RETURN-TO-PERFORMANCE PROGRAM AT CANADIAN SPORT INSTITUTE PACIFIC – WHISTLER CAMPUS

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The topic of my Major Project in KIN 517 is the development of a formal structured Return-to-Performance (RTP) program at the Canadian Sport Institute Pacific (CSI Pacific) Whistler campus. The purpose of this RTP program is to provide a world-class, evidence-based pathway leveraging cutting-edge sport science and a multi-disciplinary team approach to rehabilitate and reintegrate winter sport athletes back to an elite level of competition. The RTP program is designed around five key strategic pillars, each of which will be described in detail in this paper, supported by relevant literature. The five pillars include 1) Enhancing athlete development and the rehabilitation pathway. 2) Driving sport science research and innovation, 3) Strengthening existing relationships with key sport partners and identifying new opportunities to collaborate, 4) Upgrading current facility infrastructure and equipment, and possibly most important of all, 5) Ensuring financial sustainability for the organization which requires a specific business plan outlining the various sources of funding supporting the RTP program. This literature review will contribute to answering the question "Why does CSI Pacific need an RTP program at the Whistler campus?" It is recommended that this project be implemented in five stages over the next 18 plus months, with each stage having specific timelines and associated milestones. A Gantt chart outlining these timelines is in Appendix A.

Athlete Development and Rehabilitation Pathway

The program aims to optimize athlete performance and rehabilitation by developing customized RTP protocols for injured Snowboard, Para-Snowboard, Alpine, Para-Alpine, Freestyle, and Ski Cross athletes. As a leading winter sport nation, it is imperative that Canadian athletes have the support of a world-class program when they do experience injury. The NSOs that CSIP partners with at the Whistler campus are primarily high-risk sports where one-third of World Cup Freestyle Ski and Alpine Ski athletes sustain a time-loss injury each season (Florenes

et al., 2012). 28% of these injuries were considered severe (absence >28 days). Injury rates among World Cup snowboarders are as high as 40.1 injuries/100 athletes/season, with SBX having the highest injury rate of any discipline (Major et al., 2014)

Three world-leading examples of RTP programs will be described in this section. United States Ski and Snowboard has a comprehensive RTP approach designed to support elite athletes through injury recovery and a safe return to full performance. https://www.usskiandsnowboard.org/sport-programs/high-performance/high-performance-education Their vision is to make the USA the best in the world in Olympic skiing and snowboarding. USSA's motto is "10 sports. One team. Dedicated to being the best in the world." Alpine, Cross Country, Free Ski (Ski Cross, Halfpipe, Slopestyle, Big Air), Moguls, Aerials, Snowboard, Para-Alpine, Para-Snowboard, Ski Jumping, and Nordic Combined comprise the winter sports that are centralized out of the USANA Center of Excellence in Park City, Utah which provides world-class training facilities and an educational resource center for US ski and snowboard athletes. USSA take a multi-disciplinary approach, often guided by best-practice frameworks like the StaRRT (Strategic Assessment of Risk and Risk Tolerance) model, and progressive criteria-based protocols. Their system involves collaboration among athletic trainers, physiotherapists, S&C coaches, sports medicine physicians, sport scientists, and coaches. They use individualized, evidence-informed plans for each athlete, aligned with performance goals and risk mitigation. Five primary core elements comprise their RTP/RS process, including 1) Injury Management and Medical Oversight, 2) Progressive Criteria Based Return to Sport Protocols, 3) Sport Science and Technology Support, 4) Return-to-Snow (RTS) Protocols and Progressions, and 5) Psychological Readiness. For injury management and medical oversight, they have an in-house medical team and partnerships with specialists. They focus on immediate response,

diagnosis, and early-phase rehab coordinated through the High-Performance Center. They utilize integrated electronic medical records (EMR) and injury tracking systems to ensure communication between practitioners. Objective markers include strength asymmetry data from force plates, isokinetic testing, and hop tests with biomechanical motion capture analysis. Sport specific readiness is not determined based on time from injury, but functional testing and psychological readiness. This testing is done before and after injury, so there is always baseline data to compare. This allows for the monitoring of load tolerance and tissue capacity throughout the return. Return to Snow (RTS) progressions can be carried out locally as USSA has a partnership with Deer Valley resort supporting the on-snow training requirements of national team athletes. Coaches work toward technical and tactical goals while collaborating with USSA IST to monitor setbacks or red flags. Sport psychologists are involved in all rehabs to support mental readiness and confidence, and identify challenges related to injury. They use the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale.

The US Olympic Paralympic Committee (USOPC) Medical Network partners with USSA providing regional medical providers if an athlete cannot be in Deer Valley. Thus, includes collaboration with NCAA teams and private clinics for off-site rehab. Medical Director Dr Jaron Santelli works with support and direction from the U.S. Ski & Snowboard Medical Committee, which is comprised of the Head Team Physicians for each Sport Discipline. Medical services are provided to A, B, and C Team athletes, and each sport is allocated a medical coordinator who manages athletes' medical care. When injured, each athlete has a dedicated case manager who tracks their progress, coordinates appointments, and ensures rehab plans are cohesive across departments. The rehabilitation center at the USANA Center of Excellence is staffed by two full-time clinicians and one part-time clinician who are available to rehabilitate

any national team athletes year-round. Additionally, discipline-specific staff support the clinic during the non-travel season. Communication between athlete, coach, and therapists is considered essential. Research collaborations include the Steadman Philippon Research Institute, the Steamboat Orthopedic and Spine Institute, and the University of Utah in Salt Lake City. Appendix B depicts a comparison of current offerings from US Ski & Snowboard vs CSI Pacific Whistler campus.

