Development Pathways for the Sport Scientist: A Process for the United States

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Abstract

A variety of sport organizations employ sport scientists in a range of capacities to support team operations, while universities employ sport scientists in academic (teaching and research), consulting, and support roles. Despite the growth in professional opportunities in the United States over the last few decades, little discussion has occurred to identify best-practices in developing sport scientists. Here we identify several examples of professional development pathways used by overseas organizations that govern sport science roles and highlight key features of existing U.S.-based sport support role pathways. This information can be used to develop, implement, and evaluate professional training of sport scientists, along with shaping sport science training programs in the U.S.

Keywords: integrated support team, sport science education, high performance model, training, coach education, sport management

Introduction

The integrated support team (IST; sometimes referred to as a multidisciplinary support team) is an athlete-centric concept where specialists in multiple areas work together to influence the development and care of the athlete (Figure 1) (26). Education and experiential requirements vary between specialists in the IST, as some specialties are paramedical (e.g., sport physical therapist), while others are coaching-related (e.g., strength and conditioning specialist). One of these IST roles, the sport scientist (SS), "applies expert-level knowledge and skills to the training process, obtains and analyzes information, and evaluates processes, to solve problems and improve performance outcomes for the organization (or sport) and the athletes working within it, while enhancing the coach-athlete relationship" (26). Ideas of how to best develop SSs as researcher-practitioners have received little attention in the literature (31). While several development models are in practice, the optimal mix of pedagogy and experiential opportunities for developing sport science skills has not been formally investigated. Like most professions, SS development programs should be evaluated with respect to effectiveness of methods and best-practices discussed and shared by educators within a professional or regulatory association (e.g., National Strength and Conditioning Association; NSCA) for wider distribution. Given specific knowledge requirements (e.g., sport-specific information, scientific research methods, scientific and coaching literature, training theory and processes, coaching methods), a high level of formal training (typically a doctoral degree), and experience in sport (5+ years) is necessary to gain non-developmental employment in the industry overseas (24). International comparison is useful to elucidate effective training pathways. High-level training sites and sport organizations are strong locations for coach development (40). Provided the right infrastructure, people, processes, funding, and athlete access, opportunities are available, U.S. university athletic departments,

national-level sport training centers and sites, and professional sport teams may be excellent sites for developing SSs (and other IST specialists).

[INSERT FIGURE 1 HERE]

Chiu's observation (11) that training opportunities for strength and conditioning coaches are in a state of chaos also applies to SS roles within the U.S. sport industry. Describing one source of chaos, Stone and colleagues (41) noted that few formal and focused sport science training programs exist in the U.S. Indeed, at U.S. universities, few specialized SSs are available (faculty or practitioners employed by athletic departments), and sufficient access to athletes and coaches can be difficult to obtain to study sport. Only 1 dedicated sport science doctoral program exists in the U.S. that offers a degree in sport physiology (detailed below). A few other university programs offer master's-level sport science degrees, and some universities offer selected experiential opportunities to study sport science in their athletic departments. Despite many kinesiology departments including the word "sport" in the department or degree title and offering optional sport science coursework, most universities offer degrees with a focus on exercise science—which, despite many similarities, is not the same academic focus as sport science. To clarify, exercise science is centered on exercise and its contributions to health, while sport science deals primarily with performance enhancement (41). Because most U.S. universities lack SS faculty, limited sport science knowledge is available at those institutions; therefore, sport science courses may need to be taught by faculty specialized in other areas. This may limit or delay relevant student learning outcomes because practitioner wisdom and understanding of common practice in sport science would need to be developed in other settings (e.g., internships). Compounding the formal preparation issue, U.S. professional sport teams

seldom offer developmental opportunities for SSs, and not all have sport science infrastructure and support.

Internationally, professional development pathways often involve a foundation of relevant scientific coursework supported by specific experiential processes in a pathway overseen by a governing certification agency. Though this model has been described previously in its application within professional sport (2), little discussion has addressed mentoring opportunities (39) and other concepts, such as communities of practice specific to sport science, which may enhance professional competence. These elements are important for the broader U.S. sport market because relevant education and experiential opportunities should be available to share best practices among the SS community and support the professional development of SSs. The purpose of this article is to overview overseas SS development pathways—specifically those of Australia and the U.K.—and provide recommendations for a U.S. SS development pathway.

Sources of Learning in Sport Applied to Sport Science

Sources of learning may be broadly classified as mediated (by an educational system) and unmediated (on-the-job or self-directed learning) (28). In their commissioned report on coach education, Cushion and colleagues (14) used Coombs and Ahmed's (13) terminology to classify coach education methods into 3 categories: formal, informal, and non-formal. Applying these concepts to the sport science context, formal learning is typically delivered by a structured educational system. Common examples include a university degree, or a structured course offered by a national governing body of sport (e.g., 42) or equivalent organization for sport support specialists (e.g., 36). Some key features of formal learning are academic prerequisites, required attendance, structured curricula, and issuance of a certificate upon completion (14).

In contrast, informal learning is considered a long-term process outside of formal institutions, where a SS gains knowledge from exposure to work settings, informal mentoring, or reading scientific articles, coaching journals, and textbooks. A key feature of this type of learning is that it is self-driven. Informal mentoring may be delivered as on-the-job training, where a SS learns methods from colleagues, including peers, senior staff, mentors, and educators. Of note, Cushion and colleagues (14) considered experiential learning to be informal learning, as it involves substantial interaction with others that may help the SS develop interpersonal communication skills and specific knowledge of the sport(s). Formal mentoring is delivered within the developmental pathways of the British Association of Sport and Exercise Sciences (BASES), Exercise & Sports Science Australia (ESSA), and also the U.S. sport dietitian pathway. Formal mentoring includes activities that are structured, with learning processes recorded. A less-structured process, reflective practice—the practice of deliberately considering information around events (i.e., potential actions versus the actions taken in a situation and lessons to be learned from that experience) (27)—is also an informal strategy recommended in sport science to help the employee refine their work processes and way of thinking (15). Prior athletic experience is also categorized as informal learning; experience playing and coaching the sport may be extremely valuable for employment with professional teams in certain sports. Acceptance within the organization may be accelerated if a SS can communicate in contextually-relevant ways, using specific jargon. Integration will go much smoother if a new SS begins operations in an organization with a strong understanding of the culture and structure of the sport.

