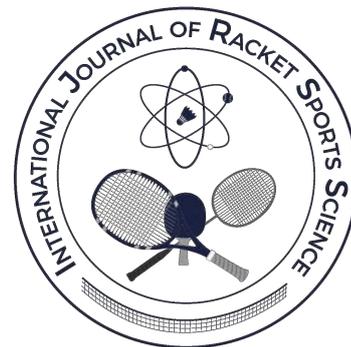


Mental training program in racket sports: A systematic review

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Abstract

The mental aspect is largely acknowledged by athletes and coaches as a salient factor explaining performance variability. The mental component of performance holds a special place in racket sports considering the inherent demands in such intense and emotional activities. The importance of mental skills in racket sports has been examined within the literature through a bulk of studies highlighting associations between mental skills and a wide range of positive outcomes. Access to the programs which aim to improve the mental skills of the athletes represents a major issue for researchers and the different stakeholders (coaches, athletes, parents). The main objectives of this study were to (a) Collect the studies that incorporate mental training programs used in racket sports, (b) Organize the current knowledge on mental training programs and provide a synthesis of the characteristics of these studies, and (c) Identify the gaps in the literature on this topic and propose potential further investigations and practical implications. The present systematic review included 27 studies which involved 715 participants. Most of the studies used a quantitative approach and were conducted on tennis. The mental skills developed varied across the studies with domination of imagery and relaxation techniques. Overall, the programs led to positive outcomes on performance indicators (e.g. improvement of service efficacy and stroke quality) and permitted the development of the targeted mental skills (e.g. concentration, motivation). This review highlighted the weak representation of females and novice players within the studies' participants. Moreover, the unequal representation of the techniques and outcomes in the examined studies encourages the development of further mental programs specifically applied to the demands of racket sports and a focus on different mental skills (e.g. emotional intelligence, coach education).

Keywords: *Mental Skills, Mental Training Program, Racket Sports, Performance, Systematic Review*

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Mental training program in racket sports: A systematic review

Racket sports refer to the physical activities involving rackets to strike a ball or a shuttlecock (Lees, 2003). These activities include some popular sports such as tennis, table-tennis, badminton, and squash but also new activities such as paddle tennis or racketlon. Previous studies have highlighted the complexity of these sports due to the role of a wide variety of factors involved in performance variability (Lees, 2003). To perform in a racket sport, an athlete has to develop technical, physiological, tactical, and mental skills. Athletes and coaches largely acknowledge that the mental aspect is a salient factor and should be trained in the same way as physical or technical components (Jones, 1995). The development of sports sciences and the growing number of studies focused on elite performance led to the implementation of training programs oriented on specific components of sport performance (Kondric, Matković, Furjan-Mandić, Hadzić, & Dervisević, 2011). In this way, mental training refers to the training dedicated to mental skills which refer to internal competences that help the athletes in their goals by learning to manage their psychological states in keeping with their objectives. Mental training mainly aims to improve the well-being and performance level of athletes (Behncke, 2004; Morais & Rui Gomes, 2019). Mental training in sport settings consists of several stage (Terry, Coakley, & Karageorghis, 1995). First, the mental trainer (coach, sport psychologist) should assess the initial skills of the athlete. Second, a mental training program is usually proposed in order to develop targeted mental skills. The programs are composed of intervention sessions including one or many techniques such as relaxation, imagery practice, or cognitive behavioural therapies (Jones, 1995). Third, partial and complete evaluations inform the development and use of mental skills. In the same way as for physical training, the preparation should be suitable for the demands of the activity (Mamassis & Doganis, 2004). Consequently, in order to implement mental training, an investigation of the specific skills

inherent to the demands of racket sports has to be realized.

Racket sports demands

Racket sports are associated with specific constraints which differ from other individual sports and involve particular training demands (Dohme, Bloom, Piggott, & Backhouse, 2019; Kondric et al., 2011). An analysis of the sport characteristics could identify the main mental demands and lead to identify the key skills to develop among racket sport athletes. First, a crucial characteristic of racket sports is the speed of the ball/shuttlecock and, in turn the associated required accuracy of all strokes played (Akpınar, Devrilmez, & Kirazci, 2012). These parameters limit the margin of error for each stroke and impose composure in stressful situations to prevent the errors (Ducrocq, Wilson, Smith, & Derakshan, 2017). These sports also require the learning of motor skills (e.g., accurate and powerful strokes) and are characterised by an important volume of training (important number of repetitions) (Doherty, Martinent, Martindale, & Faber, 2018). Consequently, an athlete practicing racket sport should have to be prepared to invest resources (sport motivation) despite the physical, psychological, and social constraints inherent to the practice of racket sports (Martinent, Decret, Guillet, & Isoard-Gauthier, 2014; Martinent & Decret, 2015). During competitive matches, racket sport players perform a series of repeated short and intense efforts (Kondric et al., 2011). Moreover, a competitive game is composed of successive matches across several competitive days. The players should continually project into future points or future games and should thus avoid ruminating about previous situations, behaviours and/or results (emotional regulation). Another major issue of racket sports is the presence of an opponent (Bebetsos & Antoniou, 2003; Caserta, Young, & Janelle, 2007; Poizat, Bourbousson, Saury, & Sève, 2009). The duel is thus central in the performance variability and every player has to focus on the reactions, choices, and behaviours of the other competitor.

