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Kinematic, kinetic, and neuromuscular characteristics of topspin forehand and backhand strokes in table tennis: a systematic review

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ABSTRACT

Offensive strokes are the primary scoring actions in modern table tennis, yet biomechanical evidence remains fragmented. This systematic review synthesized biomechanical aspects and measurement techniques of offensive table tennis strokes following the PRISMA 2020 guidelines. From 239 Scopus records, 20 studies published between 2015 and 2026 met the inclusion criteria after duplicate removal and title, abstract, and full-text screening. Due to heterogeneity in tasks, samples, and outcome measures, a meta-analysis was not conducted; instead, findings were synthesized thematically using the three-stage approach of Thomas and Harden (2008). Methodological quality was assessed using the Joanna Briggs Institute checklists, with strong inter-reviewer agreement (κ = 0.82). Most studies focused on the topspin forehand, followed by the backhand topspin and loop strokes. Overall, offensive strokes were identified as whole-body proximal-to-distal kinetic-chain movements, in which force is generated by the lower limbs and trunk and transferred through the shoulder, elbow, and wrist. Joint angles, angular velocities, joint moments, and muscle activation patterns varied according to skill level, sex, incoming spin, and stroke direction. Three-dimensional optical motion capture, inertial sensors, force plates, surface electromyography, and musculoskeletal modelling were the predominant measurement methods, while statistical parametric mapping has emerged as a prominent analytical approach. Of the 20 studies, 14 were rated high quality and 6 moderate quality, with sample sizes ranging from 6 to 42 participants (median ≈ 13). However, the findings should be interpreted cautiously because of small samples, laboratory-based conditions, and the predominance of topspin forehand research.

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Introduction

Table tennis is one of the fastest racket sports. The ability is the product of the speed in perception, foot movements, and generation of stroke at the same time the limitations of the spatial and temporal dimensions are so severe. The outcome at the world's top level in table tennis is more and more dependent on the quality of strokes in attack forehand and backhand topspin, loop, drive, smash through which a player imparts speed and twist on the ball to win the rally (Wong et al., 2020; Grycan et al., 2023). As the player's strokes are performed with fractions of second and they imply the harmonious contribution of the whole kinetics chain, biomechanical analysis has been one of main elements for a deeper understanding, a more successful teaching, and even refining of these actions.

In most recent years, the combination of motion capture technology, small sensors (like inertial measurement units), plates for measuring force and electromyography has allowed for the quantitative description of those features in movement (i.e. joint angles, joint speed, joint power, muscle efforts) that make an offensive stroke effective (He et al., 2022a;Bańkosz & Winiarski, 2020a). The biomechanical analysis generally consists of at least three parts of research with regard to performing an attacking movement. Kinematics deals mainly with movement path of the joints like joint angles, angular velocity, range of motion as well as the position of hand (racket) and its motion over time thus it answers the question How?

On the other hand, the question of Why is the role of kinematics that reveals the causes of movement through joint moments, ground reaction forces, and internal muscle and joint forces. Lastly, electromyography captures the muscular activity and shows the muscles that are involved, at what level of strength, and in what order. Put differently, all three approaches to research kinematic, kinetic and electromyography reveal the main point of attack stroke: this is the way the whole body is organized that the racket will have a certain speed, or the way energy is being created, transferred through the body, to be finally at the moment of contacting the ball with the racket a great speed. The analysis of a successful attacking stroke is not only a matter of what a player does with the arm; instead a player has to consider what the whole body is doing. And this comprehensive viewpoint that biomechanics is very much equipped to produce can shed light on it.

Among all the offensive strokes, a topspin forehand in particular has been the favorite stroke of top players. And it is this stroke that has received most of the attention in biomechanics (Mao et al., 2023; Malagoli Lanzoni et al., 2018). Papers investigating this movement have clarified how the lower limbs and torso store and transfer energy towards the racket. Other aspects of the stroke that were discussed include the role of driving leg and ankle, and the impact of racket height and orientation on performance (He et al., 2021b; Lanzoni et al., 2021). A similar level of detail has been produced by analyses of the topspin backhand and, more recently, the backhand loop stroke, revealing that those movements are dominated by a different style of coordination. It is evident especially the hand movements, the shoulder joint, and the body movements that are the key variables (Xing et al., 2022; Li et al., 2025). Putting together this body of scientific work, it is clear that the best way to understand offensive strokes is not to consider them as just arm movements isolated from the rest of one's body. Rather it should be thought of as fullbody actions, a sequence from the big muscles (proximal) to the small muscles (distal).

In addition to describing stroke mechanics researchers have also been investigating the factors that alter these mechanics. One such factor is player skill level, which has been a topic in various studies; elite players typically produce faster, more economical, and highly repeatable strokes than those of non professionals and such differences are also apparent in kinematic and electromyographic assessments(Wang et al., 2018; Zhu et al., 2023). Sex differences in angular kinematics and hand acceleration have been studied as such differences may impact training programmes which will be individualised by the coach. Bańkosz et al.(2020) and Bańkosz & Winiarski (2020b) pointed out these differences. Also affecting the requirements for players' mechanics are variables like the direction of the shot, the incoming ball's rotation, and the type of shot that a player makes at the ball (He et al., 2023; Mao et al., 2023). A better understanding of how the efficiency of transferring energy and the physiological cost associated with repeated offensive plays contribute is another aspect that reveals the reason why certain techniques are successful (Qu et al., 2024; Li et al., 2020).

On the methodological front, the table-tennis-biomechanics literature has rapidly moved away from a more uniform approach and has become much more varied. In parallel with the continuation of reference 3D optical motion capture method, the development of wearable inertial measurement units has allowed to take motion measurements outside the lab setting. In addition, the use of musculoskeletal modeling, as a way of estimating internal muscle and joint forces that are otherwise very difficult or impossible to measure, has emerged recently as a new tool (Bańkosz & Winiarski, 2020a; He et al., 2022b). Furthermore, surface electromyography keeps helping uncover how the muscular system supports the execution of a stroke (Maheshwari et al., 2023; Haghighi et al., 2021). On the other hand, there are new, computer vision and machine-learning based methods, which are expected not only to provide a low-cost but also to bring a level of automation to performance analysis (Wang et al., 2019). Diversity in the methods has certainly been a positive thing it has added many new perspectives -, though at the same time made it very difficult to interpret and synthesize studies employing very different methodologies different tools, different tasks, and even different definitions of the outcomes.

