Psychology of Sport & Exercise 72 (2024) 102615

Contents lists available at ScienceDirect

Psychology of Sport & Exercise

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

Review

Skill acquisition interventions for the learning of sports-related skills: A scoping review of randomised controlled trials☆

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A R T I C L E I N F O

Keywords:
Motor learning
Skill learning
Sport

A B S T R A C T

Background: Skill acquisition science is the study of how motor skills are acquired, developed and/or learned. There is substantive evidence for general motor skill acquisition in controlled laboratory settings yet the literature on the learning of sports-related skills is typically less conclusive.

Objectives: This scoping review aimed to summarise the current literature on skill acquisition intervention studies examining the learning of sports-related skills as part of a randomised controlled trial, by synthesizing and extracting the most relevant features.

Methods: Four electronic databases (PsychINFO, PubMed, SPORTDiscus and Web of Science) were searched for relevant studies. The sample characteristics of these studies were extracted, and summarised. Two systematic searches of the literature were conducted. In the first search, eighty-six studies were retained. A second search was conducted in July 2022 to include new studies and specifically focused on the inclusion of within-subject design studies, resulting in the inclusion of 35 additional studies. A third search was conducted in May 2023 to include new studies resulting in the inclusion of 10 additional studies.

Results: One hundred and thirty studies across 29 sports were included in the review. The vast majority of the studies in this scoping review (n = 104) examined the learning of a sport-related skill in participants with no experience. Twenty-eight percent of all retained studies (n = 35) considered only the learning of a golf skill, and all studies were practiced in a laboratory environment, examining closed motor skills (n = 130). The most common intervention categories reported were attention (n = 22), instruction and demonstration (n = 20), practice design (n = 20), and perceptual training (n = 19). Nearly half of all studies used an immediate retention test within 48 h of the cessation of practice (n = 63), and just over one quarter of studies (n = 34) reported incorporating some form of transfer test. Eighty-six percent (n = 112) reported positive findings.

Conclusions: The skewed focus on golf skills across a small number of skill acquisition interventions, the inconsistent use and reporting of performance measures, practice durations and measures of learning alongside the relatively small sample sizes consisting mostly of inexperienced learners and the skewed publication of positive findings should warrant caution. More empirical studies across a broader range of sports and with more consistent methodologies are needed to develop a robust pool of literature that can support academics and practitioners interested in which skill acquisition interventions could be used to influence the learning of sports-related skills.

1. Introduction

Skill acquisition is a multi-disciplinary sub-discipline of sport and exercise science, encompassing and building on aspects of the scientific disciplines of motor behaviour, sport and exercise psychology, and neuroscience (Fransen et al). The term skill acquisition is often used in

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
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https://doi.org/10.1016/j.psychsport.2024.102615
Received 6 June 2023; Received in revised form 8 February 2024; Accepted 20 February 2024
Available online 23 February 2024

the sports literature to describe the science that underpins the learning and execution of sports skills, yet it is more commonly known as motor skill learning. Skill acquisition science describes how motor skills are acquired, developed and/or learned by participants with a variety of expertise levels (ranging from clinical populations to elite athletes) and contexts (e.g. the learning of everyday life skills or skills required for elite sporting performance). Ultimately, the aim of skill acquisition science is to provide scientific support for the creation of optimal motor skill learning environments in contexts such as clinical settings, physical education and sport, among many others. Much of the existing knowledge about motor skill acquisition originates from motor learning studies that were conducted in samples recruited from the general population (Palmer & Meyer, 2000; Wulf et al., 2010; Ehsani et al., 2015, among others). However, more recently, skill acquisition researchers have increasingly taken an interest in motor skill learning in recreationally active or even high-level sporting populations (e.g. Tribolet et al., 2022; Verburgh et al., 2016; Krause et al., 2019; Beavan et al., 2020). Indeed, when asking sport coaches, practitioners and sport-embedded researchers about the areas of research that could directly benefit coaching practice, Fullagar, McCall, et al. (2019) found that a large proportion of respondents (84%) indicated “skill acquisition” to be an area of direct relevance to coaching. Skill acquisition specialists can use grounding skill acquisition principles to inform coaches of appropriate skill acquisition strategies, reinforcing their value in sport. Nonetheless, Steel et al. (2014) reported that skill acquisition specialists are commonly underused in sport and hypothesised this may be due to a lack of understanding of the added value of skill acquisition science on the part of ‘employers’ of skill acquisition specialists such as sporting organisations. The last years however have seen an increasing interest in the practical applications of sports skill acquisition science due to its increasing visibility thanks to popular publications such as “How we learn to move: a revolution in the way we coach and practice sports skills” (Gray, 2021), among others. Nonetheless, it remains unclear which skill acquisition principles can be used to learn sports skills. Hence, a review of the literature addressing skill acquisition interventions aimed at learning sports skills is timely and can support the booming interest in practical applications of sports skill acquisition science.

1.1. Motor learning research in different domains

Research from motor learning provides understanding of how individuals acquire and perform skills requiring the voluntary control of the head, limbs and/or torso. Motor learning research generally describes how performance and learning of motor skills is affected by different variables such as the way practice is scheduled or distributed, or how and when feedback is provided to the athlete, among many others (Czyż, 2021). Motor learning research has multiple aims: aside from answering fundamental questions about how individuals learn motor skills, it also aims to inform professional practice (e.g. how motor skills are learned in the context of sport or relearned in the context of injury rehabilitation) and to serve as the basis of pedagogies used in domains such as physical education, occupational therapy, sport and physical therapy (Muratori et al., 2013). For example, motor learning researchers in sport aim to optimise practice in order to achieve high levels of performance consistency and accuracy in athletic populations (Till et al., 2022). At the same time, skill acquisition researchers in rehabilitation use motor learning research to develop general guidelines on how to structure interventions to promote the re-learning of motor skills from an injury (Leech et al., 2022), while physical education teachers may base their curricula on studies that evaluate motor learning interventions in paediatric populations (Renshaw et al., 2010).

Despite the clear benefits of implementing motor learning research in professional practice, it remains unclear whether general learning models exist that can be applied to a variety of domains. For example, do general motor learning models exist that can be used to facilitate the learning of everyday skills such as playing the piano, while at the same time being beneficial for the relearning of skills in clinical populations such as learning to use a prosthetic arm or relearning grasping motions in individuals with temporary or permanent disablement? Ranganathan et al. (2022) argue that findings from motor learning conducted in specific contexts are not easily extrapolated, among many other reasons due to the diversity of disciplines to which they are applied but also due to the fact that there is a wide variety of possible outcomes associated with motor learning (e.g. learning can be inferred, among many others from changes in consistency, automaticity, stability, but also from changes in coordination dynamics, decision-making and the reorganisation of existing skills (Muratori et al., 2013). This exemplifies that in order for motor learning principles to be applied to sport, research findings from a wide variety of domains cannot readily be extrapolated to sport. As such, while broad principles of motor learning are often used and researched in a variety of fields such as rehabilitation and music, only specific studies aimed at the learning of sports-related skills in sporting populations can likely provide immediate applications for the acquisition of sports-related skills.

