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Where is the Sport Science in American Football?

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ABSTRACT

Despite enormous revenue production and a recent trend of investment in sport medicine research, American football has yet to make a measurable investment in sport performance science research. As a result, available knowledge is presently skewed toward technical and tactical domains, with very little knowledge development occurring in other areas within the sport science realm. In this editorial, we discuss plausible contributing factors to the current situation, and suggest ways to resolve this issue and move forward for the betterment of the sport.

Keywords: quality assurance; coaching; performance research; high performance model; National Football League; National Collegiate Athletic Association

INTRODUCTION

American football (AmF) is arguably the most popular sport in the United States. With growing momentum, the National Football League's (NFL) annual revenue is projected to reach $25 billion by 2027 [1]. The sport boasts strong television viewership; the 2021-2022 season's championship game (Super Bowl LVI) reportedly reached over 208 million viewers [2]. Some National Collegiate Athletic Association (NCAA) member universities have also capitalized on the sport's profitability. For example, the University of Texas reported $146 million in football revenue from the 2019-20 fiscal year [3]. While few college programs enjoy such profitability, private donations are often a major driver of the sport; the University of Texas football program enjoyed $33.6 million in donor contributions in that same year [3]. Demonstrating the impressive financial clout behind another powerhouse program, the University of Alabama's Crimson Tide Foundation 2021 revenue net position was reported as $276 million; assets include a $5.9 million airplane [4]. Large league incomes fueled by television revenue support growth in select college athletic programs; for instance, the Southeastern Conference (SEC) revenue for the 2020-21 fiscal year was $777.8 million, which led to payouts of $54.6 million per university that year [5]. Trends in donations and facility investments demonstrate Corbin's "athletic snowball" concept, where constantly increasing investment is required to support competitive status in collegiate sport [6]. For example, to complete a renovation project to Bryant-Denny stadium, the University of Alabama spent $91.7 million in 2020, and another $10.8 million in 2021 [4], making financial support to any individual academic department look miniscule in comparison. Despite such financial success and excess enjoyed by professional and top college teams, limited investment in knowledge-related activity is evident across the sport.

Little discussion has highlighted the deficits of knowledge-related activities supporting AmF. Due to indifference to research programs in revenue-producing sports, and obstacles to sport research program implementation described elsewhere [7,8], surprisingly little research has focused upon AmF. In fact, the volume of research projects in soccer, rugby, and other sports popular overseas dwarfs that applied to AmF. Demonstrating this point, 2 of the present authors produced the only existing GPS studies at the high school and NFL levels, respectively [9,10]. Data for these studies were collected 6-8 years ago, with no follow-on projects available at those levels of play since publication, though a small number of college team-specific projects have been published in this timeframe [e.g., 11]. A few reviews are available on the physiological demands of the game [12,13], however these are limited in scope due to available information. Practitioner-based knowledge in tactical and technical areas are undoubtedly the major focus of innovation that fuel knowledge management (KM) and knowledge translation (KT) in AmF. Technical

