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Review Article

Functional Evolution of Experimental Design in Sports Science: From Bibliometric Analysis to a Functional Concept

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Abstract

Background. Experimental design is the principal methodological framework for establishing causal relationships in sports science. Traditional classifications describe experimental designs according to structural characteristics, such as the number of factors, randomization procedures, measurement organization, or statistical methods. However, these approaches do not explain how the methodological functions of experimental design evolve from hypothesis testing to mathematical modelling, programming, and model-based decision making.

Objectives. To investigate the functional evolution of experimental design in sports science, determine the methodological role of full factorial experiments (2^k), and develop a functional concept of experimental design based on bibliometric and systematic methodological analyses.

Material and Methods. The study was conducted in two stages. First, a bibliometric analysis of publications indexed in the Scopus database (2000–2026) was performed to identify the structure of research on experimental designs and to construct an analytical corpus. After duplicate removal, the main bibliometric corpus comprised 1653 publications. Second, a systematic methodological analysis of a specialized corpus of 244 publications was carried out to evaluate the realization of the cognitive and constructive potential of experimental designs. Particular attention was paid to studies integrating full factorial experiments with mathematical modelling, regression analysis, and discriminant analysis.

Results. The bibliometric analysis demonstrated that contemporary sports science is dominated by subject-oriented terminology, whereas methodological concepts related to experimental design are rarely represented in author keywords or publication titles. The systematic methodological analysis showed that experimental designs with similar structural characteristics perform substantially different methodological functions. A functional concept of experimental design was developed, according to which its methodological significance is determined by the level of realization of its cognitive and constructive potential. Full factorial experiments were identified as the methodological link connecting experimental analysis with mathematical modelling. Three levels of realization of the constructive potential of experimental design were identified: local model-based control, programming of the pedagogical process, and system-level management.

Conclusions. The study proposes a functional concept of experimental design that complements traditional structural classifications. The methodological contribution of the study consists in introducing a new principle for classifying experimental designs according to the level of realization of their cognitive and constructive potential. Full factorial experiments occupy a central methodological position in this framework by enabling the transition from hypothesis testing to mathematical modelling, programming, and model-based management of pedagogical and training processes.

Keywords: experimental design, full factorial experiment, sports science, mathematical modelling, regression analysis, discriminant analysis, bibliometric analysis, systematic methodological analysis, pedagogical programming, model-based decision making.

Introduction

Experimentation is one of the principal methods for establishing causal relationships in the natural sciences, medicine, education, and sports science. Experimental design determines the structure of a study, the way experimental factors are manipulated, data collection procedures, and the statistical approaches available for analyzing the obtained results (Goodwin, 2004; Creswell & Creswell, 2018). Consequently, the development of experimental methods is inseparably linked to the evolution of scientific methodology.

In contemporary sports science, experimental research serves as a fundamental tool for evaluating the effectiveness of educational programmes, training interventions, recovery strategies, physical therapy, and pedagogical approaches (Bishop, 2008). One- and multifactorial experimental designs, together with analysis of variance, regression techniques, and mixed-effects models, are widely applied, particularly in studies involving repeated measurements and longitudinal observations (Hopkins et al., 2009; Newans et al., 2022). At the same time, the evolution of experimental design has been accompanied not only by increasingly sophisticated research strategies but also by the expansion of mathematical modelling techniques and the integration of multivariate analytical methods.

Experimental designs are traditionally classified according to their structural characteristics, including the number and type of experimental factors, the structure of the experimental plan, randomization procedures, repeated-measures organization, and the corresponding statistical methods (Alferes, 2012; Kirk, 2012; Montgomery, 2020). Although this approach is essential for describing the organization of experimental research, it primarily characterizes the structure of the experiment rather than the methodological functions it performs in scientific inquiry. Studies based on similar experimental structures may differ substantially in the knowledge they generate, the interpretation of their findings, and the extent to which their results can be translated into practical applications. Consequently, structural classification alone is insufficient for evaluating the cognitive and constructive potential of experimental design.

In contemporary sports science, experimental studies are predominantly interpreted in terms of statistical hypothesis testing, estimation of main effects and interactions, and the application of analysis of variance, regression, and related statistical techniques (Montgomery, 2020). Considerably less attention has been devoted to the use of experimental results for constructing mathematical models, describing factor spaces, optimizing pedagogical or training interventions, and developing systems of model-based decision making (Box & Wilson, 1951; Myers et al., 2016).

