Journal of Science and Medicine in Sport xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Performance determinants and evidence-based practice in track cycling: A survey of coaches, practitioners, and athletes

Antony M.J. Stadnyk [a,b,*], Franco M. Impellizzeri [a], Jamie Stanley [c,d,e], Paolo Menaspà [f,g], Katie M. Slattery [a]

[a] School of Sport, Exercise, and Rehabilitation, University of Technology Sydney, Australia
[b] New South Wales Institute of Sport, Australia
[c] South Australian Sports Institute, Australia
[d] Australian Cycling Team, Australia
[e] Allied Health and Human Performance, University of South Australia, Australia
[f] Centre for Exercise and Sports Science Research, School of Medical and Health Sciences, Edith Cowan University, Australia
[g] Australian Institute of Sport, Australia

ARTICLE INFO

Article history:
Received 2 October 2023
Received in revised form 21 May 2024
Accepted 3 June 2024
Available online xxxx

Keywords:
Athletic performance
Elite sport
Implementation science
Knowledge discovery
Surveys and questionnaires

ABSTRACT

Objectives: This study examined how track cycling coaches, practitioners, and athletes: develop knowledge and practices; value performance areas; and, implement research into practice.
Design: Cross-sectional survey.
Methods: An online REDCap survey of track cycling coaches, practitioners, and athletes was conducted involving questions related to demographics, performance area importance, knowledge acquisition and application, research relevance, and research direction.
Results: A total of 159 responses were received from coaches (n = 55), practitioners (n = 29), and athletes (n = 75). Participants' highest track cycling competition level involvement ranged from local/regional (12.7%) to Olympic/Paralympic (39.9%). Respondents primarily develop practices by observing 'the sport' or 'others competing/working in it' (both 85.8%). Practitioners develop practices through self-guided learning (96.4%). The primary reason for practice use was prior experience (84.9%), whilst individuals were least likely to use practices resulting in marginal gains with potentially negative outcomes (27.3%). Areas of greatest perceived importance were Aerodynamics, Strength & Conditioning, and Tactics (all > 96% agreed/strongly agreed). Scientific evidence for Tactics (30%) and Mental Skills (26%) was perceived to be lacking, resulting in greater reliance on personal experience (74% and 62%, respectively) to inform training decisions. The main barrier to implementing research into practice was athlete buy-in (84.3%).
Conclusions: Within track cycling, informal learning was most popular amongst respondents. Greater reliance on personal experience within evidence-based practice for many performance areas aligns with limited existing research. Most respondents reported multiple barriers affecting research implementation in practice.

Practical implications

- Researchers can pursue several key performance areas, including *Aerodynamics*, *Mental Skills*, *Tactics/Strategy*, *Talent Identification*, and *Technical/Skills Development*, identified by participants where research is lacking and/or desired. However, they should seek guidance from those within the sport on the specific research questions and communication to improve usability of findings.
- Practitioners can act as a conduit between research and practice, both in terms of finding and filtering new peer-reviewed evidence to share and apply in practice with coaches and athletes, and in fostering new and existing relationships with research institutions to develop evidence to support and advance practices.
- Coaches and athletes should seek, and National Sporting Organisations should facilitate, opportunities to engage with practitioners and researchers to identify critical testing, training, and performance questions they want answered, and have the evidence presented in ways that improve understanding, usability, and trustworthiness, which can improve confidence and potentially reduce barriers to implementation.
- National Sporting Organisations may find it beneficial to conduct similar surveys as an annual census of coaches, practitioners, and athletes to develop and update research needs, and potentially incorporating research as a pillar of successful organisational performance as opposed to simply using it for service provision.

* Corresponding author.
E-mail address: antony.stadnyk@uts.edu.au (A.M.J. Stadnyk).

https://doi.org/10.1016/j.jsams.2024.06.001
1440-2440/

1. Introduction

Much has been made in recent years of the real, perceived, and/or potential impact of sport science and research for guiding practice to improve sport performance,[1–5] with good reason. Coaches, practitioners, and athletes in track cycling, as in other sports, may benefit from the availability of sport science and research contributing to their decision-making for testing, training, and optimising performance. However, that relies on appropriate and relevant research existing and being accessible. A recent systematic mapping review of the track cycling literature demonstrated a limited volume of research available for reference to those in the sport.[6] As a result, coaches, practitioners, and athletes must then rely on either personal experience to inform practice, or adapt research from other cycling disciplines or sports. Furthermore, a major limitation of sport science literature, in general, is the frequent mismatch of methods and findings to the needs or resources of those translating it to practice.[7–9] Given the limitations of existing literature in the sport, how track cyclists, their coaches, and the various practitioners they work with develop training methods/practices for improving the various performance areas is of great interest.

Track cycling is exceedingly demanding[10] with athletes requiring highly developed mental, physical, tactical, and technical characteristics to achieve success at an elite level. Finding the most effective and efficient means to develop these characteristics and maximise performance is an ongoing endeavour for athletes, coaches, and performance support teams. The evidence-based practice model provides a framework from which decisions can be made.[3] In the long-term planning of athlete training and development, a deliberative and rational evaluation of athlete needs and potential interventions to address them should be conducted.[11] Here, key stakeholders (e.g., coaches, practitioners, athletes) can consider the positive and negative interactions of these interventions on training and performance. The evidence-based practice model aims to foster this by finding a balance between best-available scientific evidence, personal experience/expertise, and athlete values and preferences.[3] An abundance of experience may supplement a lack of scientific evidence, and vice versa, to inform decisions that are influenced by the preferred practices of the athlete.

Research to identify the perceptions and implementation of evidence-based practice amongst coaches and practitioners has been conducted more broadly.[9,12–15] Common findings amongst these studies are the skewed abundance of research in physical performance components, and limited applicability or implementation in practice due to various barriers (e.g., buy-in, time, funding). Furthermore, despite being central to the development puzzle and their perspectives critical to true evidence-based practice, the athlete voice is often lacking in these cross-sectional analyses. It is, therefore, imperative that we clarify, specifically within track cycling and its relevant stakeholders, what is most (or least) valued, and what barriers exist preventing research findings being implemented by those active within the sport so that we may more effectively develop impactful research. Understanding these key stakeholders' perspectives can help us to redirect our research focus to where it is most desired and attempt to minimise the factors limiting its implementation in practice.

