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Own Goal or Home Run? Exploring the Implementation of Virtual Reality Training in Football and Baseball Organisations

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Author Comments

Thank you very much to both reviewers for their time and comments on the re-submission. We have updated the manuscript based on the revised comments. All responses to the reviewer comments and subsequent amendments have been highlighted in red font.

Reviewer(s)' Comments to Author:
Reviewer: 1

Recommendation: Major Revision

Comments:
I thank the authors for considering the constructive comments of the reviewers. The paper has been properly revised.

Good luck with your research!

RESPONSE: Thank you very much for your time and feedback.

Additional Questions:
1. Originality: Does the paper contain new and significant information adequate to justify publication?: Excellent

RESPONSE: Thank you for your positive comment.

2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: Very good

RESPONSE: Thank you for your positive comment.

3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: Appropriate

RESPONSE: Thank you for your positive comment.

4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: Excellent

RESPONSE: Thank you for your positive comment.

5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial

impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: Excellent

RESPONSE: Thank you for your positive comment.

6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: Excellent

RESPONSE: Thank you for your positive comment.

Reviewer(s)' Comments to Author:
Reviewer: 2

Recommendation: Minor Revision

Comments:
Thank you for your extensive revisions. I hope you find my comments above constructive and helpful. Good luck on the project.

RESPONSE: Thank you again for your time and comments. All comments have been addressed and highlighted in red font.

Additional Questions:
1. Originality: Does the paper contain new and significant information adequate to justify publication?: I appreciate the authors including management theories in the introduction. To further clarify the significance of the study, the authors should explain how their findings uniquely contribute to those theories in the discussion section.

RESPONSE: We agree that these additions to the introduction warranted further discussion. We have added this to the discussion now (lines 536-566).

2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: The authors addressed my comments adequately by discussing management theories. However, prospect theory seems inappropriate to include here because it relates to individual decision making, not organizational decision making. The explanation that MLB teams have no chance of "losing" because the league does not have relegation is also a bit of a stretch.

RESPONSE: Thank you for your comments here. We agree that we addressed prospect theory as though it was directly relevant to organisational decision-making. However, we still

feel as though it contributes to the discussion, and have therefore amended the wording as opposed to removing it (lines 132-137). We also agree with your second comment and have again amended the wording (lines 132-137).

3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: Although I appreciate the authors' efforts to address my comments, the two issues I raised last time have not been fully resolved.
First, regarding survey respondent recruitment, the authors said, "Respondents were specifically targeted due to a known or assumed belief that their practitioner role within their sporting organisation 1) was or would be central to any knowledge and implementation of VR in the organisation, and 2) had a sufficient understanding of the business strategy and goals of the organisation" (p. 17). However, it remains unclear how the authors ensured that the survey respondents satisfied these criteria. Did they provide potential respondents with the information about the target population when contacting them?
Second, regarding survey questionnaire development, the authors said, "Item generation for the questionnaire was initially based on knowledge gleaned from the existing literature (Gray, 2017; Gray, 2019; Neumann et al., 2018)" (p. 17). However, it remains unclear which items were adopted from which previous research. The authors should report their sources for each scale item.
Finally, the authors mentioned that they conducted a pilot study but did not provide its details. I recommend that the authors create a separate section for a pilot study and clarify its purpose, procedure, and results before reporting the main study.

RESPONSE: We apologise for the continued confusion. When contacting the participants we informed them of the target population and requested that they forward us onto the most relevant individual (if it was not them). Hopefully, this is now clear (lines 185-189). Regarding your second comment, we have now highlighted which pieces of literature were relevant to each section (lines 204-208). Finally, we have provided further details regarding the purpose, procedure and results of the pilot study and put this in a separate section along with the item generation (lines 214-219).

4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: The authors addressed my previous comments adequately. One additional comment I have is: Is the difference between football and baseball organizations in practical use of VR (p. 25) statistically significant?

RESPONSE: We chose to present the descriptive statistics for this section, predominantly due to these sections differing in multiple ways between football and baseball (i.e., different sports with different structures), hence just presenting the percentages and no p values.

5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial

impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: As stated above, the authors should elaborate on how their findings make unique contributions to the relevant literature. In the introduction section, the authors speculated on potential differences between football and baseball organizations based on management theories. After their empirical study, their discussion (pp. 32–33) was still speculative, which gave the impression that their findings did not advance the theoretical understanding of the subject matter. I understand that the current study is exploratory in nature; however, the authors still need to explain theoretical significance of their results.

RESPONSE: Thank you for your comment. We have added a theoretical implications section to the discussion (lines 536-566).

6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: The paper is well written and easy to understand. To further improve readability, I have a few minor suggestions.
1. The introduction section is a bit too long. I recommend that the authors create a new section (e.g., Theoretical Background) after line. 95.
2. I recommend that the authors create separate sections for theoretical and practical implications.

RESPONSE: These changes have been made to the introduction (line 96 & line 160) and the discussion (lines 536-566).

Own Goal or Home Run? Exploring the Implementation of Virtual Reality Training in Football and Baseball Organisations

Abstract

Purpose

Despite the perceived benefits of implementing virtual reality (VR) training in elite sport, arguably the most important element – the perceptions of practitioners – has been largely understudied. Therefore, the present study aimed to explore practitioners' perceptions of VR training in elite football and baseball, with a focus on the important factors, obstacles, perceived knowledge, and practical use of the technology.

Design/Methodology/Approach

A quantitative approach measuring practitioner perceptions via an online questionnaire was adopted. Football respondents (n = 25) represented practitioners from major football leagues across the world, and baseball respondents (n = 15) represented practitioners from Major League Baseball.

Findings

Both football and baseball respondents reported that the most important factor for implementation of VR training was improvement in on-field performance (technical and tactical); whilst cost was viewed as the biggest obstacle. Both football and baseball respondents also noted that the most likely group to receive VR training would be injured and rehabilitating athletes. Mann-Whitney U tests revealed that football respondents perceived coach (p = .02) and executive approval (p < .001) as significantly greater obstacles than baseball respondents.

Originality/Value

This research provides novel and invaluable information for stakeholders within VR regarding what the elite organisations of different sports perceive as the most important factors for implementation, as well as greatest obstacles preventing use. This information should guide future development and marketing of VR training systems in sport.

Key words: Virtual Reality (VR); User Acceptance; Sport Business; Soccer; Football; Baseball.

Introduction

In recent years, there has been an increased desire to explore the possibility of using virtual reality (VR) to train skills in sport (Gray, 2017; Harris *et al.,* 2020). VR can be defined as immersive technology which enables users to interact with a 3D computer generated simulation of a real environment, in real time, using their internal senses and motor skills (Burdea and Coiffet, 2003). There are multiple applications and benefits of using VR in sport, either as an addition to physical practice or in place of it, such as: a) allows for high volumes of repetition (Duking *et al.,* 2018); b) ability to manipulate and gain greater control over the training environment; c) ability to assess the impact of contextual information on performance; d) aids in the rehabilitation of injured athletes and allows training to continue when physical practice does not permit (Bird, 2020; Gokeler *et al.,* 2014); and e) ability to induce anxiety and train athletes for high-pressure situations (Lagos *et al.,* 2011; Stinson and Bowman, 2014). For a comprehensive review on the benefits of VR training in sport, see Gray (2019) and Le Noury *et al.* (2022).

Despite the multiple perceived advantages of VR training, arguably the most important element for implementing VR in elite sport – organisational buy-in – has received scant attention (Mascret *et al.,* 2022). Understandably, recent research has focused on the transfer of skills developed in VR to real-world, competitive scenarios (Gray, 2017; Michalski *et al.,* 2019; Tirp *et al.,* 2015). However, the transfer of skill is largely irrelevant if the organisations that ultimately implement the systems are unreceptive. Whilst in elite sport the on-field performance of teams is critical, in most cases (particularly in the United States), sports organisations function as for-profit businesses (Pittz *et al.,* 2020). As a result, key decision-makers at these clubs need to account for finances across the spectrum, and for the implementation of new technology such as VR training, they will need to consider the cost-to-sporting-benefit ratio. Therefore, the receptivity of these organisations is dependent not

only on the sporting advantage that VR can offer, but also whether they believe it will benefit the organisation as a business. This decision should, in turn, influence VR developers and businesses as they design new, and iterate future, products.