Non-formal learning is organized but outside the framework of the formal system (13, as cited in 14). For example, attending workshops or conferences provides alternative sources of

information, allowing practitioners to discuss common practices. Non-formal learning is commonly formulated as continuing professional development, a requirement of many SS accreditation schemes (e.g., BASES and ESSA). Communities of practice are typically formed by peer groups of practitioners and foster the creation of new knowledge, sharing of best-practices, and discussion of critical concepts (17). Communities of practice may be led by a senior member of a group or peer-to-peer network. Murray and colleagues (35) outlined a structured strength and conditioning community concept tailored for use within a university semester, led by an experienced mentor. In this model, the experienced mentor schedules and leads meetings with interns, assigns important topics for discussion, and encourages community discussion of critical role-specific behaviors and issues. The mentor is careful to craft a sense of belonging among the intern group, fostering inclusive discussion while guiding hands-on learning and intern reflection. As the internship continues, the mentor offers opportunities to sit in on professional meetings (e.g., with coaches) or assist with important tasks, such as program design or developing budget proposals. The internship ends with a self-evaluation. This model may be adapted to manage learning by developing SSs in internships or academically-based service-learning.

We are unaware of studies evaluating the effectiveness of any of these educational strategies in the sport science context, or how much value can be placed upon previous work from other IST specialty areas (e.g., strength and conditioning). An effective learning strategy for one specialty may not be relevant or effective in another. Challenges exist with any type of learning if some element of quality assurance is not employed. For example, during experiential learning, a developing SS may acquire knowledge of a particular method (e.g., using and endorsing an unvetted tech device) and accept it as factual without applying critical evaluation.

In this example, during experiential training, guidance from a qualified university-based mentor for the developmental SS may provide excellent opportunities for critical thinking and refine learning outcomes of experiential learning. Industry-wide debates about the effectiveness of certain technologies or training load management strategies may be necessary to bring to the developmental SS's awareness as they learn to ensure they employ critical thinking during experiential learning. Empirical research is necessary to evaluate educational strategies, which will greatly aid educators and professional course developers to create and shape common strategies used to develop professionals in the field. For example, studies evaluating learning outcomes of various pedagogical strategies, such as those recommended by Murray and colleagues (35) or other sources, may be conducted in collaboration with sport organization staff to seek the most efficient and efficacious application for developing SSs, which benefits academic programs, organizations, and students alike.

Experiential Training in Sport Science

The Integrated Research Training Model

Bartlett and Drust (2) described a practical development model for SSs common in professional sport organizations in the U.K., Australia, and New Zealand. In this integrated research training [program] model, a developmental SS, or research-practitioner, is employed by a sport organization through a salaried doctoral fellowship (full-time, paid by the sport organization). The developmental SS provides service to the organization over the course of their studies. The critical structure of this model is that the SS is embedded within a professional sport organization to perform services, and they report to both academic and professional sport supervisors (2, 29). Because supervision and mentorship are provided by supervisors and

mentors employed in both professional practitioner and academic roles, this model appears well-suited to develop the SS's technical knowledge, practical knowledge, and interpersonal skills necessary within the sport industry (2). The influences upon the developing SS are modeled in Figure 2. This model also offers advantages to the sport organization because they obtain the services of a developing worker, and mid-career and late-career employees in the organization may be up-skilled in areas such as technology or social media, as well as connecting with a younger generation (39).

[INSERT FIGURE 2 HERE]

There are several shortcomings of this embedded development model. Because the model most commonly employs a junior professional who is likely a novice in many areas of sport science methods and research, successful integration and quality interaction within the organization is not necessarily guaranteed. In addition, some sport organizations may lack the capacity to mentor or supervise a junior SS due to the limitations of existing staff, an issue prevalent within the U.S. collegiate setting. In addition, despite its government regulation, various challenges have been recently identified for SS roles in the Australian sport industry, including unsustainable working conditions such as long hours, low pay, and poor job security (16). These issues have also been reported in the U.K. (15) and may be a result of widespread use of this development system—from an organizational budget perspective, hiring a developing SS to service the organization is cheaper than a full-time, experienced practitioner. Bruce and colleagues (10) suggested this trend was evident in Australia, possibly reflecting an oversupply of applicants. Importantly, some organizations using this model discount the knowledge and experience of a well-developed SS, minimize the continuity of projects within the organization, undermine the potency of collaborative influence over programming the athletes are exposed to,

and reduce the organization's ability to mentor the developing SS effectively. Interns and developing SSs must be mentored by qualified personnel, which is critical for developing specialist skills.

Internship and Volunteer Guidelines, Options, and Pitfalls

An organization can offer a suite of developmental options, and it is important to determine specific duties for all of these and detail the level of commitment each option carries. Volunteers work without pay to benefit the organization and gain industry experience (23). To maintain volunteer status, the volunteer must operate by their own free will and without coercion. Volunteers are not obligated to attend or perform work, and the duration of these arrangements can be open-ended, with no requirement for official documentation. Student internships (termed student placements overseas) are offered for a specific time commitment aligned with academic credit. Similar to student internships, unpaid internships provide the intern with industry experience via observing, learning, training, and development of skills, but academic credit is not provided. Unpaid internships are conducted for a set duration and have more structured hours and administrative requirements (23). Organizations considering offering unpaid internships for individuals not seeking academic credit should confirm that the practice is permitted in their state before proceeding. To comply with federal labor law, student interns or unpaid interns should be the primary beneficiary of the relationship with the organization (43). Paid internships may be part-time or full-time for a specific duration. Pay is at minimum wage or above and may involve in-kind payment such as meals or housing.

Conceptually the sport science internship experience allows for developing critical thinking and interpersonal skills required for working in a high-level sport environment.

Internships benefit the organization by identifying potential hires and learning more about their business via student projects (23). A mutually beneficial situation only occurs when the supervisor has adequate time to mentor and supervise the intern. The organization providing the internship must ensure that the intern receives a meaningful learning experience focused on training or skill development. To avoid violating U.S. federal labor laws, the intern should not be viewed as inexpensive labor in place of a full-time employee. Interns should proudly complement the organization, and their daily tasks should not involve completing tasks typically performed by a paid employee (43).