The aim of this study was to examine coach, practitioner, and athlete perceptions of training and performance components, and their perceived contribution to successful track cycling performance. Research objectives were: 1) to gain knowledge of how evidence is acquired to support training practices; 2) identify areas of training that are most (and least) valued in track cycling, and at what stages of athlete development they should be used; and, 3) highlight common issues with research implementation in practice. The present study is reported in accordance with the Checklist for Reporting Results of Internet E-Surveys (CHERRIES).[16]

2. Methods

2.1. Participant recruitment

The target population for this research was coaches, athletes, and practitioners involved in track cycling within the past two years. Individuals were eligible to participate in the survey if they were aged ≥18 years and residing or working in one of 21 countries at time of completion. Survey invitations were distributed via social media posts, emails to cycling organisations/federations, and within the personal networks of the authors. Participants were invited to share the survey invitation with others within their network to increase participation (i.e., snowball sampling). Prospective participants were provided with survey information, answered eligibility screening questions, and provided informed consent on the survey introduction page (see protocol files and full survey at osf.io/fdg2n) before being permitted to access the survey. The survey invitation remained open for a three-month period and no incentives were offered for participation. The study was granted ethics approval (ETH20–5383) by the University of Technology Sydney Human Research Ethics Committee and complied with the Declaration of Helsinki. Participant demographic data are reported in Table 1.

Table 1
Demographic characteristics of survey participants as percentages of group.

Characteristic	Response	Coach %, n = 55	Practitioner %, n = 29	Athlete %, n = 75	Total %, n = 159
Track cycling specialisation	Endurance	69.1	31.0	46.7	51.6
	Sprint	14.5	24.1	28.0	22.6
	Both	16.4	44.8	25.3	25.8
Experience in track cycling	<6 months	3.9	3.4	6.7	5.2
	6 months–2 years	2.0	13.8	10.7	8.4
	2–5 years	11.8	48.3	38.7	31.6
	5–10 years	19.6	17.2	21.3	20.0
	10+ years	62.7	17.2	22.7	34.8
Experience at current role/competition level	<6 months	0.0	3.4	13.3	7.1
	6 months–2 years	15.7	24.1	21.3	20.0
	2–5 years	45.1	62.1	34.7	43.2
	5–10 years	13.7	10.3	20.0	16.1
	10+ years	25.5	0.0	10.7	13.5
Number of track cyclists currently working with	≤5	32.7	17.9	–	27.7
	6–10	34.5	14.3	–	27.7
	11–20	25.5	32.1	–	27.7
	21–49	1.8	35.7	–	13.3
	50+	5.5	0.0	–	3.6
Current competition level working/competing	Local/regional	5.5	3.6	34.7	18.9
	State	3.6	3.6	26.7	14.5
	National	21.8	3.6	25.3	20.1
	International	27.3	7.1	9.3	15.1
	Oly/Paralympic	41.8	82.1	4.0	30.8
Highest competition level worked/competed	Local/regional	3.6	3.6	22.7	12.7
	State	1.8	3.6	26.7	13.9
	National	7.3	3.6	20.0	12.7
	International	21.8	3.6	26.7	20.9
	Oly/Paralympic	65.5	85.7	4.0	39.9
Current age level working/competing	U15	0.0	7.1	–	1.3
	U17	3.6	0.0	–	1.3
	U19	1.8	0.0	4.0	2.5
	U23	3.6	0.0	8.0	5.1
	Senior/elite	56.4	82.1	38.7	52.5
	Masters	34.5	10.7	49.3	37.3

2.2. Design & methodology

The study used a cross-sectional survey design[17] with data collected using REDCap (Vanderbilt University, USA), and presented only in English language. Survey questions were developed from previous research[9,12–15] and adapted for a track cycling setting. The survey was organised within five primary topics: demographics; performance area importance; knowledge acquisition & implementation; research perceptions; and, research direction. Across these topics there were 26 items for coaches, 25 for practitioners, and 21 for athletes (i.e., non-relevant items removed; see protocol files and full survey at osf.io/fdg2n). Participants were prompted to respond with their own perspectives for each question reflecting their current personal practice rather than an ideal or expected perspective (e.g., "which of the following have *you used*.../impacted *your decision*..."). The survey items were primarily closed-response (5-point Likert scale [n = 5], sliding scale [n = 2], multiple choice [n = 10]), with some open-ended response items to provide comments or specify *Other* responses. Likert scales ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) were used to understand perceptions of research, and the importance of performance areas, scientific evidence, and personal experience. Sliding scales (0–100) were used to quantify relative contribution of scientific evidence and personal experience in decision-making, and desired research funding simulation where the participant was asked to allocate a total of $100,000 to performance areas of their choice. The performance areas participants were prompted with throughout the survey were *Aerodynamics*, *Biomechanics*, *Rehabilitation and/or Injury Prevention*, *Mental Skills Training*, *Nutrition*, *Performance Analysis/Data Analytics*, *Physiology*, *Recovery*, *Strength & Conditioning*, *Tactics/Strategy Development*, *Talent Identification and Recruitment*, *Team Building/Leadership Development*, *Technical/Skills Development*, *Training Load Monitoring*, and *Other* (self-specified). The survey was piloted with 10 non-participating state institute-level coaches, practitioners, athletes, and university academics to ensure content and face validity, and assess question comprehension and respondent fatigue prior to finalisation of the survey structure. All data collected were anonymous and stored within the password-protected REDCap data management server.