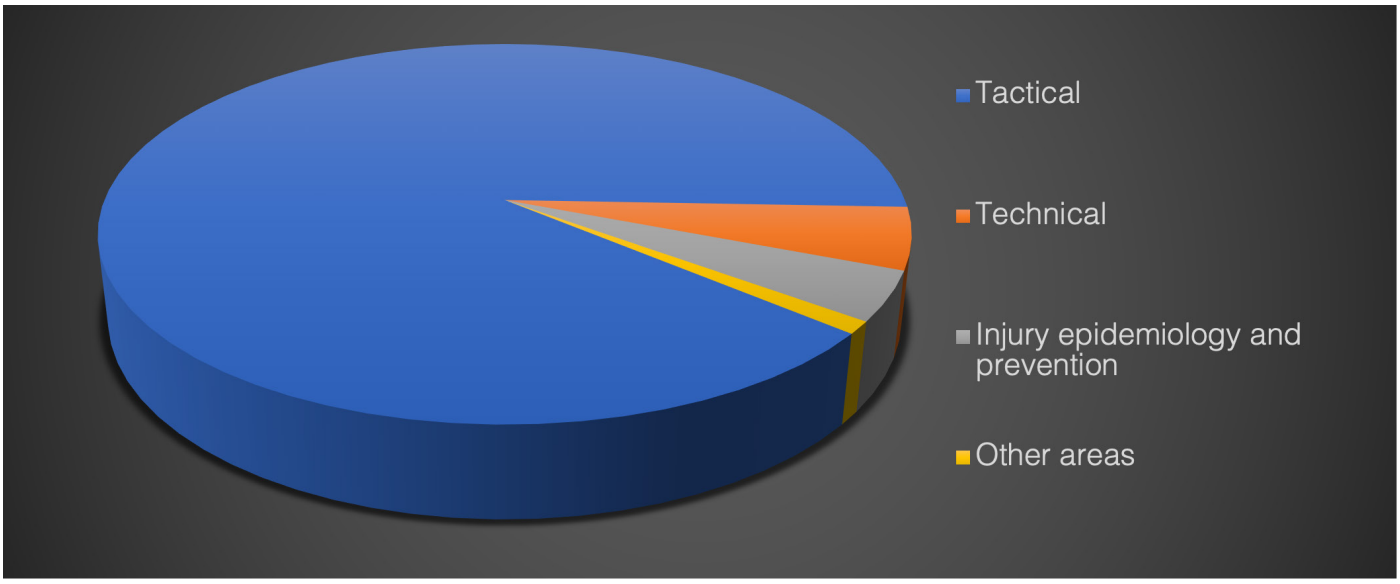

Figure 1. Anecdotal representation of sources of innovation in American football.

topics include tackling, route running, and coverage techniques, etc., while tactical topics include offensive and defensive play concepts, coverage schemes, reading a defense, etc. Although exact percentages of time spent studying these different areas is currently unknown, due to the paucity of research, an anecdotal representation can be viewed in Figure 1, based on the authors' experience in AmF at various levels.

It has been encouraging to see that a few technical advances have occurred in recent years: shoulder tackling strategies have been endorsed and publicized by governing organizations (e.g., USA Football) [14], and some blocking strategies have been designed to reduce head impacts [15]. Additionally, some administrative efforts to reduce head trauma have been implemented by sport leagues. For example, in 2016 the Ivy League banned full contact tackling in-season [16]. Though relevant and of honorable intent, forbidding tackling in-season is a medically-driven (reactive) policy, and is not a performance-based decision, per se. To our knowledge, no efforts have been made by any leagues or governing organizations to produce sport science projects intended to improve on-field performance.

Many of the available studies assume on-field performance improvements by using proxy measurements such as a 40-yard sprint, instead of actual gameplay. This may make sense from a strength and conditioning lens; however, an improvement in such a discrete test may not always transfer to improved gameplay, and small differences may not discriminate between good and excellent players. Efforts to explore performance concepts are limited to study by independent author groups with poor funding opportunities and limited access to explore athlete performance. On an encouraging note, one recent study evaluated several tackling performance parameters using video recordings of high school games [17], finding better shoulder tackling skills led to less yards after contact. The purpose of this narrative review is to highlight issues producing a lack of sport performance science research in AmF, and discuss potential corrective actions.

SPORT RESEARCH

Drawing from an international precedent, the International Olympic Committee (IOC) supports a Medical and Scientific Commission, which is tasked to foster knowledge development, produce and disseminate consensus statements, and other knowledge-related efforts to protect athlete health [18]. The IOC takes a stance that sport organizations should "widely disseminate" advances in sport science and sport medicine research, implying that those with research resources have an ethical obligation to share knowledge with the sporting community at large [19 (p.8)]. This philosophy is necessary because some countries lack infrastructure that can support knowledge-related activity (e.g., well-funded universities with relevant specialists). In addition, greater compliance with anti-doping policies and athlete care standards may lead to better training practices, etc., that suggest fair play.