1.2. Skill acquisition in sports

Despite its recent increase in popularity (Fransen et al), the study of sport skill acquisition is still relatively new, especially when compared with the extensive research base on other (e.g. physiological or psychological) aspects of performance. Sport skill acquisition science borrows heavily from motor learning research, which has a strong tradition of laboratory-based studies dating back several decades. For a historical perspective on motor learning research, we direct the reader to Abernethy and Sparrow (1992) and Schmidt, Lee, Winstein, Wulf, & Zelaznik (2018). Many of the concepts examined and used by sport skill acquisition researchers and practitioners today such as practice distribution (e.g. the contextual interference effect; Shea & Morgan, 1979), learning paradigms (e.g implicit learning; Pew, 1974), and how and when feedback should be provided to optimise motor learning (for a review of augmented feedback in the context of motor learning consult Salmoni et al. (1984) find their origin in this vast repertoire of motor learning studies conducted in highly controlled laboratory settings. Yet, soon after these studies on motor learning interventions were published, Goode and Magill (1986, p. 308) already concluded that:

> “Speculations made as to the effect of various treatments on human learning are tested in a setting that is as realistic as possible. […] These results also present to the practitioner more translatable information than might be derived from laboratory data”.

This quote exemplifies that it is difficult to apply findings obtained from laboratory-based motor learning studies to the learning of sport skills in the field. For example, the findings by Pollatou et al. (1997) on the role played by contextual interference (i.e. the phenomenon in which the random scheduling of practice trials appears to be beneficial for motor learning) in the learning of a seated kicking and throwing skill offer insights into the mechanisms related to contextual interference but not into how the learning of football-specific kicking or handball-specific throwing skills can be optimised. In other words, existing knowledge from lab-based motor learning studies may not be transferable to the performance and learning of motor skills outside of this highly controlled setting. While the debate about the generalisability of findings from motor learning studies obtained in lab settings still exists today, technological advances have made it more straightforward for skill acquisition scientists to embed their work within sports practice (e.g. Kachel et al., 2015; Farrow & Buszard, 2017; Verhoeff et al., 2020, Teune et al., 2022a, Teune et al., 2022b, among others). As such, there is a need to summarise and synthesise the research literature available on sports skill acquisition, as well as a need to understand which studies may yield high levels of evidence in support of or against the use of specific skill acquisition principles for the learning of sports-related skills.

1.3. The need for evidence-based skill acquisition practice

Evidence-based practice refers to using the best available evidence (together with experience and patient/participant/learner values and preferences) for decision-making and providing efficient and effective interventions, rather than relying on tradition or past practice (Li et al., 2019). For example, evidence-based practice is crucial to the translation of research findings to practice in many health care disciplines, where it is used to optimise patient health outcomes. Similarly, evidence-based practice has permeated sport science. For example, the preparation of athletes to withstand the demands of competition through strength and conditioning training has benefited greatly from decades of research with high-performance populations (Fullagar, Harper, et al., 2019; Weldon, Duncan, Turner, Lockie, & Loturco, 2022).

Scientific evidence is also a prerequisite to making inferences about the effectiveness of certain practice designs. Yet, the extent of the literature that has empirically studied the use of skill acquisition interventions for the learning of sport specific skills is poorly described, which can in part explain the low uptake of skill acquisition specialists reported by Steel et al. (2014), despite the clear need for skill acquisition science to inform sports coaching (Fullagar, McCall et al., 2019). Several studies have synthesised the evidence for the use of specific interventions for motor learning (e.g. external focus of attention (Wulf, 2013), implicit learning (Kal et al., 2018), and contextual interference (Graser et al., 2019). This scoping review aims to fill a gap in the literature, as no study, to our knowledge, has yet provided a comprehensive summary and visualisation of the available literature on commonly used interventions for sports skill learning in a single review. By synthesizing and presenting this information, our review will provide valuable insights to practitioners seeking to understand the application of skill acquisition principles to sports skill learning. Furthermore, our review will be useful for researchers interested in identifying studies that can be meta-analysed to provide effect estimates. In addition to providing an overview of the available literature, this scoping review also aimed to summarise important characteristics of the retained research studies, including the specific sports and skills addressed, performance outcome and process measures used, and whether retention and/or transfer tests were employed. By synthesizing this information, we aim to provide a comprehensive summary of the available research on the effect of implementing skill acquisition interventions in the context of learning sport-related motor skills, which can be of interest to practitioners and researchers concerned with practice design in the context of sports.

2. Methods

2.1. Search strategies and databases

This scoping review approach and reporting were guided by the PRISMA-ScR checklist (Appendix 2 All extracted data can be found in this table https://osf.io/pjk5x/files/osfstorage/65dae53d0d9acb02d4c2e2fd) (Tricco et al., 2018). The following electronic databases were first searched on January 28, 2021: PsycINFO, PubMed, SPORTDiscus and Web of Science. The search query was based on the PICO (Population, Intervention, Comparison, Outcome) framework (Methley et al., 2014). The population of interest for this scoping review were healthy adult males and females of at least 18 years or older. The age group for this scoping review was chosen given that adult samples are less influenced by changes in skill performance and learning that may be associated by physical, neural or cognitive maturation. Given the aim of the review was to examine the literature on the effect of interventions aimed at the acquisition of sport-related motor skills (from here on referred to as *skill acquisition interventions*), this scoping review focused on randomised controlled trials (RCTs) using both between and within-subject designs. This review focussed because they are the optimal design (if well conducted) from which to estimate causal effects, reducing selection bias and confounding. The comparison component of the PICO referred to the inclusion of a control group in the study in which participants either engaged in physical practice without the intervention (active controls) or did not engage in any physical practice (passive controls). Allocation to control or intervention groups had to be randomised. Finally, the outcomes of interest were related to the learning of motor skills. It was decided to only retain studies in which a retention and/or transfer test was used to infer the learning of a sport-related motor skill. It should be noted however that other methods of inferring motor learning from practice exist such as inferring learning from practice observations, examining the efficiency of movements before and after practice, studying the attention demands of performance before and after practice, examining error patterns (i.e. error counts and consistency) during practice, etc. which were not examined in the context of this scoping review. Prior to developing the final search terms for this study, scoping searches were conducted on each database using variations of search terms and operators. For an example of the final search query used, consult Appendix 1 https://osf.io/pjk5x/files/osfstorage/65e0c3cd325de50410dd04a8.

No restrictions with regards to publication year, language or publication type were employed, to limit the introduction of systematic bias. The combined search results were first extracted and imported into Covidence (Covidence online systematic review platform, Veritas Health Innovation Ltd., Melbourne, Australia, www.covidence.org) for duplicate removal as well as for a first screening based on the sample used (search queries used returned many studies in clinical and underage samples). This was followed by a title and abstract, full-text screening and data extraction process, which all occurred in Covidence. The review was registered with the Centre for Open Science on January 28, 2021: (https://doi.org/10.17605/OSF.IO/PJK5X). The only deviation from the protocol registered with the Centre for Open Science and the current review is the aim of the review. Rather than focusing specifically on which skill acquisition interventions are effective, the current scoping review - given the breadth of the literature - examined which literature is available without a critical appraisal of the literature (i.e. a scoping review rather than a systematic review). It is commonplace to use scoping reviews when the aim is to provide an overview of the volume of literature on a broad topic before more specific questions can be posed and addressed by systematic reviews, such as which skill acquisition interventions are most effective for the learning of sports-related skills (Munn et al., 2018).

