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The use of physically constraining tools for grip-specific skill development in racket, stick and club sports: A scoping review

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ABSTRACT

Coaches use physically constraining tools to supplement their coaching when developing sport-specific skills, however, their effectiveness is unknown. This scoping review aimed to understand the efficacy of physically constraining tools used in racket, stick, and club sports for grip-specific skill development. This scoping review followed the Joanna Briggs Institute methodology and PRISMA guidelines. Peer-reviewed research, including quasi-experimental, true-experimental, case studies, and grey literature were considered. Peer-reviewed sources were searched on Web of Science, Medline, and SPORTDiscus until October 6th, 2022. Exclusion criteria were (1) not original peer-reviewed research; (2) disabled participants or used for rehabilitation; or (3) not available in English. Data extracted were the type of tool, research foci, measures, and outcomes of the tool's efficacy. Zero peer-reviewed sources were identified on the efficacy of using physically constraining tools for grip-specific skill development. Common trends identified from the excluded sources were explored to provide a basis for the importance of using physically constraining tools for grip-specific skill development. Many tools are used in coaching despite their unclear efficacy, however, the current results can guide future work to assess the acute and longitudinal effects of using these tools, specifically within the development and performance of sport-specific skills.

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Training device; skill; biomechanics; coaching; technique

1 Introduction

The sports-performance environment is dynamic and unpredictable, which requires individuals to be adaptable under multiple scenarios (Araújo et al., 2013). To equip athletes to perform well in these dynamic environments, coaches use multiple training methods to develop coordinated and adaptable sport-specific skills (Araújo et al., 2006; Hodges & Williams, 2012). Traditionally, coaches use techniques such as feedback, manipulation of practice design, and scheduling to develop skills (Fery & Morizot, 2000; Merbah & Meulemans, 2011; Nicholls & Polman, 2005; Reid et al., 2010). The timing, frequency, and accuracy of feedback are crucial as providing excessive and incorrect feedback can be detrimental to the athlete's skill development (Wulf & Shea, 2004).

During training, coaches often use specialised equipment to supplement the learning process. These specialised tools can take many forms, including newer technologies such as virtual reality devices (Miles et al., 2017), as well as more traditional items that allow for physical guidance, leading to a desired movement pattern. These devices physically constrain and/or guide an athlete's movement with the intent to facilitate skill development. For example, physically-constraining tools (PCTs) are popular in golf, in particular the Explanar® Golf Training System, which has been endorsed by professional athletes and coaches despite any empirical evidence of their efficacy for skill development (Glazier, 2010). A PCT allows athletes to actively engage with the device, where they can be in primary control of their movement (e.g., timing and swing velocity) with support in the form of physical guidance towards a movement pattern. There are three general classifications of PCTs which; 1) can be attached to the user's equipment and themselves simultaneously (e.g., Roberts, 1980), which is an angular positioning enforcing tool), 2) are an apparatus that guides movement (e.g., Zimmerman et al., 2016), which is a large user-containing apparatus that has a pre-determined swing path for golf clubs, and; 3) a specialised tool (external to the user's equipment that constrains movement, e.g., Baker, 2007), which is a grip mould that constrains finger positions for the tennis serve. Using a PCT for training and acute performance has been researched to some extent in golf where using a PCT in an acute setting reported to result in improved shot accuracy and altered club kinematics (Bertram et al., 2007; Skrinar & Hoffman, 1978; Yost et al., 1976). Physically constraining tools used in a passive sense (where the learner is not in primary control of movement) has been well-researched and implemented in robotics, also known as Physical or Robotic guidance (Bested et al., 2019; Kümmel et al., 2014), however, this is not desirable within sports settings as individuals are ultimately required to

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perform actions without forms of movement constraints. Using a PCT may allow learners the opportunity to explore movement solutions with the device through tactile information and generated intrinsic/kinaesthetic feedback mechanisms to develop perceptual-motor abilities which is an important characteristic for sports performance.