Several pitfalls are evident for volunteer relationships and unpaid internships, realities the sport organization needs to approach carefully. Of primary concern, an employment relationship may be established when the volunteer or unpaid intern is required to perform daily tasks that paid employees normally perform. Also of concern, providing in-kind benefits (e.g., game tickets, food, etc.) may change a volunteer or unpaid relationship to an employment relationship. Thus, the volunteer or unpaid intern may be legally eligible to pursue back pay.

Several pitfalls exist for part-time interns; for example, they may not work full-time hours, or they technically become full-time employees and may be legally entitled to full time pay and benefits. Organizations considering offering paid internships are recommended to research federal labor laws outlined in the Fair Labor Standards Act (see 43, 44) and state department of labor to identify the requirements for exempt employee pay, minimum wage, and overtime and reimburse the intern accordingly. In addition, organizations should ensure that employee requirements and pay are clearly stated in an employment contract and the contract is followed (23).

Internships at different levels of sport (along the spectrum of youth through elite) or development (along the spectrum of sport exposure through full-time employment readiness) may require different levels of prior knowledge and experience. For example, behavior and skill expectations of professional sport clubs may require an individual with several years of previous experience at a lower level of sport that fits the internship description. In contrast, requirements for a volunteer arrangement, unpaid internship, or student internship may not require any previous experience. The internship supervisor should have sufficient qualifications, professional experience, supervisory skills, pedagogical skills, and time available to deliver a quality experience. Time spent with volunteers and interns adds to the supervisor's workload, so organizations should carefully consider offering developmental opportunities and carefully evaluate their willingness and ability to provide sufficient resources.

For the organization to set up effective developmental opportunities, design and coordination must occur ahead of time across the organization. The specific goals and duration of the developmental experience must be designed with these outcomes in mind, and an internship needs to be long enough to achieve these goals. In addition, requirements must be aligned with responsibility and compensation provided (i.e., do not offer an unpaid internship or volunteer position and require a graduate degree or certification for it). Requirements and outcomes must be formalized in writing before offering an internship and referred to during the hiring process (note: this may not be required for volunteers).

Those seeking to develop postgraduate scholarship experiences within their organizations are advised to see ESSA's internship guidelines (23). Further details are provided by McGuigan and colleagues (34), outlining lessons learned in applying this model—including guidance for the student and the industry and university partners.

The willingness of employers to engage in unethical labor practices for developmental employees is an ongoing concern across the sport industry internationally. Unethical practices may be seen in many settings. Aside from avoiding violations of labor law, to maintain ethical integrity, organizational leaders must be vigilant about proper application of developmental roles to demonstrate legitimacy and cultural excellence. In many cases, a developmental employee is exposed to high-level sport for the first time by volunteering or through an internship. Aside from the various legal implications, taking advantage of the developmental employee may damage the organization's reputation and those of the people in it, damage a sport organization's relationship with a university, and prevent future intern supply. In addition, maltreatment will likely deter the developmental employee from seeking further employment in the industry.

Remuneration influences intern quality. Suppose an unpaid internship (i.e., not for academic credit) is offered. In that case, an organization may get lucky and find a good employee to work for a short time, but organizations unwilling or unable to offer paid developmental opportunities are unlikely to obtain outstanding interns who are well-prepared to make an immediate impact. Because SSs have typically obtained graduate degrees and many have education-related debt, expecting them to work for any duration for no pay or minimal pay is simply unrealistic. Of great concern, the practice of offering unpaid and low-paid internships, particularly for those that require long work hours, tends to cater to people from wealthy families and strongly inhibits diversity in the workplace. To our awareness, no funding opportunities are presently available from any U.S. sport leagues or USOC to support SS developmental roles. Until this changes, direct funding via scholarships, stipends, and salaries from sport organizations, national governing bodies of sport, and academic institutions may be the only available developmental SS support mechanisms.

Practitioner Guidance on Relevant Learning

To effectively participate in a high-performance environment, aside from knowledge of the sport, a practitioner must have some prior experience in a high-performance organization (i.e., advanced, professional, or Olympic level). Experience with organizational dysfunction is also advantageous to learn how to navigate pitfalls and challenges commonly seen in the role (e.g., trying to "convert" a firmly resistant-to-change and poorly-informed sport coach to explore alternative processes). SSs must learn effective communication, process development, suitable organizational structure and reporting lines, and sound leadership and followership skills. As high performance sport can be unforgiving—in that the nature of high performance is fleeting and difficult to foster—it is critical to deliver a return on investment for the high-level sport organization in all of its enterprises. As a result of this reality, a SS must be trained to provide detailed and meaningful insight for the organization. An effective SS is talented in ways that may bring about those insights, positively affect the athlete training process, and maintain a good working relationship with organizational stakeholders. Further investigation is necessary to explore how effective workers accomplish their fit within their respective organizations. This may include investigation of personality types common among those serving in SS and in coaching roles, in addition to exploring nuances of roles (variation of job tasks between equivalent roles, etc.) seen across the industry in different sports and at various levels of sport.

Ultimately experiential learning opportunities must provide the learner with exposure to common operations within high performance sport that may be influenced by or influence sport science work and show the developmental SS how to explore details of the sport effectively. Further, opportunities must teach the learner how to build rapport with stakeholders, reinforce

effective time management and task prioritization, help them learn how and when to communicate effectively and honor reporting lines, and help them learn how to navigate different personalities throughout low-stress and high-stress situations. The embedded SS will support many people with lofty goals that can be demanding customers at times; humility and preparedness can be great allies.

SS Development Models

An international comparison of pathways is necessary to conceptualize an appropriate pathway model for SS development in the U.S. We begin by exploring the pathways offered by BASES and ESSA, then turn attention to available U.S. opportunities.

BASES Development Model

The BASES development model, established in the U.K., has an aspiring SS begin with a sport and exercise undergraduate degree that incorporates 3 core elements: biomechanics, physiology, and psychology (3). Specialization occurs in 1 or more areas via postgraduate study, alongside professional organization participation, internships, and academic experiences (3). BASES offers 2 routes to achieve accreditation: the supervised experience program and direct application. Supervised experience requires the applicant to have an undergraduate degree in sport and exercise science (3). To begin the supervised program, the applicant must be enrolled in or have completed a sport and exercise science graduate program (7). The 2-6 year program provides professional development and develops skills under the guidance of a BASES-registered supervisor. Requirements are listed in Table 1. The supervisor may end supervised

experience when the trainee has demonstrated mastery of essential competencies and met educational requirements (8).