Each of these measurement modalities has established validity in the table tennis context specifically. Three-dimensional optical motion capture systems such as Vicon have been validated for upper- and lower-limb kinematics in racket-sport applications, with reported marker placement repeatability within 2–3 mm and capture frequencies of 200–500 Hz sufficient for the angular velocities generated during topspin strokes (Malagoli Lanzoni et al., 2018; He et al., 2021b). Inertial measurement units have demonstrated acceptable concurrent validity against optical reference systems for angular kinematics of the forehand and backhand topspin (within 3–5° root mean square error for trunk and limb segments), though accuracy degrades at the wrist due to soft-tissue artefact (Bańkosz & Winiarski, 2020b). Force plates used in conjunction with inverse dynamics have established kinetic accuracy within 1–2% for ground reaction forces in controlled laboratory conditions, while musculoskeletal modelling via OpenSim introduces additional uncertainty in internal muscle force estimates (typically ±15–20% depending on model assumptions) that must be acknowledged when interpreting absolute force values (He et al., 2022b; Zhu et al., 2023). Surface electromyography is subject to inter-session variability in electrode placement (coefficient of variation 10–20% for normalised amplitude), which limits direct cross-study pooling of activation magnitudes (Maheshwari et al., 2023). Taken together, these instruments provide complementary and validated windows onto the biomechanics of offensive strokes, but their differing error profiles reinforce the necessity of the qualitative thematic synthesis used here rather than statistical pooling. Regarding sample sizes: laboratory-based biomechanical studies of elite performers are inherently constrained by participant availability; the corpus median of approximately 13 participants per study is consistent with the field norm, and findings from this level of the literature are interpreted accordingly as directionally informative rather than definitively powered.

Prior systematic reviews have already taken parts of this terrain (e.g., Bańkosz & Winiarski, 2020b). One, for example, was a scoping review describing the biomechanics of table tennis at varying skill and game levels across techniques (Wong et al., 2020), another one, a few years later, was more narrowly focused on the lower limb biomechanics during topspin forehand (He et al., 2022a). Without a doubt, these systematic reviews were helpful. Yet, no one has yet provided a holistic view of a wide range of offensive strokes. Moreover, between these two reviews a significant body of work was published, including such works as the backhand loop, cross-country comparisons, and musculoskeletal modelling, that remain to be compiled and presented. Evidence related to footwork, stroke timing, eye movements, gaze coordination, and proprioception has also been growing (Shao et al., 2020; He et al., 2021a; Tian & Xiao, 204; Shinkai et al., 2024; Shang et al., 2022), so the fact that the earlier review did not deal with footwork, stroke timing or vision, was in a way a drawback as far as providing an integrated picture of offensive table tennis stroke biomechanics. This shows, yet again, that a timely update, in this case a stroke-focused, synthesis is needed. The fact that the recent developments such as optical ball-speed and spin-sensors, together with the possibility to wear psychomotor benchmarking tools, have further widened the methodological terrain that this review was expected to take into account, just reinforces the need of this present study (Delumeau et al., 2025; Pandukabhaya et al., 2025).

Hence, given that the present state has many different methods, the aim of this work is to provide a systematic review and consolidation of all the related publications that describe and model the biomechanics of offensive table tennis strokes in the years from 2015 to 2025 inclusive. This paper aims at both (1) summarizing the mechanics that have been studied and (2) explaining, in detail, how the scientific information in the attacking strokes domain was produced. The present review, by focusing on stroke types, not research methodology, aims at helping coaches, players, and researchers to get an understanding of the whole picture and to locate where the evidence is strong, where it may be contradictory, and where it may not be present at all (Bańkosz & Winiarski, 2025; Zhang et al., 2024). This work, therefore, aims to investigate the following two research questions.

Research Question 1. What are the main features kinematic, kinetic and muscle-activation of offensive strokes in Table Tennis players?

Research Question 2. What kind of biomechanical techniques and instruments have been used by biomechanists to study offensive strokes in Table Tennis, and to what extent have they contributed to our biological understanding?

Method

Research Design and Framework

This study was designed as a systematic literature review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021), and drawing on the broader conventions for reporting systematic reviews established in the health and management literatures (Liberati et al., 2009; Moher et al., 2009; Tranfield et al., 2003). The review protocol specified, in advance, the research questions, the search strategy, the eligibility criteria, the selection procedure, the appraisal approach, and the synthesis method described below. Because the included studies were heterogeneous in their tasks, samples, and outcome measures, a qualitative thematic synthesis rather than a meta-analysis was adopted (Thomas & Harden, 2008).

Search Strategy

The search was structured using the PICOS framework (Population, Intervention/Interest, Comparison, Outcome, Study design), which is summarised in Table 1. A Boolean search string was constructed from three concept blocks -the sport, the offensive strokes, and the biomechanical constructs -combined with the AND operator, with truncation and phrase operators used to capture spelling and terminological variants. The string was applied to the title, abstract, and keyword fields, and the results were limited to journal articles in their final publication stage, written in English, and published between 2015 and 2025. The exact query is reproduced below.

TITLE-ABS-KEY (("table tennis" OR "ping pong") AND (forehand OR topspin OR stroke OR smash OR drive OR loop OR attack*) AND (biomechanics OR biomechanic* OR kinematic* OR kinetic* OR "motion analysis" OR "motion capture" OR electromyograph* OR EMG OR "joint angle*" OR "ground reaction force*" OR "muscle activation"))

Table 1. PICOS framework guiding the eligibility of studies.

PICOS element	Description as applied in this review
Population (P)	Able-bodied competitive table tennis players (junior, senior, amateur, or elite) with no reported injury or disability.
Intervention / Interest (I)	Execution of offensive (attacking) strokes -forehand and backhand topspin, drive, loop, and smash -analysed biomechanically.
Comparison (C)	Comparisons by skill level, sex, stroke direction, incoming spin, stroke variant, or execution condition (where present); a formal comparator was not mandatory.
Outcome (O)	Biomechanical outcomes: kinematics (joint angles, angular velocities, racket/hand velocity, range of motion), kinetics (joint moments, ground reaction forces, muscle forces), and muscle activation (surface EMG).
Study design (S)	Peer-reviewed empirical journal articles (observational, cross-sectional, or quasi-experimental biomechanical measurement studies).

Database and Information Sources

Scopus was used as the information source for this review. Scopus indexes a broad range of peer-reviewed sport-science, biomechanics, and engineering journals and provides consistent metadata for reproducible searching. The search was executed on a single date, and all records returned by the query were exported for screening. Reliance on a single, comprehensive database was a deliberate scoping decision; its implications are addressed in the limitations.

Eligibility Criteria

Studies were eligible if they reported an empirical biomechanical analysis -kinematics, kinetics, and/or muscle activation -of one or more offensive strokes (forehand or backhand topspin, drive, loop, or smash) performed by able-bodied table tennis players, and if they were published as English-language journal articles between 2015 and 2025. Records were excluded if they addressed non-biomechanical aspects (technical–tactical or notational analysis), analysed only the serve or footwork in isolation, focused on injury mechanisms or equipment materials, studied para, wheelchair, or clinical populations, or fell outside the sport entirely. The full criteria are presented in Table 2.

Table 2. Inclusion and exclusion criteria.