A second search was conducted using the initial search terms in all databases in July 2022 to further identify relevant studies which appeared since the first search in January 2021. This new search also specifically targeted randomized controlled trials with a within-subjects design which, after examining the retained literature after the first screening of 86 studies, may not have made it to the full text screening phase in the first search. To do so, the authors used the EndNote library before the abstract and title screening from the first search and searched for key words associated with crossover design studies (Mixture design, Cross over design, Cross-over design, repeated measures design, repeated-measures design, within group design, within-group design, factorial design, within-subjects design, within subjects design, Solomon design). The selection of within-subject design studies which seemingly met the inclusion and exclusion criteria was made by one author and checked by another. Following, abstracts and full texts were screened, and relevant papers were retained for extraction. A third and final search was conducted to update the search results in May 2023 using the initial search terms in all the databases to further identify relevant studies appeared since July 2022.

2.2. Study inclusion criteria

Only peer-reviewed sources were considered for the current scoping review. Studies included were i) published in English or could be translated into English, ii) unrestricted by publication year, iii) randomised controlled trials (i.e., control groups consisting of specific type of practice and cross over design, and iv) with a pre- and post-test. Studies were excluded if i) participants were younger than 18 years, ii) participants were sampled from a clinical population or unhealthy, iii) there was no inclusion of a retention and/or transfer test. As this was a scoping review aimed at summarising the available research, no risk of bias evaluation was performed (Lockwood & Tricco, 2020).

2.3. Screening process/study selection

There were two steps to the screening process. First, all studies were screened preliminarily against the population selection criteria given the large numbers of studies on clinical or paediatric populations. A total of 10,757 studies were excluded based on a title and abstract screening by a single author as they did not meet the population criteria (i.e. either clinical or <18 years old). This method of manual extraction was preferred over a restriction of the search terms in order to favour inclusivity over a potential systematic exclusion of some studies, given the wide scope of the current scoping review.

In a second step, the remaining records were uploaded to Covidence and screened by title and abstract against selection criteria. Titles and abstracts of articles were initially screened by two authors to ensure all studies matched inclusion and exclusion criteria. If the two authors did not agree on one article, the third author decided whether the study should be included. This process was replicated for full-text screening. The agreement between the two authors was Kappa = 0.90. A reason for exclusion was noted for each article removed during the full-text screening stage. When full text articles were not available in English, the authors translated the article to the English language using a text-translation application (Google Translate, https://translate.google.com). When the full text for an article could not be found through any means at the disposal of the authors of this review, the corresponding author of the article was contacted to obtain the full text. An overview of the evidence selection process is outlined in the PRISMA flow diagram (Figure 1).

2.4. Data extraction

To provide a summary of the research, all data pertaining to study details (title, author, published date, type of sport), population (sample size, gender, age, participant experience/expertise level), task (sport, skill), study aim, intervention (skill acquisition concept addressed, context, assessments, practice design, procedures and outcome

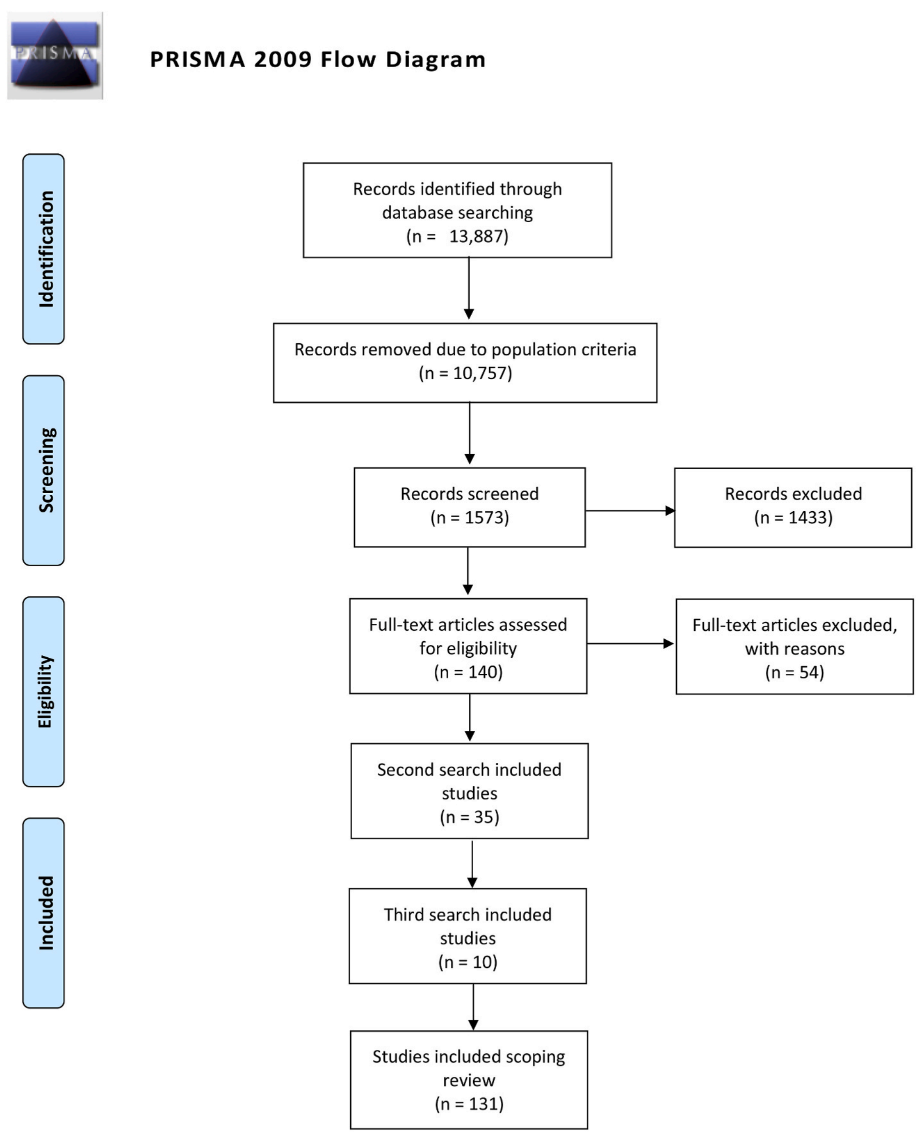

Figure 1. PRISMA flow diagram of the screening and selection process.

measures) and the study's general findings were extracted using Covidence into a customized Excel spreadsheet (https://osf.io/pjk5x/files/osfstorage/65e0e26e6d0cb813a11a937e). While some of the extracted information is logical, operational definitions were designed for others. These can be found here:

- **Aim of the study:** a paraphrasing of the aim of the study as reported by the authors
- **Assessment:** the number and nature (pre, post, retention and/or transfer test) of the assessment trials used
- **Environmental Context:** The environmental context and general task parameters in which the study was conducted.
- **Experience/expertise level:** inexperienced (no experience in the task at hand), recreationally experienced (non-competition experience with the task at hand) and experienced (competition experience with the task at hand such as varsity, national, elite and international athletes).
- **General findings:** general findings of the study paraphrased from the authors' description of the main finding(s)
- **Outcome measures:** the outcome/process measures used to infer changes in skill performance
- **Practice design:** the number of practice trials and the practice duration
- **Procedures:** a general overview of the study paraphrased from the authors' description
- **Skill:** the skill being learned by the participants
- **Sport:** the 'mother' sporting discipline, i.e. swimming when the task was 50m freestyle or skiing when the task was slalom ski

After initial data extraction, a random sample of studies was allocated to one other author to cross-check extracted data against the respective full-text article to ensure accuracy. The reference list for the included studies can be found here: https://osf.io/pjk5x/files/osfstorage/65e0e20e0d9acb096ac2e765).