2.3. Statistical analysis

Survey responses were exported from REDCap, inspected and cleaned (e.g., removing empty records [n = 38]) in Excel 2016 (Microsoft, USA), and analysed using R (version 4.3.2)[18] and relevant packages ('likert',[19] 'rstatix',[20] 'irr'[21]). Records where participants had identified as being a coach and/or practitioner and athlete (n = 9) were excluded from analyses due to the inability to delineate responses by their individual roles. Descriptive statistics are presented as percentages. Likert-type responses are presented as median [interquartile range], with between-area differences assessed using Friedman's Test with Nemenyi All-Pairs Rank Comparison post-hoc test for pairwise comparisons, and the Kruskal–Wallis Test used to assess between-group differences with post-hoc pairwise comparisons performed using Dunn's test with Holm correction. Cochran's Q Test was used to assess differences in multiple selection-type question responses. Fleiss' Kappa κ was calculated to assess participant agreement. Statistical significance level was set at an alpha of 0.05 for all tests.

3. Results

3.1. Demographics

A total of 159 individuals (55 coaches, 75 athletes, 29 practitioners; see Table 1), from 14 nations, participated in the survey of 182 whom

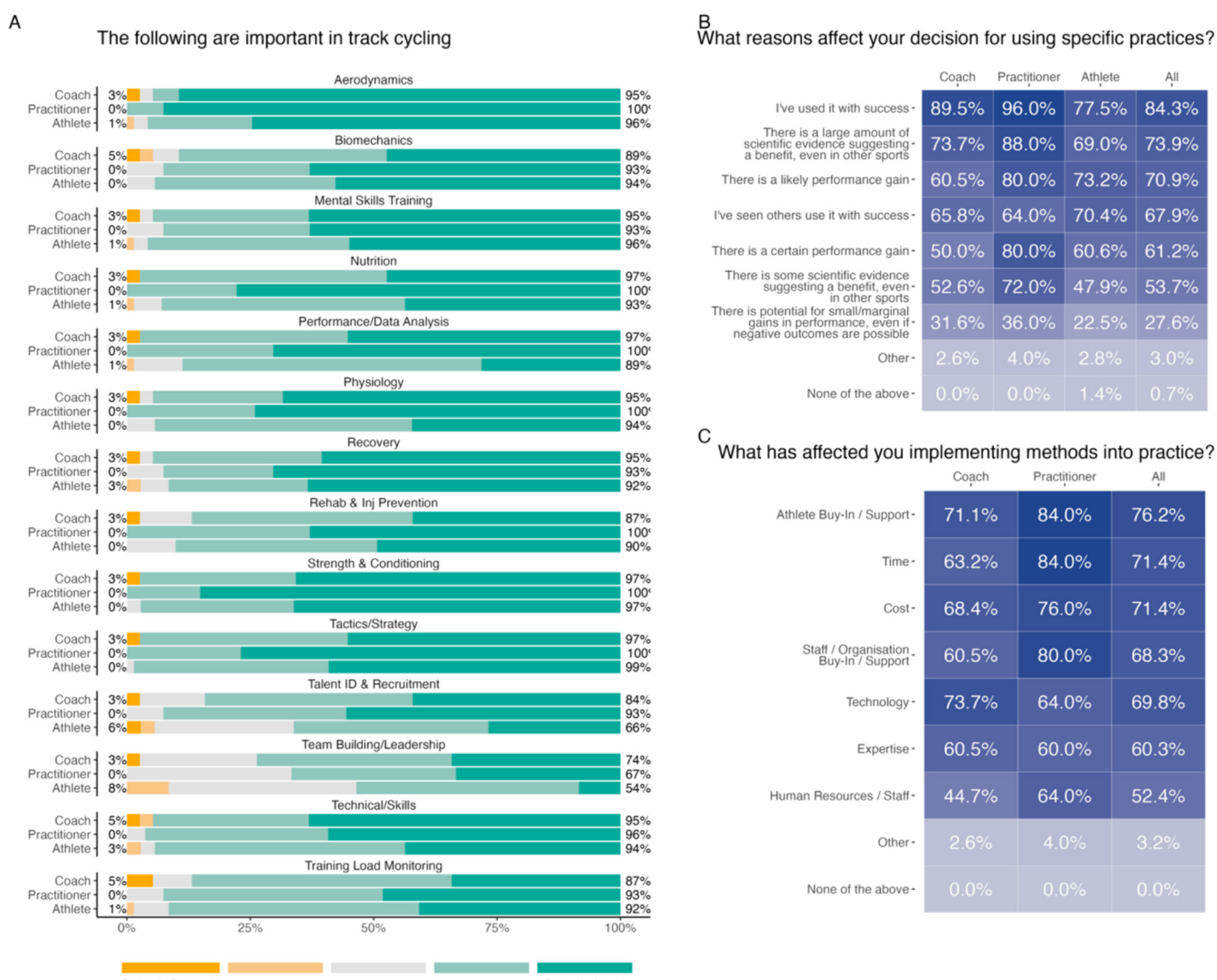

Fig. 1. Responses of track cycling coaches, practitioners, and athletes regarding the A) perceived importance of specific performance areas, with percent total disagreement/agreement per group; B) reasons that affect their decisions to implement methods/practices in their training/performance programmes; and, C) barriers that have affected their implementing of methods into practice.

accessed the survey and met eligibility criteria (87% response rate). The survey had a 65% completion rate (n = 119). The Practitioner group included Sport Scientists (e.g., physiologists, biomechanists, performance analysts), Strength & Conditioning Coaches, Nutritionists/Dietitians, Physiotherapists, Aerodynamics Engineers, Technical Directors, and High Performance Managers.

A large majority of participants were involved with track endurance (77%) cycling in some capacity, whilst fewer than 49% were involved with track sprint. Over 86% of all participants had more than two years of experience in the sport. Participants presented views from the highest levels of competition with 72% of coaches and practitioners having worked with Olympic/Paralympic track cyclists at any point in their career, and 76% working with International (e.g., UCI World Championships/Cups) or Olympic/Paralympic athletes at the time of participation. Overall agreement for Likert-response questions was $\kappa = 0.12$, $p < 0.001$, and $\kappa = 0.27$, $p < 0.001$ for nominal-response questions.