One of the first studies to consider organisation receptivity utilised a qualitative approach to explore barriers and opportunities in the implementation of VR training in elite football (Thatcher *et al.,* 2020). Semi-structured interviews with six coaches and performance analysts from elite football clubs in England, Netherlands, and Norway, revealed four key themes related to barriers (lack of empirical evidence; practicality; quality of software; and cognitive workload), and four key themes related to key opportunities (creation of team models; isolated incidents; player development; and rehabilitation and recovery). The authors emphasised the ability for VR to aid rehabilitation and recovery, especially during periods of the season when physical workload is high, as one of the major potential benefits of VR implementation. The interviews also uncovered coaches actively seek a competitive advantage and are more likely to use technology if rival clubs are not. Greenhough *et al.* (2021) extended this research in elite football to incorporate perceptions of players as well as coaches and support staff. The authors found that performance expectancy (*i.e.,* the degree of belief that VR will improve performance) was the largest contributor toward likeliness to use VR, closely followed by facilitating conditions (*i.e.,* the belief that there are few barriers affecting the implementation of VR). The two major barriers highlighted were the limited evidence base to support VR, and the absence of coach buy-in. The authors note that these factors could be driving scepticism and negative perceptions of VR, resulting in widespread poor first impressions of the technology.

More recently, Mascret *et al.* (2022) explored the intention to use VR before first use in a large sample of 1162 recreational, departmental, regional, national, and international athletes from 17 sports. Regarding level of sport, the authors found that athletes of all levels

demonstrated a significant intention to use VR to increase sport performance, as well as perceiving VR as easy and pleasant to use. Notably for the present study, the football participants rated the perceived usefulness of VR, perceived ease of use, perceived enjoyment, and intention to use VR all as significantly higher than the mean, along with other ball-centred sports such as tennis, basketball, handball, rugby, and volleyball. Therefore, it would appear that if there is resistance from football organisations to implement VR (as evidenced by Thatcher *et al.,* 2020 and Greenhough *et al.,* 2021), this is not driven by the athletes, as they appear to generally have positive perceptions of VR.

The present study aims to build on the previous literature, by exploring the perception of practitioners in the sport of baseball alongside the perceptions of those in elite football, allowing direct comparisons between the two sports to be made. To the authors' knowledge, whilst previous literature has explored the role of VR training in baseball (*e.g.,* Gray, 2017; Ranganathan and Carlton, 2007), to date no studies have explored the perceptions practitioners in the sport of baseball have toward VR training, despite this being one of the most financially viable sports (Forbes, 2021) for the implementation of this training method.

Theoretical Background

Whilst both football and baseball are two sports which appear to have the financial means to invest in new technology such as VR training, there are some key differences between the two sports with regard to the decision-making mechanisms and organisational structure. An example in the differences in organisational structure between sports teams has been identified through research examining Sporting Organisations using a Resource-Based View of strategic management (Berman *et al.,* 2002). The central tenet of this theory is that better resource management affords organisations reduced financial burden or distinct

resources compared to their competitors, resulting in above normal economic performance and thus a competitive advantage (Poppo and Weigelt, 2000).

Indeed, there are institutional differences in the way football and baseball are governed (player spending, mobility, trading etc.) which influence the impact that spending has on success and therefore how funds are allocated within the organisation (Hall *et al.,* 2002). In 2020/21, the average player wage-revenue ratio in the English football's Premier League was 71%, with other elite leagues such as Italy's Serie A and France's Ligue 1 being as high as 82% and 98%, respectively (Deloitte Annual Review of Football Finance, 2022). In comparison, in 2018 the average organisation player wage-revenue ratio in MLB was reported as 54.2%, lower than any of the elite football leagues (Forbes, 2019), with player compensations projected to continue falling. Therefore, it is clear that the spend structure in elite football is quite unique, in that a large amount of club revenue goes directly into player wages. This could suggest why spending in football is under greater scrutiny in comparison to sports such as baseball, which could be manifested in a lack of desire to invest in new technology purporting to provide minimal gains.

Building on this, another interesting difference between elite football and baseball is the general structure of the sports at a holistic level. In all of the major European football leagues, clubs face the constant battle for finishing in a league position to qualify for European football which results in large injections of money into the club. Perhaps more importantly, clubs also face the possibility of relegation to a lower league. For example, relegation from the Premier League can result in a loss of £50 million in the first season alone, largely due to the loss of broadcasting revenue (Deloitte Annual Review of Football Finance, 2022). Organisations in the MLB do not face this same fear of relegation and the financial loss that is associated with it, and as a result could perhaps be less risk averse with

spending than football clubs, which could be manifested in perceptions towards new technology. Conversely, Prospect Theory (Kahneman and Tversky, 1979) offers an alternative possibility. This theory posits that people are naturally loss-averse, and as a result will often gravitate toward risk-seeking tendencies when there is the possibility of loss. If Prospect Theory predicts that the key decision-makers within an organisation are more likely to demonstrate risk-seeking tendencies when there is the possibility of loss (relegation in football), but risk averse tendencies when there is the possibility of gain (prize money present in both sports), it could be that the individuals within the baseball organisations – without the financial risk of relegation – are expected to engage in more risk-averse decision-making than the individuals within the football clubs. Therefore, there is a possibility that football clubs will be more receptive to VR than baseball organisations.

Finally, there are also organisational differences between football and baseball that exist in the structure of the coaching departments. That is, MLB organisations have coaches and staff specifically for defence (e.g., pitching coaches and fielding coaches) and offense (e.g., hitting coaches). It is feasible that as a result of this distinction, each structure of the organisation can make decisions to purchase equipment to suit their own training. Conversely, the coaching structure within football clubs tends to be less siloed and more interdependent. This could introduce more complex layers to decision-making processes and stymie the adoption of new technologies such as VR. This could perhaps explain some of the current resistance around VR implementation in elite football (e.g., Greenhough *et al.,* 2021).

As well as the off-field factors, there are on-field differences between the sports which may drive differing requirements and desire to implement VR technology. Namely, football is a largely open skill sport, whereas baseball is both an open and closed skill sport. Open skill sports are predominantly externally paced, requiring constant adaptation in a

dynamic, unpredictable environment. Conversely, closed skill sports are predominantly self-paced, highly consistent, and predictable (Wang *et al.,* 2013). The differences between football and baseball are amplified further in training, where baseball training predominantly involves consistent repetitions of batting or pitching (largely closed skill), and football training often involves ecologically driven variations of small, externally paced drills (largely open skill) to replicate the real match and facilitate tactical decision making (Vilar *et al.,* 2014). As a result, it is feasible that practitioners would differ in their perceived important factors and obstacles of VR implementation.

Aims and Hypotheses

Therefore, the aim of the present study is to explore the perceptions of practitioners towards VR training in elite football and baseball. Further, due to the differences between the two sports with regard to organisational structure and decision-making processes, this study will aim to provide insightful information regarding how the receptivity of VR in baseball differs from football, specifically highlighting any notable similarities or differences regarding important factors and obstacles preventing use. Finally, the present study will look to either confirm or refute the findings of past research (Greenhough *et al.,* 2021; Thatcher *et al.,* 2020) regarding the important factors and obstacles in elite football. Based on the aforementioned research, it is hypothesised that practitioners will perceive enhancements to on-field performance as the most important factor for VR training to target. Secondly, it is hypothesised that respondents will perceive the greatest obstacles to VR implementation as cost, lack of coach approval, and general negative perceptions of VR. Finally, regarding comparisons between football and baseball, the multiple organisational differences that exist between the sports could conceivably produce responses at both end of the spectrum. This coupled with the exploratory nature of the comparison means that no hypotheses will be made regarding this specific research question.