Anecdotally, coaches use PCTs with a range of athletes (novice to elite) to aid skill development either during the early foundational learning or when "fine-tuning" their technique in their selected sport. Many devices have been designed to supplement coaching (Bertram et al., 2007; Skrinar & Hoffman, 1978; Yost et al., 1976), with inventors/developers claiming that their product improves an athlete's development and execution of sport-specific skills. Physically constraining tools within racket, stick and club sports are commonly designed for the development and persistence of using specific grip positions for separate sport-specific tasks (Gripfixer, 2023; Sklz, 2023). Sports such as tennis, hockey, and golf have many specific shot techniques that are situation-dependent. Some general shots include (but are not limited to) the forehand, backhand and serve in tennis (Elliott, 2006); the hit and drag-flick in field hockey (Ng et al., 2018); and the drive, chip, and putt in golf (Cole & Grimshaw, 2016). The grip position "style", the way in which an individual's hand is orientated around handle (referred to as "grip style" throughout) is a vital technical component that can affect shot biomechanics. Grip styles have been shown to affect shot performance (accuracy, ball landing coordinates and ball speed), upper limb, and racket/club kinematics in tennis and golf (Busuttil et al., 2020, 2022; Carson et al., 2019). Specific grip styles in tennis and golf have continually evolved such that certain grip positions may be beneficial to either reduce injury risk or enhance shot performance (Busuttil et al., 2020, 2022; Carson et al., 2019; Reid et al., 2013; Stuelcken et al., 2017; Tagliafico et al., 2009). Grip positions have a fundamental role in sports performance for racket, stick and club sports, importantly contributing to the effective performance of gross motor tasks (Araújo et al., 2013; Busuttil et al., 2020, 2022; Carson et al., 2019; Cole & Grimshaw, 2016; Elliott, 2006; Ng et al., 2018; Reid et al., 2013; Stuelcken et al., 2017; Tagliafico et al., 2009), however, to the knowledge of the authors the efficacy of using PCTs in developing grip-specific skills is unknown.

A preliminary search for existing scoping and systematic reviews that incorporated the use of PCTs for sport- and grip-specific skill development was completed on two online data review data bases, JBI Evidence Synthesis and Cochrane Database of Systematic Reviews. No publication or protocol was found that had reviewed the efficacy of PCTs for grip positions in a sport-specific domain. Therefore, the aim of this scoping review was to map the existing literature relating to the efficacy of PCTs in developing grip-specific skills in racket, stick, and club sports. This scoping review was guided by the following research questions:

- What types of PCTs have been investigated to develop sport-specific skills in racket, stick, and club sports?
- What protocols/methodologies are used when investigating the efficacy of PCTs for grip positions?
- How effective are PCTs for sport-specific skill development?

2 Methods

The methodology for scoping reviews was followed as outlined by the Joanna Briggs Institute and PRISMA guidelines for scoping reviews (Peters et al., 2015). The objectives, inclusion criteria, and methods of this scoping review were completed according to a previously published protocol (Busuttil et al., 2021).

2.1 Eligibility criteria

2.1.1 Participants

The scoping review considered sources that assessed participants from novice to professional level where PCTs were used to develop sport-specific grip style skills in racket, stick, and club sports.

2.1.2 Concept and context

The concept and context examined by this scoping review were the various types of PCTs, their associated testing intervention, and outcomes that are used to develop grip positions in racket, stick, and club sports. Sports that do not require the athlete to grip the handle of an object were excluded.

2.1.3 Types of sources

The scoping review considered sources that assessed participants executing tasks in racket, stick, and club sports from a novice to professional level where PCTs were used to develop sport-specific grip style skills.

2.2 Search strategy

The search strategy for this scoping review followed the guidelines outlined in the original protocol (Busuttil et al., 2021) (Appendix I). In accordance with the Joanna Briggs Institute recommendations, the search was designed using the PCC framework (Population, Concept, and Context (Peters et al., 2015)) to which assisted in identifying the target population of racket, stick, and club sports that use different grip styles and for various sport-specific tasks. The scoping review search considered available sources until October 6th, 2022, with no earliest time frame set. A final search from October 7th, 2022, to December 20th, 2022, was completed and did not produce any additional relevant sources. Only sources published in English were included. The final literature search (Appendix II) was completed using Web of Science, Medline, and SPORTDiscus.

2.3 Inclusion criteria

The below inclusion criteria were followed during the screening process. The included sources were required to be: (1) published in English; (2) either a research article in peer-reviewed journals or grey literature (theses or conference abstracts); (3)

research associated with a racket, stick or club sport; (4) using a PCT; (5) research articles investigating the effects of PCTs for sport-specific skill development. Sources were excluded if they: (1) were not peer-reviewed research; (2) included participants with a disability; (3) involved physical or robotic guidance where movement was externally led by a human or robotic device, respectively; (4) used for rehabilitation in any context. Sources that included participants with a disability were excluded from the review as the severity of impairment can vary when performing in organised sport (Tweedy & Vanlandewijck, 2011).