Ireland has a highly specialized ACL rehabilitation facility at SPARC Sports Physiotherapy & Athletic Rehabilitation Clinic (SPARC), which is considered one of the leading centers for ACL rehab in Europe and the world. https://www.sparc.ie/south-dublin-physio The facility integrates advanced testing and rehabilitation technologies to optimize the recovery process for athletes and the public. Dr. Enda King, PhD combines his roles as a sports physiotherapist, strength and conditioning coach, researcher, and educator through his work with individual athletes and elite teams across a spectrum of sports and disciplines. Through his role as Head of Performance at the Sports Surgery Clinic in Dublin, he led the development and delivery of their ACL and Athletic Groin Pain clinical and research pathways and their Elite Athlete Program Rehabilitating catering to athletes from Premier League, NBA, NFL, NHL, Premiership Rugby, European Tour Golf, AFL, and the UFC. There are 4 key causes of ACL injuries as outlined by O'Reilly in 2025. Deceleration and direction change and quick forceful movements in sports like soccer and rugby are major contributors to ACL injuries. Landing mechanics or improper landing patterns such as valgus collapse put excess strain on the knee joint. Muscle imbalances or weakness in the hamstrings, quadriceps, or glutes can lead to faulty mechanics that increase ACL load. Neuromuscular control or the inadequate stability in the lower body during dynamic movements increases risk of injury. Under Dr. King's oversight, key

features of SPARC's ACL Rehabilitation program include 'The ACL Club', which is a dedicated program offering a structured recovery pathway from surgery to full return to sport. It provides personalized rehabilitation plans, supervised training, and a strong community support system for individuals recovering from ACL injuries. SPARC utilizes state-of-the-art technology including isokinetic dynamometry and VALD Force Decks (force plate) strength testing to assess and monitor recovery progress. SPARC's elite level rehabilitation specialists are CORU-registered professionals with extensive experience in ACL recovery. Comprehensive return-to-sport protocols anchor rehab programs which focus on sport-specific movements, running biomechanics, multidirectional agility, and sport specific strength development to ensure a safe return to peak performance. The SPARC program available to elite athletes also operates in multiple locations, including Dublin, Greystones, and Sandyford, and is scaled to be available to the public on an insurance pay basis. Each patient receives individualized physiotherapy guidance and supervised rehabilitation to maximize functional recovery and minimize the risk of re-injury. SPARC offers a range of rehab and performance services beyond ACL recovery.

Canada has also invested in a world-leading rehabilitation framework focused on returning athletes to pre-injury levels of performance. In March 2019 Own the Podium created a Return to Health and Performance 'Think Tank' that brought together Canada's most experienced medical, para-medical, strength and conditioning, sport science, biomechanics, mental performance, nutrition, and physiology practitioners from the COPSIN as well as from private practice. The result of this event led to the creation by Sport Scientist Canada of a Return to Health and Performance Working Group comprised primarily of key practitioners from CSI Calgary (now CSI Alberta) and chaired by Dr. Matt Jordan. The mandate of this group includes identifying defined rehabilitation stages and milestones based on evidence-informed practices.

Mentorship and succession planning with ongoing education and professional development is a key staple. Ongoing IST communication supported by consistently conducted high-impact meetings and frequent organic touchpoints in the daily training environment (DTE) between the involved practitioners to ensure and improve best practices and enhance knowledge translation strategies. An established set of protocols and guidelines support the RTS framework, high-risk sport profiling, and athlete intake management. Best practice data collection, data storage, data analysis, and data reporting are hallmark of this working group. CSI Alberta was identified as the premier sport institute and as such was granted 3 years of funding (2020 through 2023) to employ a full time Return-to-Performance Lead role (Isabel Aldrich-Witt). This funding no longer exists and the practitioners at CSI Alberta now implement the RTP framework with their NSO and PSO partners. It is important to note that the majority of CSI Pacific NSO partners will send their athletes to CSI Alberta for the specialized isokinetic testing/assessments that they cannot get from CSI Pacific in Whistler.

Sport Science and Innovation

Innovation in sport science and technology is a key strategic priority at CSI Pacific, with efforts focused on implementing neuromuscular and biomechanical assessments for objective recovery tracking. This world-leading RTP program will utilize state-of-the-art testing tools, such as AMTI force plates and an isokinetic dynamometer. The program will monitor athlete recovery progress, inform return-to-sport decisions, and reduce both rehabilitation time and re-injury rates. Force plates and motion capture video with wearable sensors will analyze movement and integrate an isokinetic dynamometer for comprehensive strength and joint function testing. Force plates are a commonly found tool in many facilities as they have become increasingly affordable and easier to use in the past five years. Selecting the most appropriate tests and

subsequent metrics that really matter is of utmost importance. A simple test such as a Countermovement Jump (CMJ) can be done for many reasons. The data can be used as a proxy for athletic performance, as part of neuromuscular fatigue monitoring, or as part of a test battery for return to performance with injured athletes (Bishop et al., 2023). To assess post injury progress and preparedness for return to sport, metrics such as Peak Propulsive Force (N), Peak Landing Force (N), Landing Impulse (Ns), and Asymmetry Index (%) can differentiate between athletes with and without injuries. Much attention is afforded the concept of asymmetry between limbs. The question of WHY an asymmetry occurs and exactly which musculature is responsible cannot be answered with force plate testing alone. In terms of preventing injuries in alpine skiing, Sporri et al., (2016) discuss the benefits of a detailed neuromuscular assessment as a critical first step in identifying weaknesses or biomechanical issues. Jordan et al., (2021) did a retrospective analysis of longitudinally collected athlete monitoring data to generate a model of neuromuscular recovery after ACL ligament injury and reconstruction (ACLR). Testing data from CMJ (eccentric deceleration phase and concentric phases) and isokinetic knee extensor strength (both maximum voluntary force and rate of torque development) was investigated. The capacity to forecast individual neuromuscular recovery after ACLR is particularly useful for clinicians and practitioners as the post-injury recovery may unfold differently over time depending on the type of surgery and the combined injuries associated with the primary ACL tear. The ability to generate high vertical rate of force development throughout the eccentric deceleration phase of the CMJ is strongly associated with the capacity to perform coupled eccentric-concentric movements measured as the reactive strength index (RSI). Diminished RSI has been shown to predict future ACL re-injury highlighting the importance of assessing the stretch shortening cycle. Field tests such as single leg hops and max squats fail to identify

neuromuscular deficits that are associated with poor RTS outcomes, which is why isokinetic dynamometer testing of the quads and hamstrings is so critical. Jordan describes four advantages to building a data set of expansive neuromuscular testing; a) allows the practitioner to predict the time course of neuromuscular recovery which informs a robust rehabilitation plan, 2) allows the early identification of lagging neuromuscular capacity so targeted training can be administered, 3) modeling can help practitioners identify an athlete who is tracking behind expectations due to ineffective rehab or other factors like severity of injury, and 4) allows practitioners to account for the variation, complexity, and intra-subject correlation that is inherent in the ACLR rehabilitation process. Jordan, Morris, Nimphius, Aagaard, and Herzog (2022) highlight the importance of long-term athlete monitoring both before and after significant ACL injury. Isokinetic measures coupled with the eccentric deceleration phase of the CMJ are a critical step to identifying limb asymmetry in ski racers. It is likely that this also applies to other mountain snow sport athletes such as freestyle skiers and snowboarders.