While sport medicine resources have likely been supported for a longer timeframe in the United

States, the U.S. Olympic Committee has supported a variety of sport science initiatives at training centers for around 40 years [20]. Embedded sport science resources are also present within many U.S.-based professional sport teams, and sport science roles are becoming more common at universities [21]. This is encouraging because research programs are necessary to understand sport and shape common practice based upon available information [22].

At the highest level of AmF, the NFL supports the NFL Research & Innovation Committee, a medical group that advises the league and supports research projects in sport medicine and equipment development [23,24]. In addition, groups such as the hamstring and soft tissue task force share league-wide injury information across teams. However, the NFL has not established a comparable research program to explore performance concepts, or disseminate performance knowledge across the spectrum of league and sport system stakeholders. It appears such endeavors are left to team staff, should coaches and administrators: 1) be interested in performance knowledge development (KD), and 2) choose to devote resources toward relevant internal projects or collaborate with other teams to embark upon collaborative KD.

Similarly, at the advanced (and perhaps junior professional) level, the National Collegiate Athletic Association (NCAA) funds injury epidemiology and mental health projects through their Sport Science Institute [25]. Ironically, it appears the NCAA Sport Science Institute does not presently employ any sport scientists, only medical specialists and administrative staff. This perhaps explains a lack of investment in sport science research by the NCAA, and the list of fundable research areas suggests either indifference toward, or poor awareness of performance research.

To paint a current picture of research in AmF, projects commonly include: injury epidemiology [e.g., 26,27,28,29,30], prediction of combine performance to NFL production [e.g., 31,32], relationship of combine performance to draft success [e.g., 33], physical development of athletes [e.g., 34-38], body composition [e.g., 39,40], body and performance changes over high school or collegiate careers [e.g., 41-43], athlete height/weight trends over time [e.g., 44,45], GPS/accelerometry in college games or practice [e.g., 9-11,46,47], and reviews intended to translate knowledge for coaches [e.g., 13,48-50]. Most studies are descriptive in nature, with few studies exploring on-field performance or concepts contributing to it. For example, as important and pervasive as blocking is in game play, only a few studies are available investigating the skill or factors related to it [51-53]. NFL Research and Innovation Committee research topics are comprised of orthopedic, neurological, internal medicine, and sport medicine research [23]—the reader should note that all topics are sport medicine-related.

The present state of AmF knowledge suggests performance KD is either under-valued or not well understood by the majority of stakeholders, with respect to proper formulation of research questions or how to study those questions. Additionally, knowledge management (KM) in AmF is typically placed in hands of coaches and scouts. This is problematic because development pathways for these positions require only selective experiential training. In addition, a process of rigorous development and evaluation of employee knowledge and skills is absent (i.e., specific formal education and certification), and placement of staff is heavily influenced by nepotism and cronyism, while a coach's trajectory is set by level of jobs he (few examples are available of female coaches) is able to obtain through personal connections. This situation has led to a primary emphasis placed by coaches upon tactical and technical elements of the game, with precious little innovation in other areas. Though revenue sharing agreements with players exist in the NFL, the funding streams discussed at the universities above are primarily invested in facilities, coach salaries, marketing, and recruiting efforts, placing primary importance upon obtaining athlete talent via flashy recruiting strategies vs. process management and quality assurance within the program. Indeed, flash over-shadows process in many collegiate sport organizations.

Because KD is so sparse, support staff (i.e., sport scientists or strength and conditioning coaches) carry the load of KM and KT of performance training concepts, often informing sport coaches in methods of application where it is welcomed [54]. Limited connection exists with experts in sport science, and few professional opportunities are available for sport scientists with AmF teams or in faculty positions at the universities that sponsor high level teams. Despite the fact that all 14 Southeastern Conference (SEC) universities are Carnegie R-1 institutions [55]—indicating "very high" research activity [56]—at this time few SEC universities employ faculty sport scientists, none employ faculty sport scientists who specialize in AmF, and none offer graduate degrees primarily focused upon sport science. This situation