Methods

Respondents

Respondents were contacted predominantly via email or LinkedIn and were asked if they would be interested in completing a short, online questionnaire exploring practitioner perceptions of VR in their sport. Respondents were specifically targeted due to a known or assumed belief that their practitioner role within their sporting organisation: 1) was or would be central to any knowledge and implementation of VR in the organisation, and 2) had a sufficient understanding of the business strategy and goals of the organisation. The present authors also informed the contacts of the intended target population and requested that if they were not the most suitable individual, to direct the authors towards more relevant individuals within the organisation who were able to complete the questionnaire. In five instances, this was found to be the case and the authors were subsequently redirected.

In total, the questionnaire was completed by 40 practitioners (25 football, M_{age} = 32.76, SD = 7.17; and 15 baseball, M_{age} = 38.93, SD = 9.60). All respondents were over the age of 18. A maximum of one practitioner from each organisation or club was recruited. Respondents for the football questionnaire were sampled from elite level football leagues (highest tier) in the following countries: England (28%); Germany (12%); Italy (4%); Netherlands (4%); Portugal (4%); Belgium (8%); United States of America (USA; 12%); as well as the second tier from England (28%). Respondents for the baseball questionnaire were sampled from Major League Baseball (USA; 100%). For the football respondents, 48% of the sample occupied a sport science role, 28% a sport psychology role, 16% a performance-based role, and 8% an athletic development role. For the baseball respondents, 33% occupied a sport science role, and 67% occupied a performance-based role. All respondents provided informed consent, and the study gained institutional ethical approval prior to data collection.

Item Generation and Pilot Testing

Item generation for the questionnaire was initially based on knowledge gleaned from the existing literature. Section A (knowledge) was initially based on suggestions from Neumann *et al.* (2018) that research should capture participants' prior experience with VR in general and with a specific VR system. Section B (important factors and obstacles) was based predominantly on Gray (2017) and Gray (2019). Finally, Section C (implementation) was driven primarily from collaborative discussions with the practitioners in the field.

Following the item generation, two of the authors engaged in multiple, collaborative discussions with one practitioner from elite football (a coach) and two practitioners from elite baseball (a coach and a sports scientist) via a commercial video conferencing platform and email. Iterations to the questionnaire were made based on the practitioners' feedback relating to wording, length (*i.e.,* time taken to complete), and sport-specific suitability. Finally, a pilot test of the questionnaire was conducted. The purpose of this pilot was to ensure the questions were appropriate in their aims and suitably worded. Two practitioners in elite baseball were asked to complete the questionnaire, time themselves, and provide feedback on how easy it was to understand and any recommendations to improve its readability and instructions. As a result of this process, only minor changes to the wording of items in Section C were made to reduce ambiguity.

Procedure

After agreeing to complete the questionnaire, respondents were sent the link to the online questionnaire. Data were collected via an online survey platform (www.onlinesurveys.ac.uk, Bristol, UK). After demographic information (club/organisation, job title, date of birth) was obtained, respondents were presented with a short piece of information about VR to enhance understanding. However, this was placed after the knowledge questions as to not influence their self-reported knowledge. The entire

questionnaire took approximately 10 minutes to complete. Throughout the questionnaire, ethical standards were maintained, including the ability to not answer any of the questions and to discontinue the study.

Measures

1. ***Self-reported level of knowledge***

In an attempt to establish knowledge in relation to technology and VR, respondents were asked three questions and informed to respond on a 10-point Likert scale from *none at all* (1) to *as much as anyone in professional football/baseball* (10).

2. ***Important factors for implementation of VR training***

Section two focused on which factors practitioners thought were most vital for VR training to target. The question read: "When considering a VR system to purchase, please indicate the degree to which each of the following factors would be/were important to you?" Respondents could respond from *not at all important* (1) to *absolutely essential* (10). The 12 factors presented to respondents were based on three conceptually related areas:

a. Practice Design (five factors): allows for controlled testing, allows for more repetitions, allows for safer practice, allows for contextual information to be integrated, allows for fun and variation in practice.

b. Outcome Oriented/Performance (two factors): improves on-field technical performance, improves on-field mental/tactical performance.

c. Application and Logistics (five factors): allows for training despite weather conditions, allows injured players to practice, allows the inclusion of sport-science methods, allows the inclusion of sport-science data, eases the workload of coaches.

3. *Potential obstacles for the implementation of VR training*

Respondents were then asked to turn their attention to potential obstacles: "With respect to past, current, or future deployment of VR training at your club/organisation, please rate the degree to which you have seen or foresee the following to present obstacles." Respondents could respond from *no issue at all* (1) to *impossible to resolve* (10). The 10 factors presented to respondents were based on two conceptually related areas:

a. Approval/Perception (four factors): player approval, coach approval, executive approval, general negative perceptions (VR seen as a 'gimmick').
b. Logistics (five factors): cost, lack of customisation, lack of time, lack of space, difficult to use.

4. *Thoughts on practical implementation of VR training*

The fourth section focused on the practical implementation of VR either now or in the future, specifically in relation to: responsibility for use, frequency of use, and athlete use. Table 1 below contains a list of all the questions for each section, whilst the full questionnaire including items can be found in the appendix.

INSERT TABLE 1 HERE

Data Analysis

Data were analysed via IBM SPSS (version 26), with an alpha level of $p = .05$ used to denote significance throughout. Descriptive data were chosen to represent the important factors and obstacles for each sport individually. To address the comparison between football and baseball, data were analysed using one-way MANOVAs. For all MANOVAs performed, Box's M Test of Equality of Covariance Matrices was not significant ($p > .05$), therefore equality of covariance matrices can be assumed throughout. Shapiro-Wilks tests of normality

revealed that the majority of data was not normally distributed ($p < .05$). Consequently, Mann-Whitney U Tests were used to explore significant results from the MANOVAs.

Results

Football Respondents

The football respondents perceived improvements in on-field mental/tactical performance ($M = 8.64$, $SD = 1.75$), improvements in on-field technical performance ($M = 7.76$, $SD = 2.70$), and allowance of rehabilitating players to practice ($M = 7.48$, $SD = 2.49$) as the most important factors for VR training to target. Alternatively, the least important factors for VR training to target were identified as easing the physical workload of the coaches ($M = 4.72$, $SD = 2.17$), allowance of practice despite weather conditions ($M = 5.48$, $SD = 2.45$), allowing inclusion of other sport-science data ($M = 6.04$, $SD = 2.26$), and providing greater variation and fun to training ($M = 6.04$, $SD = 1.49$). The football respondents perceived the greatest obstacles to VR training as cost ($M = 7.21$, $SD = 2.52$), lack of coach approval ($M = 6.38$, $SD = 2.16$), and general negative perceptions of VR ($M = 6.29$, $SD = 1.90$). Alternatively, lack of player approval ($M = 4.17$, $SD = 2.24$), difficulty of use ($M = 4.42$, $SD = 1.98$), and lack of customisation to club needs ($M = 4.46$, $SD = 1.84$) were perceived as the least significant obstacles. See Figures 1-3 for all descriptive statistics.

Baseball Respondents

The baseball respondents perceived improvements in on-field mental/tactical performance ($M = 9.33$, $SD = 1.05$), improvements in on-field technical performance ($M = 8.47$, $SD = 2.61$), and allowance of more repetitions ($M = 8.33$, $SD = 1.50$) as the most important factors for VR training to target. Alternatively, the least important factors for VR

training to target were allowing inclusion of contextual information (M = 5.13, SD = 2.20), allowing practice despite weather conditions (M = 6.47, SD = 2.53), and easing the physical workload of coaches (M = 6.60, SD = 2.58). The baseball respondents perceived the greatest obstacles to VR training as cost (M = 6.47, SD = 2.32), lack of customisation to club needs (M = 5.40, SD = 2.13), and general negative perceptions of VR (M = 5.20, SD = 1.57). Alternatively, lack of space (M = 3.00, SD = 2.17), difficulty of use (M = 3.13, SD = 1.36), and lack of executive approval (M = 3.20, SD = 1.61) were perceived as the least significant obstacles. See Figures 1-3 for all descriptive statistics.