Mental skills

In line with the exploration of the main characteristics of racket sports, a variety of key skills were revealed within a large body of literature (Crespo & Reid, 2007; Gould, Lauer, Rolo, Jannes, & Pennisi, 2008; Lees, 2003; Martinent, Cece, Elferink-Gemser, Faber, & Decret, 2018; Riemer & Chelladurai, 1998). This knowledgebase provides the basis for developing mental training programs. A review has highlighted the role of the mental toughness in major racket sports (Lees, 2003) involving targeted skills (e.g. motivation, emotional control, self-confidence). In particular, considering the daily training demands of these activities, motivation has been identified as an essential factor of the long-term performance and continued participation in tennis (Crespo & Reid, 2007) and table tennis (Martinent, Cece, Elferink-Gemser, Faber, & Decret, 2018). During the career, determination and enthusiasm have been identified as factors of performance (Lees, 2003). The environment has also been identified as a determinant of well-being and performance in racket sports especially considering the impact of parents (Gould et al., 2008; Harwood & Knight, 2009) and coaching leadership (González-García, Martinent, & Trinidad, 2019; Kwon, Pyun, & Kim, 2010; Riemer & Chelladurai, 1998; Sharma, 2015) on the athletes' outcomes, behaviours, and performance. Due to the competitive format and the necessity to repeat efforts despite the errors or under-performance, self-confidence has been identified as a salient factor in racket sports studies such as tennis (Covassin & Pero, 2004) and badminton (Bebetsos & Antoniou, 2003). Moreover, the stressful nature of matches in racket sports leads to special attention to the athletes' emotional skills. In particular, emotional control (emotional regulation) has been revealed as a central skill in racket sports such as table tennis (Martinent & Ferrand, 2009; Martinent, Ledos, Ferrand, Campo, & Nicolas, 2015; Sève, Ria, Poizat, Saury, & Durand, 2007) and tennis (Bolgar, Janelle, & Giacobbi, 2008; Laborde, Lautenbach, Allen, Herbert, & Achtzehn, 2014). Similarly, the racket

sports literature has also mentioned anxiety control and use of coping strategies as predictors of various outcomes such as well-being and competitive performance in badminton (Bebetsos & Antoniou, 2003), tennis (Bolgar et al., 2008), squash (Mace & Carroll, 1986) and table tennis (Laborde et al., 2014; Martinent & Decret, 2015). Other skills consistent with the high requirements of accuracy and velocity of the racket sports strokes have been highlighted. The literature has provided evidence of the importance of attention control skills in badminton (Bastug, Ağılönü, & Balkan, 2017) and table tennis (Caliari, 2008). In the same way, flow and awareness skills have been related to racket sports performance (Koehn, Morris, & Watt, 2013; Wolf et al., 2015). Finally, based on the rationale that racket sports can be categorised as open skills activities, previous studies have revealed the main role of decision making (del Villar, González, Iglesias, Moreno, & Cervelló, 2007; Hastie, Sinelnikov, & Guarino, 2009) and mental quickness (Williams, Ward, Smeeton, & Allen, 2004) in performance variability.

The present study

Racket sports characteristics lead to specific training requests for these activities (Lees, 2003; Mamassis & Doganis, 2004). Simultaneously, the mental aspect of performance has become a central preoccupation for athletes and coaches (Jones, 1995; Lees, 2003). The relevance of the mental skills in racket sports has been proved through a vast body of literature highlighting associations between mental skills and positive outcomes such as performance and well-being (Jones, 1995; Lees, 2003). For both researchers and practitioners, it seems important to disseminate the studies implementing mental training programs designed to improve athletes' mental skills. However, to the best of our knowledge, no study has summarized the research dealing with mental training programs in racket sports. As such, the main aims of this study were to (a) collect the studies that incorporate mental training programs used in racket sports, (b) organize the current knowledge on mental training programs and provide a synthesis of the characteristics of these studies, and

(c) identify gaps in the literature on this topic, and propose potential further investigations and practical implications.

Methods

Procedure

The electronic search was performed via EbscoHost. Three databases were used including PsyARTICLES; PsyINFO; SPORTDiscuss and the following keywords were researched (within the title and abstract): Mental, psychological, racket, tennis, table-tennis, badminton or squash. The reference lists of all articles obtained were also examined for other relevant studies.

