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Modern scientific approaches to the analysis of competitive activity in boxing

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Abstract

Purpose. Purpose: to generalise and systematise contemporary scientific approaches to the analysis of competitive activity in boxing.

Material and methods. The study was based on the analysis and synthesis of modern scientific and methodological sources devoted to the investigation of boxers' competitive activity. The literature search was conducted using scientometric databases (in particular Google Scholar), open-access scientific repositories, and specialised international journals, applying relevant search queries in both Ukrainian and English. Scientific articles, systematic reviews, and dissertation studies addressing technical-tactical, physiological, biomechanical, and psychophysiological aspects of competitive activity in boxing were included in the analysis. Comparative and structural-logical methods were used to systematise the selected sources and to identify the main research directions.

Results. The analysis of scientific literature demonstrated that contemporary studies of competitive activity in boxing are characterised by a comprehensive and multidimensional approach. The key research areas include the identification of performance indicators, analysis of technical-tactical actions, determination of factors influencing victory, and the impact of athletes' individual characteristics. It was established that the most informative indicators of performance are the number and accuracy of punches, the effectiveness of offensive and defensive actions, as well as the variability of technical-tactical decisions during a bout. The findings indicate that successful boxers demonstrate higher technical efficiency, greater attacking activity, and more rational tactical behaviour. At the same time, competitive activity indicators vary depending on athletes' qualification level, sex, age, and weight category. Additionally, a growing body of research focuses on physiological, biomechanical, and psychophysiological aspects, expanding the understanding of the structure of competitive performance in boxing.

Conclusions. The generalisation of modern scientific approaches allows competitive activity in boxing to be considered as a multifactorial system formed by the interaction of technical-tactical, functional, and psychophysiological components. Technical efficiency, punch accuracy, and activity volume are identified as the most significant determinants of performance. At the same time, current research trends highlight the need for integrating different analytical approaches, which provides a basis for improving the objectivity of performance assessment and optimising the training process in boxing.

Keywords: boxing; competitive activity; technical-tactical performance; performance indicators; time-motion analysis.

Анотація

Сучасні наукові підходи до аналізу змагальної діяльності в боксі

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Мета. Мета: здійснити узагальнення та систематизацію сучасних наукових підходів до аналізу змагальної діяльності у боксі.

Матеріал і методи. Дослідження базувалося на аналізі та узагальненні сучасних науково-методичних джерел, присвячених вивченню змагальної діяльності боксерів. Пошук наукових публікацій здійснювався в електронів наукометричній базі даних (зокрема Google Scholar), відкритих наукових репозиторіях та профільних міжнародних виданнях із використанням релевантних пошукових запитів українською та англійською мовами. До аналізу включалися наукові статті, систематичні огляди та дисертаційні дослідження, що висвітлюють техніко-тактичні, фізіологічні, біомеханічні та психофізіологічні аспекти змагальної діяльності у боксі. Для систематизації джерел застосовано методи порівняльного та структурно-логічного аналізу, що дозволило виокремити основні напрями досліджень і узагальнити їх результати.

Результати. Аналіз наукової літератури показав, що сучасні дослідження змагальної діяльності у боксі мають комплексний характер і охоплюють широкий спектр напрямів, серед яких ключове місце займають визначення показників ефективності, аналіз техніко-тактичних дій, вивчення факторів перемоги та впливу індивідуальних характеристик спортсменів. Встановлено, що провідними показниками результативності є кількість і точність ударів, ефективність атакувальних і захисних дій, а також варіативність техніко-тактичних рішень у поєдинку. Узагальнення даних свідчить, що переможці характеризуються вищим рівнем технічної ефективності, більшою атакувальною активністю та раціональнішою тактичною поведінкою. Водночас підтверджено, що показники змагальної діяльності варіюють залежно від рівня кваліфікації, статі, віку та вагової категорії спортсменів. Окремо відзначено активний розвиток досліджень, пов'язаних із фізіологічними, біомеханічними та психофізіологічними показниками боксерів, що розширює уявлення про структуру змагальної діяльності.

Висновки. Узагальнення сучасних наукових підходів дозволяє розглядати змагальну діяльність у боксі як багатокомпонентну систему, що формується під впливом техніко-тактичних, функціональних і психофізіологічних чинників. Найбільш інформативними показниками успішності виступу є технічна ефективність, точність і обсяг виконаних дій. Водночас сучасні тенденції розвитку наукових досліджень свідчать про необхідність інтеграції різних підходів до аналізу змагальної діяльності, що створює підґрунтя для підвищення об'єктивності оцінювання та оптимізації тренувального процесу боксерів.

Ключові слова: бокс; змагальна діяльність; техніко-тактична підготовленість; показники ефективності; часові характеристики.