3. Results

The database search identified an initial 13,887 studies and imported into an EndNote library. A total 10,757 studies from EndNote were manually removed because they clearly studied paediatric or clinical samples. After, 1573 titles and abstracts were screened for eligibility. Following the title and abstract screening process, a further 1433 studies were excluded for not meeting the inclusion criteria, leaving a total of 140 full-text studies to be assessed for eligibility. After full-text reading, 54 further studies were excluded as they had no retention and/or transfer test (n = 16), used a different study design (i.e. not a RCT, n = 17), examined a youth population (<18 years old, n = 7), studied a non-sporting population (i.e. military, air-force population, n = 3), studied a clinical population (n = 2), had no control group (n = 4), had no motor skill as an outcome measure (i.e. decision making performance, cognitive performance, perceptual performance only), n = 3), practice occurred between intervention and transfer test (n = 1), only had an abstract but no full text available (n = 3). In the case of not being able to access the full text of an article, the study's authors were contacted through email to provide the full text. A total of 86 studies were retained for data synthesis and analysis following the first search. A second database search was conducted between the date of the first search and July 2022 using the same search query yet with a specific focus on identifying within-subjects studies which may have been missed in the first search. After full text reading, a further 35 studies were included. A third database search was conducted between the date of the second search and May 2023 using the same search query. After full text reading, a further 10 additional studies were included.

3.1. Sample characteristics

All extracted data can be found in this table: https://osf.io/pjk5x/files/osfstorage/65e0e26e6d0cb813a11a937e

3.1.1. Sport

The 130 studies included in the review covered 29 sports (see Figure 2). One-hundred-and-twenty-seven studies examined a single sport such as golf (n = 35, 28%), basketball (n = 17, 13%), darts = (n = 10, 8%), baseball (n = 7, 6%), soccer (n = 6, 5%), gymnastics (n = 5, 4%), volleyball (n = 5, 4%), skiing (n = 5, 4%), table tennis (n = 4, 3%), shooting (n = 4, 3%), swimming (n = 3, 2%), badminton (n = 3, 2%), tennis (n = 3, 2%), cricket (n = 2, 2%), field hockey (n = 2, 2%), judo (n = 2, 2%), taekwondo (n = 2, 2%), Australian Football (n = 1, 1%), racquetball (n = 1, 1%), track and field (high jump) (n = 1, 1%), weightlifting (n = 1, 1%), snowboarding (n = 1, 1%), dance (n = 1, 1%), netball (n = 1, 1%), handball (n = 1, %), rugby (n = 1, 1%), karate (n = 1, %), speed skating (n = 1, 1%), and surfing (n = 1, 1 %). Three studies studied examined two sports in separate experiments: golf and basketball (n = 2) and golf and tennis (n = 1).

3.1.2. Representativeness

All the studies included (n = 130) used training conducted in relatively predictable, controllable and static settings, such as in a laboratory. All studies (n = 130) practiced closed skills in isolation rather than open skills as part of the training routine used. All skills observed in the studies were relevant to the sport to which the results of the study intended to generalise but were generally assessed in controlled environments. Four studies (n = 4) measured the learning of a sport-related skill in a dynamic environment in the context of a match or competition.

3.1.3. Publication year

Seventy-one percent (n = 92) of the studies in this review were published in the last decade between 2011 and 2022. Twenty-nine percent of studies (n = 38) were published prior to 2011.

3.1.4. Participants

The total sample size was 5680 participants, of which 2939 (52%) were male, and 1797 were female (32%). A total of 839 (16%) study participants had no reported sex. The median sample size was 47, with the smallest sample consisting of eight participants and the largest

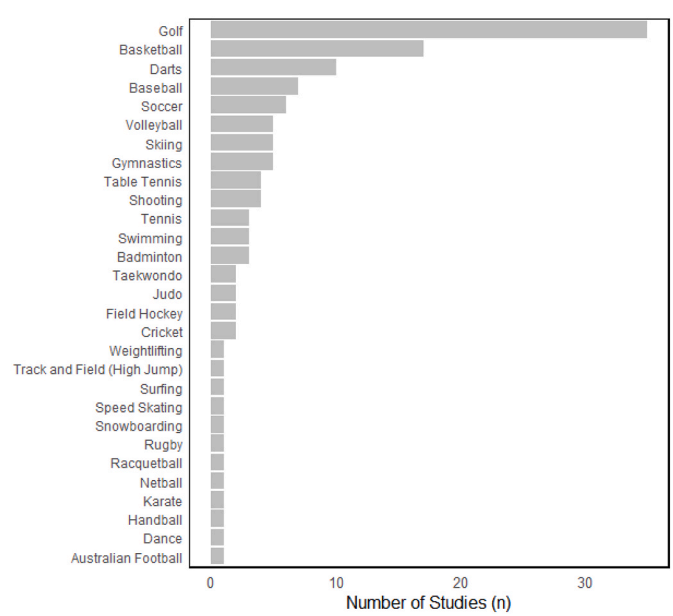

Figure 2. The relative frequency of studies per sport.

sample consisting of 249 participants. The median age of the samples across all included studies was 23 years old. The interquartile range was 4.1 years. Eighty percent (n = 104) of studies included inexperienced participants. Eighteen percent (n = 24) studied experienced participants and two percent (n = 2) studied recreationally active (intermediately experienced) participants. The experience status of participants was classified by the research team into three groups: experienced athletes (varsity/national/elite/international athletes competitive athletes), recreationally experienced (non-competition experience with the task at hand) and inexperienced athletes (no experience in the task at hand). For the purpose of the scoping review, we aligned experience and skill, where experienced participants are considered more skilled than recreational and inexperienced participants.

3.1.5. Skill acquisition interventions

While not an exhaustive list of all skill acquisition interventions, the studies in this scoping review were classified into one of the following categories based on the main intervention addressed: instruction and demonstration, attention, task difficulty, self-regulation and self-control, imagery and mental practice, practice design, augmented feedback, perceptual training and any other training interventions not previously addressed combined in one intervention type (see Table 1). It should be noted that this method can be subject to bias, as some studies address multiple interventions (in this case the main intervention relevant to the study aim was used) or the intervention they address is not easily delineated. The skill acquisition categorisations used in the study are based on the expertise of the authors in the area of motor learning and skill acquisition and represent commonly used interventions discussed in motor learning and skill acquisition literature (e.g. Hodges & Williams, 2012; Magill & Anderson, 2021). A list of examples of sub-topics classified under each skill acquisition intervention is also provided in Table 1. The most frequently used intervention category was attention (n = 22, 17%). Fifteen percent of studies used instruction and demonstration (n = 20), practice design (n = 20), or perceptual training (n = 19) interventions. Twelve percent of studies used self-regulation and self-control (n = 16) or augmented feedback (n = 15) interventions. Five percent of studies trained using imagery or mental practice (n = 7) and eight percent (n = 12) used other interventions such as goal setting, the use of enhanced expectancies, modifying equipment, self-talk, the learning of other sports skills, decision training, robot-guided practice and the application of multifactorial interventions like Optimising Performance Through Intrinsic Motivation and Attention for Learning (OPTIMAL) Theory which did not clearly adhere to the predetermined categories (Figure 3). A large majority of the studies (n = 113) also showed a positive effect of the intervention on motor skill acquisition. Skill acquisition intervention durations reported ranged from 1 day to 19 weeks. Fourty-six percent of studies (n = 61) used a one-day skill acquisition intervention duration.

Table 1
Short descriptions and examples of the skill acquisition interventions used in this study.