Among multifactorial experimental designs, the full factorial experiment (FFE, 2^k design) occupies a distinctive methodological position. It has been widely employed to investigate main effects and factor interactions across numerous scientific disciplines (Box & Wilson, 1951; Montgomery, 2020). Beyond its traditional role in statistical hypothesis testing, the FFE provides the methodological foundation for constructing mathematical models of factor spaces, identifying local optima, and optimizing the processes under investigation (Myers et al., 2016). When combined with mathematical modelling techniques, the FFE enables the transition from analysing experimental effects to quantitatively describing relationships and supporting evidence-based practical decision making.

The practical implementation of this approach has been demonstrated in a series of studies devoted to modelling motor learning, the development of motor abilities, and pedagogical control in school physical education, where full factorial experiments were integrated with regression and discriminant analyses to construct mathematical models of the educational process (Ivashchenko, 2020; Khudolii et al., 2019). Subsequent studies further demonstrated the possibility of integrating the results of a series of interrelated experiments into systems of mathematical models intended for predicting learning outcomes, programming pedagogical interventions, and supporting educational decision making. These findings indicate that the full factorial experiment performs not only an analytical function associated with hypothesis testing but also a constructive function through mathematical modelling, pedagogical programming, and model-based management of educational and training processes.

Despite the widespread application of experimental designs in sports science, recent methodological studies increasingly emphasize the need to move beyond the formal description of research designs toward understanding their role in generating and integrating scientific knowledge (Khudolii et al., 2026a; Khudolii et al., 2026b). However, it remains unclear how experimental design evolves from an instrument of statistical hypothesis testing into a methodological framework for mathematical modelling, programming, and model-based management. Likewise, the methodological position of the full factorial experiment within this transition and the relationship between the cognitive and constructive potential of experimental design have not yet been systematically established. Although the classical theory of factorial experimentation and response surface methodology provides the theoretical foundations for such a transition, it does not conceptualize it as an evolution of the methodological functions of experimental design (Box & Wilson, 1951).

Therefore, there is a need to move beyond the structural classification of experimental designs toward a functional framework that explains not only how experiments are organized but also how they contribute to knowledge generation, mathematical modelling, and evidence-based management of pedagogical and training processes. This perspective constitutes the conceptual foundation of the present study.

The purpose of this study was to develop and substantiate a functional concept of the evolution of experimental design in sports science based on bibliometric and systematic methodological analyses, to determine the methodological role of the full factorial experiment, and to construct a conceptual model describing the transition from statistical hypothesis testing to model-based design and management of pedagogical and training processes.

Матеріали і методи

Study design

The study was conducted in two interrelated stages combining bibliometric analysis and systematic methodological analysis. The first stage comprised a bibliometric analysis of scientific publications to characterize the structure of research on experimental designs in sports science, physical education, and related fields, identify temporal and methodological trends, and form analytical corpora for the subsequent methodological evaluation (Creswell, 2018; Page et al., 2021).

The second stage involved a systematic methodological analysis of the selected publications. Unlike conventional systematic reviews focused on evaluating the effectiveness of interventions, this stage was designed to investigate the methodological functions of experimental design in the process of scientific inquiry. Each publication was examined with respect to the structure of the experimental design, the methodological role of the design in the study, the use of mathematical modelling, and the extent to which experimental results were employed for optimization, programming, or model-based decision making.

During the comparative analysis, an analytical framework was developed that enabled the classification of publications according to the level of realization of the cognitive and constructive potential of experimental design. The analytical categories were not predefined but were derived inductively through an iterative comparative analysis of the selected publications.

Thus, the bibliometric analysis provided a quantitative characterization of the scientific field of experimental design research, whereas the systematic methodological analysis enabled the reconstruction of the functional evolution of experimental design, identification of the methodological role of the full factorial experiment (2^k) in contemporary sports science, and development of a functional concept describing the transition from statistical hypothesis testing to mathematical modelling, programming, and model-based management (Lopatiev, Bartik, & Cieślicka, 2026; Ivashchenko, Khudolii, & Khudolii, 2026).