leads to limited knowledge-related activities or bridging between local academic programs and sport teams, and shows severely mismatched research and ancillary operational goals (i.e., goals of the athletic department are, in principle, not primary operations of an academic institution…or are they?). To further demonstrate this point, the University of Alabama athletic department has built a "Sport Science Center", but doesn't presently employ an experienced or formally trained sport scientist—a role typically held by someone with PhD in a sport science domain such as sport physiology, skill acquisition, or several other specific emphases [22]. However, university leadership has positioned the University of Alabama to be both a perennial powerhouse in collegiate sport and a powerhouse research institution … albeit, in areas other than sport science.

CAN ATHLETIC MANAGEMENT UNDERMINE RESEARCH?

Perhaps an important factor to consider is that—particularly at the highest level of college sport—head coaches are often hired as a cult of personality, enjoying immediate prestige and celebrity on campus. At the end of their coaching cycle, coaches are typically fired abruptly by administrators who have clear outcome-based performance expectations and a simple evaluation structure. This management strategy can be irreverently summarized as "toilet bowl management", in which unpleasant products (coaches who can't win) are removed quickly from the toilet bowl (the football program that can't win) by the press of a lever (firing the head coach during the season in a half-flush, or firing the entire staff at the season's end in a full flush). Sadly, as head coach salaries soar out of control and only a small pool of who's-who candidates is considered for jobs leading college football teams, the patience of boosters and administrators appears to be waning. One longtime college coach recently vented to one of the present coauthors that the timeframe to meet lofty winning expectations has now been shortened from about 5 years to 3 or less. In support of that comment, an evaluation of the coaching market from 1983-2006 showed that games lost within the most recent 3 years greatly influenced a coach's risk of being fired, regardless of prior performance [57]. It is likely that pressure to win has increased in the present market, and reflects the growing trend of in-season half-flushes.

Because this management style of extremes is so commonplace across the college football landscape, and results of coaching changes appear to have a random effect, it appears a more stringent vetting process is necessary for both coaching staffs and athletic administrators. In addition, more detailed and patient management awareness of operations within AmF programs appears necessary to foster an acceptable level of quality and construct reasonable supervisor expectations. Should strong management be established within a college athletic department, a system to limit the influence of unrealistic booster expectations is also warranted. Because performance research programs take time to establish (build relationships among staff members, identify research questions, etc.) they are threatened by rapid and frequent leadership change. The short duration of the typical coaching cycle in AmF may prohibit meaningful knowledge-related activities at the college level unless coaches and administrators start welcoming embedded sport science researchers inside their programs to help them construct meaningful processes.

SUPPORT STAFF AND INFORMED DECISION MAKING

Current best-practices commonly employed in high-level sport organizations overseas include organizational infrastructure fostering sport specialist involvement in shared decision making. Working within oversight of a high-performance manager (also termed director) [58], specialists (sport scientist, sport dietitian, etc.) use knowledge from their domain and information they are able to collect on the athletes under their care to assist the coaching staff in decision making [59]. Of relevance, Gleason and colleagues [22] identified knowledge-related tasks as a major responsibility of the sport scientist role, suggesting this role is an invaluable staff addition for a sport organization seeking a sustained high level of performance. By establishing a strong standard of care, processes supporting athletes may lead to organizational excellence and help establish competitive advantage, including projects supporting knowledge-related activities within the organization and beyond [22]. Logically, specialist staff employed to support coaches, athlete performance, and athlete well-being should easily demonstrate their value and provide leverage in the recruiting process for college sport teams.

In a recent editorial targeting U.S. high-performance sport, DeWeese and colleagues highlighted that a high-performance sport organization deliberately invests in employee knowledge [60]. This is done

to establish a sustainable culture featuring a transdisciplinary environment fueled by growth-minded employees, which is posited to enhance organizational effectiveness and ultimately establish competitive advantage. In principle, the high-performing staff strives to do what they do better, together [59]. DeWeese and colleagues also emphasized that a high-performance environment requires a director role, ideally held by a specialist with advanced relevant education, to oversee implementation of departmental support offerings [60]. In all, similar to presence of a specialist staff, knowledge-related activities have a valued place in a high-performing organization—in many cases, this may include partnering with external research entities/personnel to obtain necessary answers to performance problems [22,59].