Skill acquisition intervention	Description	Examples
Attention	Interventions that focus on how directing attentional resources can impact skill acquisition.	The use of dual task paradigms or externalising attentional focus
Augmented feedback	Interventions aimed at providing feedback that supplements or replaces sensory feedback.	The use of video feedback or comparing augmented feedback timings.
Instruction/ demonstration	Interventions that use guidance or modelling of the skill to be learned.	The use of implicit learning paradigms or the use of a demonstration.
Practice design	Interventions that focus on the practice structure	The use of task difficulty manipulations and practice variability.
Perceptual training	Interventions using training that affects sensory systems.	The use of quiet eye training or visual occlusion.
Self-regulation and self-control	Interventions aimed at allowing learners to regulate their own practice behaviours.	Interventions using self-controlled practice schedules.
Imagery and mental practice	Intervention where learners mentally rehearse or visualise the performance of a skill, even without physical practice.	The use of mental rehearsals or motor imagery interventions.
Other	All interventions that did not clearly adhere to the definitions of the interventions above.	The use of robot-guided practice or practicing with enhanced expectancies

3.1.6. Retention/transfer test

Forty-eight percent (n = 63) of studies used a retention test either 24 or 48 h following the cessation of practice. A further twenty-five percent (n = 32) had a retention test between 48 h to one week following the cessation of practice. Twenty percent (n = 26) of studies used a retention test that was completed one week following the cessation of practice and seven percent (n = 9) of retention tests were completed after an interval between four to seven weeks following the acquisition phase (see Figure 4). Twenty seven percent (n = 35) of studies used a transfer test. Seventeen percent (n = 22) used a transfer test within one week following the cessation of practice. Seven percent (n = 9) of transfer tests were completed after an interval between two to eight weeks following practice. One study used a transfer test that was completed a year later and one study adopted a transfer test completed five years later.

4. Discussion

The current scoping review aimed to illustrate, synthesise and discuss the current literature examining skill acquisition interventions used to facilitate the learning of sports-related skills in RCTs. In summary, this review revealed a skewed distribution among sports skills trained, with just over one quarter (28%) examining golf skills. All studies practiced closed skills in a predictable, non-dynamic environment despite making inferences about the learning of sports skills which are usually performed in more dynamic environments. There was limited diversity in terms of the skill level of the participants who were sampled for the included studies, with eighty percent of studies

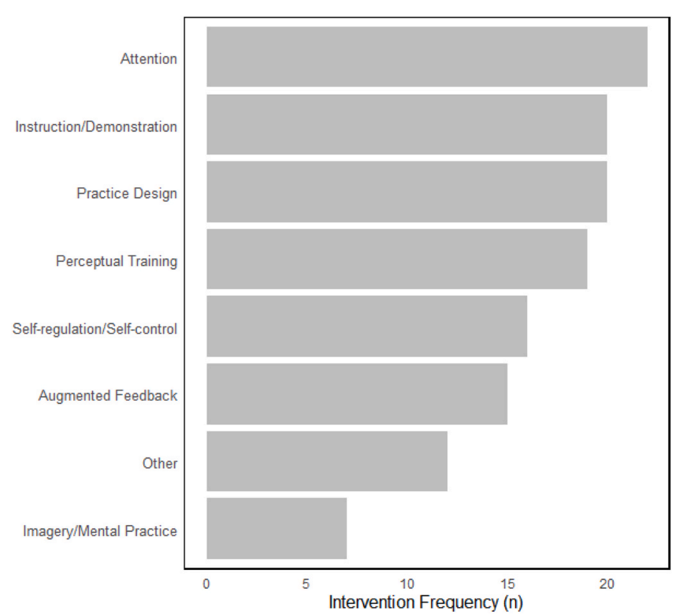

Figure 3. Relative frequencies of studies examining specific skill acquisition intervention types.

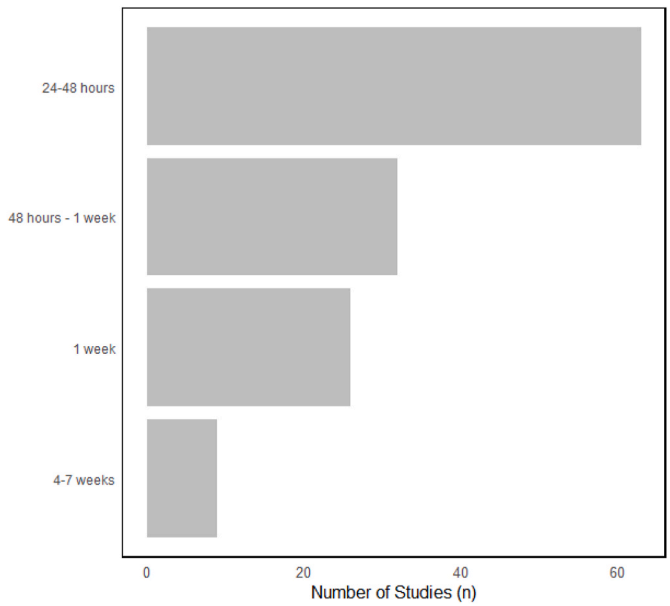

Figure 4. The number of studies (n) relative to the retention time interval between training cessation and testing.

sampling participants inexperienced in the task at hand and therefore potentially lacking application for athletes with any level of experience, including high-performance environments. The results of this scoping review also show that more than two thirds of all interventions used in the RCTs could be classified as attentional focus, instruction and demonstration, practice design and perceptual training interventions and that almost half of all interventions lasted no longer than a single day. Finally, this review reports that the literature on skill acquisition interventions for the learning of sports skills has inconsistencies in the use of tests from which learning can be assessed (i.e. inconsistent use of retention intervals, inconsistent and infrequent use of transfer tests, and inconsistencies in the exposure to practice), which brings into question the extent to which research using skill acquisition interventions to learn sports-related skills can actually be generalised to learning in a sports setting.

4.1. Sample characteristics

The majority of studies have studied adults who did not have experience in the skill at hand. While the notion of examining skill learning in inexperienced participants is sensical given the nature of the skill learning process (i.e., early improvements in practice performance may be more substantial than later on [e.g., Lee & Swinnen, 1993 for an overview], it may limit the usefulness of findings for experienced learners. On the premise that more cognitive resources are used (e.g., Fitts' and Posner's stage model), the same practice may be more demanding and perhaps yield different learning outcomes for beginners than for experienced participants (Guadagnoli & Lee, 2004). Therefore, it is difficult to determine that learning outcomes would occur for experienced participants by inferring from studies using less experienced participants. This lack of generalisability of the findings of RCTs in skill acquisition research to the learning of sports skills in high performance settings can present a significant obstacle for the uptake of skill acquisition research in high-performance sport, which remains underrepresented in the skill acquisition literature. Hence, skill acquisition researchers should consider studies with highly experienced participants taking into account that conducting high-quality randomised control trials in true high-performance athletes may be complcated given the difficulties to randomise participants into a group that does or does not receive an intervention. Additionally, there is a lack of incentives for high-performance athletes or organisations to participate in such studies and it may interfere with their typical training preparations (Coutts, 2017). Practitioners might therefore feel that existing research examining mostly inexperienced learners may be unrepresentative or difficult to replicate in an applied context, further limiting the uptake of findings from skill acquisition research in sports practice.