Information source

The source of information for this study was the Scopus database (Elsevier), one of the world's largest multidisciplinary bibliographic and citation databases indexing peer-reviewed journals, conference proceedings, book series, and other scholarly publications. Scopus was selected because of its broad coverage of sports science, physical education, health sciences, and related disciplines, as well as its advanced search capabilities and the possibility of exporting complete bibliographic records for subsequent bibliometric analysis.

The search was performed using the Scopus Advanced Search interface on 30 July 2026 and covered publications published between 2000 and 2026. This time span enabled the analysis of the long-term development of experimental designs in sports science over the past quarter century.

The analysis included documents indexed by Scopus as Articles, Reviews, Conference Papers, and Book Chapters. Bibliographic records were exported in Plain Text format, which preserves the complete set of bibliographic metadata required for bibliometric analysis, including publication title, authors, affiliations, abstract, author keywords, source title, publication year, references, and citation information. Duplicate records were identified and removed before the bibliometric analysis. The resulting metadata constituted the basis for the bibliometric analysis, formation of analytical corpora, and the subsequent systematic methodological analysis (Aria & Cuccurullo, 2017).

The search strategy, publication selection criteria, and the procedures used to construct the analytical corpora are described in the following subsection.

Search Strategy

The literature search was conducted in a stepwise manner using the Advanced Search interface of the Scopus database. The search strategy was based on the principle of progressively narrowing the subject area, thereby enabling the construction of analytical publication corpora corresponding to the objectives of each stage of the study.

At the first stage, a broad search query was employed to identify publications related to experimental designs, full factorial experiments, design of experiments, and statistical methods used in multifactorial research. The search included different terminological variants describing full factorial experiments (full factorial design, 2 × 2 factorial design, 2^k factorial design, and two-level factorial design), together with related methodological concepts such as design of experiments, response surface methodology, factorial ANOVA, mixed-design ANOVA, and group × time interaction. Search terms were combined using Boolean operators to maximize the sensitivity and completeness of the initial search.

At the second stage, the search was restricted to publications in sports science, physical education, exercise science, sports training, motor learning, motor development, kinesiology, and related disciplines. In addition, a publication-year filter (2000–2026) was applied to construct the main main bibliometric corpus used to analyse publication trends, the structure of the research field, and methodological developments in experimental design.

At the third stage, a targeted search was performed to identify studies in which experimental results were used not only for statistical hypothesis testing but also for mathematical modelling, optimization, programming, or model-based management. Accordingly, the search strategy was expanded by incorporating the terms regression model, response surface methodology, optimization, programming, decision making, control, and discriminant analysis, combined with terms describing experimental designs.

The search strategy was refined iteratively through repeated evaluation of the search results and adjustment of keywords to ensure both comprehensive coverage and high relevance of the retrieved publications. Each successive stage involved not only thematic refinement but also increasing methodological specificity of the selection criteria, allowing a transition from a broad main bibliometric corpus to a specialized corpus suitable for systematic methodological analysis (Page et al., 2021; Creswell & Creswell, 2018).

Following methodological refinement, publications were included in the final corpus if they met all of the following criteria: (1) application of a multifactorial experimental design; (2) development of mathematical models based on experimental results; and (3) use of these models for optimization, programming, pedagogical control, or model-based decision making. Studies in which multifactorial experimental designs were used exclusively for statistical hypothesis testing, without subsequent mathematical modelling or constructive interpretation of the obtained results, were excluded from the final corpus.

Construction of the Analytical Publication Corpus

The analytical publication corpus was constructed sequentially in accordance with the study design and research objectives.

At the first stage, a broad main bibliometric corpus comprising 3,514 publications was established. This corpus

Table 1. Stages of constructing publication corpora for bibliometric and systematic methodological analyses

Stage	Objective	Main search terms	Output
1. Initial search	Identification of publications on experimental designs regardless of research field	factorial design, full factorial design, 2 × 2 factorial design, 2^k factorial design, design of experiments, response surface methodology, factorial ANOVA, mixed-design ANOVA	Initial publication corpus
2. Thematic refinement	Construction of the sports science corpus	sport, sports science, physical education, exercise, motor learning, motor development, physical training, kinesiology	Main main bibliometric corpus
3. Methodological refinement	Identification of studies demonstrating the constructive use of experimental results	regression model, response surface methodology, optimization, programming, decision making, control, discriminant analysis	Specialized methodological corpus
4. Final selection	Construction of the final corpus for systematic methodological analysis	Application of inclusion and exclusion criteria	Confirmed core of constructive implementation

included studies on experimental designs irrespective of their disciplinary field and was used to characterize the overall structure of the research domain, assess the extent of application of experimental approaches, and identify major methodological trends.