The second pathway to accreditation is available for applicants who did not obtain a BASES-endorsed undergraduate sport and exercise science degree. However, the alternate pathway still requires applicants to demonstrate knowledge in the 3 core elements. An alternative route to accreditation is also provided for individuals who did not complete the supervised program but have sufficient industry experience.

[INSERT FIGURE 3 HERE]

Two specialization pathways are available within BASES following accreditation as a sport and exercise scientist: 1) certified exercise practitioner, and 2) high performance sport (3). In addition, those interested in specializing in pedagogy, research, coaching, and sport development are provided specific guidance (3). Demonstrating a specialty in pedagogy, for example, requires experience in related research, administration, and program development (4). A separate training route is available for successful sport and exercise psychology candidates to register with the Health and Care Professions Council as a registered practitioner psychologist. To demonstrate research expertise, an applicant must have achieved at least 5 peer-reviewed publications (indicating research leadership) and supervised at least 2 successful postgraduate students (degrees awarded by research) to publish results. The applicant must also document evidence of relevant and continued professional development (5). Individuals with more advanced experience are eligible to apply for professional qualification as a Chartered Scientist, considered the highest level of professionalism and competence (detailed in 26).

The high performance sport accreditation (HPSA) pathway is our focus here, as it was specifically designed for individuals performing sport science services to high performance sport

programs and is intended to demonstrate adequate experience (≥5 years of experience is required) and evidence of successful service provision (6). Competencies are focused on work experience in high performance sport (Table 2). The HPSA specialty is only available for those working in high performance sport, not at the university level. This arrangement does provide a division between SSs across the industry. It could limit opportunities for many experienced practitioners to work in professional and elite sport unless access is provided from within.

[INSERT TABLE 2 HERE]

ESSA Development Model

ESSA is authorized by the National Alliance of Self-Regulating Health Professions in Australia to provide accredited professionals, similar to how the Science Council authorizes BASES in the U.K. ESSA provides 2 specific areas of specialization for health and fitness professionals (Accredited Exercise Physiologist, Accredited Exercise Scientist), and 2 specific areas for people working in sport roles: Accredited Sports Scientist (ASpS), and Accredited High Performance Manager (AHPM). Each area of specialization has a specific scope of practice that clearly outlines minimum activities and professional standards for accredited professionals in that role (21, 22). Within the ASpS scope of practice, 6 areas of knowledge are recognized: performance analysis, skill acquisition, sports biomechanics, sports physiology, strength science, and data science (19). ESSA has established 2 levels in the ASpS program.

Level 1 ASpS

The base-level qualification, Level 1 accreditation, provides practitioners who are "university-qualified exercise and sport science professionals who provide expert advice and support to coaches, athletes, and teams, to help them understand and enhance sports

performance; adopting evidence-based, quality-assured practice to evaluate and develop effective strategies or interventions in training and/or competition" (19). A total of 5 professional standards are relevant for the ASpS: professional practice, planning and decision making, implementation of sport science services, understanding and implementation of research, and data handling and management, details of which are provided elsewhere (21).

There are 3 pathways for Level 1 accreditation (Figure 4). All applicants must have completed an undergraduate degree, met the professional standards of an Accredited Exercise Scientist (requires ESSA-accredited or non-accredited program that meets ESSA exercise science standards and 140 hours relevant practicum), or hold a master's degree in sport science (18). Applicants must obtain mentored sport science experience (360 hours) under the guidance of an ESSA-approved mentor and meet ASpS Level 1 standards. Pathway 3 is the alternate pathway for individuals who obtained an unrelated bachelor's degree; a master's degree in sport science and 3 years full-time experience (FTE) in supervised sport science activities is required to ensure sufficient knowledge.

[INSERT FIGURE 4 HERE]

Foundational coursework in sport science-related material is critical architecture in all pathways to achieve ASpS Level 1. Required coursework includes biomechanics, exercise physiology, exercise prescription and delivery, functional anatomy, growth and development, health and exercise assessment, human anatomy, human physiology, motor learning and control, nutrition, physical activity for health, psychology of health and exercise, and research methods and data analysis (18). ESSA has compiled a list of approved programs that meet these requirements, so the foundational education can be standardized and the pathway is streamlined

for interested students. Applicants who come through alternative pathways must demonstrate that they have completed the required coursework.

Level 2 ASpS

Level 2 standards indicate advanced skills as an accredited SS (Table 1). Typically, these individuals have performed research within a specialty area of sport science. Level 2 accreditation is provided through 2 pathways, indicated in Figure 4. The pathways require advanced degrees and 5 or 7 years of FTE in sport science, along with meeting Level 2 ASpS professional standards (20). Practicum requirements for mentored sport science experience include requirements for an experienced and credentialed supervisor. Appropriate supervisors are Level 1 ASpS with >2 years FTE experience, Level 2 ASpS, SS accredited by BASES, Sport and Exercise Science New Zealand, an Australian Strength and Conditioning Association Pro (Level 2) coach with a 3-year degree in exercise, sport, or movement science, or a UKSCA accredited coach.

[INSERT TABLE 3 HERE]

U.S.-Based SS Development Opportunities

Several U.S. universities have developed institutes or laboratories focused on sport established by faculty members pursuing sport research interests; however, few universities have established longstanding academic-athletic integration focused on sport science. Currently, only 2 U.S. universities (East Tennessee State University and Carroll University) are developing students through sport physiology academic programs formally integrated with athletic departments, providing sport science services and research, delivered via strength and conditioning methodology. Initially modeled after Finland's sport science program delivered by

the Finnish Institute of High Performance Sport (KIHU), East Tennessee State University offers the only U.S. doctoral program providing this structure (see Figure 5 for curriculum). Students obtain practical experience performing services for 2 university athletic departments, competitive club weightlifting, and powerlifting athletes, or professional athletes affiliated with the Center of Excellence for Sport Science and Coach Education training site. This arrangement was partly designed to develop graduates for a scientist-coach role that provides extensive value in advanced, professional, and elite sport settings, providing personnel with practical coaching and sport support experience, and an advanced or terminal degree. Such a coach may serve as a SS, strength and conditioning coach, sport coach, researcher, practitioner-researcher, or administrator. This program seeks to develop a student's capability to evaluate scientific methodology, create new knowledge, and produce (via formal or informal methods) translational knowledge, efforts detailing best practices in sport training while coaching and providing services for a team. Stone and colleagues (41) observed that this level of expertise was uncommon in the U.S. sport industry, which may explain the large volume of foreign SS working in U.S. professional sport.