4.2. Sports, skills & environment

Twenty-eight percent of studies included in this scoping review examined golf-related skills such as the golf putt or golf swing. This may be due to the relative ease of observation of closed skills typical to golf play, as well as due to the fact that the short duration of the activity and the limited susceptibility of participants engaging in golf skills to experience high levels of activity-related fatigue mean that a high volume of skill repetitions can be performed in a short period of time. Additionally, both the outcome and process measures are relatively straightforward to measure (e.g., outcomes: percentage of balls that went in, distance of the ball from the hole, or distance of a drive; processes: biomechanical analysis of the swing for a stationary athlete via motion capture). Despite the fact that many of the sports included in the review also require the performance of open skills, many of the skills used in the studies are closed versions of those open skills (e.g. batting without catchers, or with a pitching machine) or are closed skills in an open skill sport (e.g. free throws in basketball without any opposition). As it stands, the current literature on skill acquisition interventions applied to sport may be largely informed by RCTs examining golf, yet golf skills are classified to have vastly different demands on the motor control system compared to many other sports skills (Evans & Tuttle, 2015). Golf skills are considered to be relatively closed skills as their performance is not vastly influenced by fluctuations in the performance context. In contrast, open skills like passing a football to another player during a game of soccer or rugby are influenced by the performance context, where the pass length, direction and spin needs to be adjusted to the movements of teammates and opposition players. However, open skills are vastly more difficult to control in an intervention study, and hence are often not considered. The over-reliance on closed motor skills may limit the translation of findings the existing body of literature to the learning of sports skills in general. As such, it can be concluded from this scoping review that more RCTs are needed to support the (in)effectiveness of skill acquisition interventions for the learning of open sport-related skills.

Overall, there was a lack of variety of skills performed, interventions used and a lack of a representative environment across all sports. Many of the skills performed in the studies included in this scoping review were conducted in isolation, meaning they were performed in environments that are not representative to those to which the performance of these skills would ideally be transferred. Representative learning design argues that practice contexts should closely replicate performance contexts to maximise the transferability of the learned skills by sampling constraints in practice from actual competition environment and by recreating the spatial and temporal coupling of information and movement (Pinder et al., 2011). The lack of representative design is likely due to the difficulty measuring sports skills in an unpredictable and dynamic setting (McCalman et. al, 2022). For example, in a highly dynamic team sport, an athlete may be required to make multiple decisions and perform multiple motor skills in sequence, each affected by their own preceding actions as well as the movements and actions of their team-mates and opponents (Otte et al., 2019). This relative lack of practice and assessment tasks that accurately represent the demands of the sport used in the existing literature may again limit the implementation of findings from these RCTs used in contemporary skill acquisition literature to the learning of sports-related skills in practice. Hence, in order to improve the uptake of research literature in practice, representative learning design should be readily integrated in the procedure of the studies where the acquisition phase should simulate the environment and the demands of competition (Krause et al., 2019). For now, it is unlikely the existing body of literature would be able to support evidence-based skill acquisition practices across a range of sports.

4.3. Skill acquisition interventions

A large proportion of the RCTs in the sports skill acquisition literature used interventions aimed at attention, instruction and demonstration, practice design and perceptual training in more or less equal shares of 62% of the total interventions. However, there is significant variation in the procedures used in studies using the same skill acquisition intervention. For example, in the studies using perceptual training as an intervention, seven out of 19 studies (37%) examined quiet eye training, while six studies (32%) examined sensory feedback training such as vision training, video based training or VR and six studies (32%) examined some type of training aimed at altering visual selecting attention which was not quiet eye training (changing gaze direction, occlusion paradigms or the use of visual cues). Additionally, five of these studies (32%) examined basketball and five (32%) used a golf skill. The remaining 36% was divided between cricket, darts, karate, rugby, shooting, soccer and volleyball. Finally, the acquisition phases in these studies had a median acquisition time of 10.5 days but a range between 1 and 91 days. This shows there is significant heterogeneity in study procedures (e.g. methods of testing, acquisition duration, sport observed, sample characteristics, etc.) complicate the drawing of collective inferences from these studies. Additionally, almost half of all studies in this scoping review did not use an acquisition period longer than one day, with anywhere between five and 360 practice trials during that day. While short acquisition periods of a single day drastically improve the feasibility of skill acquisition research, it is highly unlikely that engaging in a single day of learning, whether through only five learning trials or through 360, leads to robust motor skill learning. Skill acquisition researchers and practitioners should take into account the very short duration interventions in almost half of the published RCTs using skill acquisition interventions, before making inferences about the learning of sports skills outside of research settings. Finally, an overwhelming majority of studies reported that the skill acquisition intervention used was beneficial for the learning of the sports skill at hand. While a formal investigation of potential publication bias, or the consideration of pooled effects was not in the scope of this study, researchers and practitioners using this review should consider that non-significant findings may not have been published (e.g. the file-drawer phenomenon) and hence the findings the studies represented in this review should be considered in that light.

4.4. The use of retention test and transfer tests

This study also identified a large diversity in the characteristics of the RCTs included in this review such as inconsistencies in the retention period duration, the limited use of transfer tests and limited use of transfer tests in desirable situations, such as competition. Of the 130 studies examined, only two (Memmert, 2006; Gray, 2017) assessed the influence of a learning intervention of a sports-related skills over a period longer than one year. These studies reported conducting a transfer test one year later and five years later, respectively. While a greater time between engaging in a practice intervention and a measure of learner does not equate a more relevant measure of learning (e.g. long periods of retention or transfer may be confounded by uncontrollable factors affecting that time period such as specific training, injuries, etc.), there is a need for studies that examine both the short and the long term acquisition of sports skills following a period of practice, and the latent transferability of these skills. Most studies examined in this scoping review used a retention test conducted twenty-four or 48 h following the cessation of practice. While including a retention test is important to examine the persistence of learned behaviour, a twenty-four or 48-h retention test can be a limiting time frame to assess whether a skill has truly been learned. Behaviour change can take more than 48 h to occur and could take months before resulting in a learning effect depending on the nature of practice and skill (Schendel & Sheilds, 1978). Therefore, an important point to consider is the various duration times between acquisition phase and retention test in this scoping review and whether this would affect the magnitude of learning reported in these studies.

It has been suggested that, particularly within applied settings such as sport, transfer tests should take precedence over results from retention tests, as they may provide a more representative measure of learning (Pinder, et al., 2011; Farrow & Buszard, 2017; Porter et al, 2019). The mere inclusion of a retention tests can be an unreliable index of whether relatively long-term changes that constitute learning have taken place (Soderstrom & Bjork, 2015). A retention test does not allow researchers to assess whether a learning intervention of a sport-specific skill can be adapted to situations that differ from those in which the skill was practiced. Despite the relevance of transfers in examining the learning of sport skills, only about one quarter of studies in this scoping review used a transfer test. Retention tests were used more frequently to examine learning, yet the retention intervals they used (the time interval between training cessation and testing, without additional training) varied widely between 24 h and seven weeks. The aim of a retention test is to examine the degree to which the learned skill was retained after a period of no practice, and hence the heterogeneous retention intervals observed in this scoping review do not allow direct comparison of studies, even those using the same skill acquisition intervention in the similar sport skill, with one another. Furthermore, while the ideal retention length is debatable (and undoubtedly dependent on the intervention type, intervention length and skill at hand (Schendel & Sheilds, 1978), it is understood that retention of a skill decreases with increases in the retention interval and therefore inconsistencies in retention test intervals may present a barrier to translating findings from motor learning experiments to real-world learning. It is recommended that future research considers the use of a more consistent retention interval time frame to facilitate between-study comparison.