At the second stage, thematic filtering combined with a publication-year restriction (2000–2026) resulted in the construction of the main main bibliometric corpus, consisting of 1,653 publications in sports science, physical education, exercise science, sports training, motor learning, motor development, kinesiology, and related disciplines. This corpus served as the empirical basis for analysing publication trends, the structure of the research field, leading publication sources, thematic directions, and methodological developments in experimental design.

At the third stage, a specialized methodological corpus of 244 publications was established for in-depth methodological analysis. This corpus included studies in which experimental designs were potentially used not only for statistical hypothesis testing but also for mathematical modelling, optimization, programming, or the development of model-based management systems.

Subsequent systematic methodological analysis identified a confirmed core of constructive implementation, consisting of 11 publications. These studies demonstrated the complete realization of the constructive potential of experimental design, encompassing the planning of full factorial experiments, analysis of experimental data, development of mathematical models, and the application of these models to programming, prediction, and evidence-based management of educational and training processes.

Accordingly, the study was based on three interrelated analytical publication corpora, each serving a distinct methodological purpose. The broad main bibliometric corpus was used to characterize the overall structure of the research field, the main main bibliometric corpus to analyse the development of experimental designs in sports science, and the specialized methodological corpus to investigate the functional evolution of experimental design and evaluate the realization of its cognitive and constructive potential.

The sequential construction of the analytical publication corpora and their application at different stages of the study are presented in Table 1.

Bibliometric Analysis

Bibliometric analysis was performed using the metadata of publications exported from the Scopus database (Aria & Cuccurullo, 2017). Bibliographic data were processed and analysed using the bibliometrix package implemented in the Renvironment, which provides comprehensive bibliometric analysis, statistical summarization of bibliographic metadata, and visualization of bibliometric indicators.

The main main bibliometric corpus (1,653 publications) was analysed to examine annual publication trends, the distribution of publications across sources, thematic areas, author keywords, and other bibliometric characteristics. Particular attention was given to publications addressing multifactorial experimental designs, full factorial experiments (FFE, 2^k), and the statistical approaches used to analyse experimental data.

The results of the bibliometric analysis were used to characterize the structure of the research field, evaluate temporal trends in the development of experimental designs, and identify methodological trends in sports science. These bibliometric characteristics also provided the basis for constructing the specialized methodological corpus and for the subsequent systematic methodological analysis.

In the present study, bibliometric analysis was considered a tool for mapping the research field, whereas the evaluation of the cognitive and constructive potential of experimental designs was performed at the subsequent stage through systematic methodological analysis (Donthu et al., 2021).

Systematic Methodological Analysis

Following the construction of the analytical publication corpora, a systematic methodological analysis was conducted. Unlike conventional systematic reviews, which primarily evaluate the effectiveness of interventions, this stage aimed to investigate the functions of experimental design in scientific inquiry, identify patterns in their functional evolution, and determine the methodological role of the full factorial experiment within the development of contemporary experimental methodology. The analysis was grounded in the principles of systems research, inductive

Table 2. Protocol for the Systematic Methodological Analysis of the Functional Evolution of Experimental Designs

Stage	Object of evaluation	Main evaluation criteria	Evaluation outcome
1. Structural analysis	Characteristics of the experimental design	Number and type of experimental factors, structure of the experimental design, factor combination strategy, and statistical methods employed	Identification of the experimental design type and its methodological characteristics
2. Evaluation of cognitive potential	Functions of experimental design in scientific inquiry	Identification of main effects and factor interactions, construction of mathematical models, description of the factor space, and explanation of experimental relationships	Determination of the level of realization of the cognitive potential of the experimental design
3. Evaluation of constructive potential	Practical application of experimental results	Use of mathematical models for optimization, programming, prediction, pedagogical control, and model-based management	Determination of the level of realization of the constructive potential of the experimental design
4. Integrated methodological evaluation	Synthesis of analytical findings	Integrated assessment of the realization of experimental design functions	Classification of the study according to its functional category (local management, programming, or system-level management)

generalization, and conceptual modelling (Creswell & Creswell, 2018; Lopatiev et al., 2026).

