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Tests in the Evaluation of Physical Performance in Racket Sports: A Scoping Review

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Abstract: *The development of physical capacities has evolved significantly. In racket sports, the demand for greater physical development in athletes has been increasing in recent years. Therefore, the application of physical tests has become a necessary practice for monitoring athletes' development. The central aim of this scoping review is to identify the main physical tests used to assess racket sports players. This scoping review was carried out in accordance with the JBI methodology and the PRISMA guidelines. A systematic search was conducted in the PubMed/MEDLINE, Web of Science, SCOPUS and Scielo databases, with the most recent search conducted on 20 November 2024, published in English or Portuguese. Eligible studies included those that assessed the physical abilities of racket sports athletes using physical tests, regardless of age. Studies evaluating para-sports or table tennis were not included. Of the 810 studies identified, 78 were eligible to be assessed by full text, and 60 studies met the criteria and were included in the review. A wide variety of tests were identified, 104 tests or variations, 80 considered general and 24 specific tests. Field tests were used most frequently in the studies, with tests characterised by the ability to perform short explosive efforts, such as countermovement jumping, handgrip strength, 20, 10 and 5 m speed, being the most prevalent in the studies. In addition, sport-specific tests have been incorporated into test batteries to improve racket players' sporting performance, thus enabling a more complete and sport-specific assessment.*

Keywords: *Physical tests, racket sports, assessment, performance.*

1. INTRODUCTION

Racquet sports include traditional modalities such as tennis, badminton, table tennis and squash (1), as well as emerging ones such as padel and beach tennis (2,3). The growing interest in these modalities encourages the improvement of sporting performance levels, which is a multifactorial phenomenon involving technical, tactical, physical and psychological aspects (4).

The evolution of performance in racket sports has been driven by scientific and technological advances (5). Initially centred on technical and tactical skills, performance has also come to consider physical attributes as determining factors (6,7). In this context, monitoring physical capacities through specific tests has become essential to optimise training and athlete performance (8,9).

The implementation of physical tests facilitates the identification of an athlete's strengths and weaknesses, the monitoring of their progress, and the assessment of the efficacy of their training regime (10). While each sport possesses its own unique characteristics, certain physiological demands are shared among different modalities. Thus, it is essential to select appropriate tests for accurate assessment (11,12). Consequently, we consider that a scoping review, which addresses broad questions and descriptively maps the literature on an emerging topic, is the most appropriate methodology to examine the use of the most common physical tests in racquet sports (13).

The central aim of this study is to identify main physical tests used in the evaluation of racket sports players. Furthermore, a comprehensive mapping exercise was conducted, encompassing the most

extensively studied modalities, the objectives of the evaluations, and the physical capacities most frequently monitored.

2. METHODS

This scoping review was conducted according to the JBI methodology for scoping reviews, as described in the JBI Handbook for Evidence Synthesis (14), using the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Extension for Scoping Reviews (PRISMA-ScR) (15). The protocol was registered with the Open Science Framework (OSF), with the following DOI 10.17605/OSF.IO/THM3Y.

Studies published from 1993 to October 2024, peer-reviewed primary research with quantitative data published in English or Portuguese, as well as descriptive observational and descriptive cross-sectional study designs were considered for inclusion. In addition, they had to include racket sports athletes who were taking part in a training programme and competing, with no age limitation and who had undergone tests to assess physical performance.

Studies evaluating recreational racket sports players, parathletes or table tennis athletes were excluded. The exclusion of this sport was due to its particularities, especially regarding the types of movement and coverage space. Also excluded were interventional studies that used physical tests or assessments in the pre- or post-intervention period, as well as comparative studies between racquet sports and other sports.

A systematic search was carried out in the following electronic databases: Pubmed, Scopus, Web of Science and Scielo, with the most recent search conducted on 20 November 2024. The search strategy used in the PUBMED database was limited to the search for keywords limited to the title and abstract, covering the time frame and languages mentioned above, and utilised the terms: ((((‘Racquet sports’ OR ‘racket sports’ OR ‘racket players’ OR badminton OR ‘badminton players’ OR squash OR ‘squash sport’ OR padel OR ‘padel tennis’ OR ‘padel players’ OR tennis OR ‘tennis player’ OR racquetball OR ‘racquetball player’ OR ‘beach tennis’ OR ‘beach tennis player’ OR pickleball OR ‘pickleball player’))) AND ((‘Physical Performance’ OR ‘Physical Factors’ OR ‘Physical Fitness’ OR ‘Fitness Characteristics’ OR ‘ Physical Test’ OR ‘Physical Fitness Test’)))) NOT ((‘table tennis’ OR ‘ping pong’ OR ‘table tennis players’ OR ‘wheelchair tennis’)).