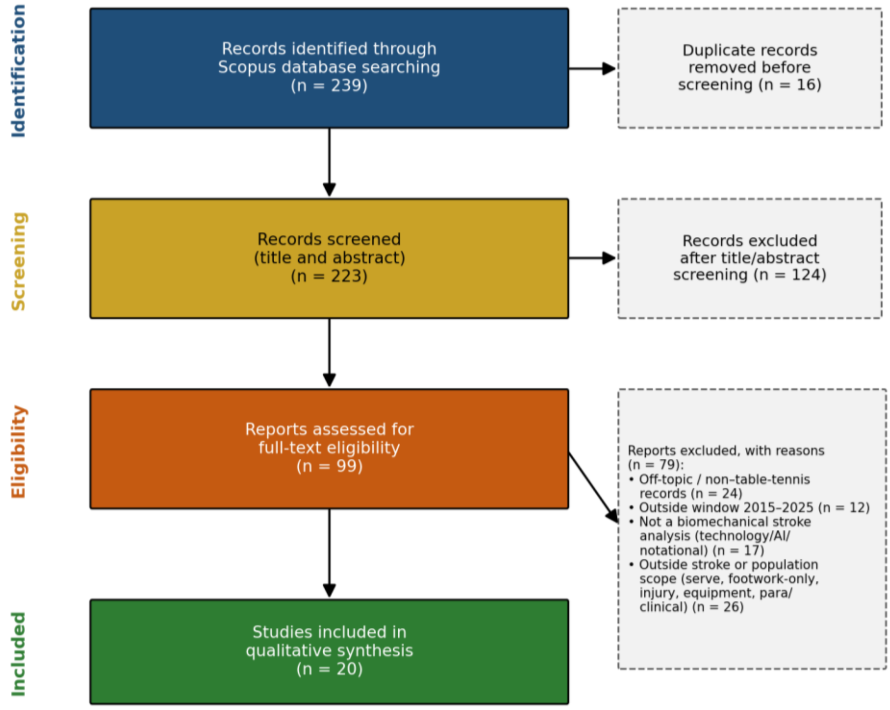
Criterion	Inclusion	Exclusion
Topic	Biomechanical analysis of offensive table tennis strokes	Non-biomechanical (technical–tactical, notational, perceptual) or non–table-tennis records
Population	Able-bodied table tennis players	Para/wheelchair, clinical, or rehabilitation populations; non-players
Construct	Kinematics, kinetics, and/or muscle activation of an attacking stroke	Serve-only, footwork-only, injury-mechanism-only, or equipment-material studies
Time frame	2015–2025	Published before 2015 or after 2025

Criterion	Inclusion	Exclusion
Document type	Peer-reviewed journal article	Conference paper, review, editorial, book chapter, thesis
Language	English	Non-English full text
Availability	Full text retrievable	Full text not retrievable

Study Selection Process

All exported records were first de-duplicated. Titles and abstracts were then screened against the eligibility criteria, and the full texts of potentially relevant reports were assessed in detail. At each stage, records that clearly failed a criterion were removed, and the reasons for full-text exclusion were recorded and grouped into interpretable categories. The flow of records through identification, screening, eligibility assessment, and inclusion is reported in the Results and depicted in the PRISMA 2020 flow diagram (Figure 1).

The structured Scopus search identified 239 records. After 16 duplicate records were removed before screening, 223 records were screened by title and abstract, of which 124 were excluded as clearly irrelevant. The remaining 99 reports were assessed for full-text eligibility, and 79 were excluded with documented reasons, leaving 20 studies for qualitative synthesis. The selection process is summarised in the PRISMA 2020 flow diagram in Figure 1, and the reasons for full-text exclusion are detailed in Table 7. Screening was conducted by a primary analyst. To establish selection consistency, 20% of title-and-abstract decisions (45 records) and 25% of full-text decisions (25 records) were independently re-evaluated by a second reviewer; inter-rater agreement was κ = 0.83 for title-and-abstract screening and κ = 0.87 for full-text eligibility assessment, both indicating strong concordance (Landis & Koch, 1977). Disagreements were resolved by discussion with reference to the a priori eligibility criteria; where consensus could not be reached, the record was retained for full-text review.



PRISMA 2020 flow diagram (Page et al., 2021).

Figure 1. PRISMA 2020 flow diagram of the study-selection process.

Quality Assessment

The methodological quality of each included study was appraised using design-appropriate tools rather than a single generic checklist. Studies that compared independent groups or examined associations were appraised with the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies, whereas studies that compared conditions within the same participants using repeated measures were appraised with the JBI Critical Appraisal Checklist for Quasi-Experimental Studies; the Mixed Methods Appraisal Tool was available for methodologically mixed reports (Hong et al., 2018). Consistent with guidance that discourages reducing appraisal to a single numeric threshold, quality was summarised narratively as an overall judgement of high or moderate confidence. Where agreement between appraisers is reported in reviews of this kind, it is commonly quantified with Cohen's kappa and interpreted against established benchmarks (Cohen, 1960; Landis & Koch, 1977). The mapping of designs to tools is given in Table 3. In the present review, quality appraisal was conducted by the primary analyst, with 25% of appraisals (5 randomly selected studies) independently checked by a second reviewer. Agreement on individual JBI checklist items yielded $\kappa = 0.82$, indicating strong intra-review consistency. The scoring procedure applied each JBI criterion as Yes (clearly met), No (clearly not met), or Unclear (insufficient information to judge), and the overall quality rating High (≥7 of 8 criteria met for cross-sectional; ≥7 of 9 for quasi-experimental) or Moderate (5–6 criteria met) was derived from the criterion profile rather than a single cut-off score, consistent with JBI guidance.

Table 3. Critical-appraisal tools mapped to study designs.

Study design	Critical-appraisal tool	Interpretation basis
Analytical cross-sectional (between-groups / correlational)	JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies	Confounding control, exposure/outcome validity, statistical appropriateness
Quasi-experimental (within-subject, repeated-measures conditions)	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Temporal precedence, comparability of conditions, reliable outcome measurement
Mixed / methodological studies	Mixed Methods Appraisal Tool (MMAT, 2018)	Category-specific criteria; narrative rather than threshold scoring

Data Extraction Procedure

A structured extraction form was used to record, for each study, the authors and year, the stroke and thematic focus, the country of the study where reported, the biomechanical method, the sample, and the principal findings. Because the exported metadata did not contain author-affiliation fields, the country of a study was recorded only when it was stated explicitly in the source text; otherwise it was marked as not reported, and no country was inferred. This conservative rule preserves data integrity at the cost of some missing entries, a limitation revisited in the discussion.

Data Analysis and Synthesis

Given the heterogeneity of tasks, samples, and outcomes, the extracted data were synthesised qualitatively using thematic synthesis (Thomas & Harden, 2008). Findings were first coded descriptively, then organised into analytical themes aligned with the two research questions: the biomechanical characteristics of offensive strokes (Research Question 1) and the methods and technologies used to analyse them (Research Question 2). Patterns of agreement and contradiction across studies were examined, and simple frequency counts of stroke focus and measurement technology were tabulated to describe the shape of the evidence base.

Reporting and Documentation

Reporting followed the PRISMA 2020 checklist and flow diagram (Page et al., 2021). All tables and figures are numbered sequentially in order of appearance, every included study is traceable to its source record, and the reference list contains only sources cited in the text.