[INSERT FIGURE 5 HERE]

To lay the groundwork to compare pathways, we overviewed the U.S. pathway for the sport dietitian (nutritionist). This role was chosen due to 3 factors: recent rapid proliferation within high level sport organizations, government regulation by most U.S. states requiring formal education and mentored experience, and protection of the title across industry.

IST Example: The Sport Dietitian (Nutritionist) Pathway

Given the effects of nutrition on recovery and performance (9), the skills of a sport dietitian are a necessary part of the IST (38). This paramedical practitioner role is proliferating rapidly across U.S. high-level sport. The Commission on Dietetic Registration provides a detailed pathway description to achieve Certified Specialist in Sport Dietetics (CSSD) (12). The primary training pathway begins with matriculation into an Accreditation Council for Education in Nutrition and Dietetics (ACEND) accredited bachelor's degree program (1) (note: beginning in 2024, a graduate degree will be required). The program continues with completion of an ACEND-accredited supervised practice dietetic internship program or the individual supervised practice pathway. It ends with the Commission on Dietetic Registration exam and state licensure. A minimum of 75 hours of continuing education within 5 years is required to maintain registration. Three alternative pathways are available to become a Registered Dietitian Nutritionist (RDN), and for brevity, they are not discussed here (see 1 for more information).

Two years after obtaining status as an RDN, an applicant may pursue CSSD certification and complete the secondary requirements. Two elements are required for an applicant to obtain certification: current status as an RDN and documentation of 1,500 hours of practical experience in sport dietetics as an RDN within the past 5 years. Up to 500 hours of relevant work (see Table 4) may be substituted to meet the minimum requirement.

[INSERT TABLE 4 HERE]

Several points are important to highlight in the sport dietitian pathway: 1) a specific base level of training as a generalist is required, involving acquisition of state licensure as an RDN, 2) certification is recognized/required at the state level, 3) a specific volume of professional development activity completed within a time period is required to develop skills and maintain currency, and 4) additional training (above generalist) is recommended to obtain certification to

work independently and effectively in sport settings. This formal development structure will equip the dietitian with sufficient skills, knowledge, and expertise to assist the athlete and the sport organization. Qualified training topics include education, research, and professional activities, providing breadth to non-formal development.

Recommendations for Formalizing a U.S. SS Development Pathway

Several critical themes are evident in SS development pathways offering accreditation: 1) formal education providing a base in multiple disciplines that underpin sport science, 2) 3-7 years of FTE experience in high performance sport, and 3) supervised development within high performance sport organizations overseen by approved mentors. As demonstrated by the U.S. sport dietitian pathway, development pathways for roles in the IST can be formalized by governing organizations, leading to accreditation or licensure at the state level.

Education

Formal education specific to the specialty serves to establish the foundation of knowledge. A doctorate is required to enter many full-time non-developmental sport science roles in Australian sport (24). Based on personal experience in this area, we consider this a reasonable minimum education level for full-time SS. However, there appear to be some master's-educated practitioners with sufficient knowledge of the literature and the ability to apply scientific methods to their work. In systems that allow for alternative entry pathways to accreditation, an applicant still must demonstrate achievement of specific knowledge—this is considered by certifying organizations as an essential requirement to prepare SSs with sufficient specific knowledge to work in the field. Interestingly, this coursework is similar in nature to recommendations for developing strength and conditioning coaches (33).

Experience

A range of 3-7 years of FTE work in sport is the minimum typically required by foreign governing organizations for accreditation in sport science. This experience is necessary for the SS to learn how to apply their knowledge, interact with coaches and athletes, and provide time to develop an understanding of the culture, jargon, policies and procedures—all elements critical to integrating within a sport organization. The SS must also understand stressors encountered by athletes. Direct experience in the sport (playing, coaching, or support roles) is valuable to prepare the SS for integration, enhance their status within the organization, and position themselves to obtain a greater level of access so they can embark upon useful work. Importantly, mentored experience may be influential in helping the developing SS gain skills efficiently, reflect on their experience, and refine practices they have learned. As the duration of FTE experience varies between organizations, a benchmark of 5 years of experience is recommended as the necessary time requirement for qualification in the U.S., in parallel with the Australian sport industry.

Supervised Development

Both foreign sport science pathways discussed here have professional requirements for mentors, improving the chances that the developing SS may be exposed to well-founded practices. Duration of supervised experience varies, with minimums of a 2-year requirement by BASES and a 3-year requirement by ESSA. Given that a doctoral degree appears to be a common requirement for a non-developmental job in sport science, a 3-year supervised mentorship may be advised, particularly as the only U.S.-based doctoral training program in sport physiology is delivered over 3 years.

Because of the number of strength and conditioning coaches performing sport science duties in the U.S. and role confusion that may be observed, mentored experience in sport science processes is recommended. Prior guidance for experiential learning in strength and conditioning may also be applied in principle to sport science internships to enhance the quality of learning experiences (see 30, 35). Because of their commitment to offering the Certified Performance and Sport Scientist (CPSS) certification, the NSCA is challenged to provide this infrastructure in light of the lack of alternative invested organizations. An acceptable alternative is for the NSCA to seek industry partners to offer supporting infrastructure. Further, a push toward centralized role protection (i.e., developing a process leading from certification to licensure or an overseas accreditation equivalent) is also recommended to form a U.S. equivalent to accreditation of roles used widely overseas. Centralized role protection is essential to formalize and protect the title "sport scientist," ensure a minimum level of capability among professionals, and formalize continuing education requirements.

Pursuing further specialization between researchers and practitioners (i.e., in the BASES model) is not recommended. This appears to draw an artificial separation between high-level sport and academic roles ("applied sport scientist" working in sport vs. "research sport scientist" working in … "research") that may limit employment opportunities and collaborative efforts between organizations (discussed in 26). A vast array of potential professional opportunities (i.e., SS teaching and performing services for an athletic department) could be available in the collegiate setting. These are necessary to establish research programs and develop junior SSs. Further, U.S. professional sport practitioners collaborating with university faculty is extremely rare but necessary to perform activities such as sport knowledge development. Avoiding the

above artificial separation will likely aid SSs in developing relationships with sport organizations, particularly sport coaches.

