimizing player performance and refining tactical strategies in rugby.

GPS devices worn by rugby players during training sessions and matches provide real-time data on various performance parameters, including distance covered, speed, acceleration, and changes in direction. This comprehensive dataset offers coaches and sports scientists unparalleled insights into players' physical exertion levels, movement patterns, and positional effectiveness, allowing for the development of tailored training programs and game strategies to maximize performance outcomes.

One significant advantage of GPS technology in rugby lies in its ability to monitor player workload and fatigue levels. By analysing data collected from GPS devices, coaches and medical staff can gauge players' physiological responses to training loads, identify signs of overexertion or fatigue, and adjust training intensities and recovery protocols accordingly. This proactive approach to workload management helps mitigate injury risks and optimize players' overall health and performance throughout the season.

Furthermore, GPS technology enables coaches to conduct detailed performance analysis and tactical evaluations. By overlaying GPS data onto match footage, coaches can assess players' movement patterns, positioning, and decision-making in real-time, identifying areas for improvement and refining game strategies accordingly. This granular analysis fosters a deeper understanding of player dynamics and team performance, ultimately leading to enhanced on-field success.

4.2. REFERENTIAL

We can separate rugby gameplay in 3 parts:

Attack

Attacking in rugby hinges on four vital components: passing, plays, tactics, and dribbling. Passing maintains possession and creates space. Strategic plays exploit defensive weaknesses, fostering cohesive manoeuvres from scrums or open play. Tactical decisions adapt to match dynamics, dictating when to run, pass, or kick. Dribbling, though less common, offers agile players opportunities to evade defenders. Mastery of these elements forms a dynamic attacking strategy, crucial for breaching defensive lines and creating scoring opportunities on the rugby field.

Defence

Defending in rugby relies on tackles, positioning, and opponent knowledge. Tackling with proper technique halts opponents' progress and regains possession. Strategic positioning forms a cohesive defensive line, minimizing gaps and anticipating attacking moves. Understanding opponents' tendencies and patterns enables defenders to anticipate actions, apply pressure, and disrupt the opposition's game plan. By mastering these aspects, defenders create a resilient defensive unit, capable of thwarting attacks and securing turnovers on the rugby field.

Formations

Formations in rugby are strategic arrangements crucial for effective gameplay. Four key formations include scrums, rucks, lineouts, and conversions. Scrums involve players from both teams binding together to contest possession after a minor infringement. Rucks occur when a player is tackled and players from both teams compete for the ball on the ground. Lineouts are set piece plays where players lift teammates to catch the ball thrown in from touch. Conversions follow a try, with the scoring team kicking the ball through the goal posts to earn extra points. Understanding and executing these formations are essential for success on the rugby field.

	Attack			
Areas	pass	Play	Tatics	Dribble
Wearable Technologies	1. Heartbeat measurement			2. Fatigue measurement
Video	3. Quality of pass	4. Play analysis	5. Tactics Analysis	6. Movement Analysis
Global Positioning System (GPS)		7. Positioning corrections	7. Positioning corrections	

Table 1 – Attack recommendations matrix

	Formations			
Areas	Scrums	Lineout	Ruck	Conversions
Wearable Technologies	8. Strength applied in the scrum			
Video	9. Scrum alignment correction	10. Jump and lift technique	11. Support correction on rucks	12. Kicking technic
Global Positioning System (GPS)				

Table 2 – Formations recommendations matrix

	Defence		
Areas	Tackles	Positioning	Opponents knowledge
Wearable Technologies	13. Collision impact measurement		
Video	14. Tackle improvement	7. Positioning corrections	15. Past games analysis
Global Positioning System (GPS)		7. Positioning corrections	

Table 3 – Defence recommendations matrix

1. Heartbeat measurement

The heart beat measurement is a very common feature from wearable technologies like smartwatches, therefore this is a technology that can measure the pressure that a player can be under during the game and can be used to understand what are the most challenging moments of a game, which a lot of times are the passes made by players specially close to their own try area or the opposite team's try area.