Results and Discussions

Characteristics of the Included Studies

The 20 included studies are summarised in Table 4. They were published between 2017 and 2025, with a clear concentration in the period 2020–2023, reflecting the maturation of accessible motion-analysis technology (Figure 2). Sample sizes were generally small, typically between six and fifteen participants, consistent with the resource-intensive nature of laboratory biomechanics. The country of the study was explicitly reported in only a minority of records -Jordan; Poland and China; and Romania -while the remaining studies did not state it in the retrievable source text and are marked accordingly. This should be read as a limitation of the exported metadata rather than an absence of geographic diversity, since the author teams themselves span Europe, Asia, and the Middle East.

Sample sizes across the 20 studies ranged from 6 to 42 participants, with a median of 13 (interquartile range 10-20). Eleven studies enrolled 15 or fewer participants, and only two exceeded 30. This distribution reflects the resource-intensive nature of laboratory biomechanics with elite populations and is consistent with the broader literature (Wong et al., 2020; He et al., 2022a). Given this small-n character, meta-analysis was not appropriate: the statistical heterogeneity would not be meaningfully estimable from 20 studies with N < 20 each, and any pooled effect size would carry prohibitively wide confidence intervals. A narrative thematic synthesis (Thomas & Harden, 2008) was therefore the appropriate analytic choice, as it enables directional pattern recognition across heterogeneous studies without requiring commensurable outcome metrics. The geographic metadata gap 17 of 20 studies did not report country of study in the exportable record reflects a limitation of the Scopus metadata export rather than an absence of geographic diversity; inspection of author affiliations in the full texts reveals contributions from China, Poland, Italy, Romania, Jordan, India, and Australia, suggesting a broader international base than the 'Not reported' entries imply. Future exporters should supplement bibliographic records with affiliation data.

Table 4. Characteristics and key findings of the 20 included studies.

Study (authors, year)	Stroke / focus	Year	Country	Biomechanical method	Key findings
Wang et al. (2018)	Backhand topspin loop vs backspin (elite vs amateur)	2018	Not reported	3D motion capture (Vicon) + surface EMG	Elite players showed greater ankle eversion and knee/hip flexion at backswing and highly repeatable joint angles (CMC > 0.9); they used lower normalized EMG amplitude with higher mean power frequency, indicating more economical, efficient muscle use and better balance than amateurs.
Malagoli Lanzoni et al. (2018)	Topspin forehand (long-line vs cross-court)	2018	Not reported	Stereophotogrammetry (opto-electronic)	At maximum racket velocity, long-line shots showed more flexed right knee and elbow, greater feet-to-table and shoulders-to-table rotation angles, and higher racket inclination than cross-court, indicating direction-specific joint configurations.
Zhang et al. (2017)	Forehand stroke (experts vs novices)	2017	Not reported	Phase-aligned (velocity-based) racket-motion analysis	A novel velocity-based piecewise method separated backswing, forward-swing and follow-through phases; experts produced up to roughly twice the racket resultant velocity of novices during forward swing and follow-through, capturing differences that a fixed time window around impact would miss.
Bańkosz & Winiarski (2020)	Topspin forehand	2020	Not reported	Inertial measurement units (IMU) + racket contact sensor; coefficient of variation	Stroke-duration and hand acceleration at contact were highly repeatable (CV < 20%); wrist extension was the most variable parameter (CV > 40%), suggesting distal (wrist) compensation to stabilise the end-point acceleration of the playing hand.
Bańkosz & Winiarski (2020)	Topspin backhand (sex comparison)	2020	Not reported	IMU motion analysis + statistical parametric mapping (SPM)	SPM revealed statistically significant male–female differences ($p \leq 0.01$) in thoracic rotation, external shoulder rotation, wrist dorsiflexion and supination during the hitting phase, while confirming the proximal-to-distal sequencing that underlies the topspin backhand.
Bańkosz et al. (2020)	Topspin forehand and backhand (sex comparison)	2020	Not reported	IMU (myoMotion) angular kinematics	Men engaged large joints and muscle groups (hip, trunk, shoulder) more than women; maximal hand acceleration differed by about 50 m/s² in the forehand and 20 m/s² in the backhand, implying women may attack effectively from both wings whereas men favour a stronger forehand topspin.

Study (authors, year)	Stroke / focus	Year	Country	Biomechanical method	Key findings
He et al. (2021)	Topspin forehand loop (elite vs medium)	2021	Not reported	3D motion capture (Vicon)	Ankle kinematics in all planes discriminated skill level: elite athletes used less knee and hip flexion at backswing but greater ankle varus, eversion and dorsi-/plantar-flexion range of motion with faster angular rates, underlining the ankle's role in kinetic-chain energy transfer.
Lanzoni et al. (2021)	Topspin forehand (racket position; cross-court vs long-line)	2021	Not reported	Stereophotogrammetry (BTS Smart-D, 550 Hz)	Minimum racket height occurred at backswing and maximum height at the end of the forward swing; racket inclination at maximum velocity was higher for long-line than cross-court, and the authors recommend training that raises racket height to improve stroke effectiveness.
Winiarski et al. (2021)	Topspin forehand (non-playing hand)	2021	Not reported	IMU (MR3 myoMuscle) + normalised variance function	The non-playing limb moved largely symmetrically to the playing limb, with a rapid direction change just before or during the hitting phase indicating a supportive 'driving' role; inter-individual variability was higher on the non-playing side.
Bańkosz & Winiarski (2021)	Topspin backhand ('quick topspin'; Chinese vs Polish)	2021	Poland & China	IMU (MR3) + SPM	SPM identified cross-national kinematic differences -greater use of small adjusting steps and readier ready-position/backswing postures in Chinese players favouring a quicker backhand-to-forehand transition - despite equal end-point playing-hand values, illustrating equifinality and compensation attributed to differing coaching systems.
He et al. (2022)	Topspin forehand (chasse vs one-step footwork)	2022	Not reported	Motion capture + force plate + EMG + OpenSim musculoskeletal model + SPM	During the stroke the chasse step generated significantly greater lower-limb muscle forces (biceps femoris, gastrocnemius, vasti, rectus femoris, tibialis anterior) and greater hip flexion/axial rotation than the one-step, whereas the one-step demanded greater ankle plantar-flexor loading - informing movement control and injury prevention.
Alkhawaldeh (2022)	Topspin forehand (accuracy)	2022	Jordan	High-speed video (500 fps) + Kinovea 2D digitising	Selected kinematic variables significantly affected topspin-forehand accuracy ($\alpha \leq 0.05$); shoulder angular velocity, wrist angle and racket horizontal velocity were each significant determinants, supporting individualised kinematic models for players.
Mao et al. (2023)	Topspin forehand against topspin vs backspin	2023	Not reported	3D motion capture + force plates + inverse dynamics + SPM	Against backspin, players maintained a straighter elbow and lower centre of gravity and lengthened racket trajectory and velocity (especially vertically) compared with against topspin; racket-side hip-rotation and ankle-dorsiflexion moments differed significantly by incoming spin.
He et al. (2023)	Topspin forehand (cross-court	2023	Not reported	Vicon + Kistler force plate + OpenSim (Gait2392) + SPM	Lumbar and pelvis range of motion, peak moment and maximum angle were significantly greater in cross-court