5. Limitations

The focus of this review was on a specific subset of (arbitrarily chosen) skill acquisition interventions. Despite capturing the large majority of popular skill acquisition principles, there are more types of skill acquisition categories which were not considered, or which would not traditionally be considered skill acquisition interventions. For example, other skill acquisition categories which may be included in subsequent reviews of the literature include studies using non-linear pedagogy interventions such as those described in the constraints-led pedagogies, the manipulation of training implements or equipment or self-discovery. Additionally, this review only focused on crossover and parallel group RCTs. While including only RCTs omits other, often very relevant, research designs used to study motor skill interventions, the inclusion of other study designs (observational) increases the risk that other factors than the intervention may also account for at least part of the observed changes. It should be acknowledged that a variety of factors may contribute to the fact that a study was not an RCT such as financial limitations or “inflexibility” of training programs, especially for high performing athletes. Uncontrolled or non-randomised study designs are often less expensive and more feasible to conduct than RCTs. Nevertheless, to determine the efficacy or effectiveness of interventions, RCTs, if available, are the optimal choice as they allow for a reduction of confounding, collider and selection bias (at least at baseline) by design. Additionally, it may be that other ‘lower level’ evidence from well-conducted case-control studies for example, adds more to the existing evidence base on the acquisition of sports skills. However, these study designs were not considered in the current scoping review. Therefore, we invite other researchers to expand on this review by examining specific skill acquisition interventions which may have been omitted from our categorisation or which use other designs than randomised controlled trials. Finally, scoping studies are not designed to assess the quality of research designs or determine the weight of evidence provided by the studies (Arksey & O'Malley, 2005). We merely present insight into the extent of the research activity, major conclusions and potential research gaps.

6. Conclusion

While the effectiveness of skill acquisition interventions was not the focus of this review, the diversity in sample characteristics, skills observed, research methods and training paradigms in the available literature on RCTs applied to the learning of sports-related skills likely challenges the skill acquisition specialists and coaches to develop and implement evidence-based training programmes using the available research literature. Therefore, we conclude that, regardless of the quality of the studies involved in this scoping review, there is currently not enough research available across different sports and different skill acquisition intervention types to draw definitive inferences on whether skill acquisition interventions could be effective for the learning of specific sports-related skills, especially in non-novice learners. We encourage skill acquisition scientists to join forces to continue empirically studying the effects of common skill acquisition interventions on sport skill learning using rigorous study designs across a range of sports, sport skills and participant experience levels. Additionally, this review stimulates researchers to also publish negative findings, for example by exploring pre-registration of their trial protocols or using registered reports.

CRediT authorship contribution statement

Leanne Choo: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Andrew Novak:** Investigation, Supervision, Visualization, Writing – review & editing. **Franco M. Impellizzeri:** Conceptualization, Data curation, Methodology, Supervision, Validation, Writing – review & editing. **Courtney Porter:** Data curation, Formal analysis, Validation, Writing – review & editing. **Job Fransen:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

A link to the full extraction table will be shared. For now the table is added as a supplementary file for the purpose of facilitating the review process

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2024.102615.

References

Abernethy, B., & Sparrow, W. A. (1992). The rise and fall of dominant paradigms in motor behaviour research. In *In Summers J. J. (Ed.), Approaches to the study of motor control and learning* (pp. 3–45). North-Holland.
Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19–32. https://doi.org/10.1080/1364557032000119616
Beavan, A., Spielmann, J., Mayer, J., Skorski, S., Meyer, T., & Fransen, J. (2020). The rise and fall of executive functions in high-level football players. *Psychology of Sport and Exercise, 49*, Article 101677.
Coutts, A. J. (2017). Challenges in developing evidence-based practice in high-performance sport. *International Journal of Sports Physiology and Performance, 12*(6), 717–718. https://doi.org/10.1123/IJSPP.2017-0455
Czyż, S. H. (2021). Variability of practice, information processing, and decision making-how much do we know? *Frontiers in Psychology, 12*, Article 639131. https://doi.org/10.3389/fpsyg.2021.639131
Ehsani, F., Abdollahi, I., Mohseni Bandpei, M. A., Zahiri, N., & Jaberzadeh, S. (2015). Motor learning and movement performance: Older versus younger adults. *Basic and Clinical Neuroscience, 6*(4), 231–238.
Evans, K., & Tuttle, N. (2015). Improving performance in golf: Current research and implications from a clinical perspective. *Brazilian Journal of Physical Therapy, 19*(5), 381–389. https://doi.org/10.1590/bjpt-rbf.2014.0122
Farrow, D., & Buszard, T. (2017). Exploring the applicability of the contextual interference effect in sports practice. *Progress in Brain Research, 234*, 69–83. https://doi.org/10.1016/bs.pbr.2017.07.002
Fransen, J., Pepping, G. J., & MacMahon, C. Introductory statement for the Journal of Sport and Exercise Science special issue: Skill acquisition–research and practice. Journal of Sport and Exercise Science, 5(1), 1-2.
Fullagar, H. H., Harper, L. D., Govus, A., McCunn, R., Eisenmann, J., & McCall, A. (2019b). Practitioner perceptions of evidence-based practice in elite sport in the United States of America. *The Journal of Strength & Conditioning Research, 33*(11), 2897–2904. https://doi.org/10.1519/JSC.0000000000003348
Fullagar, H. H. K., McCall, A., Impellizzeri, F. M., Favero, T., & Coutts, A. J. (2019a). The translation of sport science research to the field: A current opinion and overview on the perceptions of practitioners, researchers and coaches. *Sports Medicine, 49*(12), 1817–1824. https://doi.org/10.1007/s40279-019-01139-0
Goode, S., & Magill, R. A. (1986). Contextual interference effects in learning three badminton serves. *Research Quarterly for Exercise & Sport, 57*(4), 308–314. https://doi.org/10.1080/02701367.1986.10608091
Graser, J. V., Bastiaenen, C. H. G., & van Hedel, H. J. A. (2019). The role of the practice order: A systematic review about contextual interference in children. *PLoS One, 14*(1), Article e0209979. https://doi.org/10.1371/journal.pone.0209979
Gray, R. (2017). Transfer of training from virtual to real baseball batting. *Frontiers in Psychology, 8*, 2183. https://doi.org/10.3389/fpsyg.2017.02183
Gray, R. (2021). *How we learn to move: A revolution in the way we coach and practice sports skills*. Independently published.
Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behavior, 36*(2), 212–224. https://doi.org/10.3200/JMBR.36.2.212-224
Hodges, N. J., & Williams, A. M. (Eds.). (2012). *Skill acquisition in sport: Research, theory and practice*.
Kachel, K., Buszard, T., & Reid, M. (2015). The effect of ball compression on the match-play characteristics of elite junior tennis players. *Journal of Sports Sciences, 33*(3), 320–326. https://doi.org/10.1080/02640414.2014.942683
Kal, E., Prosée, R., Winters, M., & van der Kamp, J. (2018). Does implicit motor learning lead to greater automatization of motor skills compared to explicit motor learning? A systematic review. *PLoS One, 13*(9), Article e0203591. https://doi.org/10.1371/journal.pone.0203591
Krause, L., Farrow, D., Pinder, R., Buszard, T., Kovalchik, S., & Reid, M. (2019). Enhancing skill transfer in tennis using representative learning design. *Journal of Sports Sciences, 37*(22), 2560–2568. https://doi.org/10.1080/02640414.2019.164773
Lee, T. D., & Swinnen, S. P. (1993). Three legacies of Bryan and Harter: Automaticity, variability and change in skilled performance. In *In Advances in psychology, 102* pp. 295–315). North-Holland.
Leech, K. A., Roemmich, R. T., Gordon, J., Reisman, D. S., & Cherry-Allen, K. M. (2022). Updates in motor learning: Implications for physical therapist practice and education. *Physical Therapy, 102*(1), pzab250. https://doi.org/10.1093/ptj/pzab250
Li, S., Cao, M., & Zhu, X. (2019). Evidence-based practice: Knowledge, attitudes, implementation, facilitators, and barriers among community nurses-systematic review. *Medicine, 98*(39), Article e17209. https://doi.org/10.1097/MD.0000000000017209
Lockwood, C., & Tricco, A. C. (2020). Preparing scoping reviews for publication using methodological guides and reporting standards. *Nursing and Health Sciences, 22*(1), 1–4. https://doi.org/10.1111/nhs.12673
Magill, R., & Anderson, D. I. (2021). *Motor learning and control* (12th ed.). New York: McGraw-Hill Publishing.
McCalman, W., Crowley-McHattan, Z. J., Fransen, J., & Bennett, K. J. M. (2022). Skill assessments in youth soccer: A scoping review. *Journal of Sports Sciences, 40*(6), 667–695. https://doi.org/10.1080/02640414.2021.2013617
Memmert, D. (2006). Long-term effects of type of practice on the learning and transfer of a complex motor skill. *Perceptual and Motor Skills, 103*(3), 912–916. https://doi.org/10.2466/pms.103.3.912-916
Methley, A. M., Campbell, S., Chew-Graham, C., McNally, R., & Cheraghi-Sohi, S. (2014). PICO, PICOS and SPIDER: A comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. *BMC Health Services Research, 14*, 579. https://doi.org/10.1186/s12913-014-0579-0
Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*(1), 143. https://doi.org/10.1186/s12874-018-0611-x
Muratori, L. M., Lamberg, E. M., Quinn, L., & Duff, S. V. (2013). Applying principles of motor learning and control to upper extremity rehabilitation. *Journal of Hand*