After eliminating duplicate references, titles and abstracts were examined by two reviewers independently (MLDZ, HEGN) in the Rayyan application in relation to the eligibility criteria. Disagreements tried to be resolved by consensus between the two reviewers; if there was no agreement, it was up to the third reviewer (GS) to decide whether to include or exclude the article. Subsequently, in the identification and screening stage, articles were eligible for full-text evaluation by the researcher (MLDZ) to be included in the review. If access to the full text was not possible, the study was excluded.

Data was extracted from the articles included by the researcher (MLDZ) using a data extraction tool adapted by the researchers and which included the following information: author(s)/year/title, objective, population (sample characteristics), concept (physical tests or other variables) and context (modality) and will be presented in supplementary file.

3. RESULTS

The results will be presented in blocks, i.e. according to the number of articles, the racquets sports discussed in them, the objectives of the studies and the identification of the tests carried out.

The first search identified 810 articles, of which 323 were duplicates. Of the remaining 487, 410 were removed based on reading the titles and abstracts. Of the 77 eligible for full text evaluation, 11 were not found, 3 were in languages other than English and Portuguese and the other 4 were removed for the following reasons: their main objective was to assess nutritional and anthropometric profile (two), to assess the association of pain with physical fitness (one), and the tests used were not identified and detailed (one). Therefore, 60 articles were included in the review. Figure 1 shows the flowchart for selecting the studies, and Table 1 shows the articles included, with the information summarised.