3.2. Performance area importance

Tactics/Strategy, *Strength & Conditioning*, and *Aerodynamics* had the highest overall rating of importance for track cycling performance, although *Aerodynamics* received the highest proportion of 'Strongly Agree' ratings from respondents (Fig. 1-*A*). Athletes had lower median sentiment than coaches and practitioners for *Performance/Data Analysis* ($\chi^2 = -2.88$ and -3.91; $p = 0.008$ and $p < 0.001$, respectively) importance, however the responses of athletes and coaches at the elite level (i.e., national level and higher) were not different ($\chi^2 = 1.50$, $p = 0.268$). Practitioners' perceptions of nutrition importance for performance were higher than both coaches ($\chi^2 = 2.37$, $p = 0.036$) and athletes ($\chi^2 = 3.11$, $p = 0.006$), but not amongst the elite subsample ($\chi^2 = 2.29$ and $\chi^2 = 2.16$; $p = 0.066$ and 0.066, respectively). Overall sentiment for *Team Building/Leadership* was significantly lower than all other areas ($p < 0.001$). Athletes also rated *Team Building/Leadership* importance lower than coaches ($\chi^2 = -3.01$, $p = 0.008$) and practitioners ($\chi^2 = -2.30$, $p = 0.043$), however between-group differences were not present in the elite subsample (i.e., national level and higher; $z = 4.13$, $p = 0.127$).

Coaches, practitioners, and athletes agreed that *Technical/Skills Development* should be a target area in training programmes at the earliest opportunity (i.e., Local/Regional level; $\chi^2 = 2.31$, $p = 0.316$). Compared to coaches, athletes indicated a desire for earlier access to all other resources/services except *Physiology* ($\chi^2 = -2.14$. $p = 0.065$), *Injury Prevention/Rehabilitation* ($\chi^2 = -2.06$. $p = 0.078$), *Tactics/Strategy Development* ($\chi^2 = -1.02$, $p = 0.308$), *Technical/Skills Development* ($\chi^2 = -1.10$, $p = 0.546$), and *Team Building/Leadership* ($\chi^2 = -0.21$, $p = 0.831$). The largest differences of opinions between coaches and athletes were for *Aerodynamics* (ΔMdn = 1.0; $\chi^2 = -3.37$, $p = 0.002$) and *Recovery* (ΔMdn = 1.0; $\chi^2 = -3.31$, $p = 0.002$). Practitioners disagreed with athletes on level of access to all resources/services except for *Injury Prevention/Rehabilitation* ($\chi^2 = 2.33$, $p = 0.059$), *Nutrition* ($\chi^2 = 1.93$, $p = 0.107$), and *Technical Skills/Development* ($\chi^2 = 1.37$, $p = 0.514$). Over half of all respondents believed athletes' access to *Aerodynamics* (54.5%) or *Performance/Data Analysis* (58.0%) support/services should wait until national-level competition or higher. One respondent, an Olympic-/Paralympic-level track endurance athlete, commented that earlier exposure to these resources/areas can enable better athlete preparation for those that reach the highest level, and that one could "*scaffold the approach so that there's at least a basic understanding at the local/regional level and build on it at each stage of development through the system*".

3.3. Knowledge acquisition & implementation

Within an evidence-based practice model, the relative importance and availability of scientific evidence (Fig. 2-*A*) and personal experiences (Fig. 2-*C*) can be observed in their contribution to participants' decision-making for specific performance areas (Fig. 2-*B*). Between-group differences were observed in two areas, with practitioners reporting lower contribution of personal experience to decision making for *Mental Skills Training* than coaches ($\chi^2 = 2.31$, $p = 0.042$) and athletes ($\chi^2 = 3.67$, $p < 0.001$). Athletes reported greater contribution of personal experience for *Recovery* than coaches ($\chi^2 = 2.60$, $p = 0.019$) and practitioners ($\chi^2 = 3.70$, $p < 0.001$), although the difference between coaches and athletes was not present amongst respondents at national level and higher ($\chi^2 = 2.05$, $p = 0.081$). Across all areas

Fig. 2. Participants' perceived importance of A) scientific evidence, and C) personal experience for track cycling performance, and B) the relative contribution of scientific evidence and personal experience in training/performance decision-making.

there was a 16% (IQR: −55–+34, $\chi^2 = 214$, $p < 0.001$) lean towards scientific evidence over personal experience in decision-making. The areas having highest contribution of scientific evidence were *Aerodynamics*, *Nutrition*, and Physiology, which were significantly different (all $p < 0.001$) from *Tactics/Strategy* ($\chi^2 = 13.0$, 12.2, and 10.9, respectively), *Technical/Skills Development* ($\chi^2 = 10.6$, 9.71, and 8.46, respectively), and *Mental Skills Training* ($\chi^2 = 9.00$, 8.16, and 6.91, respectively), which had greater contribution of personal experience. In comments, several participants highlighted a lack of evidence for some areas, and that a performance support team or person, when there is a lack of personal experience, is beneficial "*to overcome [the lack of personal experience] or assist in making decisions*".

Participants relied on broad sources of information and inspiration to develop their coaching and training practices. For the majority of respondents, informal development methods were most popular. Over 85% of respondents, and ~90% of coaches, learned from others working in track cycling or observing the sport (Fig. 3-*B*). Amongst practitioners, resources used were varied with no specific preferences ($p > 0.05$), and greater use of self-guided learning methods and formal education evident, especially compared to coaches and athletes. Further evidence of this preference is observed in practitioners' use of peer-reviewed research amongst other research-based resources (Fig. 3-*C*). For athletes, participation in track cycling and other cycling disciplines accompanied learning from others in the sport (e.g., coaches) as primary development methods (all $p < 0.007$ vs other methods), along with self-guided learning (all $p < 0.040$ vs other methods). 'Other' sources mentioned by respondents included reflective practices, conducting applied research, and analysis of training data to identify areas to be targeted/addressed. Over half of all respondents (51.6%) performed one or more of the identified development methods monthly, with 91.9% undertaking personal/professional development at least semi-annually.