2. Fatigue measurement

Measuring fatigue in rugby is crucial for improving player performance, ensuring effective game strategies and preventing injuries. It helps coaches to adjust the workload during training and the decision making of the substitutions. When tracking the fatigue of players, teams can increase players longevity and achieve better results both individually and as a team.

3. Quality of pass

Improving the passing technique of rugby players is vital for fluid gameplay, effective attack strategies, and maintaining possession. Video analysis help this improvement by providing precise feedback on techniques and identifying errors. Coaches and players can review successful passes, make informed adjustments and understand game dynamics.

4. Play analysis

Play analysis is one of the most crucial advantages of video analysis because it is where we can the most input on attacking strategies. Video footages of trainings and games provide detailed visual feedback on attacking plays, allowing teams to study successful strategies and pinpoint areas for improvement. Players can better understand their roles, improve decision-making, and develop more effective attacking patterns, leading to increased scoring opportunities and overall team performance.

5. Tactics Analysis

Tactics analysis is essential in rugby for optimizing team strategies and countering opponents. It can be both highly analysed by video footages and Global Positioning System (GPS). On one hand video assists coaches and players understand successful tactics and identify strategic weaknesses. GPS technology tracks player movements and positioning, providing valuable data on team formations and spatial dynamics. Together, these technologies enhance the

tactical perspective by refining team coordination, improving decision-making, and developing more effective game plans, ultimately leading to superior strategic execution on the field.

6. Movement Analysis

Understanding player dynamics and team coordination in rugby is done by the movement analysis. This analysis can be done with video technologies and gps. The first allows detailed review of individual and team movement, identifying effective patterns and areas for improvement. GPS technology tracks player positions, speeds, and distances covered, providing data on spatial dynamics and player efficiency. Together, these technologies enhance attacking tactics by refining positioning, improving decision-making, and developing more cohesive and effective offensive strategies, ultimately boosting team performance and scoring opportunities.

7. Positioning corrections

GPS and video technology in rugby enables precise tracking of player positions and movements, facilitating positioning corrections in both attacking and defending. GPS tracks player movements and positions, highlighting spatial dynamics and inefficiencies, while video analysis visually captures these moments, showing real-time gameplay and tactical execution. For attacking, this combined data helps optimize spacing, timing, and exploitation of defensive gaps. For defending, it ensures proper alignment, gap coverage, and tracking of opponents.

8. Strength applied in the scrum

Wearable technologies in rugby, such as sensor-embedded garments and smart devices, can accurately measure the strength and force applied during scrums. These devices capture real-time data on metrics like force exertion, body angles, and pressure distribution. Coaches and analysts can use this information to assess individual and team performance, identify technique improvements, and optimize training programs. By providing precise feedback, wearable technologies help players enhance their scrum techniques, increase overall scrum efficiency, and reduce the risk of injury.

9. Scrum alignment correction

Video analysis improves scrums in rugby by providing detailed visual feedback on technique, body positioning, and team coordination. By reviewing footage, players and coaches can

identify technical flaws, such as incorrect binding or poor posture, and understand how this impact scrum effectiveness. This analysis allows for targeted corrections, ensuring better alignment, timing, and force application. Continuous review and adjustment through video help players refine their techniques, enhance team synergy, and ultimately achieve more powerful and efficient scrums.

10. Jump and lift technique

By reviewing footage, players and coaches can have detailed visual feedback on timing, coordination, and body positioning. Which they can use to identify flaws in the jump or lift execution, such as improper hand placement or timing issues. Continuous analysis helps players synchronize their movements better, ensuring more effective and efficient lineouts, ultimately enhancing overall team performance during matches.

11. Support correction on rucks

By reviewing footage, players and coaches can identify issues such as delayed support, incorrect body angles, or poor entry points. This allows for targeted adjustments and drills to enhance ruck support. Continuous video review helps players understand their roles better, synchronize movements, and maintain proper body posture, leading to more effective and secure ruck formations, improved ball retention, and overall team performance.