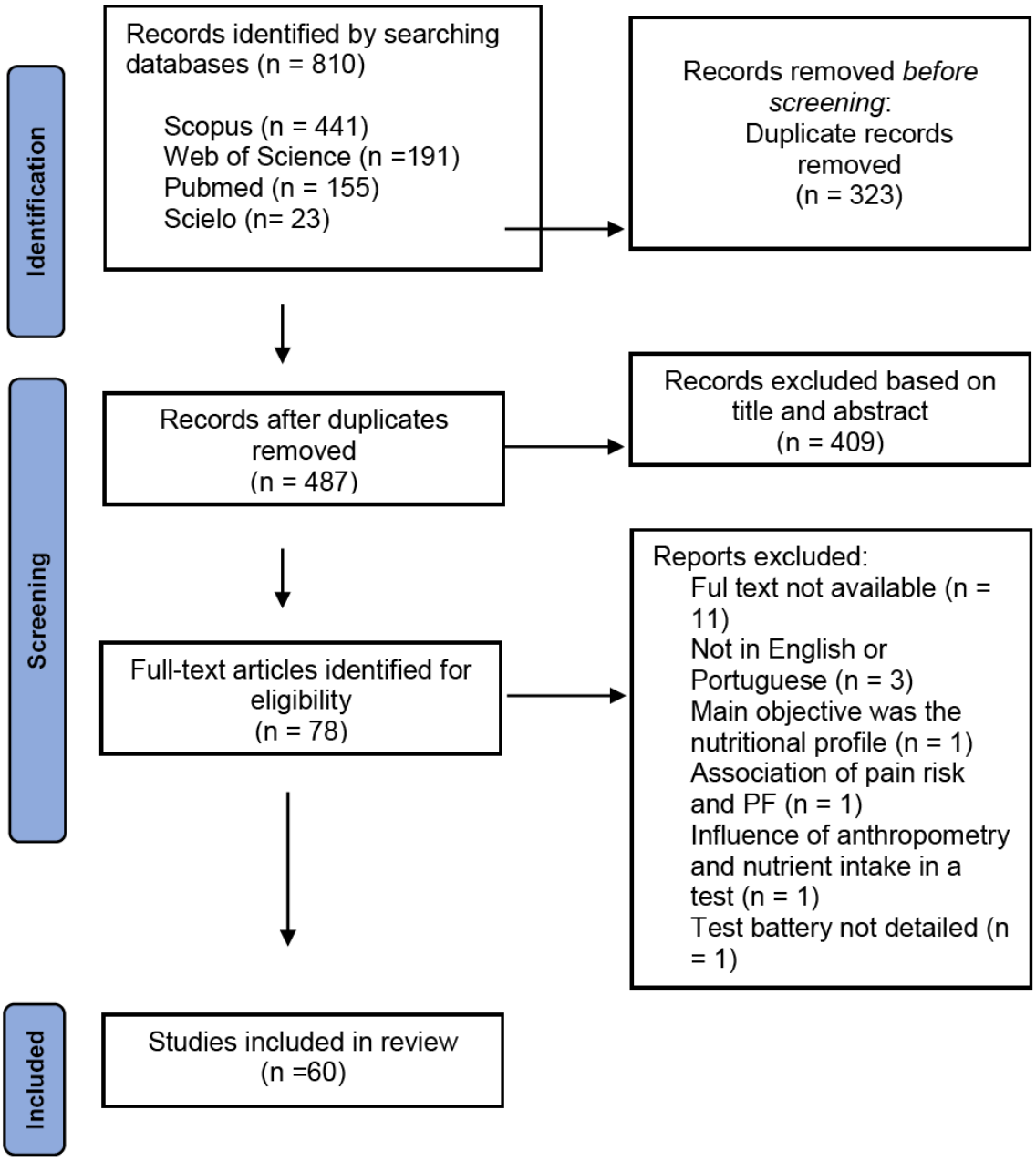

Figure 1. *Study Flow Diagram - PRISMA-ScR flow chart*

Table 1. *Summarised information on articles and tests*

Study	Tests and equipment used
(CHIN et al., 1995) (17)	Cycle ergometer test, treadmill running test, Isokinetic dynamometer (flexor and extensor strength? of knee), HGS, SaR, Squash specific fitness
(ROETERT et al., 1995) (18)	SaR, hexagon, spider run, sideways shuffle, 20 y dash, push up, sit up, HGS, 1 and half mile, VJ, MBT chest pass
(CHIN et al., 1995) (19)	Badminton field test
(ROETERT et al., 1996) (20)	Isokinetic strength of trunk (flexion and extension), overhead, reverse overhead, forehand and backhand MB toss.
(FAFF; ŁADYGA; STARCZEWSKA-CZAPOWSKA, 2000) (21)	Treadmill running
(GIRARD et al., 2005) (22)	Treadmill running incremental, Field specific sport test
(GIRARD, O. et al., 2006) (23)	Treadmill running, Tennis specific incremental test