The systematic methodological analysis was performed according to an author-developed evaluation protocol, which involved the sequential assessment of each publication across four interrelated analytical domains (Table 2).

According to the proposed protocol, the functional role of the experimental design was determined following the structural analysis of each study. Particular attention was paid to publications in which full factorial experiments were combined with mathematical modelling techniques, especially regression, discriminant, and logistic analyses. For each publication, the level of realization of the cognitive potential of the experimental design, the manner in which mathematical models were applied, and the degree to which these models were integrated into the programming, prediction, or model-based management of educational and training processes were evaluated. This approach is consistent with the contemporary understanding of mathematical modelling as the final stage of interpreting experimental findings and the transition from identifying empirical regularities to supporting evidence-based practical decision making (Lopatiev et al., 2026; Ivashchenko et al., 2026).

The analytical categories were not predefined but emerged inductively through a comparative analysis of the selected publications. For each study, the structure of the experimental design, statistical interpretation of the results, application of mathematical modelling, and the level of practical implementation of the developed models were systematically compared. The synthesis of shared methodological characteristics enabled the development of a functional classification of experimental designs, identification of the levels of realization of their cognitive and constructive potential, reconstruction of the transition from statistical hypothesis testing to mathematical modelling, programming, and model-based management, and the formulation of a conceptual model describing the functional evolution of experimental design (Lopatiev et al., 2026; Ivashchenko et al., 2026).

Results

Structure of the Research Field of Multifactorial Experimental Designs

The bibliometric analysis of the main bibliometric corpus (1,653 publications) revealed a steady increase in the number of studies addressing multifactorial experimental designs in sports science between 2000 and 2026 (Figure 1). The most pronounced growth in publication activity occurred after the mid-2010s, indicating increasing methodological interest in experimental approaches, multifactorial research designs, and contemporary statistical methods. These findings demonstrate that experimental design has become one of the principal methodological tools in contemporary sports science.

The search strategy enabled the sequential construction of analytical publication corpora, each serving a distinct methodological function within the study (Table 3).

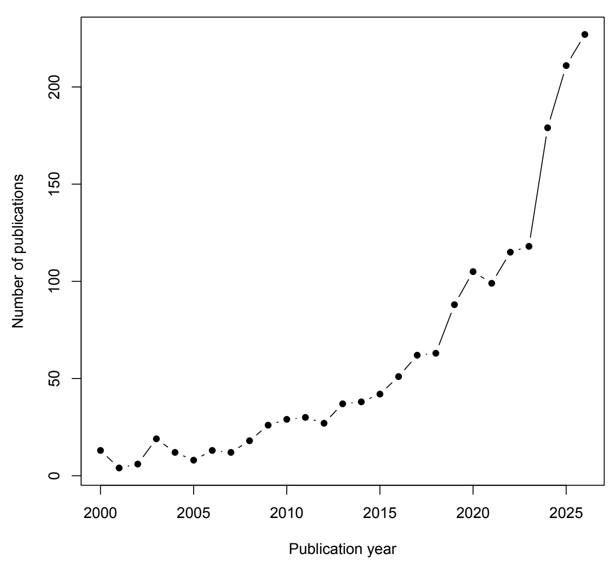

Fig. 1. Annual scientific production on multifactorial experimental designs in sports science (2000–2026)

Table 3. Construction of the Analytical Publication Corpora

Stage	Analytical corpus	Number of publications	Purpose
1	General search corpus	3,514	Identification of the overall research field of multifactorial experimental studies
2	Main sports science corpus (2000–2026)	1,653	Analysis of experimental design structures, publication sources, and temporal trends
3	Specialized corpus of model-based management studies	244	Identification of studies in which mathematical models were used to support practical decision making
4	Confirmed core of constructive implementation	11	Analysis of the transition from experiment → mathematical model → practical management

The general search corpus (3,514 publications) represented the contemporary research field of multifactorial experimental studies without disciplinary restrictions. Its analysis demonstrated that factorial experimental approaches are applied across a broad spectrum of scientific disciplines, confirming their universal methodological significance.