The studies should respect the following inclusion criteria to be included in the study: (1) electronically-accessible in the English language; (2) publication in a scientific peer-reviewed journal; (3) original studies

with a specific mental training program presented and tested in the study; and (4) applied exclusively on one or many racket sports. The inclusion/exclusion procedure of the present study respected the systematic review process and is summarised in Figure 1. The first search revealed 565 references. We choose to not include timeframe selection criteria because of the limited number of studies on the thematic of mental training programs in racket sports. Then, 492 references remained with the removal of duplicates. We assessed the electronic abstract of the references and 357 were removed due to non-compliance of inclusion criteria. This level of loss could be explained by the importance of studies exploring the associations between mental skills and performance without a mental training program. Then, the electronic full-text articles were assessed, and 27 references remained after the final assessment for eligibility.

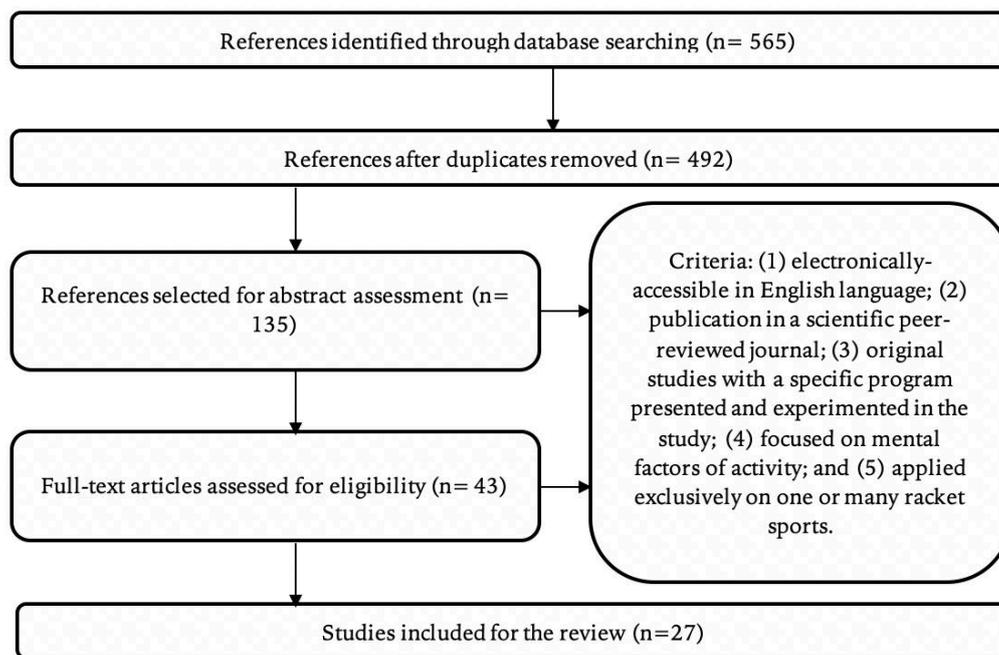


Figure 1. Procedure of inclusion and exclusion of studies

Data extraction

The selected studies were classified according to date of publication, sample characteristics (sample size, gender, competitive level), sport studied, mental training techniques, the goal of the program,

and outcomes of the program. The results were analysed using descriptive statistics including distribution with the software Statistica (Hilbe, 2007). The characteristics of the studies were summarised in Table 1.

Table 1.
Characteristics of the studies

Author	Date	Journal	Title	Sport	Sample size	Gender	Age	Level	Intervention time	Method	Aim(s)	Results
Atienza et al.	1998	Perceptual and Motor Skills	Video Modelling and Imaging Training on Performance of Tennis Service of 9- to 12-Year-Old Children	Tennis	12	Females	9-12 years	Intermediate	24 weeks (15min/week)	Video modelling + Imagery	Technique of service	Improvement of service score (speed, accuracy and technique)
Caliari	2008	Journal of Applied Sport Psychology	Enhancing Forehand Acquisition in Table Tennis: The role of Mental Practice	Table tennis	112	-	14-15 years	Novice	A physical education cycle	Imagery	Forehand performance	Improvement of forehand performance (accuracy)
Caserta et al.	2007	Journal of Sport & Exercise Psychology	Old Dogs, New Tricks: Training the Perceptual Skills of Senior Tennis Players	Tennis	27	10 Males / 17 Females	62,50 years / 59,59 years	Intermediate	50 days (40min)	Perceptual-cognitive skills training (situational awareness) + Anticipation + Decision making	Perceptual skills during competition	Improvement of response speed, accurate responses, performance decision making
Coelho et al.	2007	Perceptual and Motor Skills	Imagery Intervention in Open and Closed Tennis Motor Skill Performance	Tennis	48	Males	17-18 years (av. = 17,2)	National	Three times a week (15min), two consecutive months	Imagery (self-confidence + positive feedback) + Technical practice	Service and receiving services	Improvement of service skill and not receiving services
Dana & Gozalzadeh	2017	Perceptual and Motor Skills	Internal and External Imagery Effects on Tennis Skills Among Novices.	Tennis	36	Males	15-18 years	Novice	Six weeks (three times/week - 30 minutes)	Mental imagery (internal or external) + Physical practice	Performance accuracy on serve, forehand, backhand strokes	Increasing performance accuracy for service, forehand and backhand Internal imagery: Greater improvement of serve and backhand accuracy
Daw & Burton	1994	The Sport Psychologist	Evaluation of a Comprehensive Psychological Skills Training Program for Collegiate Tennis Players.	Tennis	26	13 Males / 13 Females	18-23 years	Intermediate	three sessions (20min-1h)	Goal setting + Imagery + Arousal regulation	Quality of shots + Self-confidence	Higher self-confidence and fewer double fault