Additional Recommendations for Successful Development and Additional Challenges

Considering the impact of sport science on professional sport organizations, greater access to dedicated sport science academic training is recommended as the U.S. SS pathway formalizes; presently, limited formal training opportunities exist. In addition, as an enterprise, U.S. sport science desperately needs funding opportunities for sport science students, along with resources to fund research projects (25). In the integrated research training model described above, a professional sport organization offers a salaried position for a junior SS undergoing doctoral training (2, 29). Though this model may be seen at the university level in the U.S. (e.g., ETSU doctoral program), it is largely absent in U.S. professional sport. High-level U.S. sport organizations must offer sufficient developmental opportunities to ensure that American SSs are competitive with foreign counterparts in applying for professional sport roles.

Whether they realize it or not, high-level sports organizations influence certification and training programs. Aside from employees potentially contributing to the development of certification standards, this influence is applied through the details listed in job advertisements. Without clarity and consistency of requirements for roles across the industry, requirements in job postings may vary substantially and collectively influence what developmental opportunities potential workers pursue (i.e., I want to be a SS for a pro baseball team, so I must do x, y, and z to prepare for the role).

Many issues across the sport industry affect SSs. Of these, a head sport coach's perceived value of services seems to be a critical factor in pay elevation (16). In U.S. professional sport,

value of services may be also be determined by a general manager or senior administrator. Most sport coaches and front office professionals working in U.S. college or professional sport are unaccustomed to sport science services. As a result, coaches may not fully understand the role until they have worked with a SS for several years and seen the fruits of a mature sport science program. A critical point for sport administrators and decision makers to understand is if certain tasks are deemed important, they're important enough to hire a qualified full-time SS when starting a sport science program within the organization. In this way, better quality of work and continuity are possible.

Poor diversity is also an issue in the sport science workforce—which, anecdotally, is predominantly Caucasian and male. Deliberate effort is required to recruit, fund, and develop talented learners from various racial and socioeconomic backgrounds and genders. Diversity will likely enhance the ecological validity of research projects and service provision within the sport organization.

Finally, appropriate entry points for allied professionals who seek to become dual-skilled may be necessary. For example, a physical therapist seeking to work in a SS role (i.e., hybrid performance enhancement and injury rehabilitation, monitoring, and prevention) may require education in training theory, research methods, and a certain amount of practical experience in performance enhancement to perform duties in a SS role effectively. No clear pathway exists in the U.S. for skilled individuals from other IST roles to gain sport science expertise. Further discussion of alternative pathways is recommended.

Conclusions and Practical Applications

This article overviewed existing development pathways for SSs overseas, discussed availability and issues in U.S. developmental opportunities, reviewed an IST specialty that has established formal development and accreditation processes and professional licensure, and provided guidance for developmental opportunities. Common themes observed for the development pathways overviewed include formal education in sport science, sport-based experiential learning, and mentored development, with the pathway managed by a governing organization. In addition, U.S. paramedical IST specialties have aligned with state medical associations, so licensure or registration is necessary to practice in the role. To ensure a smoother evolution, some role protection is recommended for SSs. Further research is necessary to compare the effectiveness of training programs within each step of the pathway (e.g., specific education, internships). Governing organizations may use this information to evaluate programs and adjust timelines and requirements of each area of the development pathway. In this way, an effective mix of educational opportunities extending from formal education through the suite of developmental options may be established to prepare learners to excel in the field. This project focuses on developing entry-level SS professionals; further discussion and research are necessary to elucidate the developmental needs of mid- and late-career professional SSs.

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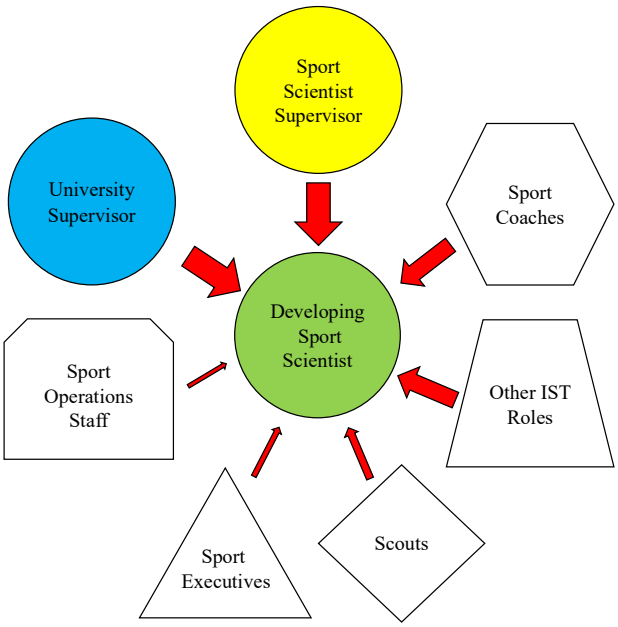
Figure 1. The Integrated Support Team concept

From (26), used with permission.

Figure 2. Influences upon the embedded sport scientist in the Integrated Research Training Model



Note 1: The width of the arrow indicates the level of influence upon SS development and time invested; color and shape indicate differences in development pathways or role focus.
Note 2: Typically included within the IST concept, Sport Coaches and the Sport Scientist Supervisor are separated here to specify the amount of influence upon SS development.
Note 3: Sport Operations includes a wide array of functions (facility maintenance, ticket office, etc.)