(OOI et al., 2009) (24)	SJ, CMJ, DJ, 5 MST, sideway agility, four corner specific badminton, 1 RM squat or leg press / bench press, 20 MST
(GIRARD, OLIVIER; MILLET, 2009) (25)	5m, 10m, 20m, HGS dominant and non-dominant and maximal voluntary contraction torque of plantar flexors (dynamometer), SJ, CMJ, DJ, Multi-rebound jumps.
(PEREIRA et al., 2011) (26)	HGS
(ZIEMANN et al., 2011) (27)	Cooper test (12 min), Wingate Anaerobic power)
(AGNE`; FARGEAS-GLUCK; GER, 2012) (28)	20 MST, NAVTEN
(WILKINSON et al., 2012) (29)	CMJ, DJ, Specific Squash CODS, Multiple sprint test, 20 MST
(ULBRICHT, ALEXANDER; FERNANDEZ-FERNANDEZ; FERRAUTI, 2013) (30)	HGS, push-ups, sit ups, CMJ, repetition jump, 20 m (5m-10m), tennis specific sprint, MBT overhead, MBT forehand, MBT backhand, serve velocity, Hit and Turn tennis test
(FILIPČIČ; FILIPČIČ; LESKOŠEK, 2015) (31)	Backwards obstacle course, Forward bend on the bench, hand-tapping, sit-ups
(BARBAROS TUDOR et al., 2015) (32)	Treadmill running
(OLCUCU; VATANSEVER, 2015) (33)	Tennis Ball Throwing, 10 and 30 m sprint, STB, VJ, Flamingo Balance Test, SaR, Curl-up, 90º Push-up, Agility Illinois, Auditory and Visual Reaction Test and ITN Mobility Tests
(ULBRICHT, A et al., 2015) (34)	HGS, CMJ, 20 m, serve velocity, Hit and Turn tennis test
(TSOULFA et al., 2016) (35)	SaR, flexibility of the shoulder, 20 m, spider run, 20 MST
(KRAMER; VALENTE-DOS-SANTOS; et al., 2016) (36)	CMJ, 5 m
(ULBRICHT, A et al., 2016) (37)	HGS, push-ups, sit ups, CMJ, repetition jump, 20 m (5m-10m), tennis specific sprint, MBT overhead, MBT forehand, MBT backhand, serve velocity, Hit and Turn tennis test
(KRAMER; HUIJGEN; et al., 2016) (38)	SJ, CMJ, MBT overhead, MBT reverse overhead, ball throwing overhead, Spider test, 10 m (5m and 10m)
(FETT et al., 2017) (39)	HGS, push-ups, sit ups, CMJ, repetition jump, 20 m (5m-10m), tennis specific sprint, MBT overhead, MBT forehand, MBT backhand, serve velocity, Hit and Turn tennis test
(ABDULLAHI et al., 2017) (40)	SaR, VJ, LJ, Sit up, Push-up, 35m
(KRAMER et al., 2017) (41)	SJ, CMJ, MBT overhead, MBT reverse overhead, ball throwing overhead, Spider run, 10 m (5m and 10m)
(MÜLLER; VECCHIO, 2018) (42)	YOYOIR1, HAST, SJ, MBT, HGS
(SÖĞÜT; LUZ; KAYA; ALTUNSOY, 2019) (43)	HGS, Hexagon
(ÖZKATAR KAYA; KARAHAN, 2019) (44)	20 MST, RAST, VJ, MBT overhead, Spider run
(MADRUGA-PARERA et al., 2019) (45)	SLCMJ, SEBT, 180º CODS
(SÖĞÜT; LUZ; KAYA; ALTUNSOY; et al., 2019) (46)	HGS, Hexagon
(SOBKO et al., 2020) (47)	Sit-ups, jumps with skipping-rope, double jumps with skipping-rope, jumps with pulling the knees to the chest, push-ups, SLJ, 4x9 MST, 100 m run, pulling up on the bar, stretch of the upper-body forward from a sitting position
(FETT, J; ULBRICHT; FERRAUTI, 2020) (48)	HGS, push-ups, sit ups, CMJ, repetition jump, 20 m (5m-10m), tennis specific sprint, MBT overhead, MBT forehand, MBT backhand, serve velocity, Hit and Turn tennis test
(ÖZGÜR, B; HOTAMAN, 2020) (49)	20 m, 20 m backward, 20 m reaction speed, t-test, SaR, HGS, back and leg strength, SLJ, VJ, MBT, and 20 MST
(MADRUGA-PARERA et al., 2020) (50)	180° CODS, single leg jump (vertical jump), SLBJ, SLLJ, COD with isoinertial resistance (shuffle lateral step, cross overstep)