When balancing potential benefits against risks in decisions, a large majority of respondents were unlikely to try methods that may provide small/marginal performance improvement when a risk of negative outcomes exists, especially compared to practices they have previously used resulting in success for themselves or others (both $p < 0.001$; Fig. 1-*B*). Individuals working or competing at an international level or higher were more likely to use methods less proven in track cycling, with 82.9% likely to consider a practice with *some evidence of a benefit, even in other sports*, compared to a population average of 54.7%. The most cited reason for using a specific method/practice was prior use resulting in success. Some notable barriers to implementing practices were *Athlete Buy-In/Support* and, amongst practitioners, *Time*, *Expertise*, and *Staff* (Fig. 1-*C*), although there were no significant differences in barriers reported. *Other* factors mentioned by participants as reasons for use included: low cost and/or ease of implementation; training

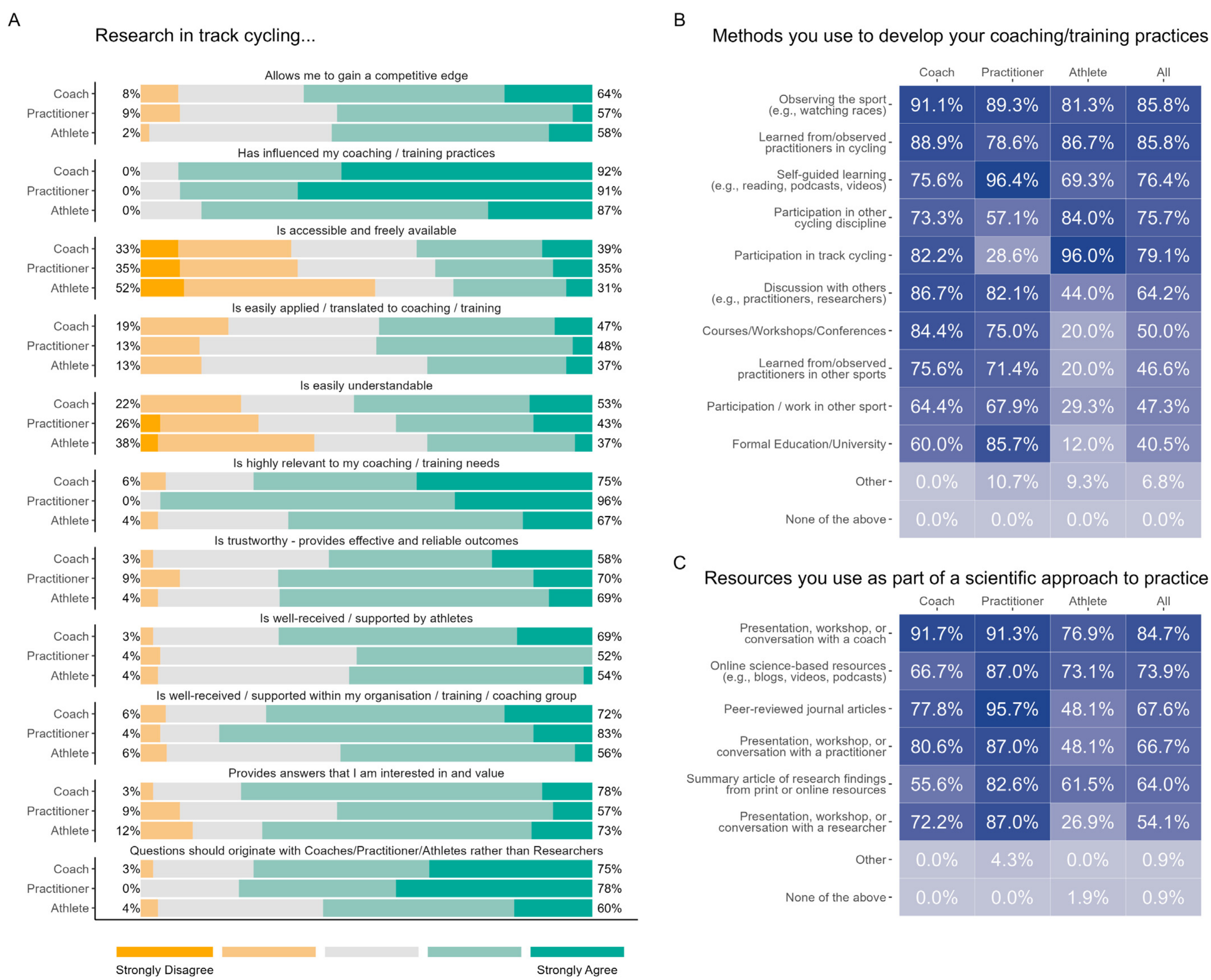

Fig. 3. Track cycling coach, practitioner, and athlete A) perceptions of research in track cycling with percent total disagreement/agreement per group; B) methods used develop their coaching/training practices; and, C) resources used in a scientific approach to developing practices.

facility proximity and access; athlete belief or coach recommendation; seeking and applying practices before others; and, ultimately, the "*phase of the Olympic cycle, and the gap to gold medal performance*".

3.4. Research role in track cycling

Despite the vast majority (89.2%; Fig. 3-*A*) of those within track cycling perceiving research as having influenced their practices (Mdn = 4 [4–5]; $\eta^2 = -0.012$, pairwise differences: A-C, $\chi^2 = 2.80$, $p = 0.010$; A-P, $\chi^2 = 3.07$, $p = 0.007$; C-P, $\chi^2 = 0.60$, $p = 0.549$), only 34.2% thought it was easy to access compared to 42.3% perceiving it as not (Mdn = 3 [2–4]; $\eta^2 = 0.003$, $\chi^2 = 2.2$, $p = 0.337$). Additionally, only 43.1% of participants found track cycling research easy to understand (Mdn = 3 [2–4]; $\eta^2 = 0.010$, $\chi^2 = 4.1$, $p = 0.127$) and, subsequently, only 42.3% believed it was easy to implement in practice (Mdn = 3 [3–4]; $\eta^2 = -0.013$, $\chi^2 = 0.5$, $p = 0.784$). Despite these issues, the research that does become available to coaches, practitioners, and athletes was perceived to have some relevance (Mdn = 4 [4–5]; $\eta^2 = 0.045$, A-P, $\chi^2 = 2.4$, $p = 0.048$) and value (Mdn = 4 [3–4]; $\eta^2 = 0.009$, $\chi^2 = 2.4$, $p = 0.307$) for improving performance. However, respondents felt that research quality and direction can be improved, partly by having research questions originate with those in the field, rather than researchers (Mdn = 4 [3–5]; $\eta^2 = 0.016$, $\chi^2 = 7.0$, $p = 0.030$, pairwise differences all $p > 0.05$), because they are "*best placed to see gaps [or] have questions that need to be answered*".