Figure 3. BASES Development Pathway

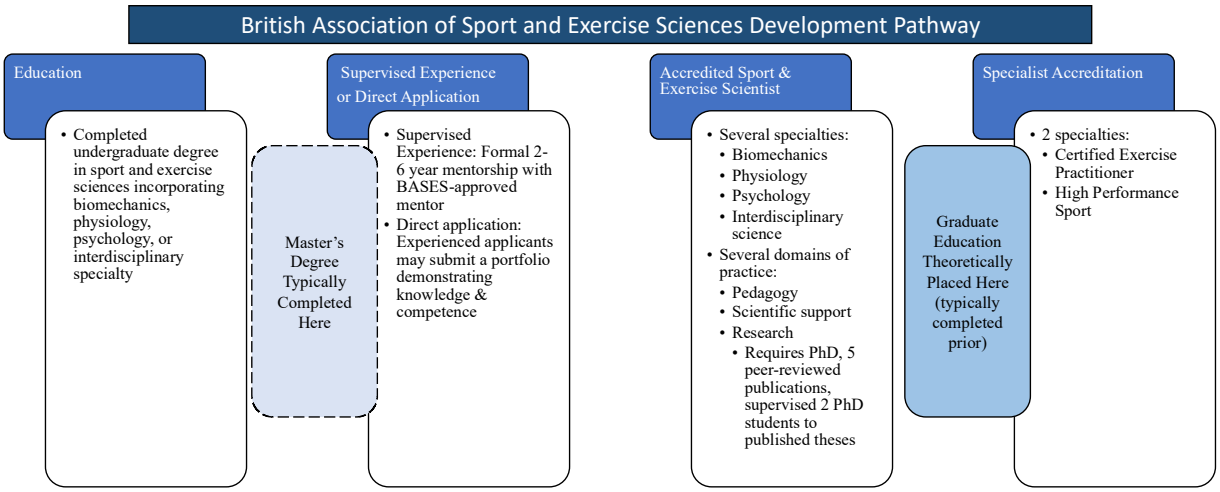


Figure 4. ESSA Development Pathways

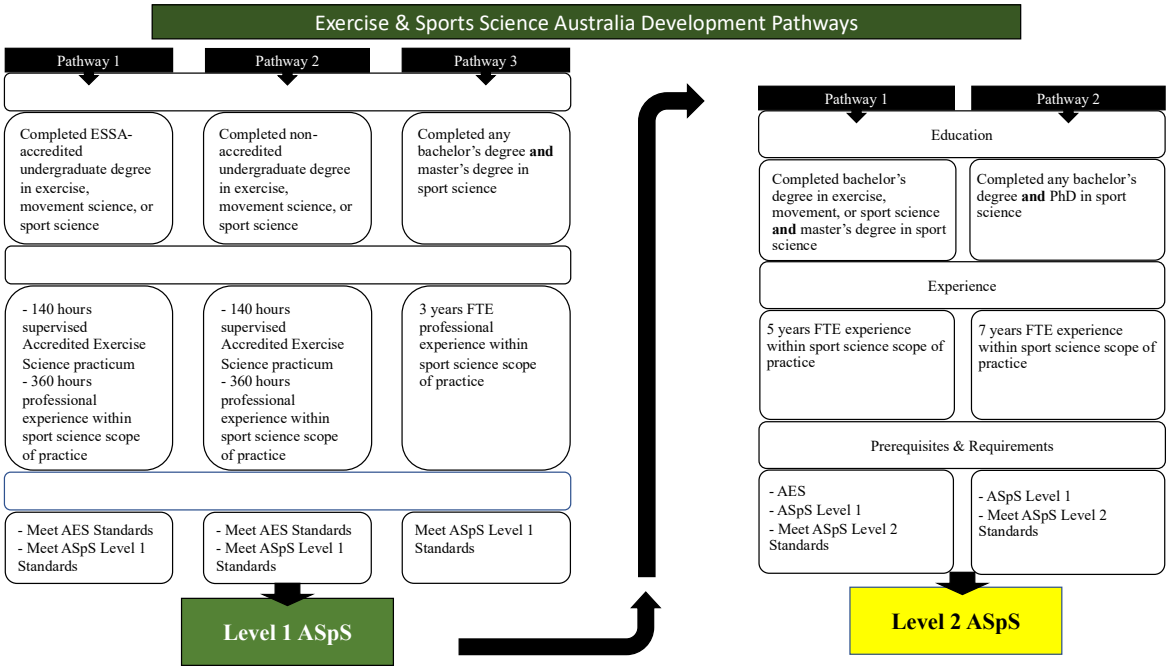
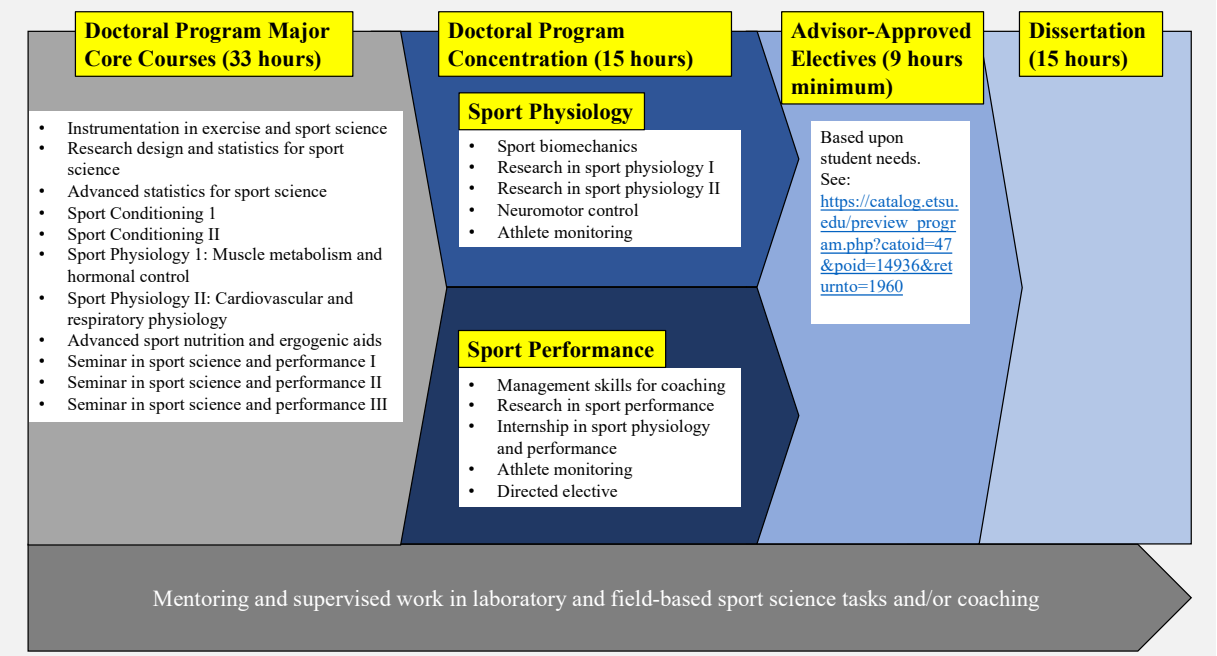


Figure 5. East Tennessee State University Sport Physiology & Performance Curriculum



Note: hours totals listed above are for academic credit only. This program requires extensive additional supervised and unsupervised hours for duties servicing sport teams, which may be similar to or exceed international equivalents. Experiential hours vary according to student interests and duties assigned by faculty mentors.