2.4 Source of evidence screening and selection

All records first had their titles and abstracts screened by two reviewers (NB and MC) using Covidence (v2691, Veritas Health Innovation, Melbourne, Australia, Covidence.org). Any conflicts between reviewers were resolved by discussion and consensus. If a source was not resolved by NB and MC, then its inclusion/exclusion was determined by a third reviewer (AR). Only one article was required to involve AR, all remaining conflicts between reviewers NB and MC were resolved by discussion and consensus.

2.5 Data extraction

For the included peer-reviewed sources, data were extracted using the extraction tool (Appendix III). Information extracted included: author, concept, context, inclusion/exclusion criteria, source type, participant details, tool type, intended skill, type of analysis, outcome measures, the key findings and therefore outcomes of the paper.

2.6 Analysis and presentation of results

Information from sources was reviewed to form a basis for PCTs for grip-specific skill development and grouped in sporting codes where appropriate.

3 Results

3.1 Search results

The initial search identified 609 sources. After removing 154 duplicate documents, the title and abstracts of 455 sources were screened, with 454 excluded as they did not meet the inclusion criteria (Figure 1). One source met the inclusion criteria and underwent full-text screening. Through full-text screening, the singular source was removed because it was a review without relevant information for this scoping review's research questions (Reid et al., 2010). In total, zero sources met the inclusion criteria for the scoping review (Figure 1).

3.2 Confounding variables within screened sources

The sources screened within the title abstract stage resulted in counts of empirical and original research in relation to grip, however with no relation to the acquisition of grip positions

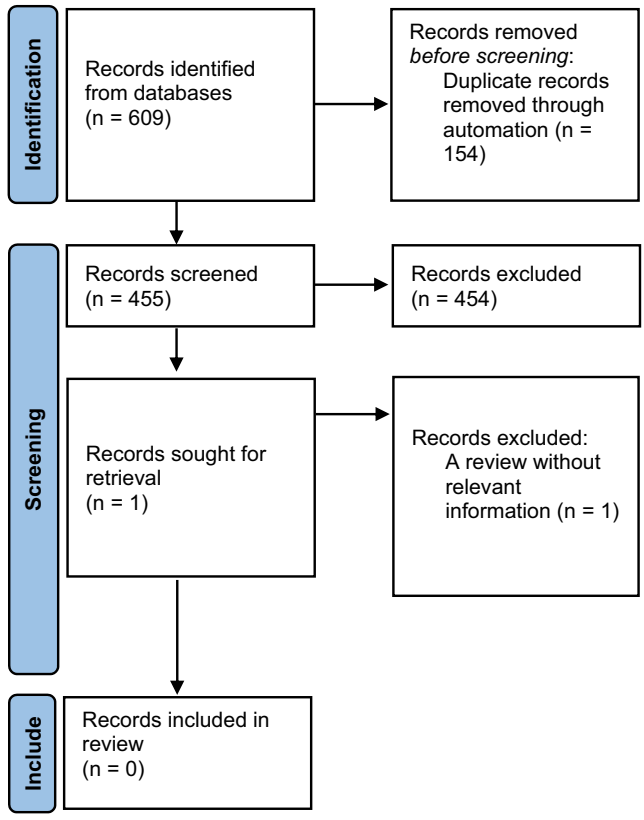

Figure 1. Flowchart of the systematic search and selection process for peer-reviewed sources.

using a PCT. Almost half of sources screened assessed the effect of strength training for grip strength (44%) (Stark et al., 2009; Strohmeyer, 1978), the use of smart technology to track motion and provide feedback on the specific grip positions during movement (<1%) (Badjate et al., 2021; Song et al., 2020), the effect of different grip positions on relevant biomechanics (1.3%) (D 'Arcy et al., 2021; Merbah & Meulemans, 2011), and the associated injuries in relation to grip positions (<1%) (Miles et al., 2017; Wulf & Shea, 2004). These studies, among others, did not empirically investigate the effects of a PCT on developing grip positions in racket, stick, or club sports.

3.3 Sources in relation to grip positions

Six articles across four sports were identified within the excluded sources that addressed the effect of grip style on shot performance. In one article, the differences between an Eastern forehand and Continental non-dominant hand grip style were assessed during a tennis cross-court topspin double-handed backhand (Busuttil et al., 2020). Another article reported on the differences between the Shakehand and Penhold grip style techniques during table tennis returns from topspin and backspin balls (Xia et al., 2020). Two articles reported on the differences between a Weak, Neutral and Strong grip style during golf drives (D 'Arcy et al., 2021; Nicholls & Polman, 2005). Lastly, two studies reported on the effect of different grip positions in relation to the number of fingers "gripping the bat" and position from the bottom of the

handle during baseball "soft toss" batting (Escamilla et al., 2009; Flynn et al., 2021) All associated articles in relation to grip positions reported that kinematics were altered for either the racket/stick/club and/or upper body during various phases of the swing.