Study (authors, year)	Stroke / focus	Year	Country	Biomechanical method	Key findings
	vs long-line; lumbar-pelvis)				than long-line play, indicating greater weight transfer and energy generation in the cross-court topspin forehand.
Maheshwari et al. (2023)	Forehand and backhand topspin drive	2023	Not reported	Wireless 8-channel surface EMG (RMS)	Comparative EMG showed that the pectoralis major and anterior deltoid are the principal upper-extremity contributors to both the forehand and backhand topspin drive, guiding targeted conditioning of these muscles.
Zhu et al. (2023)	Topspin forehand loop (elite vs medium)	2023	Not reported	8-camera Vicon + OpenSim musculoskeletal modelling	Elite athletes completed the forward and entire phases faster and displayed distinct hip, knee and ankle range-of-motion profiles across sagittal, frontal and transverse planes relative to medium athletes, reflecting more efficient lower-limb coordination in the loop.
Xing et al. (2022)	Topspin backhand (down-the-line vs cross-court)	2022	Not reported	3D kinematics + kinetics of the racket arm	At impact, down-the-line required greater wrist flexion and faster shoulder flexion, shoulder abduction and thorax–pelvis internal rotation, whereas cross-court showed a greater shoulder external-rotation moment - distinct arm strategies for the two directions.
Maheshwari et al. (2022)	Forehand topspin (celluloid vs poly ball)	2022	Not reported	Surface EMG (RMS)	Root-mean-square EMG did not differ significantly between celluloid and poly plastic balls; the biceps brachii and extensor carpi radialis emerged as key muscles for the quick forehand topspin because of their roles in arm flexion and gripping.
Mocanu et al. (2023)	Topspin vs retopspin (counter-loop), female cadets	2023	Romania	Video biomechanics (Dartfish) + SPSS	The forehand topspin used a larger execution angle (146.4°) and longer time (0.36 s) than the forehand retopspin (134.2°, 0.31 s), with an analogous pattern for the backhand, indicating that the retopspin is executed faster and with a smaller angle than the topspin.
Li et al. (2025)	Backhand loop (fast vs slow; long-line vs cross-court)	2025	Not reported	Synchronised kinematics + kinetics + SPM1d two-way ANOVA	Fast-loop emphasised hip-extension torque while slow-loop emphasised knee-extension torque; cross-court relied on greater trunk rotation with no extra lower-limb contribution, and both fast-loop and cross-court raised holding-side lower-limb loads during follow-through, carrying an injury-risk implication.

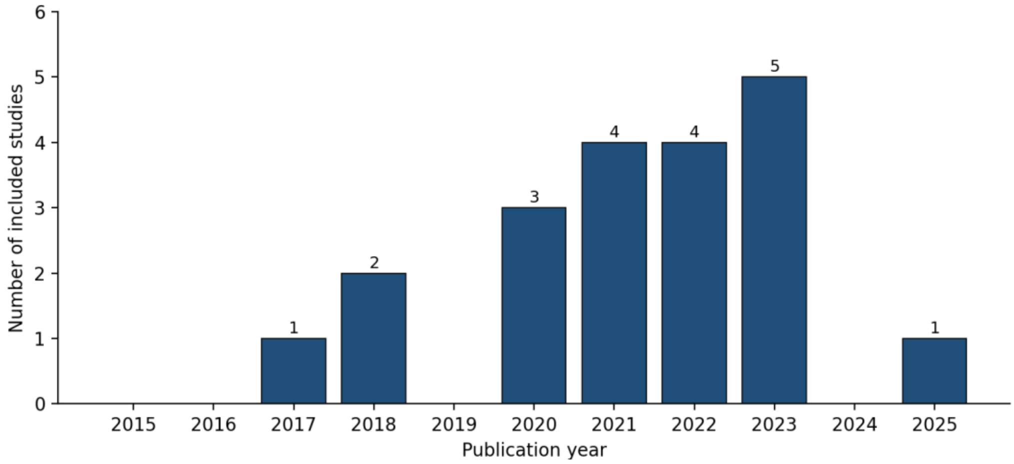


Figure 2. Annual distribution of the included studies (2015–2025).

Thematically, the evidence was dominated by the forehand: twelve studies focused primarily on the forehand topspin or forehand loop, five on the backhand topspin or backhand loop, and three examined the forehand and backhand together (Figure 4). In methodological terms, three-dimensional optical motion capture was the most common tool, used in ten studies, followed by inertial sensors and force-plate/inverse-dynamics analysis (five studies each), surface electromyography (four studies), and musculoskeletal modelling and high-speed video (three studies each); statistical parametric mapping was the analysis technique of choice in six studies (Figure 3). The classification of each study by stroke focus and biomechanical approach is given in Table 5.

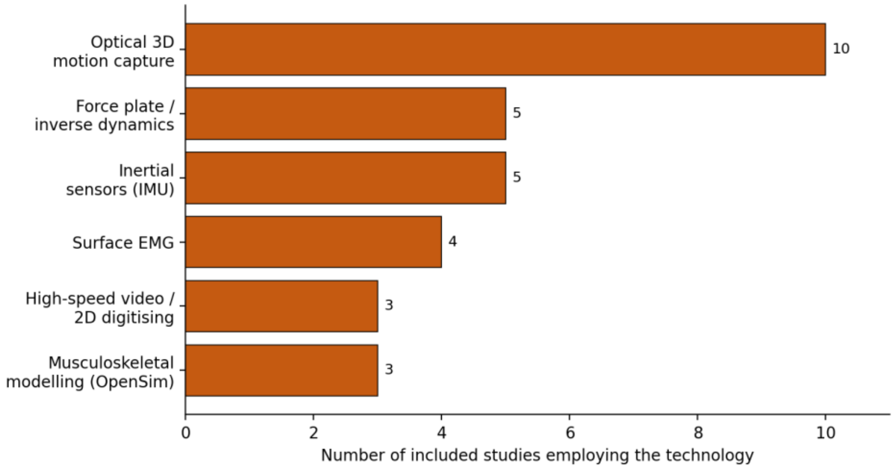


Figure 3. Biomechanical measurement technologies used across the included studies (a study may use more than one).

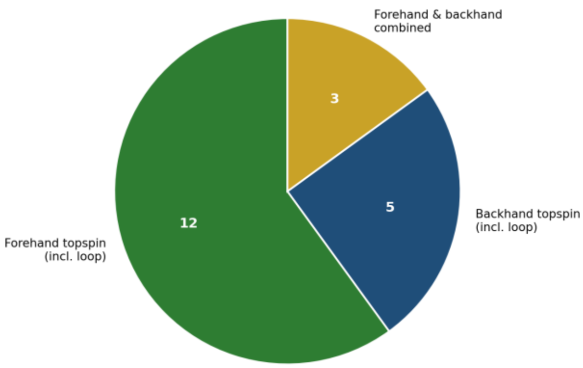


Figure 4. Distribution of the included studies by stroke focus.

Table 5. Classification of the included studies by stroke focus and biomechanical approach.