Comparative Statistical Analyses

1. Important Factors

The mean scores for important factors of both football and baseball respondents are presented in Figure 1. For the following analyses, three one-way MANOVAs were conducted based on the groups outlined in the methods section.

Practice Design

A one-way MANOVA showed a significant difference in scores for 'practice design' based on sport ($F(5,34) = 5.83$, $p < .001$, $\eta_p^2 = .46$). Separate Mann-Whitney U tests revealed a significant difference between baseball and football in terms of allowing more repetitions ($U = 74.00$, $p < .001$), with baseball (M = 8.33, SD = 1.50) rating this as a significantly more important factor than football (M = 6.20, SD = 1.96). Further, there was a significant difference between baseball and football in terms of allowing the addition of contextual information ($U = 118.00$, $p = < .05$), with football (M = 6.60, SD = 2.20) rating this as a significantly more important factor than baseball (M = 5.13, SD = 2.20). There was no

significant difference between the sports in allowing for controlled testing (p = .52), allowing for safer practice (p = .99), or allowing for more fun and variation (p = .18).

b. Outcome Oriented/Performance

A one-way MANOVA showed no significant difference in scores for 'outcome oriented/performance' based on sport ($F(2,37) = 0.98$, p = .38, η_p^2 = .05). Separate Mann-Whitney U tests revealed no significant difference between the sports in improving on-field technical performance (p = .25), or on-field mental/tactical performance (p = .25).

c. Application and Logistics

A one-way MANOVA showed no significant difference in scores for 'application and logistics' based on sport ($F(5,34) = 1.49$, p = .22, η_p^2 = .18). Separate Mann-Whitney U tests revealed a significant difference between baseball and football in terms of allowing a reduction in coach workload (U = 108.00, p = .03), with baseball (M = 6.60, SD = 2.59) rating this as a significantly more important factor than football (M = 4.72, SD = 2.17). There was a significant difference in allowing incorporation of sport-science methods (U = 118.50, p < .05), with baseball (M = 7.80, SD = 2.21) rating this as significantly more important factor than football (M = 6.76, SD = 1.76). Further, there was a significant difference in allowing incorporation of sport-science data (U = 117.00, p = .03), with baseball (M = 7.40, SD = 2.67) rating this as significantly more important factor than football (M = 6.04, SD = 2.26). There was no significant difference between the sports in allowing training despite weather conditions (p = .23) or allowing injured players to practice (p = .45).

INSERT FIGURE 1 HERE

2. Perceived Obstacles

The mean scores for perceived obstacles of both football and baseball respondents are presented in Figure 2. For the following analyses, two one-way MANOVAs were conducted based on the groups outlined in the methods section.

a. Approval/Perception

A one-way MANOVA showed a significant difference in scores for 'approval/perception' as perceived obstacles based on sport ($F(4,34) = 4.58$, $p = .01$, $\eta_p^2 = .35$). Separate Mann-Whitney U tests revealed a significant difference between football and baseball in terms of lack of coach approval ($U = 97.50$, $p = .02$), with football ($M = 6.38$, $SD = 2.16$) rating this as a significantly greater perceived obstacle than baseball ($M = 4.60$, $SD = 1.99$). There was a significant difference between football and baseball in terms of lack of executive approval ($U = 67.00$, $p < .001$), with football ($M = 5.79$, $SD = 2.20$) rating this as a significantly greater perceived obstacle than baseball ($M = 3.20$, $SD = 1.61$). Further, there was a significant difference between football and baseball in terms of general negative perceptions of VR ($U = 112.00$, $p < .05$), with football ($M = 6.29$, $SD = 1.90$) rating this as a significantly greater perceived obstacle than baseball ($M = 5.20$, $SD = 1.57$). There was no significant difference between the sports in player approval as a perceived obstacle ($p = .76$).

b. Logistics

A one-way MANOVA showed no significant difference in scores for 'logistics' as perceived obstacles based on sport, although this was approaching significance ($F(5,33) = 2.32$, $p = .07$, $\eta_p^2 = .26$). Separate Mann-Whitney U tests revealed a significant difference between football and baseball in terms of difficulty to use ($U = 111.50$, $p = .04$), with football ($M = 4.42$, $SD = 1.98$) rating this as a significantly greater perceived obstacle than baseball ($M = 3.13$, $SD = 1.36$). Further, there was a significant difference between football and baseball in terms of lack of space ($U = 112.00$, $p < .05$), with football ($M = 4.54$, $SD = 2.55$)

rating this as a significantly greater perceived obstacle than baseball (M = 3.00, SD = 2.17). Whilst not statistically significant, the alpha level was approaching significance between football and baseball with regard to lack of time (U = 113.50, p > .05), with football rating this as a greater perceived obstacle than baseball. Finally, there was no significant difference between the sports in lack of customisation as a perceived obstacle (p = .18), or cost of the system (p = .24).

INSERT FIGURE 2 HERE

3. Perceived Knowledge

The descriptive statistics for perceived knowledge of both football and baseball are presented in Figure 3. For the following analysis, a one-way MANOVA was conducted based on the group outlined in the methods section.

A one-way MANOVA showed a significant difference in scores for 'perceived knowledge' based on sport (F(3,35) = 13.49, p = < .001, η_p^2 = .54). Separate Mann-Whitney U tests revealed a significant difference between baseball and football in terms of sport technology knowledge (U = 71.50, p < .001; baseball M = 8.27, SD = 1.16, football M = 6.60, SD = 1.50), knowledge of VR in sports generally (U = 38.00, p < .001; baseball M = 7.00, SD = 1.56, football M = 3.76, SD = 1.86), and knowledge of sport-specific VR (U = 27.00, p < .001; baseball M = 7.60, SD = 1.59, football M = 3.64, SD = 1.96). In each case, baseball practitioners reported themselves as more knowledgeable than football practitioners.

INSERT FIGURE 3 HERE

Practical Use of VR

A clear majority (56.0%) of football practitioners believed that the head sport/performance scientist would be responsible for implementing VR training. There was somewhat less agreement within baseball practitioners, with 42.9% believing a coach would be responsible, 21.4% suggesting the head sport/performance scientist, and 28.6% suggesting another sport/performance scientist. Sporting differences also emerged with regards the frequency of VR use, with all baseball respondents believing that a VR system would be used more than once per week, compared to just 36.0% of football respondents believing this to be the case. Finally, in terms of which athletes would most frequently use a VR system, the differing structures of each sport meant comparisons for most responses are not possible, though responses seemed to suggest potential uses at each of the varying stages within each sport's developmental pyramids. Notably, though, both football (68.0%) and baseball respondents (86.7%) believed that injured and rehabilitating athletes would be the most likely use cases for a VR system (see Figure 4).

INSERT FIGURE 4 HERE

Discussion

The present study aimed to explore the perceptions of VR training in elite football and baseball, with a specific focus on the important factors, obstacles, perceived knowledge, and practical use of the technology. In accordance with the first hypothesis, both football and baseball respondents perceived improvements in on-field performance as the most important factors for VR training to target. In line with the second hypothesis, both football and baseball respondents perceived cost and general negative perceptions of VR as two of the greatest obstacles to VR training. However, only the football respondents perceived lack of coach approval as one of the greatest obstacles, partially supporting the second hypothesis. Another notable finding was that both the baseball and football respondents reported that injured or rehabilitating players were the most likely to benefit from VR training in their clubs and organisations, in line with the research by Thatcher *et al.* (2020).