UNREALIZED RESEARCH AREAS OF VALUE

Talent Identification

Modern talent identification practices are lacking at this time in AmF. Simply put, despite their diligence, team employees who are tasked to evaluate potential talent (college coaches and professional team scouts) miss their targets often [61-63]. Frequent examples exist of undrafted players who become starters and are recognized as top players in the league (selected as All-Pro and invited to the Pro Bowl) [64]. Further, high draft order does not necessarily forecast substantial playing time in the NFL [61,65,66]. Two primary causes may explain these issues.

Firstly, at the team employee (micro) level, scouts are typically untrained in measurement (i.e., seldom are they required to undergo formal education in athlete evaluation and assessment) and use few tools that objectively measure constructs they seek to understand. These issues introduce error and bias to recommendations informing draft choices that are delivered to top decision makers (i.e., general managers or head coaches). For example, physical performance test results from the NFL Scouting Combine have been shown to be related to draft status of players [33], demonstrating overemphasis on physical tests that isolate limited areas of athleticism and perhaps do not evaluate playing ability in a sufficiently comprehensive manner (i.e., some areas of talent are called “intangibles”, implying measurement is impossible).

Secondly, because the sport features several independent entities, no grassroots to professional talent identification programs exist (macro-level). Examples of government-funded and managed sport systems overseas demonstrate that some countries can be very successful in international competition if a long-term talent identification and development system is in place (e.g., Australian rowing). As this applies to domestic sport, a more effective talent identification program should improve selection decisions and reduce selection error, leading to a greater talent pool within the team at the highest level.

Performance Optimization

Comparative studies for training and conditioning programs are lacking, particularly across multiple specialty domains. Because of this issue, practitioner knowledge (anecdotal and experiential) and KT from better-researched sports and general training doctrine tend to be primary sources of contemporary program design. Limited physiological and biomechanical knowledge of the sport may lead strength and conditioning coaches and sport medicine personnel (i.e., athletic trainers; ATCs) to select training methods that may not be efficacious for improving performance.

Admittedly, informing program design can be challenging for NFL athletes, as team personnel are unable to control offseason training due to staff-athlete contact limitations set forth in the collective bargaining agreement. Unless the player directly seeks input from the team’s staff, the staff are unable to provide much guidance. However, this reality does not dismiss performance research programs as an impossible dream; athletes may indeed serve as volunteers in studies to evaluate program efficacy and practicality, particularly if they perceive the training offered to be of high quality. In addition, leagues and players’ associations can sponsor studies intended to identify best practices, as these are in the best interest of all stakeholders. Further, despite the players being away from their respective teams during the offseason, such research may help strength and conditioning coaches in private sector gyms to develop an evidence-informed approach to prepare players for the physical demands of the sport prior to returning for training camp. Powerful incentives may be offered to teams who participate in research—for example, priority draft choices, roster number increases, and player salary bonuses (paid by the league) may foster heavy participation in relevant research projects and fuel KD efforts.
Another challenge is that modern skill acquisition

concepts typically do not filter into sport practices. Instead, experientially-derived coaching knowledge and routine are typically emphasized in sport skill training sessions. Some experientially-accultured routine drills, called "every day drills", can be cumbersome to tailor to address specific athlete needs. Contemporary practice in coaching is presently undermined by a dearth of formal coach education requirements. Unfortunately, often coaches don't know what they don't know; however, many do manage to foster a strong performance environment using common sense, experiential evidence, and intent to do right by their players. Programming efficacy and the prevalence of issues such as overuse injuries are unknown across the sport, perhaps indicating that we don't want to know what we don't know. From a team management perspective, evaluation of contemporary training methods should occur in the context to shape norms in coaching (i.e., practice design, drill selection, etc.). Several studies with youth, high school, and low-level college athletes suggest that assessing athlete performance limitations, applying bespoke training (including some novel or uncommon techniques), and improving evaluation and communication processes may improve athlete competency [67-74]. At this time, due to researcher access challenges, little is known—by coaches and researchers alike—about how specific skill acquisition and maintenance strategies may be effectively applied with high-level athletes.