Funding Sustainability and Business Model

Ensuring funding stability and operational viability is a key objective, achieved through diversified revenue streams. Increased and stable NSO and PSO investment in performance services is a critical aspect of CSI Pacific's financial viability. Becoming a leader in this space will ensure winter national team programs choose CSI Pacific and Whistler as a location for their athletes to centralize and/or return to for all their rehabilitation needs. It will be important to gain an understanding of how much money NSOs stakeholders currently invest at CSI Alberta for these services and how much it costs each of these NSOs in travel, accommodation, meals, and time each time an athlete travels to Alberta. This is NSO funding that could be resourced with CSI Pacific. Developing a private pay RTP service for non-elite athletes and general public will

further enhance the long-term financial sustainability of CSI Pacific and support the costs of purchasing a Biodex isokinetic dynamometer. The integration of RTP into the Performance Nation initiative will further enhance its financial sustainability. RTP programming and assessment packages can be scaled for 'small-group' training at the Whistler HPTC through Performance Nation offerings.

In 2021, McKay, Stellingwerff, Smith, Martin, Mujika, Goosey-Tolfrey, Sheppard, and Burke created an athlete classification framework (Table 1 Participant Classification System). The majority of athletes that CSI Pacific currently works with range from Tier 3 through Tier 5. Athletes from provincial level programs (BC Freestyle, BC Alpine, BC Snowboard, BC Cross Country Ski, SDC Luge) would be representative of Tier 3 as they are enrolled in structured programs with periodized training and developing proficiency in the key skills required in each respective sport. Our NSO partner sports (Freestyle Ski, Snowboard, Ski Cross, Alpine, and Luge) represent the elite international level of Tier 4. Very important to note that each of these winter sport NSO's contains multiple Tier 5 athletes in several disciplines. For example, Freestyle has multiple Tier 5 athletes competing in Moguls, Halfpipe, and Slopestyle, while Snowboard also has Tier 5 athletes in SBX, Slopestyle, and Big Air disciplines. These same researchers devised a classification of sports into seven broad categories. (Table 2 Classification of Sports within 7 Broad Categories). Most sport partners that CSI Pacific provides performance services directly to in Whistler or that CSI Pacific has access to are Speed/Strength sports or Precision/Skill dependent sports. Alpine Ski, Ski Cross, Bobsleigh, Luge, Skeleton, and Ski Jumping are individual Speed/Strength sports, while Freestyle Skiing, Snowboard, and Skateboard are primarily Precision/Skill dependent sports.

Canadian National Teams and NextGen Teams are commonly comprised of between 5-20 athletes with provincial level teams typically have between 6-15 athletes each. https://www.canadasnowboard.ca/en/team/slopestyle/#b2, https://freestylecanada.ski/?team-disc=moguls#, https://alpinecanada.org/team/ski-cross, https://freestylebc.ski/team/, https://home.bcalpine.com/athletes/. The number of elite athletes serviced at the Whistler campus is relatively small.

The population in Whistler is approaching 16,000 residents, with almost 30,000 in Squamish and 4,000 in Pemberton. https://worldpopulationreview.com/canadian-cities/whistler

The Sea2Sky region is not a large population center, however, it should be considered a very active population as recreational pursuits are often cited as the number one reason people choose the Sea2Sky. This means there is a sizeable Tier 1 (Recreationally Active) and Tier 2 (Trained/Developmental) population. There are hundreds of club-level skiers within the Whistler Mountain Ski Club U21, U18, U16, U14, and U12 programs and the Whistler Blackcomb Freestyle Club. Dozens of master's level athletes train and compete at various levels. Some of these compete in team sports such as hockey (75 women plus 300 men), adult recreational soccer as well as competitive U18, U16, U14 programs, recreational field hockey, and volleyball. As well there are endurance and long-distance sports such as cross-country ski, biathlon, an age group triathlon club, and a burgeoning road cycling population along with a group of dedicated ultra endurance runners. The Whistler Offroad Cycling Association (WORCA) boasts over 1500 members, many of whom compete in cross-country, downhill, and enduro events. There are approximately 200 members of the Whistler Tennis Club (tennis and pickleball) and 50+

members of the Whistler Squash club. A detailed market analysis of potential Performance Nation is required for the Sea2Sky region.

Several potential funding opportunities exist within both government and private sector agencies, as well as organizations that focus on sports, research, or health and wellness. Government grants such Canadian Heritage from Sport Canada provide funding to support the development of high-performance sport in Canada. They offer funding opportunities that could support multi-sport organizations, training facilities, and programs that help athletes at the national and provincial levels. If integrating research on performance, injury prevention, or sports science using the Biodex Isokinetic Dynamometer, the Canadian Institutes of Health Research (CIHR) funds projects related to health and wellness research in sports. The Sport Medicine and Science Council of British Columbia (SMSBC) provides funding for organizations working on improving athlete health and performance, specifically projects that can enhance athlete care, which aligns with this proposal. The Western Economic Diversification Canada (WD) offers funding to help support the economic development of communities in Western Canada. While these grants are generally business-focused, projects aimed at improving sports infrastructure or athlete development may be eligible. The provincial government of BC – Ministry of Tourism, Arts, Culture, and Sport offers various funding opportunities that focus on enhancing sports and recreation in the province. They may provide grants specifically for equipment, especially if there is a public access component to the RTP program. If the Biodex Isokinetic Dynamometer is intended for sport science research, the Canadian Foundation for Innovation (CFI) may offer funding opportunities to support research infrastructure that enhances innovation in Canada. The Drake Foundation is focused on improving athletic improvement through science and technology. They have previously funded sport organizations

and initiatives that aim to improve athlete health and performance. The Rick Hansen Foundation provides funding for projects that improve accessibility and mobility, which may overlap with CSI Pacific's goals of supporting Para-athletes and the rehabilitation of injured athletes.

The Natural Sciences and Engineering Research Council of Canada (NSERC) offers funding to support scientific and technological advancements in engineering and health sciences. Since our work involves studying athletic performance, injury prevention, and rehabilitation, NSERC would be a good fit. The Mitacs Accelerate program funds graduate students and post-doctorate fellows to work on research projects that can drive innovation.