Respondents identified several areas of interest for future research, including: longitudinal case studies analysing changes in performance markers; concurrent and contrasting training targets (e.g., strength vs velocity); cerebral palsy and multiple sclerosis in para-cycling athletes; athlete development and wellbeing; sport sustainability, talent identification, and coach development; equipment/technology development; training load monitoring and periodisation; and, aerodynamics, biomechanics, and their interactions.

4. Discussion

4.1. Summary of findings

The purpose of this research was to gain an understanding of coach, practitioner, and athlete perceptions of performance area importance, knowledge acquisition and implementation, and the perceived role of research in contributing to improving track cycling performance. The results represent the views of individuals from 14 nations involved in track cycling across the competition spectrum (i.e., from Local/Regional to Olympic/Paralympic).

The findings support the notion that track cycling performance is multifactorial with participants showing general positive sentiment regarding the importance of each individual performance area. However, differences in importance were evident in the proportional strength of opinion for some areas. Specifically, *Aerodynamics*, *Strength & Conditioning*, and *Tactics/Strategy* had the greatest proportion of respondents that 'Strongly Agree' about their importance to performance. As expected, *Physiology* also gained high proportional agreement about its importance to performance, reflecting the requisite physiological characteristics for success at an elite level.[10] There was often a large dependence on personal experience, rather than scientific evidence, to inform practices for athlete development. Dependence on experience likely reflects its immense value in informing practice and the evolution of the sport, but is possibly also influenced by the limited availability of research and difficulty understanding the research that is available. This weighting towards experience may also be reflective of a trust in expert intuition or the perceived needs within a broader training philosophy. Together with, and possibly in lieu of, scientific evidence, many coaches and athletes acquire knowledge through informal situations, such as observations, conversations, and participation. Much of the knowledge in cycling may have been transferred intergenerationally and now seen as self-evident. Where researchers and sport scientists can have impact is in understanding *why* those practices work – or, how effective they are – so that the underlying mechanisms can be exploited further to maximise their benefit. Practitioners might also impact decision-making by explaining the relevance of new evidence to a training philosophy and how it might be feasibly implemented in practice.

Survey research conducted in other sports has reported similar participant responses regarding the relative contribution of scientific evidence and personal experience in guiding practice for specific performance areas.[14,15] As was found in the present study, others[14,15] have reported *Recovery*, *Training Load Monitoring*, *Strength & Conditioning*, and *Nutrition* being weighted towards scientific evidence contribution. Conversely, a distinct reliance on personal experience was evident for *Mental Skills Training*, *Tactics/Strategy*, *Team Building/Leadership*, and *Talent ID/Recruitment*. The aforementioned studies' authors postulated that this may be due to practitioners viewing these areas as being outside the scope of their role. However, within track cycling, this might be partly explained by the current lack of scientific evidence existing in these performance areas.[6] Furthermore, the objective measurability of physical components of performance, compared to mental or tactical components, may lend itself to a greater ability to develop scientific evidence. Participants in this study were conscious of the lack of evidence in these areas, which is concordant with previous research that highlighted a desire for more scientific evidence for *Technical/Skills Development* and *Mental Skills*.[5,15,22] Further areas of interest for research amongst respondents were *Aerodynamics* and several *Physiology/Training Load Monitoring* topics similar to those reported previously,[13,23] including periodisation/planning and optimising training dose/load.

Formal coach education programmes have gained popularity in recent years,[24] although issues with access, delivery, and impact on development have been identified in the literature.[12,25] Informal learning opportunities have typically been perceived as more impactful and regularly performed.[12,26] These formal programmes are relatively novel, with coaches historically transitioning from an athlete career and their practices influenced by their own coaches. Without a university education, it is less likely that individuals have developed literature search and review skills, and/or the ability to develop training strategies based on scientific theories supported by evidence (including understanding whether this evidence is sound). Therefore, it is not surprising to observe a large preference for informal knowledge acquisition amongst participants of this study, a finding consistently reported in previous literature.[5,12,22] Observations and conversations were preferred by coaches and athletes, even against online resources (e.g., videos, podcasts), or summary research articles (e.g., infographics). Fewer coaches than practitioners (and very few athletes) have used presentations or conversations with researchers to inform training practices, which may reflect the role of the sport scientist/practitioner as bridging the gap between the applied and research setting.[27] This under-utilised link may present an opportunity to bring those groups together to create a dialogue and share potentially valuable, new information to inform practice, and for coaches and athletes to direct researchers in development of relevant, important research questions. Sporting organisations should continue to explore and develop strategies to provide coaches with more opportunities to engage with other stakeholders and develop tools to support their learning and practices, with structured approaches showing value for improving the effectiveness of coaches in supporting athletes' development.[28]

Given the limited number of sport scientists operating at a grassroots level for coaches to interact with (see Table 1), educational resources for accessing relevant research may need to be provided by national sporting organisations and researchers as a coaching development tool. It might be argued that investment in coach development, especially at the grassroots level, is critical to the long-term health of the sport and its athletes. There was clear interest from athletes to access various resources (e.g., injury prevention/rehabilitation, recovery, strength & conditioning) earlier in their development (i.e., Local/

Regional level) than when coaches or practitioners perceived it to be necessary. The decision to introduce these resources earlier should be on a needs and evidence basis, which requires trustworthy and reliable educational resources for the coach, athlete, and any practitioners within the performance support team. Whilst interest in these resources is likely related to the athlete's drive to improve performance, it may also be influenced by the desire to maintain their health and prolong their career and should be investigated.