Aside from process improvements engineered by specialists who support operations, college sport programs can benefit immensely from well-designed research projects. Despite being housed at research universities—again, many high-level programs have obtained Carnegie R1 ratings—no productive sport science performance research programs are presently in existence at college football programs at any level. In truth, something must inform coach education programs; any methodology—whether novel or accepted in the mainstream—is ideally vetted critically so best practices may be developed.

Of great concern, it is clear that best practices in a variety of areas are not applied in AmF programs. Erroneous teambuilding and selection practices are still common in AmF. In a recent example, 2 lawsuits resulted from injuries sustained by University of Oregon athletes as a result of inappropriate early off-season training in 2017. Questionable practices are common when new coaches take over ailing programs. Demonstrating this concept, during his first meeting with players after taking the head football coach job at the University of Colorado in December of 2022, a player asked Coach Prime (Deion Sanders) what the off-season program would look like. Coach Prime answered: "We're going to try to make you quit…those of you who we don't run off, we're going to try to make you quit" [75]. During the editorial phase of this project, 57 players transferred from the university as part of Sanders' roster overhaul, breaking the transfer portal record [76]. Exactly how players will be treated at Colorado remains to be seen, but the above comments highlight the common practice in which a coach sets a punitive, disciplinarian posture after assuming control of a program, regardless of the problems within the program that contributed to the previous coaching staff's losing record. This reflects a need for mandatory coach education programs fueled by performance research and modern organizational psychology concepts that would occur with effective KM and KT. As a result of the frequency and severity of offseason injuries sustained during collegiate AmF conditioning programs, a position stand had to be developed by several stakeholder organizations that proposed a standardized return to training process for athletes [77]. Prior efforts by stakeholders to highlight reckless or erroneous practices [78,79] are seldom considered by governing organizations in shaping policy, suggesting a disregard for current knowledge by sport policymakers, athletic directors, and coaches.

Positional Study Applied to Tactical Decisions

At this time, it appears that technology still lags behind human video analysis of gameplay and practice. Several years ago, the NFL integrated a Radio Frequency Identification (RFID) tracking system in stadiums [80], the accuracy of which is still un-vetted by any independent research group. The NFL and Zebra have yet to demonstrate widespread integration of the system to team decision making processes. However, the creation of the annual Big Data Bowl has provided the opportunity for independent data scientists from the public to perform analyses using team data and share results with team staff members. This helps bridge the gap between player tracking data and player evaluation or tactical understanding. The use of Zebra technology in games has led some teams to integrate the RFID technology in their practice facilities, while some others rely upon commercially available GPS and accelerometer technology in practice to support athlete monitoring programs. It is encouraging that over 30 Big Data Bowl participants have reportedly been hired by NFL teams in some

capacity [81], indicating that the NFL's investment in data has led to greater awareness of the area. However, despite widespread use of tracking technology in practice sessions and games, little information is available in the literature about the actual demands of NFL performance. Only one GPS study has been performed in the NFL (during training camp) [10]; as such, knowledge of actual in-season training demands with any team is very limited. Because of apparent technological limitations of tactical software, only game and practice demands (distances, speeds, accelerations, etc.) are available at the college level [e.g., 47].

ORGANIZATIONAL CONSIDERATIONS INFLUENCING RESEARCH PROGRAMS

Some value may be found if sport-experienced sport scientists are employed by a sport organization. Knowing the jargon, strategy, demands of game, positional differences, culture, and game nuances may lead to better integration with coaches and more rapid development of relevant research questions. Further, prior experience in the sport may help build relationships with athletes and foster athlete monitoring process integration so that the coach-athlete relationship may be better supported. However, the degree of benefit prior playing or coaching experience offers over on the-job-learning is unclear. Presently, 1 NFL team employs 3 sport scientists, and some employ 1, and only a few sport scientists working in the NFL have football playing experience.