Introduction

Modern boxing as a sport is characterised by a substantial increase in the level of competition, intensification of competitive activity, and higher demands on athletes' technical and tactical preparedness. The conditions of bout performance are becoming increasingly dynamic, and competitive success depends not only on the level of development of physical qualities but also on the athlete's ability to make rapid decisions, adapt to changing situations, and implement optimal technical and tactical actions at the appropriate moments. Of particular importance is the scientific substantiation of the boxer training system based on the objective analysis of competitive activity (Квасниця та ін., 2023; Латишев та ін., 2026; Старіков та ін., 2025; Tiwari et al., 2020).

Competitive activity serves as an integral criterion of training effectiveness, since it is under competition conditions that physical, technical, tactical, and psychophysiological capacities are comprehensively realised (Latyshev, Tropin et al., 2024; Pao et al., 2025). Its analysis makes it possible to identify key performance indicators, reveal patterns of bout conduct, and determine the factors contributing to victory. The obtained data can be used to optimise the training process, model competitive activity, and improve the effectiveness of athlete preparation across different qualification levels, which determines the relevance of this area of scientific research (Шандригось та ін., 2023; Chaabène et al., 2015; Tropin et al., 2026).

The analysis of competitive activity in combat sports is one of the leading directions of contemporary scientific research, as it enables an objective assessment of bout structure, the effectiveness of technical and tactical actions, and the behavioural characteristics of athletes in different combat situations. The scientific literature extensively addresses the identification of key performance indicators, the analysis of offensive and defensive actions, the temporal structure of bouts, and the factors underlying sporting success (Tanhaeean et al., 2022). Boxing occupies a special place among combat sports as a discipline characterised by a pronounced striking orientation, high intensity, and considerable variability of technical and tactical actions, which necessitates a detailed and comprehensive analysis of boxers' competitive activity (Гуцул та ін., 2022).

In recent years, a substantial number of studies have been published on the analysis of competitive activity in boxing and other combat sports. Therefore, there is a need to systematise current scientific approaches and summarise research findings in order to develop a comprehensive understanding of the structure and content of competitive activity in boxing, as well as to identify promising directions for further scientific investigation.

Relationship of the study with scientific programs, plans, and topics. The study was carried out in accordance with the departmental research topic of the National University of Ukraine on Physical Education and Sport entitled «Scientific and Methodological Support for the Training and Competitive Activity of Qualified Athletes in Combat Sports and Strength Sports» (state registration number 0121U108940).

Purpose – to generalise and systematise contemporary scientific approaches to the analysis of competitive activity in boxing.

Material and methods

The study was based on the analysis and synthesis of contemporary scientific and methodological sources devoted to the investigation of competitive activity in boxing. The search for scientific publications was conducted using scientometric databases, including Google Scholar, as well as open-access scientific resources and specialised international journals. Relevant sources were identified using search queries in Ukrainian and English, including: «competitive activity in boxing», «analysis of competitive activity in boxing», «performance indicators in boxing», «technical and tactical preparedness of boxers», and «analysis of technical and tactical actions in boxing». The analysis included research articles, systematic reviews, and dissertation studies addressing various aspects of boxers' competitive activity, including technical and tactical, physiological, biomechanical, and psychophysiological characteristics.

Results

The analysis of scientific and methodological literature revealed a considerable number of studies devoted to various aspects of competitive activity in boxing. The synthesis of current approaches made it possible to systematise the principal directions of scientific inquiry, including the identification of key performance indicators, methods of analysis, factors determining victory in a bout, and athletes' individual characteristics. In addition, the scientific literature demonstrates active development of specific research areas related to the physiological, biomechanical, and psychophysiological aspects of boxer preparation. The summarised findings of the analysed studies, together with their methodological characteristics, are presented in Table 1.

Performance indicators of competitive activity. The analysis of scientific sources indicates that competitive activity in boxing is characterised by a wide range of technical and tactical indicators that determine the effectiveness of bout performance. Key indicators include the total number of punches thrown, punch accuracy, the frequency of combination attacks, and the ratio of offensive to defensive actions. In particular, Slimani et al. reported that the effectiveness of technical and tactical actions, including the number of combination attacks, punches to the head, and the use of counter-attacks, represents a determining characteristic of boxers' performance. Similar findings were reported by Davis et al., who demonstrated that high-level boxers exhibit a greater frequency of actions and higher punch accuracy compared with less successful athletes.

Particular attention has been devoted to performance indicators such as punch accuracy (%) and the ratio of successful to unsuccessful attacks. For example, Pao et al. found that winners demonstrated significantly higher punch accuracy (57.3 % versus 46.5 % in defeated athletes), which was identified as one of the key determinants of success. Similarly, Shtanagei noted that winners performed a greater number of punches and movements throughout the bout, indicating a higher level of activity and greater control of the contest. Thus, contemporary studies confirm that the combination of volume, accuracy, and effectiveness of technical and tactical actions constitutes the foundation of successful competitive activity in boxing.