With regard to the noteworthy differences between the practitioners of the two sports: 1) baseball respondents rated the allowance of increased repetitions, the reduction of coach workload, and the incorporation of sport-science methods and data as significantly more important than football respondents, but the allowance of additional contextual information as significantly less important; 2) football respondents reported lack of coach approval, lack of executive approval, general negative perceptions of VR, difficulty of use, and lack of space as being significantly greater obstacles than the baseball respondents; and 3) baseball respondents reported significantly higher knowledge of sport technology and VR than the football respondents.

Differences between football and baseball respondents

The differences regarding baseball practitioners perceiving increased repetitions and reduced coach workload as significantly more important than football respondents, but

additional contextual information as significantly less important, can be explained by the primary skill classifications of each sports practice structure. As discussed in the introduction, the nature of baseball batting, which is the predominant focus of VR training, allows for large amounts of repetition of action (closed skill), and therefore it is in line with expectations that the ability to increase repetitions – as well as reduce the workload of coaches who are responsible for these repetitions – is more important for baseball respondents than for football respondents. Indeed, football respondents may have struggled to conceptualise what a 'repetition' would look like in a largely open skill sport. In a similar manner, with the very fact that open skills are characterised by dynamic, unpredictable environments, whereas closed skills are characterised by stable, predictable environments (Wang *et al.,* 2013), it is understandable that the addition of contextual information to training would be particularly valuable for football respondents, above and beyond baseball respondents.

Regarding the finding that football respondents rated lack of coach approval and lack of executive approval as significantly greater obstacles than baseball respondents, it may be that this reflects differences in the cultures of the sports. According to Nesti (2010), football coaches, especially those that have been coaching for long periods, have developed reputations as 'all-in-one' leaders that often believe they can fulfil the role of manager, coach, psychologist and more. As a result, the introduction of new technology and its subsequent impact on staff roles can, on occasion, be met with quite high resistance. Building on this, leadership literature demonstrates that the coach or manager can often be perceived as the sole decision-maker accountable for the performance of a football club (Arnulf *et al.,* 2012). It could potentially be that some executives and stakeholders maintain a similar view, relying on the coach to make key decisions and to improve performance and not seeing the value in the addition of new technology and new training methods. Furthermore, in the

present study, only 4% of football respondents indicated that the coach would be responsible for carrying out the VR training, in comparison to 42.9% of baseball respondents. Whilst it is possible that this is reflective of the practitioners route into their position and their current role in the organisation or club, it is conceivable that these two questions are related and that if coach approval could be improved in elite football, more coaches would be willing to implement VR systems. Equally, if more coaches took an active role in the implementation of new technology, this may result in increased coach approval. In this way, it is possible that there is a bi-directional relationship between increased involvement and increased approval.

It is important to acknowledge the relatively small sample size of the present study and the implications this has for the generalisability of the results. However, given that the target population – practitioners from elite football and baseball organisations with knowledge of organisational goals and a likely role in the implementation of a VR system – is also exceedingly small and specific, we believe that the findings still provide important insights. Indeed, the 15 respondents from baseball represents an impressive 50% of MLB teams and thus, the baseball-specific data may be particularly pertinent to these organisations (and to VR developers targeting this market). Whilst the sample size is similar to other published work in the area (e.g., Ebben *et al.,* 2005; Neupert *et al.,* 2022; and Read *et al.,* 2018), more research is nevertheless warranted before firm conclusions can be drawn.

Applications to rehabilitation and recovery

Both football and baseball respondents reported that the most likely group to frequently use the VR system would be injured or rehabilitating athletes. This is in accordance with the findings from Thatcher *et al.* (2020) and Greenhough *et al.* (2021). Whilst it is apparent that there is a desire for VR training to be utilised as part of rehabilitation programmes, it is important for VR developers and businesses to understand

whether practitioners believe the role of VR in rehabilitation is to: enhance or maintain perceptual-cognitive skills; reintegrate athletes back into normal movements experienced in physical training; or ensure rehabilitating athletes have the opportunity to engage in activities on site at training and offering interaction opportunities with staff and teammates. Further, as noted by Le Noury *et al.* (2022), it is unclear at this early stage whether prolonged use of VR training in this form could lead to negative transfer, especially as injured athletes are unlikely to perform any real-world skill training alongside the VR training. Whilst this research is still in its infancy, promising literature is beginning to emerge which points toward the potential value of utilising VR with injured or rehabilitating athletes (Stafford *et al.,* 2022).

Most important factors for implementation of VR

In support of Greenhough *et al.* (2021), the present study found that practitioners from both sports highlighted improvement in on-field performance as the most important factor for the VR training to target. Mean values revealed that of the two types of performance presented to respondents, both the football and baseball sample highlighted that improvement in mental/tactical performance was more important than improvement in technical performance, which suggests that the present sample placed greater emphasis on the psychological and/or tactical benefits of implementing VR. One possible explanation for this is that in elite sport, especially for those toward the end of their careers, many of the athletes may be close to their technical ceiling, and therefore coaches and practitioners may emphasise exploring alternative routes for enhancing performance such as improvements in decision-making and tactical understanding. Indeed, Le Noury *et al.* (2022) identify the ability to improve tactical skills and decision-making as a particularly fruitful area for VR training by offering the opportunity to expose athletes to high-pressure environments, reinforcing the practitioners' beliefs that VR should be used to improve the mental/tactical aspects of performance.

Greatest obstacles for implementation of VR

Whilst the football respondents rated the obstacles as significantly greater than the baseball respondents on average, both samples identified general negative perceptions (VR seen as a 'gimmick') and cost as the two greatest obstacles. The finding that general negative perceptions are a significant obstacle is in accordance with the results from Greenhough *et al.* (2021). They suggest that the absence of empirical research supporting the role of VR in improving football performance could be driving early scepticism, leading to poor first impressions of VR as a 'gimmick' or 'novelty' before the clubs or organisations can understand the potential benefits. Furthermore, given that VR falls within a rapidly growing market of sport technology where practitioners are likely to be presented with multiple pieces of technology that purport to improve athlete decision-making and performance (many of which will have little-to-no research evidence to support the claims) it is perhaps not surprising to find that scepticism towards VR exists.

Building on from this, the present study hypothesises that these poor first impressions of VR are driving beliefs that VR systems are not an effective use of funds, explaining why cost is identified as the greatest obstacle. As highlighted in the introduction, the clubs and organisations approached for this study are all in financial positions to implement state-of-the-art systems, therefore rather than there being an issue with the absolute cost, the obstacle is likely reflective of the perceived 'value for money' of VR. However, it is worth noting that this scepticism could be warranted considering the current landscape of VR research and application. Interestingly, the present study found that football respondents did not perceive cost to be a significantly greater obstacle than the baseball respondents, with both groups viewing this as a major obstacle. This may suggest that the institutional differences in spending structures and wage-revenue ratios (Deloitte, 2022; Forbes, 2019) between the sports is not a deciding factor in whether organisations invest money in new technology and

training methods. It is possible that at the elite level, there is a natural resistance to investing large amounts of money in new training aids regardless of the financial structure of that organisation.

That being said, there is cohort of literature which suggests that searching for reputable, marginal gains can lead to meaningful improvements in business and sporting performance (Hall *et al.,* 2012). Often, these marginal gains will not be found by aiming to improve the athletes, but instead improving the systems in place at these organisations (Clear, 2018). Therefore, there will be key decision-makers at these organisations aiming to deliver marginal gains that could benefit from the introduction of VR training. Critically, these decisions need to be justified from a business perspective, balancing the cost-benefit ratio. Moreover, more work needs to be done in the research community to identify the benefits of VR training with evidence-based accounts that are widely disseminated. This will provide the key decision-makers with empirical evidence of the potential benefits of VR training in a sporting environment.