A challenge seen in most college football programs is that sport scientist specialty training is lacking, as typically strength and conditioning coaches provide GPS tracking services or operate other technology tools [21]. This seldom leads to true sport science servicing at team level, as few strength and conditioning coaches are trained scientists. Though provision of information to coaches may occur, a lack of training in sport science may result in milder or erroneous influence on team processes. For example, lacking a specific research question or directed purpose may set the data collected on a road to nowhere. It is likely that many AmF teams are missing out by not providing more emphasis on staff skill and sport science process integration.

Internal research entities, such as research and development (R&D) departments may offer valuable knowledge-related resources for a sport team [59]. This precedent now has gained a lot of steam in Major League Baseball, due to the volume of technology applied to the game, the large number of athletes that a team supports (through their Minor League affiliates), and the need to develop players through the Minor League pathway in the hopes that they can matriculate up to being a valuable Major League asset. Alternatively, at the league level or at an academic institution, research institutes or other entities such as think tanks may be formed to select research initiatives that may be used to help refine policy. Of interest, these groups may explore a broad array of performance and injury topics in a collaborative effort between sport scientists and sport medicine researchers.

On a promising note, the co-owners of one U.S. sport organization (Brooklyn Nets) recently began a philanthropic entity that supports innovation in a variety of research areas. Founded around 2021, the Wu Tsai Human Performance Alliance funds a diverse range of projects and employees at 6 universities, with broad interests in medicine, engineering, development and application of technology, and a variety of sciences—including sport science [82]. At this time, the Alliance does not appear to have influenced AmF directly, however encouraging productivity has been shown in basketball research at the University of Kansas.

Finally, league administrators with sport science training may be helpful to devise strategy for knowledge-related tasks across the league. At the league or systems level, a sport science specialist may be a valuable voice at the table to keep financial interests balanced with the realities of athletes' physiological and psychological limits and fatigue. For example, performance enhancement and athlete welfare are often in conflict with trends in competitive schedule extension, and a number of options can be considered if schedule extension is deemed necessary for financial gain (e.g., roster expansion). League strategies to integrate data in decision making must be carefully made, as data security and athlete rights can present complex ethical issues and be sources of misconduct [83]. Professional sport organizations must account for collective bargaining agreements, which are designed to protect athlete interests, including health and safety. Players associations are responsible for protecting athletes and their interests, and biometric data can present a promising frontier or threat, depending on knowledge, philosophy, and intent of the user. Brown and Brison [83] highlighted that the NFL must address ownership, use, management, privacy, and security of the data, in addition to specifically identifying which personnel should have access

to it. Future discussion of ethics certainly requires sport scientist perspectives to balance athlete and team interests, while ensuring progression and modernization of the sport.

CONCLUSIONS

It is clear that both NFL and NCAA research initiatives are sport medicine-focused, which implies a reactive stance to issues in the sport. As a result of chronic indifference to sport performance science research, it should not be surprising that rhabdomyolysis events and other preventable issues are a cloud hanging around AmF. Sport performance research is necessary to refine common practice, inform coach education programs, and shape policy. Similar to the IOC's stance suggesting developed nations share resources to inform the sporting world, the authors challenge the NFL, NFL teams, NCAA, and revenue-producing NCAA member institutions to lead the charge and establish viable long-term sport performance research funding streams, jobs, and establish policies supporting knowledge-related activities and coach education programs. Specialist support appears to be a valuable resource to advance operations and increase athlete and staff capability within AmF programs. Proper application of sport scientist roles is possible without compromising competitive advantage—in reality, sport science may help leagues avoid ethical issues. Importantly, embedded sport scientist positions may help shape research programs across the sport.

DISCLAIMER

The opinions expressed in this article are those of the authors and do not reflect policies of the U.S. Army, Department of Defense, or U.S. Government.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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