Table 1 (continued)

Author	Date	Journal	Title	Sport	Sample size	Gender	Age	Level	Intervention time	Method	Aim(s)	Results
Dohme et al	2019	Journal of Applied Sport Psychology	Development, implementation, and evaluation of an athlete-informed mental skills training program for elite youth tennis players.	Tennis	11	Males	8-15 years	Elite	15 months (2 months of intervention)	Targeted cognitive behavioural program (e.g. pre-performance routines, positive self-talk, imagery)	Development of mental skills	Improvement of athletes' regulation and emotional control + Use of psychological skills
Ducrocq et al.	2017	Journal of Sport and Exercise Psychology	Adaptive Working Memory Training Reduces the Negative Impact of Anxiety on Competitive Motor Performance.	Tennis	30	25 Males / 5 Females	17-50 years (av. = 33)	Novice	10 days of training	Memory working tasks on laboratory	Working memory and performance under pressure	Increasing on working memory capacity, quiet eye offset and tennis performance in high-pressure condition
Garcia-Gonzales et al.	2014	Journal of Applied Sport Psychology	Effects of Decision Training on Decision Making and Performance in Young Tennis Players: An Applied Research.	Tennis	11	Males	12-14 years	Intermediate	10 weeks (one session/week)	Video-feedback + Questioning	Decision making and performance during match	Improvement of decision-making and performance
Guillot et al	2015	PLOS One	Implementation of Motor Imagery during Specific Aerobic Training Session in Young Tennis Players	Tennis	10	6 Males / 4 Females	av. = 13,5 years	Elite	One session	Motor imagery	Stroke accuracy and ball velocity of backhand and forehand drives after high intensity intermittent training	Similar cardiac demand Maintaining of accuracy during physical training Development of physical fitness and preservation of stroke performance
Guillot et al.	2013	Journal of Sports Science and Medicine	Motor Imagery and Tennis Serve Performance: The External Focus Efficacy.	Tennis	12	7 Males / 5 Females	av. = 11 years	Elite	12 sessions (8 weeks)	Mental imagery with external focus	Service performance in match	Increase in accuracy, velocity of serve + successful first serves, won points (in match)

Table 1 (continued)

Author	Date	Journal	Title	Sport	Sample size	Gender	Age	Level	Intervention time	Method	Aim(s)	Results
Jeon et al.	2014	Perceptual and Motor Skills	Noise Distraction and Mental Practice in Closed and Open Motor Skills	Badminton	36	Males	Exp 1: 19-27 years (av. = 23,3) Exp 2: 18-22 years (av. = 21,1)	Novice	One session	Relaxation + Video watching + Mental practice (8 minutes)	Performance of close (exp 1) and open (exp 2) skills	Close skill: greater accuracy of service Open skill: less error only in the acquisition trials
Lejeune et al.	1994	Perceptual and Motor Skills	Mental Rehearsal in Table Tennis Performance	Table tennis	40	-	19-27 year (av. = 22)	Novice	Six sessions	Relaxation + Mental imagery + Observational and physical techniques	Technic strokes + Accuracy	Performance index score improvement
Li-Wei et al.	1992	The Sport Psychologist	The Effect of Mental-Imagery Training on Performance Enhancement With 7-10-Year-Old Children	Table tennis	40	21 Males / 19 Females	7-10 years (av. = 8,3)	Elite	22 weeks (30min/week)	Mental imagery + Relaxation + Video observation	Quality of shots	Improvement in the accuracy and technical quality of their shots
Mamassis & Doganis	2004	Journal of Applied Sport Psychology	The Effects of a Mental Training Program on Juniors Pre-Competitive Anxiety, Self-Confidence, and Tennis Performance	Tennis	9	-	av. = 14,1 years	Elite	25 weeks (60min/week)	Goal setting + Positive thinking/self-talk + Concentration & routines + Arousal regulation + Imagery Education + Assessment + Mental skill learning (goal setting + Imagery + Positive self-statements + Pre-point routine) + Application	Performance and psychological factors	Increase in the direction dimension of anxiety and self-confidence + intensity of self-confidence + overall tennis performance
Mathers	2017	The Sport Psychologist	Professional Tennis on the ATP Tour: A Case Study of Mental Skills Support	Tennis	1	Males	av. = 27	Elite	3 years	Goal setting + Positive self-statements + Pre-point routine) + Application	Performance and development of mental skills	Improvements in self-reported performance and outcomes (key mental skills)

Table 1 (continued)