Corporate sponsorships and private sector funding is a potential revenue source. As the manufacturer of the isokinetic dynamometer, Biodex Medical Systems might be willing to offer direct support, sponsorship, or even discounts on the purchase. They may be keen to form a partnership with CSI Pacific if they want more exposure to elite athletes. Large corporations in the sports, fitness, and healthcare sectors might be interested in sponsorship opportunities for sport science facilities that focus on elite athletes. They may offer grants, sponsorships, or donations in exchange for branding and visibility. Targeting the various funding sources and aligning proposals with their priorities will increase the likelihood of securing the required funds necessary for acquiring this valuable piece of equipment.

Partnerships and Collaborative Network

The RTP program would be committed to strengthening stakeholder engagement by fostering collaboration with NSO and PSO partners. Strengthening these ties is important as they are a primary source of funding for CSI Pacific. We need to explore the opportunities to establish research partnerships with academic institutions such as UBC and Simon Fraser University for

RTP innovation. There is opportunity to collaborate with medical and para-medical providers in the Sea2Sky corridor such as Back in Action Physiotherapy, Peak Performance Physiotherapy, and the Movement Lab in Whistler along with Coast Range Clinic, Fall Line Fitness, and Physio Focus in Squamish to form a RTP referral network. Back In Action Physiotherapy alone reports treating 320 different patients with knee injuries annually, with the most severe generally requiring ACL reconstruction surgery and 9-12 months of rehabilitation. Broader community integration is possible as CSI Pacific has only worked in elite winter Olympic sport until now. A significant marketing effort is required locally, online, and with social media if the public is to have access to the RTP program, but important to acknowledge that each one of these "athletes" is a potential client that could benefit from CSI Pacific's testing/assessment services that could be available vis Performance Nation.

Infrastructure and Facility Enhancement

Lastly, the RTP program prioritizes facility enhancement and resource allocation by upgrading sport science equipment at CSI Pacific's Whistler campus and ensuring staff allocation aligns with the organization's strategic priorities. In 2023, Goldberg et al. did a scoping review of ACL reconstruction Return-to-Sport decision making. Many different criteria have been used to determine readiness for RTS. Time from surgery is the most prevalent criterion represented in 85% of the literature, followed by Strength as the second most common criterion. Leg symmetry index (LSI), which is a comparison of left and right leg strength, appears to be the primary variable of interest rather than absolute or relative strength values. Among all the Return to Performance criteria, muscle strength is the most important considered criterion. According to Sousa et al, 2017 and Welling et al, 2019, there are three primary methods used for evaluating strength: manual muscle testing, isometric strength tests, and

isokinetic strength tests. The isokinetic dynamometer technology is considered the “gold standard” method for evaluating muscle strength, allowing the quantification of muscle strength through determined angular velocity (Drouin et al, 2004 and Pua et al, 2008). The Neural Control of Force Production and Movement Laboratory and the Centre for Aging SMART, both at UBC, are the only locations in Lower Mainland Vancouver or the Sea2Sky that have an isokinetic dynamometer, and the equipment is utilized strictly for research and teaching purposes, not generally accessible to athletes or the public. This would position CSI Pacific at a significant advantage as there is literally zero competition for this service. Optimizing a world-class daily training environment and enhancing our facilities and performance solutions to meet the needs of our clients is a strategic priority

Through these initiatives, the RTP program will set a new standard in high-performance athlete rehabilitation and return-to-sport readiness. The Return to Performance (RTP) program will be developed and implemented through a structured five-phase process that includes Discovery and Planning, Design and Development, Pilot Implementation and Testing, Full-scale Implementation and Launch, and Continuous Evaluation and Improvement to ensure its success and long-term sustainability.

Phase 1: Discovery and Planning (months 0–3), will involve a comprehensive stakeholder consultation and needs analysis. Figure 1 illustrates the decision-making framework for integrating technology in sport. Will the promised information be helpful? Can you trust the information you’ll be getting? Can you integrate, manage, and analyze the data effectively? And can you implement the technology in your practice? Rehabilitating injuries in Canadian winter Olympic sports involves numerous stakeholders who each play a role in the athlete’s recovery,

return to performance, and long-term well-being. Appendix C depicts the Core Stakeholders (Tier 1), Performance Partners (Tier 2), and Enabling Partners (Tier 3) in the RTP stakeholder map. Undoubtedly, the athlete is the primary stakeholder whose health, performance, and career depend on effective rehab. The athlete needs to be actively involved in the rehab plan and decision-making process. National Sport Organizations (NSOs) and Provincial Sport Organizations (PSOs) are also key stakeholders as these groups oversee the athlete's development and performance pathways. NSOs and PSOs are responsible for funding, coordinating, and approving rehab and RTP strategies. High Performance Directors (HPDs) and IST Leads assemble multidisciplinary teams to define key performance indicators (KPIs) and establish performance metrics. They advise on injury risk, injury rates, injury types, time-loss data, the strengths and weaknesses of each organization's rehabilitation frameworks, if they exist, as well as the costs incurred by these organizations and/or their athletes. Along with NSOs, CSI Pacific provides integrated support teams (ISTs), including physiotherapy, strength and conditioning, and sport science expertise. IST staff, including sport medicine physicians, orthopedic surgeons, physiotherapists, and athletic therapists, are often sourced and employed by the NSOs. Working collaboratively to ensure holistic rehab and a safe return to sport can be challenging due to such a splintered structure. Coaches and technical staff must adapt training and competition schedules based on the athlete's recovery. They are critical in reintegrating athletes into training environments safely and progressively. Funding agencies such as Own the Podium and Sport Canada, and other grant bodies, may influence what resources are available for rehab and how rehab integrates into high-performance planning. The Canadian Olympic and Paralympic Committees (COC/CPC) are also key stakeholders in that they provide oversight and support for athlete health and safety at the Olympic/Paralympic level, and they may also

contribute funding, medical resources, and high-performance planning input. Independent sport medicine physicians and clinics diagnose, manage, and help monitor injury and recovery. They are sometimes linked to CSI Pacific but are often contracted directly by NSOs. These highly experienced practitioners that NSOs utilize are often linked to university clinics or private practice. Insurance providers such as CAIP, SAIP, and several private insurance companies often cover medical costs and rehab services. Universities and research partners may be involved in innovative rehab protocols, data tracking, or case study research that supports evidence-informed return-to-sport strategies. Finally, family and support networks are important stakeholders as they play emotional and logistical supporting roles, helping athletes cope with the psychological and lifestyle impacts of injury. All these stakeholders must be considered when creating a financial business plan, which includes securing initial funding, obtaining operational approval, and confirming staff resource commitments, culminating in a detailed project roadmap and a validated scope. Discovering customer needs through market research is followed by strategy development and implementation.