12. Kicking technic

Video recordings of practice or games are the best option when improving the quality of technic both for conversions or in-game kicks. It can provide detailed feedback on technique, body positioning and timing which can be analysed by the coaches and players to identify and correct flaws like foot placement, kicker's approach and strike in conversions. On the other side when analysing the footages it is also possible to improve the decision-making and execution under pressure. This targeted feedback and continuous adjustment lead to more accurate, powerful, and consistent kicks which is a very needed field because it can lead to a lot of points.

13. Collision impact measurement

Collision impact measurement in rugby helps players and coaches with data to enhance player safety by identifying potentially dangerous collisions, allowing for timely interventions. Coaches can optimize training intensity, reducing injury risk and improving recovery protocols. Additionally, analysing impact data helps refine tackling and collision techniques, promoting safer and more effective play. Overall, this technology supports better performance, player health, and informed tactical decisions, contributing to a more efficient and safer rugby environment.

14. Tackle improvement

Players and coaches can identify flaws such as poor body positioning, incorrect foot placement, or timing issues when reviewing footages from the players, his allows for targeted corrections and focused training to refine tackling techniques.

15. Past games analysis

By reviewing footage, teams can identify and correct mistakes, refine strategies, and enhance techniques. Studying opponents' tactics and formations allows teams to anticipate and counter their moves. This continuous learning process improves decision-making, coordination, and overall gameplay. Ultimately, video analysis fosters better preparation, adaptability, and confidence, leading to improved performance in future games.

4.3. EVALUATION AND DISCUSSION

The validation of the artifacts relevant to the development of rugby athletes was conducted through an interview. Given the specificity of the topic, expert opinions were required, allowing for greater contextualization.

4.3.1. Target audience

The sample included in this interview is consisted by a captain of a rugby team from Germany's regional division, who possesses extensive insider knowledge of the needs and limitations associated with new techniques and technologies for tracking and enhancing athlete performance. This approach provided a better understanding of which artifacts have the greatest feasibility. The interviews were anonymous and recorded exclusively for this study.

4.3.2. Interview Guide

The objective of the interview was to validate the recommendation of technologies, understand the needs of smaller teams and understand which of the technologies are the most appropriate to the teams when there are some financial limitations. The interview started with a presentation of the paper purpose and the technologies that are been presented to help the interviewee to understand the goal of the study. After the introduction the questions followed this structure:

Interview Guide	
Technologies	Opinion about the importance of technologies in training athletes
Experience with technologies in training	Understand what the experience with these technologies is
Opinion on the recommendations	Obtaining the opinion from the interview on how accurate the recommendations are
Budget priorities	Understand what the priority of rugby teams is when it comes to invest in technologies to improve performance

Table 4 – Interview Guide

4.3.3. Transcript of the interview

What is your opinion on how can technologies that track and improve the performance of athletes in rugby?

Of course, every additional technique is an additional way of assessment so of course you can always improve with that. But in the end of the day, we are talking about techniques that professional teams use and have the means for them like British premiership or top14 in France. They have access to all those technologies and data acquired from it which are additional input for decision making, because you have more information to have a richer decision when it comes to decide the start 15 or when to make a substitution, which type of exercises we are doing in practice. And of course 2 teams with the same quality of players will have always advantages against the other team if they use any type of technologies to improve their performance.

Have you ever used technologies while training or playing rugby? If yes which ones?

Yes, we have. the most dominant analyses technology was the video recordings. Every time that our team has the opportunity to watch the previous match it is super helpful for us. We can analyse our formations, our tactics, however individual analyses of players during the entire game are a bit difficult to analyse due to the distance aligned with the lack of quality and the distance of the cameras. But it is very useful to analyse the overall game. On the other hand, we have some time analyses where we use digital watches to track some individual performances, but it is indeed quite limited. But when combined with video analysis you can make some useful analyses. For example, track the time between the ruck is formed and the rest of the team is positioned to be able to pass and continue to play. Also, we record regularly the scrums during train to correct the positioning. Apart from these 2 technologies we haven't used them, and from the information I have from other teams on our level GPS or wearable technologies are not common to be used.