Perceptions of research and its role in track cycling were generally positive, however there were several statements for which participant agreement was low. Only 34% of participants believed research was accessible and freely available, whilst <44% believed research was easy to understand or apply/translate to training. By contrast, Schwarz and colleagues reported that <15% of participants cited lack of availability or difficulty understanding as issues, possibly related to the wider range of sports considered in their survey compared to the limited research available in track cycling. Nevertheless, the sentiments of participants in the present study echo those reported elsewhere,[5,8] suggesting limited progress in research accessibility and usability during the past decade. Despite these issues, coaches do believe that sport science is beneficial. It is imperative that the integration of sport science and research within applied settings is improved to ensure we are impacting training and performance as intended. Improving research accessibility through plain writing, open-access publication, and community outreach are potential ways to increase usability and impact.

Barriers to implementing research in practice appear to be consistent across many sports and, alarmingly, have been for an extended period. *Athlete Buy-In*, *Time*, and *Expertise* were the most cited barriers in the present study. Practitioners also often faced the challenge of not having the required *Human Resources/Staff* available. The ubiquitous set of barriers to use, highlighted in a variety of sports, suggests a broader concern that must be addressed within coaching, sport science, and research. Interrelationships between these barriers must be acknowledged, as should the fact some barriers are unavoidable consequences of an athlete preparation process with infinite permutations, for which we must weigh the probable outcomes and opportunity costs of our training and performance decisions. A lack of expertise or understanding may make it difficult to convince an athlete to 'buy-in' to a particular practice. Likewise, uncertainty about the timing of practices during saturated training and competition schedules, often with elevated performance pressure/expectations, may lead to implementation reluctance for decision makers. Overcoming these barriers can be as much about improving the design and communication of research as it is about developing confidence, trust, and expertise within an athlete's performance team to make decisions.

There are also several likely barriers to publishing research that should be acknowledged as possible reasons for the lack of available scientific evidence in track cycling. Whilst the hyper-competitive nature of the sport drives innovation in training and technology at the elite level, it also typically results in difficulty for practitioners to publish new and relevant findings due to lack of time, methodological issues, limited sample sizes, or secrecy. Some of these issues are systemic; high performance sport is inherently fast paced with few available athletes to permit randomised or sufficiently controlled interventions, and the research and publication process can be cumbersome for performance teams with limited resources. Solutions may involve parallel projects that can provide answers within the constraints of fast (applied practice) and slow (research) environments, with embedded research students and partner institutions providing additional resources and expertise.[29]

What has been done to improve knowledge translation into practice appears not to have had the desired effect.[4] Better solutions must be found to our research-to-practice issue. The sport science and research community must greatly and rapidly improve our efforts to translate and transfer knowledge and reduce barriers to research implementation in practice. Promoting communication opportunities with individuals in track cycling to create a two-way avenue of information – providing the latest research findings to those in the field and creating a dialogue about important and relevant performance-related research questions – should be expected. Embracing co-design principles to develop, deliver, and evaluate research *with* the people at the heart of the sport can be our way forward.

4.2. Limitations

This is the first study to investigate the perspectives of those within track cycling, providing insight to the areas most valued for performance, and common issues with using research and scientific evidence to inform practice. The survey was completed by a broad demographic within the global track cycling community, providing insights that may be generalisable to the population. However, a number of limitations must be acknowledged. As with any online survey, sampling and bias issues may be present. The distribution method, involving snowball sampling via social media sharing and emails to cycling organisations may have led to self-selection bias or non-response error. The 65% completion rate is not dissimilar from surveys of a similar length, though will have introduced greater error, especially for an already small sample with unequal group sizes. The athlete group was least likely to complete the survey, which may be counterbalanced by it being the largest participant group. Additionally, there were notable differences in the competition levels that respondents had been involved; athlete respondents were reasonably balanced across international level and lower, whilst the sample of coaches and practitioners was skewed towards international and Olympic/Paralympic levels. Furthermore, whilst survey items were written and tested to ensure comprehension, it is possible that participants' interpretations of questions and the perceived scope of each performance area may have differed. As the study was only provided in English language, this limitation is particularly relevant to those respondents for whom English is not the native language. To minimise these differences in interpretation, national federations may wish to conduct surveys locally as a census of their members' opinions of sport needs using terminology and themes specific to that nation. Additionally, qualitative methods such as interviews or focus groups may provide an opportunity to discuss more openly inter-individual interpretations of questions and performance needs whilst also allowing the researchers to more accurately identify biases exhibited within the cohort.

5. Conclusions

This study examined track cycling coach, practitioner, and athlete perceptions of training and performance components, evidence and experience, and how they contribute to the development of performance. Across participants there was agreement about the perceived importance of various areas of performance, notably *Aerodynamics*, *Strength & Conditioning*, and *Tactics/Strategy*. Likewise, all groups agreed that research has influenced their practices. However, research was seen to be difficult to access and, when available, was often not easy to understand. The most common means of knowledge acquisition for participants were informal, such as engaging with and observing the sport and others involved in it. Practitioners also frequently use self-guided learning, particularly peer-reviewed literature and other online science-based resources, along with engagement with coaches, researchers, and fellow practitioners. We suggest that each group surveyed, along with researchers, evolves their role in improving the understanding of the various domains and components of athlete preparation and performance in track cycling.

Funding information

None to declare.

Confirmation of ethical compliance

This research was conducted in compliance with the ethics application (ETH20-5383) approved by the University of Technology Sydney Human Research Ethics Committee.