(COUREL-IBÁÑEZ, J.; HERRERA-GÁLVEZ, 2020) (51)	Side MBT, HGS, SEBT, Illinois Agility test, YOYO IR
(SÁNCHEZ-MUÑOZ et al., 2020) (52)	CMJ, HGS, lumbar isometric Strength, SaR
(ÖZGÜR, 2020) (53)	Overhead MBT, SLJ, HGS, back strength, leg strength (dynamometer)
(FERNANDEZ-FERNANDEZ et al., 2020) (54)	20 m (5-10 m), 505 COD
(DOBOS; NOVAK; BARBAROS, 2021) (55)	5 m, SLJ, overhead MBT, overhand ball throw, serve speed, hexagon, SaR, 10x5 MST, spider test, push-ups
(HERNÁNDEZ-DAVO et al., 2021) (56)	20 m (5m-10m), 505 mod, pro-agility, t-test, CMJ, triple leg-hop for distance, hexagon
(KRAMER et al., 2021) (57)	CMJ, 5 m
(COUREL-IBÁÑEZ, JAVIER; LLORCA-MIRALLES, 2021) (58)	Overhead MBT, MBT dominant side and non-dominant, CMJ, Abalakov, Padel agility test, 3x10 MST
(PRADAS et al., 2021) (59)	HGS, SaR, 10x5 MST, CMJ, SJ, Abalakov, 1 RM (BP, LP, LE, LC, LaP, OP, SP), treadmill running
(LUNA-VILLOUTA et al., 2021) (60)	SaR, 20 m (5-10m), overhead MBT, CMJ, TAT, isometric mid-thigh pull, HGS, repeat sprint ability, Hit and Turn tennis test, tennis groundstroke assessment
(SÁNCHEZ-PAY et al., 2021) (61)	HGS, CMJ, MBT shot put, MBT overhead, serve velocity test
(FERNANDEZ-FERNANDEZ et al., 2021) (62)	20 m (5-10 m), hexagon, 505 COD, CMJ bilateral and unilateral
(PRADAS et al., 2022) (63)	HGS, tapping test, SaR, SJ, CMJ, Abalakov, Course Navette test, accelerations, lateral displacements and reaction time measurement
(AKDOGAN et al., 2022) (64)	SJ, CMJ, MRSAB
(VUONG et al., 2022) (65)	Tapping, CMJ, repetition jump, BJ, 20 m (5-10m), Tennis specific sprint test
(ROBERTSON et al., 2022) (66)	SaR, knee push up and sit-ups, SBJ, 10x5 MST, 30 m (5-10-20), 20 MST, CMJ, motor coordination test
(JAMES; JONES; FARRA, 2022) (67)	SPPT, 5 m, Squash specific CODS, Repeated-sprint ability test, SJ, CMJ
(ROȘCULEȚ et al., 2022) (68)	5 m, 10 m, 30 m, 6 x 20 m (maximum speed), LJ, consecutive lateral jumps, MBT (one and both arms), standing on the gym bench, bending the torso forward, lateral step test, hexagon, spider test, push-ups
(MORAIS; BRAGADA, 2022) (69)	Two-line-wide mode drill test
(BLAGUS et al., 2023) (70)	SJ, CMJ, Overhead MBT, 20 MST
(TURNER et al., 2023) (71)	SaR, 20 m (5-10m), overhead MBT, CMJ, TAT, Isometric mid-thigh pull, HGS, repeat sprint ability, Hit and Turn tennis test, tennis groundstroke assessment
(MANCHANDA et al., 2023) (72)	VJ, CKCUEST, repeated sprint test
(CHAPELLE et al., 2023)(73)	5m, 20 m, 505 COD, SBJ and SBJ in series, balancing backwards and jumping sideways, throw and catch test, hold tennis ball up test
(SINKOVIC et al., 2023) (74)	20 m (5m, 10m), 20 yards, 4x10 yards, t-test, sport specific CODS, sport specific RAG, CMJ, Single leg CMJ right and left, SJ, LJ, SLTJ
(FERNANDEZ-FERNANDEZ et al., 2023) (75)	CMJ, 10 m (5-10 m), 505 COD, on-court COD
(RYMAN AUGUSTSSON; OLSSON; HAGLUND, 2024) (76)	Isometric squat test, SJ, CMJ, sit-ups, side hop test each leg

HGS - handgrip strength; SaR - sit and reach; VJ - vertical jump; MBT - medicine ball throw; MB - medicine ball; SJ - squat jump; CMJ - countermovement jump; DJ - drop jump; MST - multiple shuttle test; RM - repetition maximum; NAVTEN - Navette-tennis; CODS - change of direction speed; SBJ - standing broad jump; ITN - international tennis number; LJ - long jump; HAST - handball agility specific test; YOYOIR1 - yo-yo intermittent recovery test level 1; RAST - running anaerobic sprint test; SLCMJ - single leg countermovement jump; SEBT - star excursion balance test; SLJ - standing long jump; SLBJ - single-leg broad jump; SLLJ - single-leg lateral jump; COD - change of direction; SLJ - standing long jump; BP - bench press, LP - leg press, LE - leg extension, LC - leg curl, LaP - lateral

pull downs, OP - overhead press; SP - shoulder press; TAT - tennis agility test; MRSAB - multiple repeated sprint ability test; BJ - broad jump; SBJ - standing broad jump; SPPT - squash physical performance test; CKCUEST - closed kinetic chain upper extremity stability test; RAG - reactive agility; SLTJ - single leg triple jump.

3.1. Racquet Sports Involved and Study Objectives

Among the sports that have generated the largest number of studies evaluating physical performance in racket sports, tennis stands out with the inclusion of 40 articles, badminton 9, padel 7 and squash 4 articles.

The studies had the following objectives discriminating or comparing different competitive levels, age categories, gender and maturational stage (22 articles); investigating how variables such as maturational level, anthropometry and asymmetries can interfere with physical performance (19 articles); assessing the physiological profile and characterising the physical fitness of athletes (13 articles); investigating the relationship between specific and non-specific tests or between different tests (6 articles); evaluating longitudinal changes in test batteries or specific tests (5 articles); investigating performance in specific tests (4 articles); analysing how physical performance influences technique (speed or accuracy of strikes) (4 articles); establishing percentiles/ benchmarks for certain groups (3 articles).

It has been demonstrated that the aggregate number of articles presented in conjunction with the objectives exceeds the number of articles included. This discrepancy can be attributed to the fact that certain articles are associated with multiple objectives.