Therapy: official journal of the American Society of Hand Therapists, 26(2), 94–103. https://doi.org/10.1016/j.jht.2012.12.007

Otte, F. W., Millar, S. K., & Klatt, S. (2019). Skill training periodization in "specialist" sports coaching-an introduction of the "PoST" framework for skill development. *Frontiers in Sports and Active Living, 1*, 61. https://doi.org/10.3389/fspor.2019.00061

Palmer, C., & Meyer, R. K. (2000). Conceptual and motor learning in music performance. *Psychological Science, 11*(1), 63–68. https://doi.org/10.1111/1467-9280.00216

Pew, R. W. (1974). Levels of analysis in motor control. *Brain Research, 71*(2–3), 393–400. https://doi.org/10.1016/0006-8993(74)90983-4

Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative learning design and functionality of research and practice in sport. *Journal of Sport & Exercise Psychology, 33*(1), 146–155. https://doi.org/10.1123/jsep.33.1.146

Pollatou, E., Kioumourtzoglou, E., Agelousis, N., & Mavromatis, G. (1997). Contextual interference effects in learning novel motor skills. *Perceptual and Motor Skills, 84*(2), 487–496. https://doi.org/10.2466/pms.1997.84.2.487

Porter, C., Greenwood, D., Panchuk, D., & Pepping, G.-J. (2019). Learner-adapted practice promotes skill transfer in unskilled adults learning the basketball set shot. *European Journal of Sport Science, 20*(1), 61–71.

Ranganathan, R., Lee, M. H., & Krishnan, C. (2022). Ten guidelines for designing motor learning studies. *Brazilian Journal of Motor Behavior, 16*(2), 112–133. https://doi.org/10.20338/bjmb.v16i2.283

Renshaw, I., Chow, J. Y., Davids, K., & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy, 15*(2), 117–137. https://doi.org/10.1080/17408980902791586

Salmoni, A. W., Schmidt, R. A., & Walter, C. B. (1984). Knowledge of results and motor learning: A review and critical reappraisal. *Psychological Bulletin, 95*(3), 355–386.

Schendel, J. D., & Sheilds, J. L. (1978). *Retention of motor skills: Review*. Research Institute for the Behavioral and Social Sciences.

Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G., & Zelaznik, H. N. (2018). Motor control and learning: A behavioral emphasis. *Human Kinetics, 6*, 3–21.

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning & Memory, 5*(2), 179.

Soderstrom, N. C., & Bjork, R. A. (2015). Learning versus performance: An integrative review. *Perspectives on Psychological Science: a journal of the Association for Psychological Science, 10*(2), 176–199. https://doi.org/10.1177/1745691615569000

Steel, K. A., Harris, B., Baxter, D., King, M., & Ellam, E. (2014). Coaches, athletes, skill acquisition specialists: A case of misrecognition. *International Journal of Sports Science & Coaching, 9*(2), 367–378. https://doi.org/10.1260/1747-9541.9.2.367

Teune, B., Woods, C., Sweeting, A., Inness, M., & Robertson, S. (2022a). Evaluating the influence of a constraint manipulation on technical, tactical and physical athlete behaviour. *PLoS One, 17*(12), Article e0278644. https://doi.org/10.1371/journal.pone.0278644

Teune, B., Woods, C., Sweeting, A., Inness, M., & Robertson, S. (2022b). The influence of individual, task and environmental constraint interaction on skilled behaviour in Australian Football training. *Journal of Sports Sciences, 40*(17), 1991–1999. https://doi.org/10.1080/02640414.2022.2124013

Till, K., Lloyd, R. S., McCormack, S., Williams, G., Baker, J., & Eisenmann, J. C. (2022). Optimising long-term athletic development: An investigation of practitioners' knowledge, adherence, practices and challenges. *PLoS One, 17*(1), Article e0262995. https://doi.org/10.1371/journal.pone.0262995

Tribolet, R., Sheehan, W. B., Novak, A. R., Watsford, M. L., & Fransen, J. (2022). How does practice change across the season? A descriptive study of the training structures and practice activities implemented by a professional Australian football team. *International Journal of Sports Science & Coaching, 17*(1), 63–72. https://doi.org/10.1177/1747954121101982

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169*(7), 467–473. https://doi.org/10.7326/M18-0850.

Verburgh, L., Scherder, E. J., van Lange, P. A., & Oosterlaan, J. (2016). The key to success in elite athletes? Explicit and implicit motor learning in youth elite and non-elite soccer players. *Journal of Sports Sciences, 34*(18), 1782–1790. https://doi.org/10.1080/02640414.2015.1137344

Verhoeff, W. J., Millar, S. K., Oldham, A. R., & Cronin, J. (2020). Coaching the power clean: A constraints-led approach. *Strength and Conditioning Journal, 42*(2), 16–25.

Weldon, A., Duncan, M. J., Turner, A., Lockie, R. G., & Loturco, I. (2022). Practices of strength and conditioning coaches in professional sports: A systematic review. *Biology of Sport, 39*(3), 715–726. https://doi.org/10.5114/biolsport.2022.107480

Wulf, G. (2013). Attentional focus and motor learning: A review of 15 years. *International Review of Sport and Exercise Psychology, 6*(1), 77–104.

Wulf, G., Chiviacowsky, S., Schiller, E., & Avila, L. T. (2010). Frequent external-focus feedback enhances motor learning. *Frontiers in Psychology, 1*, 190. https://doi.org/10.3389/fpsyg.2010.00190