What is your opinion on the recommended technologies for improving the athlete's performance and which one do you think is the most important for smaller teams to have?

I agree that those are the most useful and easiest technologies to have and use for smaller teams. Video is the definitely the technology which would help the most because it is the easiest to access and analyse, once that it can be done by the coaches and the athletes all at the same time by reviewing the previous match and analyse what has been done correctly and what should be improved in each moment of the game, which is something that we are doing in our team when there is someone from the spectators or the opponent team that has this cameras. Because on amateur level we are quite dependent on the individual effort and

individual provider of infrastructure. Because as a team this type of devices with the correct programs to record, follow the gameplay and the movement of the ball are quite out of the budget.

Both wearable technologies and GPS are good in tracking individual parameters of a player. Wearable technologies but at our level it is also used from players on their own for example with smart watches, which nowadays have a lot of functionalities related with your body functions like the heart rate for example which can be used by coaches when it comes to substitution decision making. GPS on the other hand it is used to track individual movement of a player which is useful, but I don't know the actual use of it because what counts is the match, the spontaneous decision on the field and I don't know how this information could help inside of a match. Also, because video even if with some limitations, can deliver the same information and with limited budget and resources it would be the one with the least priority.

What is the order of priority of your team when it comes to investments, would you go for technologies for athletes' improvement, or do you have higher priorities?

When it comes to funding an amateur German team, the number 1 priority is funding the youth teams and coaches because once rugby is not the most known and played sport there is a big lack of players that would grow the visibility of the sport in the future. So, when a team with limited funds needs to choose between new technologies and a new coach for the younger teams, we would always choose the new coach.

Recommendations after the interview	
Video	Invest in video recording equipment and software for match analysis.
	Use video analysis to review matches, focusing on formations, tactics, and overall game strategy.
	Record training sessions, particularly scrums, to correct positioning and improve technique.
	Despite limitations such as camera quality and distance, video analysis remains the most accessible and useful tool for smaller teams
Wearable Technologies	Encourage the use of wearable technologies, such as smartwatches, by individual players to track personal fitness parameters like heart rate.
	Utilize data from wearables to inform coaching decisions, particularly regarding player substitutions and individual conditioning programs.
	While more sophisticated wearable technology may be beyond the budget of smaller teams, basic fitness trackers can still provide valuable insights into player health and readiness.
GPS	Given budget constraints, prioritize video analysis tracking lower than GPS but consider it as a future investment as knowledge and resources allow.
	Although the practical application of GPS data in amateur matches may be unclear, it can still offer useful information on player positioning and movement patterns

Table 5 – Recommendations after the interview

4.4. GLOBAL ANALYSIS

Through the conducted interview it was possible to gather the opinion of a specialist in the area which provided essential insights which were crucial for the ultimate objective of this study. During the interview it was clear that using technologies in sports and more precisely in rugby is crucial to improve the performance of the team and the individual athletes.

In modern top-tier rugby, using technologies to gain a competitive edge is increasingly crucial, making the difference between winning and losing. But for smaller teams it can also be a game changer specially in a level where barely any team has access to it. The interviews revealed the current small influence of various technologies in amateur level rugby and some possibilities that have yet to be fully explored. Any advantage in individual and team performance is vital, as it enables reaching new levels of competition, surpassing the physical, technical, tactical, and psychological demands inherent at the highest levels.

During the interview it was possible to understand that the presented technologies are indeed the most useful and easiest to use for amateur teams and that video from the 3 of them is the one that stands out the most because of its versality and range of metrics it can explore and evaluate. Wearable technologies are technologies which are used mainly to track the physical condition of the athletes and in the context of smaller teams it is reduced to self-usage from each player to track and improve their fitness. Lastly there is GPS and how the precise location on the field can help coaches and players to correct their movement and positioning, for this level of rugby this is probably the least used technology due to the lack of resources and because the positioning of players in the pitch can also be tracked with cameras specially when they are fixed on a higher level.