Phase 2: Design and Development (months 3–6), facility enhancements will be planned, and new Biodex isokinetic dynamometer equipment will be procured to support RTP operations. Operational guidelines and best practice protocols will be developed, alongside staff training, to ensure effective program delivery. Establishing research partnerships with academic and clinical institutions will also be a priority in phase two to advance evidence-based methodologies within the program.

Phase 3: Pilot Implementation and Testing (months 6–12) will mark the initial rollout of RTP services through a pilot program in collaboration with select winter sport NSOs. This phase will

also involve the development of RTP service packages accessible to the broader public via Performance Nation, allowing for initial testing, feedback, and refinement.

Phase 4: Full-Scale Implementation and Launch (months 12–18), the RTP program will be fully operational and accessible to all NSO and PSO partners as well as the public via Performance Nation. A comprehensive marketing and communication strategy will be deployed to ensure widespread awareness among stakeholders and encourage public engagement with the program.

Phase 5: Evaluation and Continuous Improvement (ongoing) will focus on monitoring program outcomes against the established KPIs. CSI Pacific will conduct regular audits and impact assessments to evaluate effectiveness, refine protocols, and integrate emerging technologies. This continuous evolution will ensure that the RTP program remains at the forefront of high-performance athlete rehabilitation and return-to-sport readiness, benefiting both elite athletes and the wider community.

Conclusion

Skiing and snowboarding are among the most difficult sports to master due to the many complex and variable demands. Weather, snow conditions, varying competition venues and of course, the unique demands for strength, power, agility, endurance, skill, precision, and courage come together to challenge the skier and rider. Deficiencies in certain areas negatively affect performance and lead to injury. Three fundamental principles underpin the decision to invest in technology: *proactivity* allows key personnel to start with the end in mind and to plan ahead; *critical thinking* informs how practitioners evaluate the trustworthiness of technology and its data, and *collaboration* underpins the success of communication and data-informed decisions.

Successful implementation of any technology requires careful consideration of the time and resources required from practitioners and athletes, along with the processes and procedures that need to be in place. There are a couple of limitations to my project; most notably, the development of an RTP program in Whistler is not possible to implement on my own. Senior leadership, finance, marketing, para-medical practitioners, and admin support will be required to provide expertise, advice, and guidance. The other major question mark is whether the stakeholders will support the RTP program financially. I am aware of the challenging financial landscape that CSI Pacific is operating in, so it may not be possible at this time to invest in expensive technology. A dedicated RTP program at the Whistler campus has the potential to leverage cutting-edge sport science, multi-disciplinary expertise, and world-class facilities for our winter sport partners with Performance Nation anchoring a sustainable financial model.

References

Abeza, G., O'Reilly, N., & Seguin, B. (2019). Social Media in Relationship Marketing: The Perspective of Professional Sport Managers in the MLB, NBA, NFL, and NHL. *Communication and Sport*, *7*(1), 80–109. https://doi.org/10.1177/2167479517740343

Bishop, C., Jordan, M., Torres-Ronda, L., Loturco, I., Harry, J., Virgile, A., Mundy, P., Turner, A., & Comfort, P. (2023). Selecting Metrics That Matter: Comparing the Use of the Countermovement Jump for Performance Profiling, Neuromuscular Fatigue Monitoring, and Injury Rehabilitation Testing. *Strength and Conditioning Journal*, *45*(5), 545–553. https://doi.org/10.1519/SSC.0000000000000772

Buckthorpe, M. (2019). Optimising the Late-Stage Rehabilitation and Return-to-Sport Training and Testing Process After ACL Reconstruction. *Sports Medicine (Auckland)*, *49*(7), 1043–1058. https://doi.org/10.1007/s40279-019-01102-z

Burgi, C. R., Peters, S., Ardern, C. L., Magill, J. R., Gomez, C. D., Sylvain, J., & Reiman, M. P. (2019). Which criteria are used to clear patients to return to sport after primary ACL reconstruction? A scoping review. *British Journal of Sports Medicine*, *53*(18), 1154–1161. https://doi.org/10.1136/bjsports-2018-099982

Dos'Santos, T., Thomas, C., & Jones, P. A. (2021). Assessing Interlimb Asymmetries: Are We Heading in the Right Direction? *Strength and Conditioning Journal*, *43*(3), 91–100. https://doi.org/10.1519/SSC.0000000000000590

Fröhlich, S., Helbling, M., Fucentese, S. F., Karlen, W., Frey, W. O., & Spörri, J. (2021). Injury risks among elite competitive alpine skiers are underestimated if not registered prospectively, over the entire season and regardless of whether requiring medical attention. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, *29*(5), 1635–1643. https://doi.org/10.1007/s00167-020-06110-5

Gilgien, M., Kröll, J., Spörri, J., Crivelli, P., & Müller, E. (2018). *Application of dGNSS in alpine ski racing: Basis for evaluating physical demands and safety*. *Journal Article*. https://go.exlibris.link/V5F2xVd1

Gilgien, M., Reid, R., Raschner, C., Supej, M., & Holmberg, H.-C. (2018). The Training of Olympic Alpine Ski Racers. *Frontiers in Physiology*, *9*(Journal Article), 1772–1772. https://doi.org/10.3389/fphys.2018.01772

Herbawi, F., Lozano-Lozano, M., Lopez-Garzon, M., Postigo-Martin, P., Ortiz-Comino, L., Martin-Alguacil, J. L., Arroyo-Morales, M., & Fernandez-Lao, C. (2022). A Systematic Review and Meta-Analysis of Strength Recovery Measured by Isokinetic Dynamometer Technology after Anterior Cruciate Ligament Reconstruction Using Quadriceps Tendon Autografts vs. Hamstring Tendon Autografts or Patellar Tendon Autografts. *International Journal of Environmental Research and Public Health*, *19*(11), 6764. https://doi.org/10.3390/ijerph19116764

James, L. P., Haycraft, J. A. Z., Carey, D. L., & Robertson, S. J. (2024). A framework for test measurement selection in athlete physical preparation. *Frontiers in Sports and Active Living*, *6*(Journal Article), 1406997. https://doi.org/10.3389/fspor.2024.1406997