CRediT authorship contribution statement

Antony M.J. Stadnyk: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Visualization, Writing – original draft. **Franco M. Impellizzeri:** Conceptualization, Methodology, Writing – review & editing. **Jamie Stanley:** Conceptualization, Methodology, Writing – review & editing. **Paolo Menaspà:** Conceptualization, Methodology, Writing – review & editing. **Katie M. Slattery:** Conceptualization, Methodology, Writing – review & editing.

Declaration of interest statement

None.

Acknowledgements

The authors thank the participants for their time completing the survey. AS was supported by an Australian Government Research Training Program scholarship whilst completing this research.

References

1. Bartlett JD, Drust B. A framework for effective knowledge translation and performance delivery of sport scientists in professional sport. *Eur J Sport Sci* 2021;21(11): 1579-1587. doi:10.1080/17461391.2020.1842511.
2. Bishop D. An applied research model for the sport sciences. *Sports Med* 2008;38(3): 253-263. doi:10.2165/00007256-200838030-00005.
3. Coutts AJ. Challenges in developing evidence-based practice in high-performance sport. *Int J Sports Physiol Perform* 2017;12(6):717-718. doi:10.1123/IJSPP.2017-0455.
4. Fullagar HHK, McCall A, Impellizzeri FM et al. The translation of sport science research to the field: a current opinion and overview on the perceptions of practitioners, researchers and coaches. *Sports Med* 2019;49(12):1817-1824. doi:10.1007/s40279-019-01139-0.
5. Reade I, Rodgers W, Hall N. Knowledge transfer: how do high performance coaches access the knowledge of sport scientists? *Int J Sports Sci Coach* 2008;3(3):319-334.
6. Stadnyk AMJ, Impellizzeri FM, Stanley J et al. Testing, training, and optimising performance of track cyclists: a systematic mapping review. *Sports Med* 2022;52(2):391-401. doi:10.1007/s40279-021-01565-z.
7. Bishop D, Burnett A, Farrow D et al. Sports-science roundtable: does sports-science research influence practice? *Int J Sports Physiol Perform* 2006;1(2):161-168. doi:10.1123/ijspp.1.2.161.
8. Martindale R, Nash C. Sport science relevance and application: perceptions of UK coaches. *J Sports Sci* 2013;31(8):807-819. doi:10.1080/02640414.2012.754924.
9. Williams SJ, Kendall L. Perceptions of elite coaches and sports scientists of the research needs for elite coaching practice. *J Sports Sci* 2007;25(14):1577-1586. doi:10.1080/02640410701245550.
10. Craig NP, Norton KI. Characteristics of track cycling. *Sports Med* 2001;31(7):457-468. doi:10.2165/00007256-200131070-00001.
11. Abraham A, Collins D. Taking the next step: ways forward for coaching science. *Quest* 2011;63(4):366-384. doi:10.1080/00336297.2011.10483687.
12. Stoszkowski J, Collins D. Sources, topics and use of knowledge by coaches. *J Sports Sci* 2016;34(9):794-802. doi:10.1080/02640414.2015.1072279.
13. Buchheit M, McHugh D, Smith S. Kitman labs performance intelligence research initiative: a survey to bring research on the field. *Sport Perf Sci Res* 2021:135.
14. Fullagar HHK, Harper LD, Govus A et al. Practitioner perceptions of evidence-based practice in elite sport in the United States of America. *J Strength Cond Res* 2019;33(11): 2897-2904. doi:10.1519/JSC.0000000000003348.
15. Schwarz E, Harper LD, Duffield R et al. Practitioner, coach, and athlete perceptions of evidence-based practice in professional sport in Australia. *Int J Sports Physiol Perform* 2021;16(12):1728-1735. doi:10.1123/ijspp.2020-0835.
16. Eysenbach G. Improving the quality of web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). *J Med Internet Res* 2004;6(3):e34. doi:10.2196/jmir.6.3.e34.
17. Lavrakas P. Cross-sectional survey design, *Encyclopedia of Survey Research Methods*, Sage Publications, Inc., 2008. doi:10.4135/9781412963947.n120.
18. R Core Team. R: a language and environment for statistical computing. https://www.R-project.org/ 2020.
19. Bryer J, Speerschneider K. likert: analysis and visualization Likert items. https://CRAN.R-project.org/package=likert 2016.
20. Kassambara A. rstatix: pipe-friendly framework for basic statistical tests. https://CRAN.R-project.org/package=rstatix 2023.
21. Gamer M, Lemon J, Fellows I et al. irr: various coefficients of interrater reliability and agreement. https://CRAN.R-project.org/package=irr 2019.
22. Brink MS, Kuyvenhoven JP, Toering T et al. What do football coaches want from sport science? *Kinesiology* 2018;50(1):150-154.
23. Atkinson G, Davison R, Jeukendrup A et al. Science and cycling: current knowledge and future directions for research. *J Sports Sci* 2003;21(9):767-787. doi:10.1080/0264041031000102097.
24. Callary B, Culver D, Werthner P et al. An overview of seven national high performance coach education programs. *Int Sport Coach J* 2014;1(3):152-164. doi:10.1123/iscj.2014-0094.
25. Nash C, Sproule J. Coaches perceptions of their coach education experiences. *Int J Sport Psychol* 2012;43(1):33-52.
26. Nelson LJ, Cushion CJ, Potrac P. Formal, nonformal and informal coach learning: a holistic conceptualisation. *Int J Sports Sci Coach* 2006;1(3):247-259. doi:10.1260/174795406778604627.
27. Slattery K, Crowcroft S, Coutts AJ. Innovating together: collaborating to impact performance. *Int J Sports Physiol Perform* 2021;16(10):1383-1384. doi:10.1123/ijspp.2021-0389.
28. Muir B, North J. Supporting coaches to learn through and from their everyday experiences: a 1:1 coach development workflow for performance sport. *Int Sport Coach J* 2023:1-10. doi:10.1123/iscj.2022-0101.
29. Coutts AJ. Working fast and working slow: the benefits of embedding research in high-performance sport. *Int J Sports Physiol Perform* 2016;11(1):1-2. doi:10.1123/IJSPP.2015-0781.