Author	Date	Journal	Title	Sport	Sample size	Gender	Age	Level	Intervention time	Method	Aim(s)	Results
Morais	2019	International Journal of Sport Psychology	Pre-service routines, mental toughness and performance enhancement of young tennis athletes	Tennis	11	10 Males / 1 Female	11-14 years (av. = 12,09)	Intermediate	10 sessions (1-2 hours)	Mental and behavioural routine before service	Performance and mental toughness during match	Improvement of mental toughness + Positive impact on performance efficacy (service games won)
Noel	1980	Journal of Sport Psychology	The Effect of Visuo-motor Behavior Rehearsal on Tennis Performance	Tennis	14	Males	17-45 years (av. = 28,57)	low abilities - high abilities	Three sessions (30min) 10 days before the competition	Relaxation + Visualisation	Quality of shots	Improvement of first service and ratio winners to efforts for experts
O et al.	2014	Journal of Applied Sport Psychology	Using Motivational General-Mastery Imagery to Improve the Self-efficacy of Youth Squash Players	Squash	5	2 Males / 3 Females	7-14 years (av. = 10,71)	Intermediate	6 weeks (3 practices/day + meeting with researcher twice a week)	Imagery practice (focused on confidence, control, mental toughness and performance)	Self-efficacy	Improvements in self-efficacy scores (for 3/5)
Ramirez et al.	2010	Polish Journal of Sport & Tourism	Pettlep imagery and video-observation: a motivation case study for four badminton players	Badminton	4	2 Males / 2 Females	24-57 years	Novice	Six weeks (two/week)	PETTLEP Imagery (physical, environment, task, timing, learning, emotion, perspective) + Video observation	Situational motivation	Increasing of self-determined forms of motivation and decreases in less self-determined types of motivation
Robin et al.	2011	International Journal of Sport Psychology	Effects of motor imagery training on service return accuracy in tennis: The role of imagery ability	Tennis	80	-	-	Elite	15 sessions	Imagery training	Service returns performance	Improvement of service returns
Singer et al.	1994	The Sport Psychologist	Training Mental Quickness in Beginning/Intermediate Tennis Players	Tennis	34	16 Males / 18 Females	Undergraduate students	Novice	3 weeks (20min/week)	Mental quickness training (videotape situations)	Quickness	Faster decisions in reaction to serves; faster anticipation times, improved accuracy in predicting serve type and location

Table 1 (continued)

Author	Date	Journal	Title	Sport	Sample size	Gender	Age	Level	Intervention time	Method	Aim(s)	Results
Smeeton et al.	2005	Journal of Experimental Psychology	The Relative Effectiveness of Various Instructional Approaches in Developing Anticipation Skill.	Tennis	33	27 Males / 6 Females	av. = 10,6 years	Intermediate	4 weeks (20min/week)	Perceptual-cognitive training in laboratory	Anticipation skills on laboratory and field	Improvement of the anticipation skills
Steffgen	2017	Journal of Human Kinetics	Anger Management - Evaluation of a Cognitive-Behavioral Training Program for Table Tennis Players.	Table tennis	18	-	16-22 years (av. = 16,6)	Elite	2 months (6 sessions of 120min)	Cognitive relaxation coping training (relaxation) + Social problem-solving training (communication)	Anger management	Reduction in negative anger expression, anger reactions (one-year follow-up)
Tzetzis et al.	2008	Journal of Sports Science and Medicine	The effect of different corrective feedback methods on the outcome and self-confidence of young athletes.	Badminton	48	Males	10-14 years (av. = 12,6)	Intermediate	Two times/week	Correction cues + Positive feedbacks (+ error cues)	Performance (forehand and backhand) and self-confidence	Improvement of self-confidence scores Improvement of easy and difficult skill
Vidic & Burton	2010	The Sport Psychologist	The Roadmap: Examining the Impact of a Systematic Goal-Setting Program for Collegiate Women's Tennis Players.	Tennis	6	Females	17-22 year (av. = 19)	Elite	8 weeks (20-45min/week)	Goal-setting program	Performance, motivation, confidence	Improvements in motivation, confidence and performance scores
Yoo	2018	International Journal of Coaching Science	Using Counselling to Improve the Self-confidence of a Young Competitive Female Tennis Player: A Case Study.	Tennis	1	Female	12 years	Elite	8 counselling sessions	Self-confidence: journal writing technique (goal setting)	Self-confidence and performance	Improvement in self-confidence and tennis performance

Results

General characteristics

Twenty of the 27 studies (74.1%) examined were published between 2005 and 2019. Seven studies were published before 2005 (25.9%) and only three before 2000 (11.1%). The journals the most frequent were *Perceptual and Motor Skills*, *The Sport Psychologist*, and *Journal of Applied Sport Psychology*.