Jordan, M. J., Aagaard, P., & Herzog, W. (2015). Rapid Hamstrings/Quadriceps Strength in ACL-Reconstructed Elite Alpine Ski Racers. *Medicine and Science in Sports and Exercise*, *47*(1), 109–119. https://doi.org/10.1249/MSS.0000000000000375

Jordan, M. J., Morris, N., Barnert, J., Lawson, D., Aldrich Witt, I., & Herzog, W. (2022). Forecasting neuromuscular recovery after anterior cruciate ligament injury: Athlete recovery profiles with generalized additive modeling. *Journal of Orthopaedic Research*, *40*(12), 2803–2812. https://doi.org/10.1002/jor.25302

McKay, A. K. A., Stellingwerff, T., Smith, E. S., Martin, D. T., Mujika, I., Goosey-Tolfrey, V. L., Sheppard, J., & Burke, L. M. (2022). Defining Training and Performance Caliber: A Participant Classification Framework. *International Journal of Sports Physiology and Performance*, *17*(2), 317–331. https://doi.org/10.1123/ijspp.2021-0451

Müller, P. O., Taylor, J., Jordan, M. J., Scherr, J., Verhagen, E., Collins, D., & Spörri, J. (2023). Call for the application of a biopsychosocial and interdisciplinary approach to the return-to-sport framework of snow sports athletes. *BMJ Open Sport & Exercise Medicine*, *9*(3), e001516–e001516. https://doi.org/10.1136/bmjsem-2022-001516

Soligard, T., Palmer, D., Steffen, K., Lopes, A. D., Grant, M.-E., Kim, D., Lee, S. Y., Salmina, N., Toresdahl, B. G., Chang, J. Y., Budgett, R., & Engebretsen, L. (2019). Sports injury and illness incidence in the PyeongChang 2018 Olympic Winter Games: A prospective study of 2914 athletes from 92 countries. *British Journal of Sports Medicine*, *53*(17), 1085–1092. https://doi.org/10.1136/bjsports-2018-100236

Spörri, J., Kröll, J., Gilgien, M., & Müller, E. (2017). How to Prevent Injuries in Alpine Ski Racing: What Do We Know and Where Do We Go from Here? *Sports Medicine (Auckland)*, *47*(4), 599–614. https://doi.org/10.1007/s40279-016-0601-2

Windt, J., MacDonald, K., Taylor, D., Zumbo, B. D., Sporer, B. C., & Martin, D. T. (2020). "To Tech or Not to Tech?" A Critical Decision-Making Framework for Implementing Technology in Sport. *Journal of Athletic Training*, *55*(9), 902–910. https://doi.org/10.4085/1062-6050-0540.19

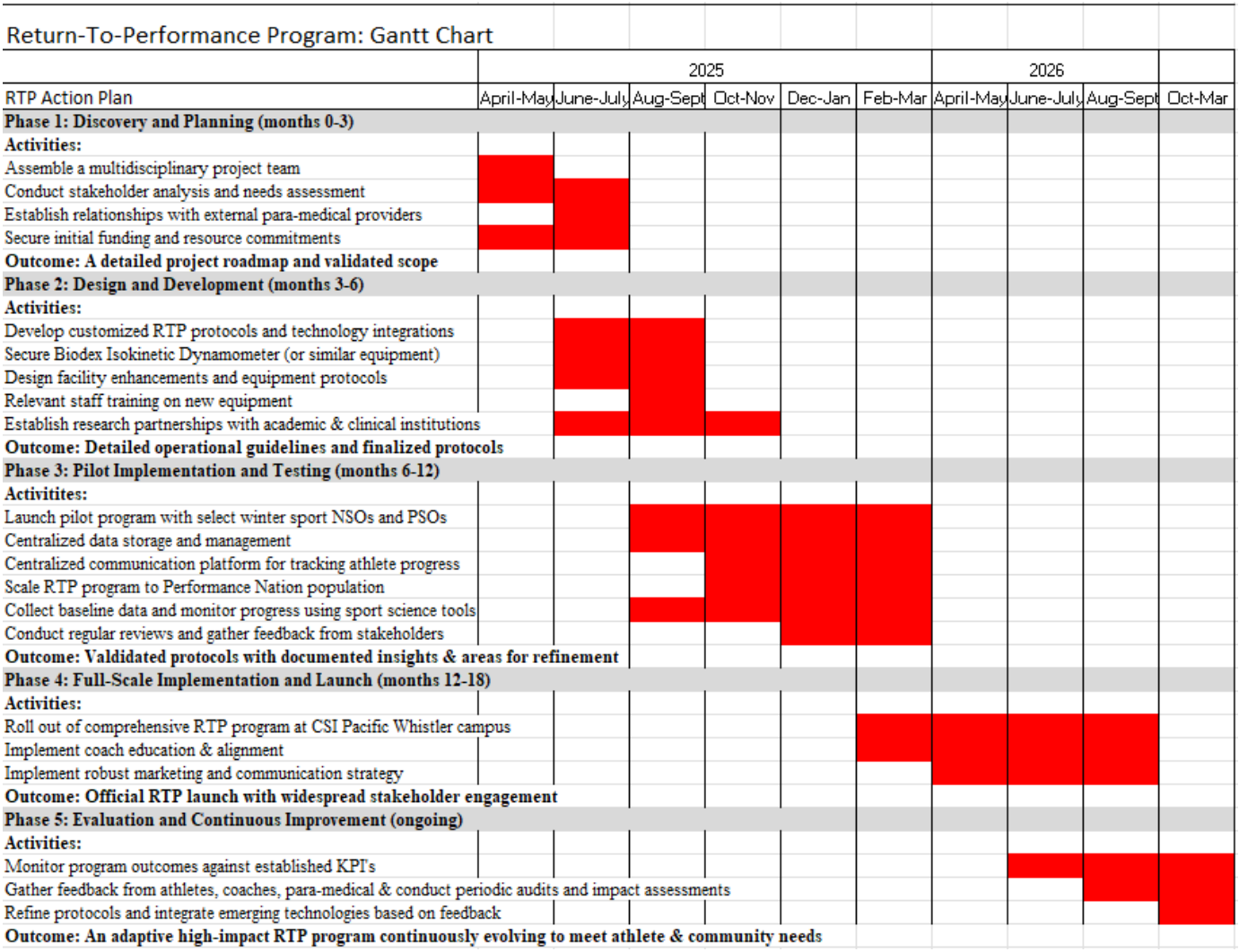
Yung, K. K., Ardern, C. L., Serpiello, F. R., & Robertson, S. (2022). A Framework for Clinicians to Improve the Decision-Making Process in Return to Sport. *Sports Medicine - Open*, *8*(1). https://doi.org/10.1186/s40798-022-00440-z