Theoretical implications

Whilst exploratory by nature, the findings from the present study have contributed to our understanding of organisational decision-making and behaviour in relation to technology in elite sport. A resource-based view of strategic management (Berman et al., 2002) is supported here. It is apparent that the practitioners in elite football are significantly more sceptical and resistant to the use of VR at their clubs than the baseball practitioners, at least in the present sample. As discussed in the introduction, one explanation is that this is the result of the unique high wage-revenue ratio or the fear of relegation, resulting in greater scrutiny placed on financial allocation. Whilst Prospect Theory (Kahneman and Tversky, 1979) was initially offered as theoretical reasoning for football clubs being more receptive to VR than

baseball organisations, it also offers an explanation as to why this was not the case in the present study. It is feasible that baseball practitioners perceive themselves as facing greater potential losses than football practitioners, and therefore are more likely to be receptive to risk-seeking such as the incorporation of new technology. That is, we highlighted the differing structures of the two sports (football clubs annually face the considerable financial consequences of relegation whereas baseball organisations do not) as a potential reason for baseball practitioners to be more risk averse, but it may be that at an individual level, the practitioners do not perceive such long-term consequences personally, or they do but they are superseded by other beliefs.

Another theoretical implication is support for the notion that structure of organisations can impact high-level decision-making. From the present study, it is feasible that the siloed nature of coaching departments in elite baseball is resulting in practitioners having greater individual responsibility and independence, especially in comparison to the more complex hierarchical structure in elite football. As a result, we could see more resistance from elite football clubs as incorporating new technology and training methods into the clubs requires approval and co-ordination from multiple parties and departments. Alternatively, it could be that the adoption of a new technology such as VR is simply not perceived from either perspective as a risk seeking or risk averse behaviour, leaving perceptions towards it to be influenced by other mechanisms (such as knowledge, or lack of knowledge, of the product). Further research is required in order to gain a more comprehensive understanding of organisational behaviour in relation to the adoption of technology in elite sport.

Further practical implications

The results from the present study have raised a number of interesting practical implications associated with VR training in elite sport. As considered earlier in the

discussion, one of the major selling points for VR is the ability to deliver a competitive advantage in an area where small improvements can result in meaningful outcomes. However, if there is to be increased receptiveness of VR and eventual widespread integration, clubs and organisations may begin to see VR as the 'norm', resulting in the perception that VR can no longer provide that competitive advantage. As a result, VR businesses should focus on delivering bespoke services which address the specific needs of a particular organisation/club as opposed to a general service that can be given to any club. Doing this will encourage practitioners, coaches, and key decision-makers at the organisations to help shape the development of the VR training, increasing user buy-in. Further, individualised services will enhance the perception of gaining a competitive advantage, linking to the aforementioned point regarding marginal gains. However, VR businesses will need to consider the practicality of this level of individuality if widespread implementation does begin to take place.

The present study found that football respondents reported significantly lower knowledge of general and sport-specific VR than the baseball respondents. This may indicate that higher resistance and scepticism in the football sample is the result of a lack of understanding and information. If this is the case (and it is representative of the target population), perhaps a first step to increasing organisation receptivity in elite football is for VR businesses to deliver educational programmes and demonstrations exploring the many perceived benefits of VR training. This may be a sensible investment from VR businesses looking to implement their services at these elite clubs. Furthermore, in the football sample, perceived coach approval was significantly lower than the baseball sample, and this supports the research by Greenhough *et al.* (2021). In line with Nesti (2010), one possible method for dealing with the lack of coach approval is through directly involving them in the development and implementation of the VR training. Whilst this is speculative, if coaches are

fearful that their job is being replaced by technology, this fear may dissipate if they are directly involved in developing the training environments and delivering or overseeing the sessions, as their value will still be realised. Equally, if the coaches are simply unconvinced as opposed to fearful, giving them practical experience with the VR system should allow them to directly understand the many benefits that VR can deliver. Exploring other methods for increasing coach approval will be critical if VR is to eventually become more commonly utilised as a tool alongside traditional training activities, especially in elite football.

Finally, it is likely that as VR continues to grow in popularity and usage, that VR businesses will begin to expand and branch out into other sports. The present study's findings will provide VR developers with invaluable information from a business perspective as to what practitioners from different sports believe are the most critical factors for VR training to target, as well as the perceived obstacles that may prevent immediate receptivity. We propose explanations for these findings that relate to the differing organisational structure and decision-making processes of the two sports which could impact adoption of VR training. If this is the case, it will allow investment and development to be carried out in the most appropriate areas to benefit these elite organisations.

Future Directions

Future research should continue exploring the perceptions of practitioners in different sports, beyond football and baseball. For example, it would be interesting to see if the findings from football extend to other sports with a similar organisational structure such as the NFL, and whether sports such as basketball with a different organisational structure offer an alternative set of results once again. This would address a the limitation of the present study, in that it is difficult to ascertain whether the differences between the football and baseball practitioners are the result of the different motor-skill requirements between the sports (*i.e.,* open versus closed skill), the cultural differences between the two samples (*i.e.,* a

predominantly European sample for football versus a complete U.S sample for baseball), or the organisational differences of the two sports. It should be noted that should such work be carried out, then validation of the questionnaire used in the present study is warranted. It may also be worthwhile to directly ascertain the perception of VR from executives and stakeholders (as opposed to indirectly through practitioners), to understand if cost is indeed the greatest obstacle, and how VR could be utilised at these elite clubs and organisations.

Finally, this study has demonstrated a promising opportunity for VR companies to aid in the rehabilitation of injured athletes in elite sport, but more research is required to understand exactly what these sport organisations believe the role of VR training could be in the context of rehabilitation. Due to the limited population of rehabbing athletes within an elite sport organisation, the most feasible methodological approach for future research may lie in case studies. Not only would this encourage the collection of rich, qualitative data, but it would also allow for the possibility of a longitudinal approach assessing the suitability of VR training in an elite sport setting over an extended period.

Conclusions

The results of the present study highlight several important differences and similarities in the perception of VR training between baseball and football practitioners. Most notably, football respondents valued the inclusion of contextual information in VR training, whereas baseball respondents valued the inclusion of increased repetitions and the reduction of coach workload. Football respondents perceived VR as having significantly greater obstacles than the baseball respondents, specifically a lack of coach approval, lack of executive approval, and negative perceptions of VR. Football and baseball respondents agreed that improvement in on-field performance and the ability to aid athletes in their rehabilitation from injury are the two most important factors for VR implementation.

Whilst continuing to conduct empirical research to explore the efficacy of VR as a training tool in various sports is critical, as noted in the introduction this research is ultimately of little use if practitioners and executives perceive VR as a waste of resources. Therefore, researchers and developers should dedicate time and resources to better understand exactly how these elite clubs and organisations feel VR could benefit their training and development, focusing on creating bespoke programmes that deliver a competitive edge and provide value alongside physical training. Whilst the current landscape for VR training in elite sport is promising, this study demonstrates that researchers and developers first need to transform pre-existing negative perceptions of VR.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, Ross Dowsett, upon reasonable request.

Declarations

Funding and/or Competing interests

The authors have no competing interests to declare that are relevant to the content of this article. No funding was received to assist with the preparation of this manuscript.

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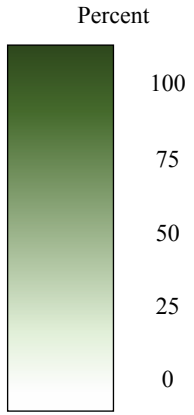
Table 1: Specification of the topics, factors, and questions presented to the study sample.