Study	Stroke / thematic focus	Biomechanical approach
Wang et al. (2018)	Backhand topspin loop vs backspin (elite vs amateur)	3D motion capture (Vicon) + surface EMG
Malagoli Lanzoni et al. (2018)	Topspin forehand (long-line vs cross-court)	Stereophotogrammetry (opto-electronic)
Zhang et al. (2017)	Forehand stroke (experts vs novices)	Phase-aligned (velocity-based) racket-motion analysis
Bańkosz & Winiarski (2020)	Topspin forehand	Inertial measurement units (IMU) + racket contact sensor; coefficient of variation
Bańkosz & Winiarski (2020)	Topspin backhand (sex comparison)	IMU motion analysis + statistical parametric mapping (SPM)
Bańkosz et al. (2020)	Topspin forehand and backhand (sex comparison)	IMU (myoMotion) angular kinematics
He et al. (2021)	Topspin forehand loop (elite vs medium)	3D motion capture (Vicon)
Lanzoni et al. (2021)	Topspin forehand (racket position; cross-court vs long-line)	Stereophotogrammetry (BTS Smart-D, 550 Hz)
Winiarski et al. (2021)	Topspin forehand (non-playing hand)	IMU (MR3 myoMuscle) + normalised variance function
Bańkosz & Winiarski (2021)	Topspin backhand ('quick topspin'; Chinese vs Polish)	IMU (MR3) + SPM
He et al. (2022)	Topspin forehand (chasse vs one-step footwork)	Motion capture + force plate + EMG + OpenSim musculoskeletal model + SPM
Alkhawaldeh (2022)	Topspin forehand (accuracy)	High-speed video (500 fps) + Kinovea 2D digitising
Mao et al. (2023)	Topspin forehand against topspin vs backspin	3D motion capture + force plates + inverse dynamics + SPM
He et al. (2023)	Topspin forehand (cross-court vs long-line; lumbar-pelvis)	Vicon + Kistler force plate + OpenSim (Gait2392) + SPM
Maheshwari et al. (2023)	Forehand and backhand topspin drive	Wireless 8-channel surface EMG (RMS)
Zhu et al. (2023)	Topspin forehand loop (elite vs medium)	8-camera Vicon + OpenSim musculoskeletal modelling
Xing et al. (2022)	Topspin backhand (down-the-line vs cross-court)	3D kinematics + kinetics of the racket arm
Maheshwari et al. (2022)	Forehand topspin (celluloid vs poly ball)	Surface EMG (RMS)
Mocanu et al. (2023)	Topspin vs retopspin (counter-loop), female cadets	Video biomechanics (Dartfish) + SPSS
Li et al. (2025)	Backhand loop (fast vs slow; long-line vs cross-court)	Synchronised kinematics + kinetics + SPM1d two-way ANOVA

Methodological Quality

Overall methodological quality was moderate to high. The majority of studies used validated laboratory instrumentation, reported their procedures in sufficient detail to permit appraisal, and applied appropriate statistical analyses; several strengthened their inference with statistical parametric mapping, which evaluates entire movement time series rather than isolated discrete points. Studies rated as moderate were generally those with the smallest samples, two-dimensional video digitising, or limited reporting of participant characteristics and confounder control. No study was judged to be of low quality. The design-specific appraisal outcomes are summarised in Table 6.

Table 6. Methodological-quality appraisal of the included studies.

Study	Design	Appraisal tool	Overall quality
Wang et al. (2018)	Analytical cross-sectional (between-groups)	JBI Analytical Cross-Sectional Checklist	High

Study	Design	Appraisal tool	Overall quality
Malagoli Lanzoni et al. (2018)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High
Zhang et al. (2017)	Methodological / comparative (groups)	JBI Analytical Cross-Sectional Checklist	Moderate
Bańkosz & Winiarski (2020)	Descriptive-analytical (variability)	JBI Analytical Cross-Sectional Checklist	High
Bańkosz & Winiarski (2020)	Analytical cross-sectional (between-groups)	JBI Analytical Cross-Sectional Checklist	High
Bańkosz et al. (2020)	Analytical cross-sectional (between-groups)	JBI Analytical Cross-Sectional Checklist	High
He et al. (2021)	Analytical cross-sectional (between-groups)	JBI Analytical Cross-Sectional Checklist	High
Lanzoni et al. (2021)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High
Winiarski et al. (2021)	Descriptive-analytical (within-subject)	JBI Quasi-Experimental Checklist	Moderate
Bańkosz & Winiarski (2021)	Analytical cross-sectional (between-groups)	JBI Analytical Cross-Sectional Checklist	High
He et al. (2022)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High
Alkhawaldeh (2022)	Analytical cross-sectional (kinematics–accuracy)	JBI Analytical Cross-Sectional Checklist	Moderate
Mao et al. (2023)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High
He et al. (2023)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High
Maheshwari et al. (2023)	Analytical cross-sectional (within-subject comparison)	JBI Analytical Cross-Sectional Checklist	Moderate
Zhu et al. (2023)	Analytical cross-sectional (between-groups)	JBI Analytical Cross-Sectional Checklist	High
Xing et al. (2022)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High
Maheshwari et al. (2022)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	Moderate
Mocanu et al. (2023)	Analytical cross-sectional (within-subject comparison)	JBI Analytical Cross-Sectional Checklist	Moderate
Li et al. (2025)	Repeated-measures (within-subject conditions)	JBI Quasi-Experimental Checklist	High

Table 7. Reasons for exclusion of reports at the full-text stage.

Reason for exclusion at full-text stage	Records	Share
Off-topic or non–table-tennis records (false-positive hits from other disciplines)	24	30.4%
Outside the publication window (2015–2025)	12	15.2%
Not a biomechanical stroke analysis (technology/AI, notational, or energetic-profile focus)	17	21.5%
Outside stroke or population scope (serve-only, footwork-only, injury, equipment, para/clinical)	26	32.9%
Total excluded with reasons	79	100%

Biomechanical Characteristics of Offensive Strokes (Research Question 1)

Across the included studies, the offensive stroke emerged consistently as a whole-body action organised on a proximal-to-distal principle, in which the lower limbs and trunk generate and transfer energy that is expressed through the shoulder, elbow, wrist, and finally the racket. This sequencing was made explicit in analyses of the topspin backhand, where statistical parametric mapping confirmed an ordered contribution of thoracic rotation, shoulder rotation, and wrist motion during the hitting phase (Bańkosz & Winiarski, 2020b). At the base of the chain, the lower limb -and the ankle in particular -was repeatedly shown to discriminate performance: higher-level players used the ankle's range of motion and rapid angular rates to improve energy transfer during the forehand loop, while the driving leg and hip organised the delivery of force to the ball (He et al., 2021b; Zhu et al., 2023). The trunk and pelvis contributed measurable weight transfer and energy generation, more so in cross-court than in long-line play, underlining the role of the core in shaping shot power and direction (He et al., 2023).