A total of 715 participants (344 males and 112 females) were included in the 27 studies with an average of 23.19 participants per study. Only two studies presented a sample size superior to 50 subjects (Caliari, 2008; Robin et al., 2007) and the majority had a sample size between 10 and 50 participants ($n = 19$). The gender distribution revealed eight studies with males, three with females, and eleven with both genders (participants' gender was not mentioned in five studies). The age of the participants ranged between 6 and 63 years old. Most of the studies comprised children between 7 and 13 years old ($n = 8$) or adolescents and young adults between 14 and 22 years old ($n = 8$) (age of the participants was not mentioned in two studies; Caliari, 2008; Robin et al., 2007). Eleven of the 27 studies concerned elite, expert, or international athletes. In contrast, seven studies mentioned beginner, novice, or recreational players. Finally, nine studies contained participants with an intermediate practice level whereas one study mixed novice, intermediate, and elite levels in the same study.

Nineteen of the 27 studies (73%) exclusively focused on tennis. Four of the programs (14%) were conducted on table tennis players (Caliari, 2008; Lejeune, Decker, & Sanchez, 1994; Li-Wei, Qi-Wei, Orlick, & Zitzelsberger, 1992; Steffgen, 2017) and three (11%) on badminton players (Jeon, Kim, Ali, & Choi, 2014; Ramirez, Smith, & Holmes, 2010; Tzetzis, Votsis, & Kourtessis, 2008). One study was conducted on squash players (O, Munroe-Chandler, Hall, & Hall, 2014). No study combined two or more racket sports.

Mental training programs

Mental training techniques

A wide variety of techniques were used in the mental training programs of the studies reviewed including relaxation, imagery, observation (i.e. video observation of athletes), goal setting, arousal regulation, mental quickness training, self-talk, competitive and pre-competitive routines, perceptual-cognitive training (i.e. which aim to perceive and understand moving patterns), feedback (i.e. targeted feedbacks from the coach), or communication. The mental training programs were always directly applied to the athletes. The most used techniques were imagery (41% of the studies), relaxation (15%), goal setting (15%), competitive and pre-competitive routines (12%).

Design of the intervention

Most of the studies used a pre-test-post-test design with an intervention and measures of the variables before and after the sessions. Three studies have used a qualitative approach with case studies (Mathers, 2017; Ramirez et al., 2010; Seang-Leol & Calderon, 2018) whereas the other research studies have based their protocol on quantitative statistical analyses. The duration of the interventions of the reviewed studies ranged between one short session and three years. Two studies used a short program including only one session, five studies used between two and five sessions, and five studies used between six and ten sessions. In contrast, one study proposed more than 50 training sessions (Mathers, 2017), nine studies mentioned between 11 and 20 sessions, and five studies between 21 and 50 sessions. The timing of the intervention was very fluctuant and ranged between 15 and 90 minutes per session and between one and three sessions for a week.

Aims and outcomes

All of the reviewed studies revealed positive outcomes of the mental training programs with complete or partial validation of the goals. The most common goal of the studies consisted of an improvement of sport performance. The performance was analysed during isolated tests ($n = 12$, 44.7% of

the studies), practice matches ($n = 5$, 18.5%) or in competitive matches ($n = 4$, 14.8%). Specifically, the service was the stroke the most explored (Atienza, Balaguer, & García-Merita, 1998; Coelho, De Campos, Silva, Okazaki, & Keller, 2007; Guillot, Desliens, Rouyer, & Rogowski, 2013; Jeon et al., 2014; Noel, 1980). Several studies also analysed the returning service (Coelho et al., 2007; Robin et al., 2007), the forehand or backhand strokes (Caliari, 2008; Daw & Burton, 1994; Guillot et al., 2015; Li-Wei et al., 1992; Tzetzis et al., 2008) or global performance scores (Gonzalez-Garcia, Pelegrin, & Luis Carballo, 2017; Mamassis & Doganis, 2004; Mathers, 2017; Seang-Leol & Calderon, 2018; Vidic & Burton, 2010) based on the criterion of technique, accuracy, velocity, or effectiveness of the strokes. Positive consequences on the performance were developed such as improvement of the technique, speed, accuracy and efficacy of the strokes, global improvement of the training, and competitive performance.

Other mental training program aimed to improve the mental competitive skills ($n = 14$) such as mental toughness (Mathers, 2017; Morais & Rui Gomes, 2019), self-confidence (Daw & Burton, 1994; Mamassis & Doganis, 2004; O et al., 2014; Seang-Leol & Calderon, 2018) or motivation (Ramirez et al., 2010; Vidic & Burton, 2010). The mental skills were measured using psychometric self-report questionnaires, interviews, or observations of the athletes during training or competition. Results revealed an improvement of mental skills. The improvement of mental skills was sometimes combined ($n = 10$) and sometimes not combined ($n = 4$) with a performance measure. Finally, specific studies aimed to improve the working memory, perceptual skills, and anticipation skills.

Discussion

To the best of our knowledge, there is no review investigating the studies testing the effects of a mental training program in racket sports. Considering the relevance of the mental aspect of the performance in racket sports, the main objectives of this study were: (a) to collect the studies that

incorporate mental training programs used in racket sports, (b) to organize the current knowledge on mental training programs and provide a synthesis of the characteristics of these studies, and (c) to identify gaps in the literature on this topic and propose potential further investigations and practical implications.