Table 1 - Characteristics of scientific studies on the analysis of competitive activity in boxing

Authors, Year	Participants / Level	Object of Analysis	Methods
Slimani et al., 2017	Male boxers of different qualification levels	Competitive activity, physiological responses	Time-motion analysis, technical and tactical analysis
Kapo et al., 2021	Qualified boxers (national level)	Comparative analysis of winners and losers	Notational analysis
Chaabène et al., 2015	Highly qualified boxers	Physical and physiological characteristics	Literature review
Ashker, 2011	Highly qualified boxers	Technical and tactical actions during the bout	Video analysis
Finlay et al., 2023	Qualified boxers	Physiological and biochemical responses	Systematic review, meta-analysis
Davis et al., 2016	Highly qualified female boxers	Technical and tactical activity	Notational analysis
Stanley, 2020	Qualified boxers	Biomechanical characteristics of punches	Kinematic and kinetic analysis
Xiao et al., 2025	Qualified female boxers	Visual-motor abilities and punch accuracy	Notational analysis, correlation analysis
Tiwari et al., 2020	Student boxers (beginner level)	Force and kinematic parameters of punches	Sensor technologies
Shtanagei, 2024	Qualified female boxers (European Championships)	Competitive activity indicators	Video analysis
Pao et al., 2025	Qualified junior boxers (World Championships)	Key performance indicators (accuracy, attack)	Notational analysis
Martusciello et al., 2025	Highly qualified female boxers (World Championships)	Bout structure	Time-motion analysis
Rohner et al., 2024	Qualified athletes	Reliability of competitive activity analysis	Time-motion analysis

Methods for analysing competitive activity. Contemporary studies of competitive activity in boxing are based on the use of a combination of analytical methods, among which Notational analysis and Time-motion analysis occupy a central place. Notational analysis involves detailed video analysis of bouts with systematic recording of technical and tactical actions, which makes it possible to determine both the quantitative and qualitative characteristics of athletes' performances. This approach has been widely employed in the studies of Ashker (2011), Kapo et al. (2021), and Martusciello et al. (2025b), in which offensive and defensive actions, their effectiveness, and their influence on bout outcomes were examined. The use of specialised software packages (e.g., Kinovea or Dartfish) substantially enhances the accuracy and objectivity of the analysis.

Time-motion analysis, in turn, is aimed at examining the temporal structure of the bout and the relationship between different phases of activity. Boxing is characterised as a high-intensity intermittent sport with a variable work-to-rest ratio. Further studies by Martusciello et al. (2025a) provide a more detailed description of bout structure by distinguishing phases of active fighting, clinching, pauses, and referee stoppages. At the same time, contemporary approaches also include the use of biomechanical analysis (Stanley, 2020; Lenetsky et al., 2020) and sensor technologies (Tiwari et al., 2020), which make it possible to assess the force, velocity, and kinematics of punches. Thus, the combination of different methods provides a comprehensive understanding of competitive activity in boxing.

Factors determining victory in boxing bouts. One of the key areas of research is the identification of factors that determine victory in boxing bouts. The majority of scientific studies agree that winners differ from defeated athletes by demonstrating a higher level of technical and tactical efficiency. In particular, it has been established that winners execute a greater number of punches, both as single attacks and as combinations, and also exhibit a higher level of technical effectiveness (Ashker, 2011). Similar findings were reported by Kapo et al. (2021), who showed that winners are characterised by more effective use of both offensive and defensive actions, including advanced slipping techniques and counter-attacks.

Another important determinant of success is punch accuracy and the choice of bout tactics. Pao et al. (2025) emphasised that winners demonstrate higher punch accuracy and adopt a more pronounced offensive strategy, whereas defeated athletes more frequently employ a defensive pattern of behaviour. In addition, Davis et al. (2016) reported that successful boxers maintain a high level of activity throughout the bout and use key technical actions more effectively during the decisive rounds. Therefore, victory in boxing is determined by a combination of factors, among which technical efficiency, punch accuracy, and rational tactical behaviour play the leading role.

Competition level and athlete characteristics. A separate line of research is devoted to the comparative analysis of different competition levels and athlete populations. The analysis of scientific studies indicates that indicators of competitive activity in boxing vary considerably depending on athletes' level of preparedness, sex, age, and weight category. In particular, Slimani et al. (2017) found that elite boxers are characterised by a higher bout intensity and a greater work-to-rest ratio compared with less experienced athletes. In addition, the study emphasised that technical and tactical actions vary across rounds, highlighting the importance of functional endurance and the strategic distribution of effort throughout the bout.