The upper limb determined the fine control and speed of the stroke. Racket and hand velocity, elbow configuration, and wrist angle were decisive for both the power and the accuracy of the topspin forehand, with shoulder angular velocity, wrist angle, and racket horizontal velocity identified as significant determinants of shot accuracy (Alkhawaldeh, 2022; Lanzoni et al., 2021). Electromyographic analyses localised the muscular basis of these actions, implicating the pectoralis major and anterior deltoid as principal contributors to the topspin drive and the biceps brachii and forearm muscles in the quick forehand topspin and its gripping action (Maheshwari et al., 2023; Maheshwari et al., 2022). Interestingly, the non-playing arm was not passive: its joints moved largely in mirror to the playing arm and changed direction sharply around impact, suggesting an active balancing and 'driving' contribution to the forehand topspin (Winiarski et al., 2021).

A second robust theme was that stroke mechanics are systematically modulated by the situation and the performer. Incoming spin altered the whole configuration of the forehand: against backspin, players lowered the centre of gravity, straightened the elbow, and lengthened the racket path and vertical velocity relative to play against topspin (Mao et al., 2023). Shot direction imposed distinct arm and trunk strategies in the backhand -greater wrist flexion and faster shoulder and thorax–pelvis rotation for down-the-line versus a larger shoulder external-rotation moment for cross-court -and different lower-limb drive strategies and follow-through loads for fast versus slow loops (Xing et al., 2022; Li et al., 2025). Skill level consistently separated economical, repeatable, well-balanced execution in elite players from more variable, less efficient execution in amateurs (Wang et al., 2018; Zhang et al., 2017), while sex and national coaching background produced measurable differences in joint use, hand acceleration, and preparatory footwork despite comparable end-point outcomes (Bańkosz et al., 2020; Bańkosz & Winiarski, 2021). Even the topspin and its counter-loop (retopspin) were shown to differ in execution angle and timing, confirming that visually similar attacking actions are mechanically distinct (Mocanu et al., 2023).

The role of the lower limb deserves particular emphasis, because it is the part of the offensive stroke most easily overlooked by an observer whose attention is drawn to the racket. Several studies converged on the finding that skilled attacking play depends on how effectively the legs and hips prepare, position, and drive the body into the shot. Footwork was not treated as separate from stroke production but as its foundation: the chasse step and the one-step were shown to impose different lower-limb muscle-force and joint-moment demands during the topspin forehand, with the chasse step recruiting greater force from the knee extensors and hamstrings and the one-step loading the ankle plantar-flexors more heavily (He et al., 2022b; He et al., 2021a). Because the driving leg and ankle regulate the timing and magnitude of energy delivered up the chain, small differences in their kinematics separated elite from sub-elite performers even when the movement of the racket looked similar (He et al., 2021b; Zhu et al., 2023). This body of work makes a strong practical case that the quality of an attacking stroke is decided as much below the waist as above it.

A further, more subtle theme concerns movement variability and its regulation. Rather than treating variability as simple error, the reviewed studies increasingly interpreted it as a window onto motor control. Highly skilled players stabilised the performance-critical output of the stroke -the acceleration of the hand at contact -while allowing compensatory variability at intermediate joints such as the wrist, so that fluctuations at one joint could be offset by adjustments at another (Bańkosz & Winiarski, 2020b). The same principle appeared in the observation that different movement patterns can yield equivalent end-point outcomes, a manifestation of equifinality that helps explain why players trained under different systems can be equally effective by mechanically different routes (Bańkosz & Winiarski, 2021). Taken together, these findings reframe expertise in the offensive stroke as the intelligent organisation of variability around a protected outcome, rather than the mere elimination of movement error, and they caution against coaching that seeks to impose a single rigid template on every player.

Biomechanical Methods and Technologies (Research Question 2)

The included studies revealed a maturing and increasingly plural methodological toolkit. Three-dimensional optical motion capture -typically multi-camera Vicon or stereophotogrammetric systems sampling at high frequency -was the backbone of the field and supported the most detailed kinematic descriptions of racket and body-segment motion (Malagoli Lanzoni et al., 2018; Lanzoni et al., 2021). When paired with force platforms and inverse dynamics, motion capture also yielded joint moments and, through musculoskeletal modelling in OpenSim, estimates of internal muscle and joint forces that cannot be measured directly -an approach used to compare footwork demands and lower-limb loading during the forehand (He et al., 2022b; He et al., 2023; Zhu et al., 2023). These laboratory methods deliver high spatial fidelity at the cost of ecological validity, because they confine measurement to a controlled setting.

To address that constraint, inertial measurement units were used to quantify kinematics and their variability during the topspin forehand and backhand, including field-friendly measurement of hand and racket motion (Bańkosz & Winiarski, 2020a; Bańkosz & Winiarski, 2020b). Surface electromyography provided the complementary muscular perspective, quantifying activation amplitude and the relative contribution of specific muscles across conditions (Wang et al., 2018; Maheshwari et al., 2023). A distinctive analytical development was the adoption of statistical parametric mapping, which tests whole normalised movement curves rather than arbitrary discrete instants and was used to expose subtle, phase-specific differences that point analyses would overlook (Bańkosz & Winiarski, 2020b; Mao et al., 2023; Li et al., 2025). Finally, accessible two-dimensional video digitising and high-speed camera analysis remained useful for applied, low-cost assessment of technique and accuracy (Alkhawaldeh, 2022; Mocanu et al., 2023). Together, these tools trace a trajectory from purely descriptive kinematics toward integrated kinematic–kinetic–neuromuscular analysis, increasingly supported by simulation and, in the wider literature, by machine-learning and wearable systems (Lyu et al., 2025; Tabrizi et al., 2021; Pandukabhaya et al., 2025).

Each measurement approach carried a characteristic balance of strengths and limitations that shaped the questions it could answer. Optical motion capture offered the highest spatial resolution and remained essential for detailed three-dimensional joint kinematics, but its dependence on a marked, calibrated laboratory volume restricted the number of trials, the naturalness of the task, and the ecological validity of the findings. Inertial sensors relaxed those spatial constraints and enabled repeated, field-adjacent measurement of the playing hand and racket, at the cost of greater sensitivity to soft-tissue artefact and orientation drift. Force plates and inverse dynamics were indispensable for kinetics but constrained participants to strike from a fixed contact area, while musculoskeletal modelling extended the reach of these data to internal muscle and joint forces that no sensor can capture directly, provided the model's assumptions are respected. Surface electromyography added the neuromuscular dimension yet remained vulnerable to normalisation and cross-talk issues that complicate between-study comparison. The growing use of statistical parametric mapping partly offset these fragmentations by standardising how whole movement curves are compared, and the appearance of computer-vision and wearable approaches in the surrounding literature signals a move toward cheaper, more scalable assessment -although their measurement validity against laboratory reference standards is still being established (Lyu et al., 2025; Tabrizi et al., 2021; Delumeau et al., 2025).

Comparative and Critical Analysis

Read together, the studies converge on a coherent model of the offensive stroke while disagreeing at the margins. There is strong agreement that attacking strokes are proximal-to-distal, whole-body actions and that skill level is expressed through greater economy, repeatability, and efficient energy transfer. There is also broad agreement that situational variables -spin, direction, and stroke variant -reshape the mechanical demands in predictable ways. Disagreements are mostly matters of emphasis and detail: studies differ over whether the ankle, the hip, or the trunk is the most important lower-limb contributor, partly because they analysed different strokes, phases, and populations. Some findings are genuinely divergent -for example, whether particular joints show higher or lower flexion in more skilled players -and these differences are difficult to reconcile because samples are small and tasks are not standardised. The strongest evidence attaches to the topspin forehand, where multiple independent groups using different tools reach compatible conclusions; the backhand loop, by contrast, is supported by fewer studies and warrants more corroboration (Li et al., 2025).