General findings

Twenty-seven studies since 1980 were selected for the present review. In an applied perspective, we can regret a limited involvement regarding the mental training programs. In contrast, a considerable amount of literature regarding the mental skills required in competitive racket sports have been developed in the scientific literature (e.g. Bastug et al., 2017; Kwon et al., 2010; Sharma, 2015). The lack of studies with mental training programs could be a consequence of the persistent weak interest of several sport stakeholders for the mental practice (Connaughton, Wadey, Hanton, & Jones, 2008). Moreover, the reduced number of scientific studies reviewed in this study could highlight an image of mental training as a less rigorous process than others such as physical training (Jones, 1995).

Inspection of the level of participants revealed 11 studies with elite athletes, nine with an intermediate level, and seven with a novice population. This distribution provides evidence of the elite aspect of mental training for a majority of the sports protagonists (Jones, 1995). This point of view is consistent with the high physical, psychological, and social demands of elite sport and fits with the research of detail of the training for elite athletes in racket sports (Doherty et al., 2018). However, every level of sport experience and practice level could benefit from the effects of mental training programs. The improvement of performance and mental skills among novice participants has provided evidence for the possibility and the interest to include low competitive levels in mental training programs (e.g. Dana & Gozalzadeh, 2017; Ducrocq et al., 2017). The gender distribution showed a total of 344 males and 112 females mentioned in the reviewed studies. This result highlights a gender imbalance and a male

predominance in the mental training programs and very few of the studies reviewed have explored the gender effect on the consequences of the mental training programs (Caserta et al., 2007; Singer et al., 1994).

The studies reviewed were exclusively conducted on the four major racket sports (tennis, table-tennis, badminton, and squash) with a large majority on tennis ($n = 19$). Badminton and table-tennis were moderately represented, and squash was weakly represented. This distribution is in line with the respective popularity of racket sports considering the mediatised and economic importance of tennis in comparison with other racket sports (Lees, 2003). No study focused on two or more racket sports simultaneously. This kind of study with a comparison between two activities could provide knowledge about the similarities and differences across the racket sports. Moreover, the lack of investigation of some racket sports could restrain the appropriation of mental training programs in such activities.

Design of the studies

A majority of studies used a quantitative approach and adopted the traditional pre-test-post-test paradigm with a control group. The quantitative methods facilitated the statistical analyses and allowed to provide a rigorous examination of the effects of mental training programs (Biddle, Markland, Gilbourne, Chatzisarantis, & Sparkes, 2001). Thus, the bulk of quantitative studies focusing on the interventions consolidated the scientific legitimacy of the tested mental training programs by providing evidence of their significant effects on performance scores and/or on psychological outcomes (e.g., anxiety scores). In addition, few case studies were also reviewed (Mathers, 2017; Ramirez et al., 2010; Seang-Leol & Calderon, 2018). These case studies have furthered knowledge base regarding the mental processes of athletes during training and competitions (Biddle et al., 2001). For instance, Mathers (2017) has recently proposed an individualised program in which

athletes were subject to successive mental interventions during a three-year period.

The mental training programs were heterogeneous as indicated by the large variety of the number of training sessions and/or the duration of the mental training programs. Indeed, several studies have proposed duration of intervention ranging from 30 minutes to three years with a majority of programs comprising between 2 and 20 sessions. A lot of studies used repeated measures before and after the interventions but very few have adopted a longitudinal approach to assess the ongoing variability of relevant psychological outcomes during the mental training programs. As such, the use of longitudinal studies continuously tracking the ongoing psychological processes involved in mental training programs could further knowledge about the overtime effects of mental training programs.

Outcomes

All of the mental training programs reviewed have reported positive outcomes. These positive results should encourage the coaches, athletes, and sports psychologists to intervene in racket sports to set up mental training programs suitable for the targeted outcomes. The main objective of the studies was the improvement of the players' performance (Gonzalez-Garcia et al., 2017; Mamassis & Doganis, 2004; Mathers, 2017; Morais & Rui Gomes, 2019; Seang-Leol & Calderon, 2018; Vidic & Burton, 2010) or the quality of their strokes. Various studies have revealed a significant improvement of the velocity, the accuracy, the efficiency, and the regularity of service (Atienza et al., 1998; Coelho et al., 2007; Guillot et al., 2013; Jeon et al., 2014; Noel, 1980), service returning (Coelho et al., 2007; Robin et al., 2007), backhand and forehand strokes (Caliari, 2008; Daw & Burton, 1994; Guillot et al., 2015; Li-Wei et al., 1992; Tzetzis et al., 2008). The open skills (e.g. service returning, decision making) have been less investigated than the closed skills (e.g., service) probably because of the difficulties to assess these factors of performance (Currell & Jeukendrup, 2008). However, open skills represent a crucial aspect of racket sports and could be a potential extension for

further mental training programs (Coelho et al., 2007).