3.4 Grey literature sources

Many of the screened sources were articles or sections found in sports-related magazines, which offered no empirical evidence-based information on grip positions and PCTs (Burns, 2007; Stetier, 2005; Stickney et al., 2008). These sources were mainly focused on golf development and performance, offering advice on utilising certain drills and devices to help improve holding grip positions and to develop an "ideal" technique for strokes. For example, one article encouraged the use of an elastic golf club (dynamic moment of inertia tool) to help develop swing kinematics (Liu et al., 2011). Previous research supports this notion within baseball as training with a dynamic moment of inertia tool has been shown to increase swing velocity, hitting distance and grip force during "soft-toss" batting (Liu et al., 2011).

4 Discussion

The purpose of this scoping review was to provide an overview of the existing literature related to PCTs to understand; 1) what type of PCTs are being used for grip-specific skill development; 2) the methodological approaches used for assessing grip-specific skill development using a PCT, and; 3) the efficacy of training with PCTs. A systematic search of Web of Science, Medline, and SPORTDiscus yielded 609 sources that, in general, addressed grip strength and related interventions for strength training or rehabilitation, grip style techniques and the effects on upper limb and racket/stick/club kinematics, and grey literature in relation to training tools. Despite these records, zero peer-reviewed sources with empirical evidence were identified in this scoping review that addressed PCTs for skill development. Based on the limited information, the efficacy of PCTs for grip-specific skill development is unknown.

4.1 Physically constraining tools and user implications

Devices that physically-constrain movement are commonly used by coaches to develop sport-specific skills. As mentioned, there are three general classifications of PCTs which; 1) can be attached to the user's equipment and themselves simultaneously (e.g Roberts, 1980), 2) are an apparatus that guides movement (e.g Zimmerman et al., 2016) and; 3) a specialised tool (external to the user's equipment) that constrains movement (e.g Baker, 2007). Predominantly explored in the golf domain, research has been completed on PCTs in relation to sport-specific tasks. PCTs categorised as an apparatus that guides an equipment's swing path have been reported to result in improved shot accuracy and altered club kinematics (Bertram et al., 2007; Skrinar & Hoffman, 1978; Yost et al., 1976). Also evident in tennis, training with a specialised robotic PCT in an augmented reality resulted in reduced movement errors when learning temporal attributes of the forehand (Marchal-Crespo et al., 2013). Although these articles provide some understanding of using PCTs for sport-specific skill development, the articles on golf drives show no account for training schedules and feedback, whereas, for tennis, it is only applicable within an acute performance setting and in virtual reality. Effective skill development can be perceived by coaches in many formats, hence the varied testing protocols and controls for using PCTs for sport-specific skill development (Cole & Grimshaw, 2016; Marchal-Crespo et al., 2013; Skrinar & Hoffman, 1978; Yost et al., 1976), however, PCTs may be a welcomed integration for refining and regaining skills. The skill refinement process, associated with the final stages of learning (skill fixation/diversification) and the "Awareness" stage of the Five-A Model, requires a learner to complete a skill under different task constraints and context-specific pressure to perform proficiently and consistently (Carson & Collins, 2011). Using a PCT may serve as a useful tool during this stage to provide the individuals with a temporarily constrained movement canvas, allowing them to realise the desired technique so that they then can replicate it without future guidance. In addition to relevant skill development practices, PCTs may be the necessary coach- and/or athlete-supporting tool to promote ideal techniques, simultaneously providing forms of feedback for effective task performance. Given the limited evidence on the efficacy of PCTs, the number of commercial devices and available research on these tools, the understanding of PCTs on skill development and shot performance requires further exploration.