The central contribution of this review is to consolidate a decade of biomechanical evidence into an integrated, stroke-centred picture of table tennis attacking play. The proximal-to-distal organisation identified here echoes established models of skilled striking in other racket and throwing sports and provides a mechanistic explanation for why lower-limb and trunk conditioning matters for what appears, superficially, to be an arm-dominated action. The finding that higher-skilled players are more economical and repeatable, rather than simply faster, has clear theoretical significance: expertise in stroke production is as much about the efficient organisation and regulation of movement variability as it is about maximal output (Bańkosz & Winiarski, 2020a; Wang et al., 2018).

These results extend the two earlier syntheses in the field. Where the scoping review by Wong et al. (2020) mapped the breadth of table tennis biomechanics and the systematic review by He et al. (2022a) concentrated on lower-limb mechanics of the topspin forehand, the present review draws the family of offensive strokes together and incorporates newer work on the backhand loop, cross-national comparison, and musculoskeletal-modelling. In doing so it confirms the earlier emphasis on the lower limb and kinetic chain while adding a more explicit account of upper-limb control, muscle activation, and the effects of spin and direction. The practical implications follow directly: coaches should treat the offensive stroke as a whole-body skill, train the lower-limb and trunk drive that underpins it, and individualise technique by sex and skill level rather than imposing a single template; the sensitivity of stroke mechanics to incoming spin and shot direction argues for practice that is varied and representative rather than narrowly repetitive.

From a theoretical standpoint, the convergence of independent studies on a proximal-to-distal, whole-body organisation strengthens the view that the offensive table tennis stroke is best modelled as a coordinated kinetic chain rather than a set of independent joint actions. The evidence that performance-critical outcomes are protected while intermediate joints absorb variability aligns the sport with contemporary theories of motor control that emphasise functional, task-specific variability and the exploitation of motor abundance. This reframing matters because it changes what counts as good technique: consistency of the end result, achieved through flexible coordination, becomes a more meaningful marker of skill than the mechanical uniformity of any single joint. It also provides a principled explanation for why players who look different can be equally successful, and why attempts to copy an elite player's joint angles in isolation may be misguided.

The practical implications for coaching and athlete development are correspondingly concrete. First, because attacking strokes are whole-body actions, physical preparation should develop the lower-limb and trunk strength and the footwork that underpin the kinetic chain, not merely the arm; the demonstrated differences in lower-limb loading between footwork patterns argue for deliberately training the movement that will support each stroke. Second, because stroke mechanics differ by sex, skill level, and even coaching background, technique instruction should be individualised, using each player's own reliable pattern as the reference rather than a universal template. Third, because incoming spin and shot direction systematically reshape the required mechanics, practice should be varied and representative, exposing players to the full range of conditions they will meet in competition rather than to narrow, blocked repetition. Finally, the elevated follow-through loads associated with the fast loop and cross-court variants suggest that conditioning and load monitoring should accompany the pursuit of stroke power, so that performance gains do not come at the cost of injury risk.

A recurring methodological lesson runs through the evidence: the field would benefit greatly from standardisation. Studies differed in how they defined stroke phases, which events they aligned to, how they normalised electromyographic signals, and which outcomes they reported, and these differences are a major reason why otherwise compatible studies cannot be pooled. Agreement on a common set of phase definitions, reporting conventions, and, where possible, shared task protocols would make future studies directly comparable and would eventually permit quantitative synthesis. The increasing adoption of statistical parametric mapping is an encouraging step in this direction, because it disciplines how whole-movement comparisons are made, but consistency in the upstream measurement and reporting decisions is equally important.

Several important gaps remain. First, the evidence is heavily skewed toward the topspin forehand, leaving the backhand loop, the smash, and stroke-to-stroke transitions comparatively under-studied (Bańkosz & Winiarski, 2025). Second, most studies used small, expert samples measured in the laboratory, so little is known about how attacking-stroke mechanics develop with training or transfer to competitive play. Third, the interaction between stroke biomechanics and injury risk -hinted at by the elevated follow-through loads of the fast loop and by fatigue-related changes at the knee -has scarcely been examined (Li et al., 2025; Zhang et al., 2024).

This review has its own limitations. It searched a single database, Scopus; although Scopus is broad and its use was a deliberate scoping decision, relevant studies indexed only elsewhere may have been missed, and the duplicate and identification counts reflect the parameters of that single-source strategy. The exported metadata did not include author affiliations, so the country of many studies could not be verified and was conservatively marked as not reported rather than inferred; readers should complete this field from the full texts. Finally, the heterogeneity of tasks and outcomes precluded meta-analysis, so the synthesis is qualitative and the relative magnitude of effects across studies cannot be pooled.

Future research should therefore broaden the stroke repertoire under study, with dedicated biomechanical analyses of the backhand loop, the smash, and rapid forehand–backhand transitions; extend measurement beyond the laboratory using validated wearable and computer-vision systems so that attacking strokes can be quantified in training and competition (Lyu et al., 2025; Delumeau et al., 2025); and connect stroke mechanics explicitly to performance outcomes and injury risk through longitudinal and larger-sample designs. Standardising tasks, phase definitions, and reporting would additionally make future studies more comparable and, in time, permit quantitative pooling.

In direct answer to the research questions, this review finds, first, that the offensive strokes of table tennis are whole-body, proximal-to-distal actions whose kinematics, kinetics, and muscle activation are systematically shaped by skill level, sex, incoming spin, and shot direction, with higher-skilled players distinguished by more economical and repeatable execution (Research Question 1). Second, it finds that these strokes have been analysed with an increasingly integrated toolkit -three-dimensional optical motion capture, inertial sensors, force plates, surface electromyography, and musculoskeletal modelling, analysed increasingly with statistical parametric mapping -each contributing a complementary layer of kinematic, kinetic, or neuromuscular insight (Research Question 2).

Conclusions

This systematic review of twenty studies published between 2015 and 2025 shows that offensive table tennis strokes are whole-body actions built on a proximal-to-distal kinetic chain, in which the lower limbs and trunk generate energy that the shoulder, elbow, and wrist deliver to the racket. Their kinematics, kinetics, and muscle activation are consistently modulated by skill level, sex, incoming spin, and shot direction, and higher-skilled players are characterised less by raw speed than by economical, repeatable, well-balanced execution. Methodologically, the field has advanced from descriptive kinematics toward integrated kinematic–kinetic–neuromuscular analysis supported by musculoskeletal modelling and statistical parametric mapping. The evidence is methodologically sound but concentrated on the topspin forehand and constrained by small laboratory samples, indicating a clear agenda for broader, field-based, and injury-aware research on attacking-stroke biomechanics.

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