The interview highlights a significant gap in understanding how to fully leverage technologies to enhance rugby athletes' performance. While the respondent acknowledges the usefulness of video technology, they emphasize the reliance on individual efforts and external providers for acquiring footage, indicating a lack of team-level infrastructure. Wearable technologies and GPS are recognized for tracking individual parameters, but their practical application at the amateur level remains unclear to the interviewee. They express uncertainty about the direct benefits of GPS in gameplay, suggesting a need for better education and resources to integrate these technologies effectively within smaller teams. This underscores the necessity for comprehensive training and investment in technology to realize its full potential in improving performance.

When asked about the order of priority for investments, the respondent highlights that, for an amateur German team, funding youth teams and coaches takes precedence over acquiring new technologies. This focus is driven by the need to grow the sport's visibility and player base in a country where rugby is not widely known. The primary investment is in nurturing young talent and ensuring they receive quality coaching, as this is seen as the foundation for the future of the sport. However, as knowledge and understanding of the benefits of technology

increase, the priority may shift. As coaches and players become more familiar with how technologies like video analysis, wearables, and GPS tracking can enhance performance, the team might begin to recognize the long-term advantages of integrating these tools. This shift would enable teams not only to develop young talent but also to optimize their performance through advanced analysis and data-driven strategies, ultimately leading to better outcomes on the field and a stronger future for rugby at all levels.

5. CONCLUSIONS AND FUTURE WORKS

5.1. SUMMARY OF THE WORK

The objective of this paper was to explore the potential of using technologies to track and improve the performance of rugby athletes in smaller teams. In particular, it sought to identify cost-effective and accessible technologies that can enhance training, monitor athlete performance, and provide valuable insights into player development. By addressing the unique challenges faced by smaller teams, this paper aimed to provide practical recommendations for leveraging technology to achieve competitive advantages in the field of rugby.

The importance of using technologies in rugby clubs cannot be overstated. Modern training methodologies have been revolutionized by the integration of various technological tools that enhance athlete performance and optimize training sessions. Technologies such as video analysis, wearable devices, and GPS tracking have changed the way athletes train by providing precise data on their physical condition, performance metrics, and tactical execution. These tools help coaches and players make informed decisions, improve techniques, and tailor training programs to meet the specific needs of each athlete. As a result, rugby clubs that effectively incorporate technology into their training regimes can achieve significant improvements in both individual and team performance, leading to better outcomes in competitions.

However, despite the clear benefits of using technology, there is a notable lack of knowledge and resources when it comes to smaller rugby teams. Many smaller teams are not fully aware of the potential advantages that these technologies can offer or how to integrate them effectively into their training sessions. This knowledge gap often results in underutilization of available tools and missed opportunities for performance enhancement. Additionally, smaller teams may face budgetary constraints that limit their ability to invest in advanced technologies. Consequently, there is a pressing need for educational initiatives and resource allocation strategies that can help bridge this gap and enable smaller teams to take full advantage of technological advancements.

By following the advised technologies presented in this paper, smaller rugby teams can significantly leverage their training sessions. When these technologies are implemented effectively, even smaller teams with limited resources can experience substantial improvements in performance and competitiveness. By educating smaller teams on the advantages and applications of these tools, and by providing practical recommendations for their implementation, it is possible to bridge the knowledge gap and empower these teams to optimize their training sessions. Ultimately, the adoption of technology in rugby training will

not only improve individual and team performance but also contribute to the overall growth and development of the sport.

5.2. LIMITATIONS

The primary limitation of this paper is that it relies on the interview of only one individual, thus reflecting the perspective of a single rugby team. This restricted viewpoint may not fully capture the diverse experiences and challenges faced by other teams. Consequently, the findings may lack generalizability.

5.3. FUTURE WORK RECOMMENDATIONS

A future work could explore the minimum budget required for a small-sized rugby team to acquire essential technologies for athlete performance development. This study would identify cost-effective solutions, including video analysis tools, wearable devices, and GPS tracking systems. By evaluating affordable options and their impact on training and performance, the research aims to provide a practical guide for teams with limited resources. This will help small teams optimize their investments in technology, enhancing their overall competitiveness and player development.

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