Zappalà, G., & Lyons, M. (2006). Factors Associated with Fundraising Dependency among Nonprofit Organisations in Australia. *The Australian Journal of Social Issues*, *41*(4), 399–417. https://doi.org/10.1002/j.1839-4655.2006.tb00027.x

Appendices

Appendix A

Return-To-Performance Program: Gantt Chart



Appendix B

US Ski & Snowboard vs CSI Pacific Whistler RTP Program

Component	U.S. Ski & Snowboard	CSI Pacific Whistler (Current/Planned)
Overall RTP Framework	Well-established, criteria-based, multidisciplinary RTP pathway with a strong Return to Snow (RTS) progression.	Strategic plan underway to build an RTP framework tailored to winter sport; aiming to establish a robust, evidence-informed, multidisciplinary model.
Medical Oversight	In-house sport medical and paramedical team, on-site physician access, and networked care with USOPC clinics.	Access to external physicians and sport med providers; must develop tighter integration and protocols with networked clinics in Sea-to-Sky corridor. NSO's required to lead this independently of CSI Pacific.
Case Management	Dedicated case managers per athlete, ensuring integrated care across rehab, training, coaching, and performance staff.	Planning for a similar integrated model; would require dedicated staffing or coordination roles to manage return cases holistically.
Testing & Monitoring	Extensive use of force plates, GPS, isokinetic devices, biomech labs (at Center of Excellence in Park City).	Some force plate capacity. Currently no capacity for motion capture; proposal underway for Biodex Isokinetic Dynamometer to bolster return-to-load and strength testing.
Return to Snow Protocols	Clearly staged RTS pathway (terrain → volume → intensity), aligned with technical progression and coach involvement.	RTS protocols for each sport are independent of one another; some informal practice exists with Freestyle and Snowboard teams, but needs formalization across sports. S&C practitioners work exclusively with each NSO/PSO.
Sport Science Integration	Embedded sport scientists work closely with S&C, physio, and coaches; ongoing performance testing during RTP.	Performance services staff somewhat embedded, but full RTP integration with sport science is an evolving goal; gaps exist in access to consistent testing tools across athletes.
Psychological Readiness	Formal support through sport psychs; use of tools like I-PRRS to assess mental readiness to return.	Access to mental performance consultants is available, though RTP-specific psychological support and tracking is less formalized. Each NSO is responsible for its own staff, protocols, and tools.
Data & Documentation	Centralized EMR and injury tracking; RTP documentation and communication tightly managed across departments.	Each NSO uses its own system, some invest in Smartabase via partnership with CSI Pacific. Need to explore ways to centralize data and enhance communication across rehab and sport staff.
Education & Prevention	Ongoing education for coaches, athletes, and staff on injury prevention and RTP principles.	Not yet formalized; potential area for growth via workshops or integration into athlete programming.

Appendix C

Return to Performance (RTP) Program Stakeholder Map

Tier 1 – Core Stakeholders

Directly involved in delivery and decision-making; daily to weekly contact

Stakeholder	Role in RTP
🧑‍🦽 **Athletes**	Central focus of RTP; active participants in planning and progression.
🧑‍⚕️ **Integrated Support Team (IST)**	Leads rehab services: physio, S&C, therapy, sport psych, nutrition, science.
🏢 **CSI Pacific (Whistler Campus)**	Coordinates IST, manages RTP delivery, data tracking, and service integration.
🩺 **Sport Medicine Physicians**	Oversee diagnosis, tissue healing, and return-to-play medical clearance.

Tier 2 – Performance Partners

Guide direction, context, or integration; weekly to monthly involvement

Stakeholder	Role in RTP
🏔️ **National Sport Organizations (NSOs)**	Align RTP with performance timelines, training demands, and team policies.
🏅 **High Performance Directors / Coaches**	Support reintegration and manage performance expectations post-injury.
🏟️ **COC/CPC Health & Performance Teams**	Offer Games-time resources, national strategy support, and medical oversight.

Tier 3 – Support & Enabling Partners

Provide infrastructure, funding, and long-term strategy; monthly or as needed

Stakeholder	Role in RTP
💰 **Own the Podium / Sport Canada**	Fund RTP staffing, equipment, innovation; expect KPIs and performance ROI.
🧑‍🔬 **Academic & Research Partners (e.g., UBC)**	Contribute knowledge, metrics, and validation of RTP frameworks.
👨‍👩‍👧 **Family & Support Networks**	Provide emotional, logistical, and motivational support to athletes.
🛡️ **Insurance / Athlete Assistance Programs**	Help cover cost of services or living during rehab.

Tables

Table 1

Table 1 Participant Classification Framework

Tier	Criteria for classification
Tier 5: World Class =<0.00006% of the global population =<0.001% of the Australian population	• Olympic and/or world medalists. • World-record holders and athletes achieving within 2% of world-record performance and/or world-leading performance. • Top 3–20 in world rankings and/or top 3–10 at an Olympics/World Championships (ie, finalists in their event), with this number determined based on size and depth of competition in the event. • Top players within top teams (teams which medal or are in the most competitive leagues) or athletes achieving individual accolades (ie, most valuable player, player of the year). • Maximal, or nearly maximal training, within the given sports norms. • Exceptional skill-level achieved (ie, running biomechanics, ball skills, acquired decision-making components).
Tier 4: Elite/International Level =~0.0025% of the global population =~0.0055% of the Australian population	• Competing at the international level (individuals or team-sport athletes on a national team). • Team-sport athletes competing in international leagues/tournaments. • Top 4–300 in world rankings, with this number dependant on size and depth of competition in the event. • Achievement of within ~7% of world-record performance and/or world-leading performance. • NCAA Division I athletes. • Maximal, or nearly maximal training, within the given sports norms, with intention to complete at top-level competition. • Highly proficient in skills required to perform sport (ie, biomechanics, ball skills, acquired decision-making components).
Tier 3: Highly Trained/National Level (Provincial/State or Academy Programs) =~0.014% of the global population =~0.027% of the Australian population	• Competing at the national level. • Team-sport athletes competing in national and/or state leagues/tournaments. • Achievement of within ~20% of world-record performance and/or world-leading performance. • NCAA Division II and III athletes. • Completing structured and periodized training and developing towards (within 20%) of maximal or nearly maximal norms within the given sport. • Developing proficiency in skills required to perform sport (ie, biomechanics, ball skills, acquired decision-making components).
Tier 2: Trained/Developmental =~12%–19% of the global population =~18% of the Australian population	• Local-level representation. • Regularly training ~3 times per week. • Identify with a specific sport. • Training with a purpose to compete. • Limited skill development.
Tier 1: Recreationally Active =~35%–42% of the global population =~30% of the Australian population	• Meet World Health Organization minimum activity guidelines: Adults aged 18–64 years old completing at least 150 to 300 min moderate-intensity activity or 75–150 min of vigorous-intensity activity a week, plus muscle-strengthening activities 2 or more days a week.[20] • May participate in multiple sports/forms of activity.
Tier 0: Sedentary =~46% of the global population =~52% of the Australian population	• Do not meet minimum activity guidelines. • Occasional and/or incidental physical activity (eg, walking to work, household activities).