The useability of PCTs for training and performance is important as these devices are commonly used in modern coaching. A coach's perception can be a valuable resource in academic research (Greenwood et al., 2012) that can provide a preliminary understanding of *in situ* use with relevant considerations for the intervention of PCTs in training settings. The sports-performance environment is chaotic and requires individuals to use anticipation, decision-making, and adaptative skills to be successful (Araújo et al., 2009; Baker et al., 2003; Williams et al., 2004), demonstrating the importance of representative training (Pinder et al., 2011). Within training sessions, coaches typically provide feedback (commonly augmented) to aid skill acquisition. Augmented feedback includes knowledge of performance (KP) which describes the quality of movement produced, and knowledge of results (KR) which provides information about the outcome (Wulf et al., 2010). It is well understood that the timing, type, and accuracy of feedback influence the learner's ability to retain skill, generally in favour of KR for greater learning and skill transfer (Chiviacowsky & Wulf, 2002; Mageau & Vallerand, 2003; Mouratidis et al., 2008; Oppici et al., 2021; Wulf et al., 2002). Haptic feedback (receiving vibration sensations based on movement requirements, or tactile information) and kinaesthetic feedback (instantaneous information about the "feeling" of movement) are inherently incorporated into PCTs. Collectively, these feedback types possibly work together to afford information for learners during (kinaesthetic and haptic feedback) and after movement (KR) to develop coordinated sport-specific skills. A recent review detailed a significant direction of effect in favour of KR in addition to

KP (Oppici et al., 2021), suggesting that the combination of both KP and KR enriches the learning experience. Using tactile information from the device, pairing kinaesthetic feedback used in a prescriptive sense and KR could be important contributors to grip-specific skill development, suggesting an ongoing interaction between feedback and movement outcomes. This information can provide the basis for an understanding of PCTs both theoretically and practically that may assist in practices for evidence-based research seeking to address the efficacy of PCTs for grip and sport-specific skill development in racket, stick and club sports.

4.2 Limitations and future directions

Only sources that utilised PCTs for grip-specific skill development were considered for this scoping review. Similar tools considered technique-promoting tools were among the excluded sources identified from the screening process (Liu et al., 2011). These tools were considered separate from PCTs as they instead promote motor behaviours through perception and task constraints whilst not physically-constraining movement. The low number of sources screened and zero included sources in this review is a possible limitation despite previous reviews identifying empirical value in yielding zero results (Harrell et al., 2022). The results of this review provide a clear basis for the necessity to address the effect of PCTs on sport- and grip-specific skill development given the limited evidence. Future research should ensure that analyses consider within-person changes, external influences, and skill level as potential variables that impact skill development (Araújo et al., 2010) while using PCTs. Researchers should also explore the coach's perceptions of the utility of PCTs within training sessions given the presence of commercially available products for coaches. Expert coaches have been an underutilised resource for sports performance development, as their experiential knowledge can provide useful insight to identify implications for best practices (Greenwood et al., 2014). It is clear that using PCTs for sport- and grip-specific skill development is an under-researched area for sports performance having yielded no results for grip-style-specific skills and as discussed limited studies on sport-specific skills with varied results and environments. Based on the results from this review, further interdisciplinary research is necessary to understand the effectiveness of PCTs for grip-specific skill development. Future research on skill acquisition strategies, such as explicit vs implicit instruction, varied practice conditions (random vs blocked), and different feedback mechanisms, can offer evidence-based guidelines for coaches and athletes to effectively use PCTs. This may enhance understanding of how these strategies affect skill development, retention, and transfer in sports-specific contexts for PCTs.

5 Conclusion

This review was conducted to identify the type, methodological approaches, and efficacy of using PCTs for grip-specific skill development. Based on the systematic process completed in this review, no peer-reviewed research has been completed which has assessed the efficacy of PCTs for grip-specific skill development, with a total of zero sources meeting the inclusion criteria. As determined in the review, the efficacy of PCTs for grip-specific skill development is unknown, despite their commercial availability. Future work should consider interdisciplinary research, factoring in relevant skill acquisition practices and technique assessment when assessing grip-specific and/or sport-specific skill development while using a PCT.

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Appendices

Appendix I: Initial search strategy

Tennis OR Badminton OR Hockey OR Golf OR Baseball OR Squash OR Cricket
AND
Skill acquisition
AND
Grip.

Appendix II: Final search strategy used for each included database.

Tennis OR Badminton OR Hockey OR Golf OR Baseball OR Squash OR Cricket OR Softball OR Lacrosse.
AND
Skill OR "skill acq*" OR learn* OR teach* OR "skill develop*" OR "motor learn*" OR "motor skill develop*" OR coach* OR protocol OR train×.
AND
Grip*

Appendix III: Data extraction tool.

Scoping review main details					Results/data extraction					
Author (Year)	Concept	Context	Inclusion/ exclusion criteria	Type of source	Participant information; Sex, Age (years), Height (cm), Weight (Kg), Playing level	Type of Tool	Sport-specific skill	Type of analysis (Time using tool)	Outcome measures	Key findings