3.2. Capacities Assessed and Physical Tests

Physical capacities are one of the variables related to the sport performance (4), and research into this component has attracted interest in the sports community in general, as well as in racket sports (6,77,78). Regarding to physical capacities, Table 2 shows the number of tests together with their variations. These capacities are not divided according to their characteristics as conditional or coordinative, they are presented in numerical order in terms of the number of tests listed for each physical capacity.

Table 2. *Physical capacities and number of tests/variations.*

Physical Capacities	Number of tests /variations	Tests
Balance	2	Flamingo, SEBT
Flexibility	3	SaR, shoulder flexibility, standing on the bench leaning the torso forward
Speed	8	20 m, 10 m, 5 m, 30 m, 35 m, 100 m, 20 m backwards, 20 m reaction speed
Coordination	8	Auditory and visual reaction, backwards obstacle course, jumping sideways, balance beams, moving sideways, take-off reaction test, double jumps with skipping-rope, jumps with skipping-rope
Endurance	9	20 MST, treadmill running, cycle ergometer, Cooper, 1 mile and half, CKCUEST, yo-yo intermittent, multiple sprints, jumps with pulling the knees to the chest
Strength	10	HGS, push-up, sit-up, curl-up, pulling on the bar, 1 RM, isokinetic dynamometer (flexor and extensor of knee), plantar flexors strength, isometric squat, isometric mid-thigh pull
Power Upper limb	11	MBT: overhead, chest pass, forehand, backhand, reverse overhead, side, one hand, both hands, shot put. Overhand ball throw, tennis ball throwing
Power Lower limb	14	VJ (8): CMJ, SJ, DJ, SLCMJ, consecutive lateral, multi rebound, repetition, Abalakov Horizontal jumps (6): LJ, *BJ, *SLJ, *SBJ, single leg lateral, single leg broad, standing broad in series, triple leg-hop for distance
Change of direction speed	15	Hexagon, Spider, Illinois, 505, 180º, sideways, sideways shuffle, 5 MST, 3x10 MST, 4x9 MST, T, lateral step test, tapping, HAST, pro-agility

SEBT - star excursion balance test; SaR - sit and reach; MST - multiple shuttle test;; CKCUEST - closed kinetic chain upper extremity stability test; HGS - handgrip strength; RM - repetition maximum; MBT - medicine ball throw; VJ - vertical jump; CMJ - countermovement jump, SJ - squat jump; DJ - drop

jump; SLCMJ - single leg countermovement jump; LJ - long jump; BJ - broad jump; SLJ - standing long jump; SBJ - standing broad jump.

*BJ, SLJ and SBJ are considered synonymies, and were computed only as one test.

A wide variety of tests were applied in the studies analysed totalling 104 tests. Of those considered general, a total of 80 are shown in the Table 2. As well as the 24 specific tests presented in the Table 3.

Table 3. *Summary of specific tests by modality*

Modality	Test	Characteristics	Technical
Padel	Paddle Agility Test (Tapas 6R)	CODS	No
Squash	Squash Field Test	Endurance	No
Squash	Squash specific graded test	Endurance	Yes, Simulated
Squash	Squash-specific change-of-direction speed	CODS	No
Squash	Squash-specific multiple-sprint test	Endurance	No
Squash	Squash physical performance test	Endurance	No
Badminton	Badminton field test	Endurance	Yes
Badminton	4 corners agility	CODS	Yes
Badminton	Sideways agility test	CODS	Yes
Badminton	On court COD	CODS	No
Badminton	Multiple Repeated Sprint Ability Test	Endurance and CODS	No
Tennis	Tennis Specific test	Endurance and agility	Yes
Tennis	NAVTEN	Endurance	Yes
Tennis	Hit and Turn Tennis	Endurance	Yes
Tennis	Tennis Specific Sprint	CODS	Yes, Simulated
Tennis	ITN - Mobility Test	CODS	No
Tennis	Serve velocity	Speed	Yes
Tennis	Two-line-wide mode drill test	Endurance	Yes
Tennis	TENCODS	CODS	Yes
Tennis	TENRAG	Agility	Yes
Tennis	TAT	Agility	Yes, Simulated
Tennis	Tennis ball control throw	Coordination	No
Tennis	Tennis ball control catch	Coordination	No
Tennis	Hold tennis ball up test	Coordination	No

CODS - change of direction speed; COD - change of direction; NAVTEN - Navette tennis; ITN - international tennis number; TENCODS - tennis change of direction; TENRAG - tennis reactive agility; TAT- tennis agility test.