The programs focused on mental skills also reported positive outcomes. These programs increased the levels of mental toughness (Mathers, 2017; Morais & Rui Gomes, 2019), self-determined motivation (Ramirez et al., 2010; Vidic & Burton, 2010), emotional control (Dohme et al., 2019) and self-confidence (Daw & Burton, 1994; Mamassis & Doganis, 2004; O et al., 2014; Seang-Leol & Calderon, 2018) and decreased the athletes' anxiety and anger scores (Mamassis & Doganis, 2004; Steffgen, 2017). The present results suggest the potential benefits of mental training on various key mental skills for racket sports (Jones, 1995; Lees, 2003). The well-being indicators were less explored in the studies with only a few studies including some well-being indicators (e.g. pleasant and unpleasant emotion). This lower preoccupation could be explained by the general focus on performance in competitive sport. However, the association between performance and well-being has been highlighted in previous racket sports studies (Martinent et al., 2018) and could be an area of improvement for sport stakeholders.

Moreover, several specificities of racket sports such as awareness or emotional control have not been explored. For example, despite the identification of keys mental skills in racket sport (Jones, 1995; Lees, 2003; Mamassis & Doganis, 2004), no study proposes a training program explicitly focused on the emotional demands of racket sports. For example, the development of emotional intelligence seems suitable for racket sports. Indeed, the ability to identify, understand, regulate, and use one's and others' emotions could represent an essential skill for coping with the emotional demands of racket sports (Laborde et al., 2014; Martinent et al., 2015).

Techniques

The distribution of the techniques indicated a wide variety of mental training methods used in the explored studies. It is also noteworthy that a particular technique could be used exclusively or

combined with other techniques. Among the variety of detailed techniques within the examined studies, imagery emerged as the most used. The results provided evidence of the positive effect of imagery on sport performance indicators related to the strokes realised in racket sports. Imagery programs have permitted to improve the velocity, accuracy, efficiency, and the regularity of serves, returns, backhands, and forehands (Atienza et al., 1998; Caliarì, 2008; Dana & Gozalzadeh, 2017; Guillot et al., 2015). Consequently, the imagery programs appeared suitable for the development of racket sports motor skills. Additionally, relaxation techniques were used in five studies, regularly in combination with other techniques such as imagery (Lejeune et al., 1994; Li-Wei et al., 1992; Mamassis & Doganis, 2004). Overall, relaxation techniques have also led to an improvement in players' strokes and performance. Goal-setting learning was proposed in five studies especially within targeted interventions grounded within cognitive behaviour therapies (Daw & Burton, 1994; Mamassis & Doganis, 2004; Mathers, 2017; Seang-Leol & Calderon, 2018; Vidic & Burton, 2010). The goal-setting techniques have permitted improving salient mental skills in racket sport such as self-confidence (Daw & Burton, 1994; Mamassis & Doganis, 2004) or self-determined motivation (Vidic & Burton, 2010). Similarly, the studies that have included competitive and pre-competitive routines techniques have led to an increase of self-confidence scores (Mamassis & Doganis, 2004) and mental toughness (Dohme et al., 2019; Morais & Rui Gomes, 2019), and a decrease of anxiety scores (Dohme et al., 2019). In sum, imagery, relaxation, goal setting, and routines seem fitting with racket sports demands and facilitate performance and the fostering of salient mental skills (self-determined motivation, emotional regulation). Moreover, the results highlighted an association between the technique used during mental training and the mental skills targeted to be improved. In an applied perspective, the present results suggested adapting the techniques of mental programs to the specific objectives and issues encountered by the athletes.

Several techniques were less or even almost not used in the studies reviewed. For instance, arousal regulation or self-talk techniques have been proposed in a very limited number of researches (Daw & Burton, 1994; Dohme et al., 2019; Mamassis & Doganis, 2004). Otherwise, all the techniques used in the reviewed studies have been almost exclusively implemented on the athletes. Very few studies focused on the salient stakeholders grounded with the athletes' environment (e.g., parents, coaches). However, previous studies have highlighted the importance of the athletes' environment in racket sports and have suggested potential techniques to help parents and coaches (Gould et al., 2008; Harwood & Knight, 2009; Kwon et al., 2010; Riemer & Chelladurai, 1998; Sharma, 2015).

Conclusions

The present review aimed to explore the studies which include a mental training program in racket sports. The 27 studies selected in the present review comprised various samples from different racket sports and were characterized by distinct study designs, mental training techniques, and outcomes. The various techniques used in the programs led to positive outcomes such as improvement of performance and mental skills. However, the results of the review highlighted the unequal distribution of the population (e.g. male and expert domination) and the sport (tennis attracting the focus of attention) in the studies. Moreover, the present results suggested several lacks in the targeted outcomes (e.g. lack of focus on well-being indices), and/or in the techniques (e.g. self-talk or relaxation, absence of programs applied on coaches or parents) given the specific constraints of racket sports. In summary, this review suggested potential implications for both researchers and practitioners. The results encouraged further investigations of mental training programs to address the aforementioned unexplored issues. Finally, we hope that this review will promote the development of mental training programs in racket sports and will help several sport stakeholders (coaches, sport

psychologists, athletes) to adapt the mental training to the practice constraints and the objectives.

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