Abbreviation: NCAA, National Collegiate Athletic Association. Note: We have presented the key classification criteria for each tier and the estimated proportion of the population that fall into each tier. These population estimates have been derived from both global and continent-specific statistics to demonstrate how densely populated each of these tiers may be. Detailed calculations for these estimates can be found in the Supplementary Material (available online).

Table 3

Table 3 Classification of Sports Within 7 Broad Categories

Sports category	Stefani's rating system[40]	Sports examples	Sport-specific considerations for implementing the Participant Classification Framework
Team sports	Object sports	Australian football, American football, baseball, basketball, cricket, field hockey, football, handball, ice hockey, netball, rugby, goalball, volleyball, and water polo	• Most often classification will occur based on the team and league the individual participates in, as well as their contribution to/position within the team. • Recognition for exceptional individual performance within a team can be considered during the classification process. This includes metrics such as most valuable player, player of the year, and player of the tournament.
Endurance/ long distance	Independent sport	Track (>5000 m) events, biathlon, cross-country skiing, road cycling, swimming (800 m+) open water swimming, triathlon, racewalking, marathon, and ultra endurance events	• A combination of current world records, world-leading performances, and world championship competition performances should be used to create benchmark performance standards for each tier. The selection of performance standard should take into account factors such as age of world record and environmental conditions of world championship performances so that these standards appropriately reflect current performances. • Where performance can be easily quantified, athletes achieving within −2% of the benchmarked standard can be classified as World Class, athletes achieving within −7 as Elite/International level, and those within −20% of the benchmarked standard as Highly Trained/National Level. • In sports where quantifying performance isn't appropriate (eg,. rowing, where environmental conditions and wind speeds can affect performance; and BMX/ Mountain biking where races are completed on different courses), athlete ranking and placings at major competitions should be the priority metric used to classify athletes. • Sport-specific ranking systems can be a useful way of comparing events within a sport (ie, the use of IAAF points in Track and Field or FINA points in swimming). • Additional physiological variables (ie, VO_2max, $Watt_{max}$) may be used in conjunction with the framework to aid classification if desired.
Middle distance/power	Independent sports	Canoe, kayak, BMX racing, mountain biking, rowing, swimming (<400 m), track (800–1500 m), and track cycling	
Speed/ strength	Independent sports	Alpine skiing, bobsleigh, field athletics, luge, skeleton, ski jumping, speed skating, sprinting, track (<400 m), and weightlifting	
Precision/ skill-dependent sports	Independent/ object sports	Archery, artistic swimming, curling, diving, equestrian, figure skating, freestyle skiing, golf, gymnastics, sailing, shooting, snowboard, surfing, skateboard, and BMX freestyle trampoline	• Majority of the sports within these sports produce individual athlete world rankings on a point based system which can be used for classification. Similarly, many of these sports already adjust the way points are obtained to prioritize key events (world championships, tennis grand slams). • In many of these sports, the number of participants in the field will be much smaller compared to other sports that have higher participation rates and an increased depth of field. This should be a key consideration when ranking athletes within these sports. • These sports likely allow a greater consideration of skill compared to other sport categories. Skill should be reflected and at the forefront in the classification of athletes within some of these sports. • For sports with tiered events (ie, combat sports with weight classifications, sailing with multiple boat classes), rankings should be done within each event, and not combined across events.
Racquet sports	Object sports	Badminton, table tennis, squash, and tennis	
Combat/ weight-making	Combat sports	Boxing, fencing, judo, karate, taekwondo, and wresting	

Abbreviation: IAAF, International Amateur Athletic Federation. Note: Specific considerations for implementation of the Participant Classification Framework are included for each sports category.

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Figures

Figure 1

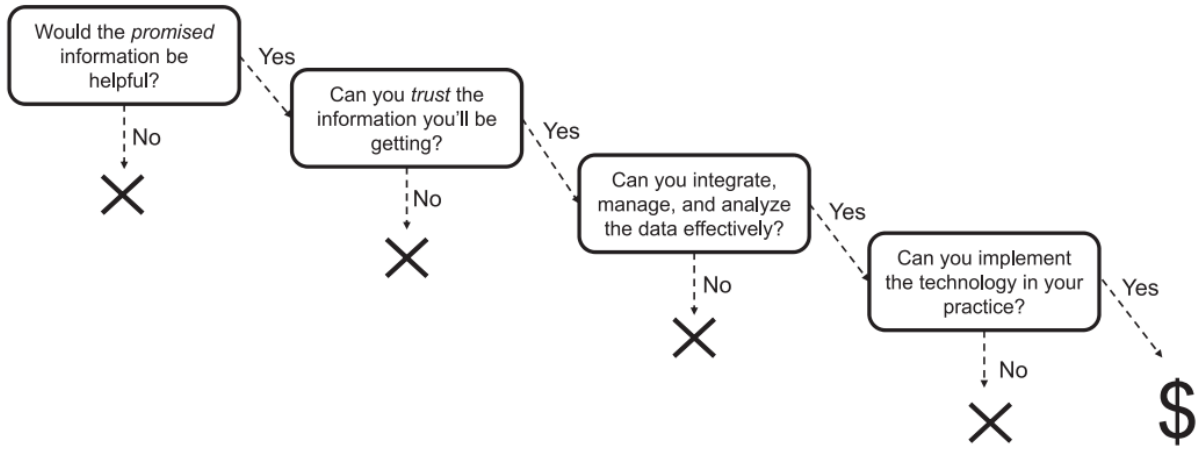

Figure 1. A critical decision-making framework for integrating technology in sport.