In view of the comprehensive list of tests that have been collated, the Table 4 presents a concise overview of the most frequently used tests.

Table 4. *Most commonly tests used to assess racket sports*

Test	Number of articles	Percentage (%)
CMJ	28	46,7
HGS	21	35,0
20 m (10 m and 5 m)	17	28,3
MBT overhead	16	26,7
SaR	13	21,7
SJ	12	20,0
Push-up	11	18,3
Sit-up	10	16,7
20 MST	10	16,7
CODS – Hexagon	7	11,7
CODS – Spider	7	11,7

CMJ - countermovement jump; HGS - handgrip strength; MBT - medicine ball throw; SaR - sit and reach; SJ - squat jump, MST - multiple shuttle test; CODS - change of direction speed.

4. DISCUSSION

The results of this study highlight the preference for research involving tennis among all other racket sports. The objectives of the studies included in the analysis largely assessed whether differences in

sociodemographic variables (e.g, age, gender) biological or physiological variables (maturational stage), and classificatory variable (competitive level or age categories) and anthropometric data affected performance in physical tests applied to athletes practicing racket sports. Among the physical tests used, the countermovement jump, hand grip strength and linear sprints were the most used in the studies.

Tennis was the sport that had the most articles included, with 67% of the total. We understand that this predominance is due to its tradition and growing popularity. Data from 2023 recorded 4.8 million new tennis players in the United States, an increase of 14% on the previous year (79). Furthermore, in 2024, tennis was played by 106 million people worldwide, an increase of 25.6% over the last five years. A possible explanation for this phenomenon could be the global visibility of the sport and the emergence of high-performance athletes from different regions of the world (80).

The other sports that produced papers included in the review were, respectively, badminton 15%, padel 12% and squash 6%. It should be noted that padel is the only sport not classified among the main racket sports (1). However, in recent years there has been great demand for and development of this and other racket sports (81,82) It is therefore important to carry out studies that investigate the popularity and scope of these newer sports, as well as to produce research that contributes to their development.

Regarding the aims of the studies, the majority sought to discriminate or compare different competitive levels (42), age categories (83), gender (59) and maturational stages (46). In addition, others aim to investigate how specific variables, such as maturational level and emphasis on certain motor skills, influence physical performance. Such investigations provide valuable insights for planning more effective training strategies aimed at achieving better sporting performances at the various stages of athletes' development (55,84) .

The main aim of the study was to recognise the physical tests most used in racket sports. Both laboratory and field tests were used, with field tests being more prevalent. Data from laboratory tests provide sensitive measures of physiological function, as they are carried out in a controlled environment and can detect significant variations in physiological capacities, but they are not as specific, as well as being more time-consuming and expensive, making them difficult to apply on a large scale. Field tests, in contrast, require minimal equipment, facilitate the testing of large groups and are more specific to sports (85,86).

Racket sports, due to their intermittent nature, require constant high-intensity efforts. According to a recent ACSM publication, tests in intermittent sports can be classified as follows, according to the duration of the high-intensity efforts: the ability to perform short explosive efforts, to perform short explosive efforts over a limited period of time and to sustain longer periods of intense intermittent exercise (87). Within this classification, the most used were those characterised by the ability to perform short explosive efforts, such as countermovement jump, handgrip strength, linear sprints that asses 20, 10 and 5 m, medicine-ball throwing overhead and squat jump.

It has been demonstrated that these physical tests are regarded as being significant within the domain of racket sports, and they have been extensively utilised and preferred in comparison to other methods that involve high-intensity stimulation over an extended duration. One potential explanation for this phenomenon is that these tests are more straightforward to incorporate into the training routine, resulting in a reduced degree of physical exertion when compared to longer, high-intensity tests. Consequently, they exert a lesser influence on other training components, such as technical and tactical aspects. Furthermore, it is important to emphasise the use of these tests as a possibility to monitor neuromuscular fatigue, an important variable within the training programme (88,89)

Regardless of the sport, the most frequently used test in studies was the CMJ, which is regarded as one of the most widely used for monitoring neuromuscular status in both individual and team sports (90). The assessment of lower limb power is related to the specific movements' characteristic of racket sports, which require efficient footwork. A particular movement is considered to be of great importance in this context: the split step. As with the CMJ, the split step involves the muscular action of the lengthening-shortening cycle, which allows the feet to start moving more quickly, something of great importance in racket sports (91,92)

Another test that has been extensively utilised in numerous studies is HGS, which quantifies the maximum static force that a hand can exert when using a dynamometer (93). In racket sports, the hand interacts with the racket implement, thus constituting the final link in the kinetic chain where forces and

torques are transferred to the implement (94). It is imperative to possess at least moderate handgrip strength, as insufficient strength can hinder the execution of specific skills (95). Conversely, an adequate level of strength can optimise performance and potentially prevent injuries (94).