Table 1. BASES Supervised Experience Requirements

Requirements
1. Provide evidence of graduate degree completion.
2. Attend 5 BASES core workshops (entry, professional ethics for sport and exercise scientists, reflection practice for sport and exercise scientists, understanding your client, and safeguarding welfare), in addition to attending 2 BASES workshops, 8 BASES webinars, or attending 2 days at BASES conferences.
3. Documented completion of ≥500 hours of logged supervised practice, with reflection, within the chosen domain.
4. Documented case study meetings with supervisors, including outcomes and reflections.
5. 2 client references.
6. Logged and signed off by supervisor and reviewer, evidence of demonstrating required level of competency in BASES standards of proficiency for sport and exercise scientists.
7. Final signing off by supervisor and reviewer.
8. An applicant may complete a case study (not required) to help demonstrate attainment of the required level of competency.

Adapted with permission from The British Association of Sport and Exercise Sciences (8). For more process detail, see: https://www.bases.org.uk/spage-professional_development-supervised_experience.html

Table 2. BASES High Performance Sport Accreditation Competencies

Competency	Criteria
1. Practical experience	Evidence of impactful sport performance-related scientific support to high performance athletes and coaches.
2. Knowledge and scientific training	Demonstrate advanced knowledge and training in a relevant scientific discipline. Demonstrate how you use knowledge, experience, skills, and broader scientific understanding to optimize the application of existing and emerging science and technology. Demonstrate critical evaluation of relevant scientific information and concepts to propose solutions to problems. Promote, implement, and take responsibility for robust policies and protocols relating to health, safety, and sustainability.
3. Knowledge of and commitment to high performance sport	Evidence of personal contribution to develop specific and meaningful areas(s) of work in high performance sport. Demonstrate commitment to high performance sporting success.
4. Knowledge of the role of sport science in high performance sport	Demonstrate an understanding of the role of sport science support within high performance sport. Demonstrate a collaborative and interdisciplinary approach to high performance sport. Evidence of integration of sport science support with other IST disciplines to deliver impactful support.
5. Communication skills	Demonstrate effective communication through a variety of platforms, with high performance coaches, athletes, peers, and support personnel. Demonstrate the ability to communicate effectively with specialist and non-specialist audiences. Demonstrate effective leadership through the ability to guide, influence, inspire, and empathize with others.
6. Professional relationships	Build understanding and trust of high performance coaches, athletes, peers, and other support staff.

	Demonstrate an ability to work in a dynamic environment with skills in conflict resolution, facing challenges and finding solutions. Demonstrate approachability, empathy, and the ability to listen actively and accurately. Demonstrate open-mindedness and adaptability in working with others. Adopt and maintain professional behaviors. Demonstrate the ability to mediate, develop, and maintain positive working relationships.
7. Teamwork & leadership	Work cooperatively and effectively lead or manage high performance coaches, athletes, peers, and other support staff to provide structured and ongoing scientific support. Work autonomously and take responsibility for the work of self and others. Comply and promote relevant codes of conduct and practice.
8. High performance sport environments	Deliver, coordinate, lead, or manage scientific support provision within required high performance sport environments. Promote and ensure compliance with all relevant regulatory requirements and quality standards. Oversee the implementation of solutions and demonstrate an understanding of potential and actual impacts of your work on your organization, the profession, and the wider community.
9. Problem solving and interdisciplinarity	Demonstrate critical and innovative thinking to provide meaningful solutions to priority problems. Exercise sound judgement and understand principles of uncertainty in complex and unpredictable situations. Demonstrate how you scope, plan, and manage projects. Demonstrate the achievement of desired outcomes with the effective management of resources and risks.
10. Evaluation and continuing professional development	Self-evaluate and evidence formal and informal reflection on the quality and impact of high performance interventions. Take responsibility for continuous improvement within a scientific or technical environment.

	Demonstrate a commitment to professional development through continuing advancement of your own knowledge, understanding, and competence.

Adapted with permission from The British Association of Sport and Exercise Sciences (6).

Table 3. ESSA Level 2 ASpS standards of professional practice

Standards of Professional Practice
1. Demonstrates advanced knowledge and training in chosen sport science domain.
2. Applies the principles of leadership to guide advancements in sports and sports programs.
3. Demonstrates the ability to support and mentor sport science and sport medicine (SSSM) colleagues, program staff, new graduates, and emerging sport scientists.
4. Critically appraises, evaluates, and advises on new and emerging evidence, technologies and techniques to recommend/design evidence-based protocols to effect changes in performance.
5. Evaluates internal and external factors that influence performance in sports settings.
6. Demonstrates collaboration with SSSM colleagues and program staff to improve the effectiveness of the athlete, coach, and team in training and competition.
7. Appraises training programs and interventions including implementing monitoring systems that assess positive/negative adaptations and performance outcomes.
8. Engages with research and development and/or innovation projects.
9. Demonstrates the ability to work with others with wide ranging views to constructively solve complex problems.

Adapted with permission from Exercise & Sports Science Australia (21).

Table 4. Additional content qualifying for CSSD

Area	Content
Education	Completion of graduate degree in sport nutrition, exercise physiology, exercise science, kinesiology, nutrition with sport emphasis, or nutrition (up to 300 hours credit for masters, up to 400 hours for doctorate).*
Professional experiences (completed within the past five years from the date of application)	Primary author of an article in a peer-reviewed scientific publication (20 hours per article).
	Co-author of an article in a scientific publication (10 hours per article).
	Author of a published sports dietetics textbook/manual (100 hours per textbook).
	Author of a chapter in a published sports dietetics textbook/manual (15 hours per chapter).
	Sports research as a sole or principal investigator (20 hours per research activity).
	Sports research as a co-investigator (10 hours per research activity).
	Sports-related continuing education (75 hours must follow Professional Development Portfolio guidelines).**
	International Olympic Committee (IOC) Diploma in Sports Nutrition (500 hours).

Adapted with permission from the Commission on Dietetic Registration (12).
*Note 1: does not count for recertification if used to qualify initially
**Note 2: Professional Development Portfolio guidelines may be found here:
https://www.cdrnet.org/knowledge-based-professional-development-portfolio-guide