Topic	Factor	Question/Option
Knowledge	Technology	How knowledgeable are you of the latest innovations in sports technology?
	VR	How knowledgeable are you in the area of VR training in sport in general?
		How knowledgeable are you in the area of VR specifically in football/baseball?
		Have you ever heard of the VR software company Rezzil/WinR, TrinityVR, Monsterful?
Important Factors	Practice Design	Allows for controlled testing (players compared under the same conditions)
		Allows for quick changes to the environment and therefore more repetitions
		Provides a safer way to practice certain skills
		Allows for contextual information to be integrated such as crowds, referees, and opposition
		Allows for fun and variation in practice
	Outcome-Oriented	Improves on-field technical performance
		Improves on-field mental/tactical performance
	Application	Allows for training despite weather conditions
		Allows injured players to practice
		Allows the inclusion of sport-science methods (*e.g.,* eye-tracking)
		Allows the inclusion of sport-science data (*e.g.,* shot velocity)
		Eases the workload of coaches/support staff
Obstacles	Approval/Perception	Lack of player approval
		Lack of coach approval
		Lack of executive approval
		General negative perception (seen as a 'gimmick')

	Logistics	Cost of VR systems
		Lack of customisation to club needs
		Lack of time to implement training
		Lack of space
		Difficult to use
Practical Usage	Practitioner Use	Who would likely be responsible for implementing its use?
	Frequency of Use	How frequently do you expect that it would be used?
	Athlete Use	To what extent would the following groups likely use it?

Figure 1: The descriptive statistics for important factors between Football (F) and Baseball (B). Asterisks indicate significance level for difference between football and baseball (* = p<.05; ** = p<.01; *** = p<.001).

Likert Scale Responses ranging from 1 ("not at all important") to 10 ("absolutely essential")												
	Sport	M (SD)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Improves on-field technical performance	*F*	7.76 (2.70)	4.0	4.0	4.0	4.0	0.0	8.0	4.0	28.0	4.0	40.0
	B	8.47 (2.61)	0.0	6.7	6.7	0.0	0.0	0.0	6.7	13.3	6.7	60.0
Improves on-field mental/tactical performance	*F*	8.64 (1.75)	0.0	0.0	0.0	0.0	12.0	0.0	12.0	16.0	8.0	52.0
	B	9.33 (1.05)	0.0	0.0	0.0	0.0	0.0	0.0	6.7	20.0	6.7	66.7
Allows for controlled testing	*F*	6.96 (2.54)	0.0	4.0	12.0	0.0	20.0	0.0	12.0	20.0	12.0	20.0
	B	7.53 (2.00)	0.0	0.0	0.0	6.7	13.3	20.0	0.0	13.3	33.3	13.3
Provides a safer way to practice certain skills	*F*	6.80 (2.47)	4.0	0.0	12.0	0.0	12.0	12.0	12.0	20.0	16.0	12.0
	B	6.80 (2.60)	0.0	13.3	0.0	6.7	6.7	6.7	20.0	26.7	0.0	20.0
Allows for more repetitions (***)	*F*	6.20 (1.96)	0.0	4.0	4.0	8.0	28.0	12.0	8.0	24.0	12.0	0.0
	B	8.33 (1.50)	0.0	0.0	0.0	0.0	6.7	6.7	6.7	33.3	20.0	26.7
Can include contextual information (*)	*F*	6.60 (2.20)	0.0	4.0	12.0	4.0	4.0	16.0	16.0	32.0	4.0	8.0
	B	5.13 (2.20)	0.0	13.3	13.3	13.3	20.0	13.3	6.7	13.3	6.7	0.0
Allows practice despite weather conditions	*F*	5.48 (2.45)	4.0	4.0	20.0	16.0	4.0	12.0	12.0	20.0	4.0	4.0
	B	6.47 (2.53)	0.0	6.7	6.7	20.0	0.0	6.7	20.0	20.0	6.7	13.3
Allows injured/ rehabbing players to practice	*F*	7.48 (2.49)	0.0	8.0	4.0	0.0	8.0	8.0	12.0	16.0	20.0	24.0
	B	8.13 (2.10)	0.0	6.7	0.0	0.0	0.0	6.7	13.3	20.0	26.7	26.7
Allows for inclusion of	*F*	6.76 (1.76)	0.0	0.0	8.0	0.0	16.0	12.0	28.0	28.0	0.0	8.0



sport-science methods (*)	*B*	7.80 (2.21)	0.0	6.7	0.0	0.0	6.7	6.7	13.3	26.7	13.3	26.7
Allows for inclusion of other sport-science data (*)	*F*	6.04 (2.26)	8.0	4.0	4.0	4.0	12.0	8.0	32.0	24.0	4.0	0.0
	B	7.40 (2.67)	0.0	6.7	6.7	6.7	0.0	13.3	6.7	13.3	20.0	26.7
Eases the physical workload of coaches and support staff (*)	*F*	4.72 (2.17)	8.0	8.0	20.0	8.0	12.0	28.0	0.0	16.0	0.0	0.0
	B	6.60 (2.58)	6.7	6.7	13.3	0.0	6.7	20.0	20.0	6.7	6.7	13.3
Provides greater variation and "fun" to training	*F*	6.04 (1.49)	0.0	0.0	8.0	8.0	12.0	36.0	16.0	20.0	0.0	0.0
	B	6.67 (2.26)	0.0	6.7	6.7	6.7	0.0	20.0	20.0	20.0	13.3	6.7

Figure 2: The descriptive statistics for perceived obstacles between Football (F) and Baseball (B). Asterisks indicate significance level for difference between football and baseball (* = p<.05; ** = p<.01; *** = p<.001).

			Likert Scale Responses ranging from 1 ("no issue at all") to 10 ("impossible to resolve")									
	Sport	M *(SD)*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Lack of player approval	*F*	4.17 (2.24)	16.7	8.3	20.8	4.2	16.7	20.8	8.3	0.0	4.2	0.0
	B	4.47 (2.42)	6.7	6.7	26.7	20.0	20.0	6.7	0.0	0.0	6.7	6.7
Lack of coach approval (*)	*F*	6.38 (2.16)	0.0	4.2	4.2	12.5	25.0	0.0	12.5	20.8	20.8	0.0
	B	4.60 (1.99)	0.0	20.0	13.3	20.0	6.7	20.0	13.3	6.7	0.0	0.0
Lack of executive approval (***)	*F*	5.79 (2.21)	0.0	12.5	0.0	12.5	29.2	4.2	12.5	16.7	12.5	0.0
	B	3.20 (1.61)	20.0	20.0	13.3	13.3	33.3	0.0	0.0	0.0	0.0	0.0
General negative perception (*)	*F*	6.29 (1.90)	4.2	0.0	0.0	12.5	16.7	12.5	25.0	20.8	8.3	0.0
	B	5.20 (1.57)	0.0	6.7	6.7	20.0	20.0	20.0	26.7	0.0	0.0	0.0
Cost	*F*	7.21 (2.52)	0.0	8.3	8.3	0.0	4.2	8.3	12.5	16.7	29.2	12.5
	B	6.47 (2.32)	0.0	6.7	6.7	6.7	13.3	13.3	13.3	20.0	13.3	6.7
Lack of customisation to club needs	*F*	4.46 (1.84)	4.2	12.5	16.7	12.5	29.2	8.3	12.5	4.2	0.0	0.0
	B	5.40 (2.13)	0.0	13.3	6.7	13.3	20.0	6.7	26.7	6.7	6.7	0.0
Lack of time	*F*	4.96 (2.22)	0.0	25.0	0.0	16.7	16.7	16.7	8.3	12.5	4.2	0.0
	B	3.53 (2.07)	20.0	13.3	20.0	20.0	6.7	13.3	0.0	6.7	0.0	0.0
Lack of space (*)	*F*	4.54 (2.55)	4.2	29.2	8.3	12.5	12.5	8.3	4.2	12.5	8.3	0.0
	B	3.00 (2.17)	26.7	26.7	20.0	6.7	6.7	0.0	6.7	6.7	0.0	0.0
Difficult to use (*)	*F*	4.42 (1.98)	4.2	12.5	16.7	25.0	12.5	16.7	4.2	4.2	4.2	0.0
	B	3.13 (1.36)	13.3	20.0	20.0	40.0	0.0	6.7	0.0	0.0	0.0	0.0

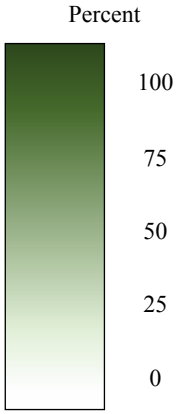


Figure 3: The descriptive statistics for self-reported knowledge between Football (F) and Baseball (B). Asterisks indicate significance level for difference between football and baseball (* = p<.05; ** = p<.01; *** = p<.001).