An analysis of the preceding tests shows that they assess conditional physical capacities. The actions characteristic of racket sports games invariably demands a high level of coordinative skills, most notably the need to change direction. A recurrent observation in racket sports is the necessity for constant changes of direction during points, which is regarded as one of the most significant athletic skills demanded in these sports (96,97). Of the tests incorporating these characteristics, the hexagon and the spider were the most frequently employed.

In both tests, elements clearly present in racket sports' movement cycles are identified. Within the hexagon, the lengthening-shortening cycle is evident, and it is imperative to respond quickly to the perception of the opponent's strike so that from the split step, the elastic energy is used for explosive movements towards the object to be hit. The "spider" test, in complement, involves a change of direction, followed by a subsequent recovery of positioning to accompany the move.

To supplement the most frequently employed assessments, the following evaluations are employed: the sit-and-reach test, linear speed tests with distances ranging from 20 to 5 metres, push-ups and sit-ups, and the 20-metre shuttle-run test. It is important to note that these tests are different from each other, but together they assess various physical capacities that are considered important in racquet sports. Although the tests are described and presented as the most commonly used in racquet sports, most are part of a battery of tests. The use of such test batteries supports the finding that in many sports there is no single motor skill that can characterise the sport, but rather the need for an interaction between these skills that leads to high performance (5,77,98).

In addition to all the tests that are widely used and accepted in sports science, those that are sport-specific have been increasingly used, involving movements based on the physical demands of the matches, looking for elements similar to the game (58), movements with simulated strikes (22), or even movements that include the technique itself (99). Of these, those with technical elements bring the scenario closer to real sports conditions, and this interaction of physical and technical capabilities tends to be more predictive than physiological tests alone (5).

5. LIMITATIONS

This review has some limitations, as only articles in English and Portuguese do not represent the totality of studies dealing with physical testing in racket sports. In addition, there was little detail on the use of specific tests for athletes who play singles or doubles, or even mixed doubles, as well as the lack of studies on some more recent sports, such as pickleball and beach tennis. Another limitation is related to the nomenclature of the tests, as well as the lack of detailed descriptions of the assessment protocols in some articles, making it difficult to compare the studies.

However, the strengths of the study are to provide a rationale for the main tests included in the assessment of rackets sports. Despite, it seems contradictory, the limitations cited above can be considered as potential strengths as well, since they have knowledge gaps and can direct improvement to future research, as well as suggesting greater production of knowledge in modalities that are still lesser explored, which seems to be a purpose of scoping reviews.

6. CONCLUSION

Racquet sports are in constant development. This scoping review can be used by sports science professionals who consider evaluation to be important in the context of sports performance, especially to understand the most used tests within test batteries as well as the battery or set of tests applied. We concluded that a wide range of tests are applied and used for different purposes, with those that use short explosive efforts being the most frequent, with the CMJ being the most widespread, but also with wide use of linear speed tests of up to 20 m, HGS, MBT overhead. Tests that involve sustaining short explosive efforts for a limited period of time include push-ups, sit-ups, as well as CODS tests such as the hexagon and spider. On the other hand, the ability to sustain longer periods of intense intermittent exercise was more frequently assessed by the 20 MST. In addition to the tests already widely used, sport-specific tests appear to be the ideal complement to the aspects not covered by the general tests, with more specific characteristics of the sport, such as COD, intermittent running, either alone or

combined with the simulation of strike, or strike itself. This attempt to include technical elements alongside physical ones could be a way of enriching and making more ecologically valid forms of assessment, providing challenges and greater athlete engagement. We therefore recommend the development of test batteries that include a comprehensive view of physical fitness for racket sports, but the possibility of applying reduced batteries that can be applied more frequently within a season or during specific periods of preparation could be a viable and useful alternative for assessing sports performance.

AUTHOR CONTRIBUTIONS

MLDZ and SMB devised the revision. MLDZ performed the online registration of the study and the literature search. MLDZ, HEGN and GS made inclusion and exclusion decisions. MLDZ wrote the final manuscript that was reviewed and approved by all authors.

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The authors declare that they have no conflicts of interest.

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