Important differences have also been identified between

men's and women's boxing. In particular, highly qualified female boxers have been shown to demonstrate a high bout tempo, a substantial number of technical actions, and specific technical and tactical characteristics that distinguish them from male athletes. The study by Martusciello et al. (2025) further confirmed that bout structure varies according to weight category: heavyweight boxers use clinching more frequently, whereas lighter weight categories are characterised by greater movement activity and a higher frequency of attacks. Thus, competition level and athletes' individual characteristics are determining factors in shaping the model of competitive activity in boxing.

Specific areas of competitive activity analysis in boxing. Contemporary research on competitive activity in boxing extends beyond traditional technical-tactical analysis and encompasses a wide range of physiological, biomechanical, and psychophysiological aspects. In particular, the systematic review by Finlay et al. (2023) demonstrated that boxing bouts are accompanied by substantial physiological and biochemical changes, including marked increases in lactate, cortisol, and other biomarkers, indicating a high level of physiological stress. At the same time, it is noteworthy that, despite these pronounced physiological responses, indicators of neuromuscular performance may remain stable, suggesting that athletes are well adapted to the specific demands of boxing competition.

A separate line of research is concerned with the investigation of the biomechanical characteristics of punching. Stanley (2020) and Lenetsky et al. (2020) established that punching effectiveness is determined by the complex interaction of kinematic and kinetic parameters, as well as by the level of development of strength and speed-strength abilities. At the same time, recent studies have emphasised the importance of sensorimotor and visual abilities. In particular, a close relationship has been identified between visuomotor coordination, reaction time, and punching accuracy in boxers (Wu et al., 2024; Xiao et al., 2025). Thus, the contemporary scientific approach to boxing analysis is comprehensive and involves the integration of multiple functional systems of the human body.

Discussion

The obtained results indicate that contemporary studies of competitive activity in boxing are of a complex nature and encompass both technical-tactical and functional aspects of athlete preparation. The consistency of findings across different authors confirms the key role of punching accuracy, volume, and effectiveness in achieving victory. In particular, most studies highlight the superiority of winners in terms of offensive activity and technical efficiency, which reflects the dominance of an active fighting model. At the same time, it has been established that not only quantitative but also qualitative characteristics of actions, such as timing of attacks, use of combinations, and defensive efficiency, play a decisive role in determining bout outcomes (Тропін та ін., 2024; Korobeynikov et al., 2025).

The literature analysis shows that approaches to studying competitive activity in boxing share many similarities with other striking combat sports such as kickboxing and taekwondo. In particular, the use of Time-motion analysis and Notational analysis is a widely accepted approach for evaluating technical-tactical actions and bout structure (Tropin et al., 2021). The study by Rohner et al. (2024) demonstrated that Time-motion analysis in combat sports is highly reliable for assessing the number of actions and the duration of activity phases, which confirms its applicability in boxing as well.

At the same time, boxing has specific features that distinguish it from other combat sports. In particular, unlike mixed or grappling disciplines, boxing is dominated by hand striking techniques, which determines a different structure of technical-tactical actions and performance evaluation criteria (Curby et al., 2023; Латишев та ін., 2024). Moreover, greater attention is paid to punching accuracy, volume, and effectiveness, whereas in wrestling or judo, throwing and holding actions play a more significant role. Thus, although general methodological approaches are similar, the specificity of competitive activity in boxing requires adaptation of research methods considering the unique characteristics of this sport.

However, the literature analysis also revealed certain contradictions and gaps in contemporary research. In particular, there is a limited number of studies focusing on women's boxing, youth categories, and comparative analyses across different competition levels. Furthermore, despite the active use of modern methods such as Time-motion analysis and biomechanical assessment, the integration of technical-tactical, physiological, and psychophysiological indicators into a unified system for evaluating competitive activity remains underdeveloped (Shandrygos et al., 2023). Therefore, a promising direction for future research is a comprehensive interdisciplinary approach to analysing boxers' performance, which would enhance the objectivity of assessment and improve the effectiveness of the training process.

Conclusions

The synthesis and systematisation of contemporary scientific research have made it possible to establish that competitive activity in boxing is a multifactorial process determined by the interaction of technical-tactical, physiological, biomechanical, and psychophysiological components. Modern approaches to the analysis of competitive activity are based on the integrated use of Notational analysis and Time-motion analysis methods, which ensure an objective assessment of athletes' performance. At the same time, it has been established that indicators of competitive activity vary significantly depending on athletes' qualification level, sex, age, and weight category, which necessitates a differentiated approach to their analysis. In addition, technical efficiency indicators, particularly punching accuracy, volume, variability, and appropriateness of actions in bout conditions, play a leading role in achieving high sporting performance.

Prospects for further research are associated with the integration of different groups of indicators into a unified system for evaluating competitive activity, which will contribute to improving the effectiveness of boxers' preparation and optimising the training process.

Conflicts of interest
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