			Likert Scale Responses ranging from 1 ("none at all") to 10 ("as much as anyone in professional football/baseball")									
	Sport	M *(SD)*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Knowledge of latest innovations in sport technology (***)	*F*	6.54 (1.50)	0.0	0.0	4.0	0.0	20.0	24.0	20.0	28.0	0.0	4.0
	B	8.27 (1.16)	0.0	0.0	0.0	0.0	0.0	6.7	20.0	26.7	33.3	13.3
Knowledge of VR training in sport in general (***)	*F*	3.92 (1.86)	8.3	20.8	12.5	20.8	16.7	8.3	12.5	0.0	0.0	0.0
	B	7.00 (1.56)	0.0	0.0	0.0	0.0	26.7	6.7	26.7	26.7	6.7	6.7
Sport-specific knowledge of VR training (***)	*F*	3.79 (1.96)	12.5	20.8	12.5	20.8	4.2	20.8	8.3	0.0	0.0	0.0
	B	7.60 (1.59)	0.0	0.0	0.0	0.0	13.3	12.3	20.0	13.3	33.3	6.7

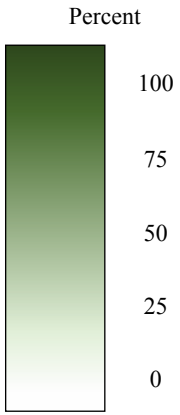
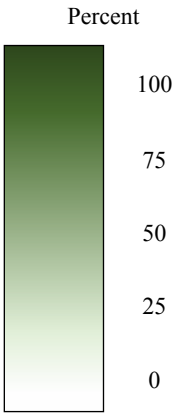


Figure 4: The percentage responses for the practical usage section of the questionnaire.

Percentage of respondents that selected each factor in the practical use section			
Topic	**Factor**	**Football**	**Baseball**
Who would implement the VR training?	Coach	4.0	42.9
	Head Sport/Performance Scientist	56.0	21.4
	Other Sport/Performance Scientist	16.0	28.6
	Data Analyst	8.0	0.0
	Intern or Associated Student/Academic	1.0	4.0
	Other Support Staff	12.0	7.1
How often would the VR system be used?	Multiple times a day	0.0	33.3
	Once a day	4.0	33.3
	Multiple times a week	36.0	33.3
	Once a week	40.0	0.0
	Once a month	12.0	0.0
Which players would frequently use the VR system?	Injured/rehabilitating players	68.0	86.7
	First team players	44.0	N/A
	Under-23 players	44.0	N/A
	Older academy players (e.g., 14-18 years old)	44.0	N/A
	Younger academy players (under-14).	24.0	N/A
	Trialists	4.0	N/A
	Big League players	N/A	40.0
	AAA players	N/A	26.7
	AA players	N/A	46.7
	A/A+ players	N/A	73.3
	Rookies	N/A	80.0
	Dominican Republic players	N/A	53.3



Appendix A – Sample Questionnaire

Section A									
1. On a scale from 1 to 10, with 1 being 'none at all' and 10 being 'as much as anyone in professional football', how knowledgeable are you of the latest innovations in sports technology?									
1	2	3	4	5	6	7	8	9	10
If possible, please expand on your answer…									
2. On a scale from 1 to 10, with 1 being 'none at all' and 10 being 'as much as anyone in professional football', how knowledgeable are you in the area of virtual reality training in sport in general?									
1	2	3	4	5	6	7	8	9	10
If possible, please expand on your answer…									
3. On a scale from 1 to 10, with 1 being 'none at all' and 10 being 'as much as anyone in professional football', how knowledgeable are you in the area of virtual reality specifically in football?									
1	2	3	4	5	6	7	8	9	10
If possible, please expand on your answer…									
4. Have you ever heard of the virtual reality software company Rezzil?									
Yes					No				
If possible, please expand on your answer…									

Section B										
5. Thinking about the potential benefits of a VR training system for your club, please rate the following factors on a scale from 1 ('not at all important') to 10 ('absolutely essential'):										
Improves on-field technical performance	1	2	3	4	5	6	7	8	9	10
Improves on-field mental/tactical performance	1	2	3	4	5	6	7	8	9	10
Allows for controlled testing (players compared under same conditions)	1	2	3	4	5	6	7	8	9	10
Provides a safer way to practice certain skills (e.g. heading)	1	2	3	4	5	6	7	8	9	10
Allows for quick changes to the environment and therefore more reps	1	2	3	4	5	6	7	8	9	10
Can include contextual information such as crowds, referees, and opposition	1	2	3	4	5	6	7	8	9	10
Allows for practice when outside conditions don't (e.g. bad weather)	1	2	3	4	5	6	7	8	9	10
Allows injured/rehabbing players to practice	1	2	3	4	5	6	7	8	9	10

Allows for inclusion of other sports-science methods (e.g. eye tracking)	1	2	3	4	5	6	7	8	9	10
Allows for collection of other sports-science data (e.g. shot velocity)	1	2	3	4	5	6	7	8	9	10
Eases the physical workload on coaches/support staff	1	2	3	4	5	6	7	8	9	10
Provides greater variation and "fun" to training	1	2	3	4	5	6	7	8	9	10
6. Thinking *specifically about your club*, please rate the following potential obstacles on a scale from 1 ('no issue at all') to 10 ('huge issue – impossible to resolve'):										
Lack of player approval	1	2	3	4	5	6	7	8	9	10
Lack of coach approval	1	2	3	4	5	6	7	8	9	10
Lack of executive approval	1	2	3	4	5	6	7	8	9	10
General negative perception (seen as a 'gimmick')	1	2	3	4	5	6	7	8	9	10

Cost	1	2	3	4	5	6	7	8	9	10
Lack of customization to club needs	1	2	3	4	5	6	7	8	9	10
Lack of time	1	2	3	4	5	6	7	8	9	10
Lack of space	1	2	3	4	5	6	7	8	9	10
Difficult to use	1	2	3	4	5	6	7	8	9	10

Section C		
7. If your club were to own a VR training system, who would likely be responsible for implementing its use?		
Head Sport Scientist	Other Sport Scientist	Data Analyst
Coach	Other Support Staff	Intern or Associated Student/Academic
External Individual	Players Themselves	Other
If possible, please expand on your answer…		
8. If your club were to own a VR training system, how frequently do you expect that it would be used?		

Multiple times a day	Once a day	Multiple times a week
Once a week	Once a month	Less than once a month
If possible, please expand on your answer…		

9. If your club were to own a VR training system, to what extent extent would each of the following groups likely use it? Please circle ONE answer.

First Team Players	*Never*	*Seldom*	*Sometimes*	*Frequently*	*Always*
Under-23 Players	*Never*	*Seldom*	*Sometimes*	*Frequently*	*Always*
Older Academy Players (e.g. 14-18 years old)	*Never*	*Seldom*	*Sometimes*	*Frequently*	*Always*
Younger Academy Players (e.g. less than 14 years old)	*Never*	*Seldom*	*Sometimes*	*Frequently*	*Always*
Injured/Rehab Players	*Never*	*Seldom*	*Sometimes*	*Frequently*	*Always*
Trialists	*Never*	*Seldom*	*Sometimes*	*Frequently*	*Always*
If possible, please expand on any of your answers…					