Following thematic refinement to sports science, physical education, sports training, exercise science, motor learning, and related disciplines, the main bibliometric corpus (1,653 publications) was established. This corpus served as the empirical basis for the bibliometric analysis of the research field, publication trends, leading publication sources, and methodological developments in experimental design.

Subsequent refinement to 244 publications identified studies in which experimental results were potentially used for mathematical modelling, optimization of pedagogical or training interventions, and evidence-based decision making. Consequently, the focus of the analysis shifted from the structural characteristics of experimental designs to their functional application.

The systematic methodological analysis of the specialized corpus demonstrated that only 11 publications represented the complete realization of the constructive potential of experimental design, encompassing the entire sequence from full factorial experimentation to the development of mathematical models and their application for programming or managing educational and training processes. These findings indicate that the transition from experimental verification of effects to model-based management remains relatively uncommon, even among studies explicitly concerned with mathematical modelling.

Overall, the results demonstrate that the sequential construction of analytical publication corpora not only ensured the representativeness of the bibliometric analysis but also provided the methodological foundation for the subsequent systematic methodological analysis. This approach made it possible to trace the transition from the broad research field of experimental studies to a confirmed core of publications in which experimental design performs a constructive methodological function. The logic of this progressive refinement constituted the methodological basis for the subsequent analysis of the functional evolution of experimental design.

Functional Evolution of Experimental Design

The systematic analysis of the main bibliometric corpus demonstrated that the evolution of experimental design has been accompanied not only by increasing structural complexity of experimental designs but also by the progressive expansion of their cognitive capabilities. The identified patterns indicate a gradual transition from the use of experimentation as a means of establishing experimental effects to its application for mathematical modelling, programming, and model-based management of pedagogical processes.

At the first level, experimental design serves to establish the effect of an intervention through comparisons between experimental groups or analyses of changes over time. Such studies determine whether statistically significant changes have occurred; however, they do not explain the mechanisms underlying these changes or identify the conditions under which the intervention is most effective.

The second and third levels are characterized by the transition to the analysis of factor interactions. The inclusion of attributive and manipulated factors makes it possible to determine for whom, under which conditions, and through which combinations of pedagogical interventions the experimental effect changes. At this stage, experimental design performs not only the function of statistical hypothesis testing but also the function of explaining the underlying relationships.

The next stage of development is associated with the application of the full factorial experiment (2^k). When combined with regression analysis, the full factorial experiment enables the construction of mathematical models describing the factor space, whereas the use of discriminant analysis makes it possible to investigate the multivariate structure of experimental outcomes and classify the implemented experimental conditions. The integration of these approaches represents a new level of scientific inquiry, at which experimental design evolves from analysing individual relationships to constructing an interconnected system of mathematical models.

The highest level of realization is achieved when the results of a series of interconnected experiments are used for programming, pedagogical monitoring, and the management of educational and training processes. At this stage, experimental design ceases to function solely as an instrument for hypothesis testing and acquires a constructive function by supporting the transition from the generation of scientific evidence to model-based management of pedagogical systems.

The synthesis of these findings made it possible to develop a hierarchy of the cognitive capabilities of experimental designs, reflecting the progressive expansion

Table 4. Hierarchy of the Cognitive Capabilities of Experimental Designs

Level	Study structure	Object of inquiry	Central question	Potential outcome
I	Experimental group × time	Effect	Did a change occur?	Identification of the experimental effect and differences in temporal dynamics
II	Experimental × attributive factor; attributive factor × time	Effect differentiation	For whom, when, or under what conditions does the effect differ?	Identification of the dependence of the effect on age, sex, qualification, or other participant characteristics
III	Two manipulated factors; 2 × 2 factorial design	Interaction	How does the effect of one factor depend on the level of another?	Main effects, interactions, synergistic or antagonistic relationships between factors
IV-A	Full factorial experiment (2^k) with regression modelling	Relationships within the factor space	Which mathematical relationship best describes the process?	Regression model describing the local factor space
IV-B	Full factorial experiment (2^k) with discriminant analysis	Multivariate structure of outcomes	Which combination of variables best discriminates among experimental conditions?	Canonical functions, centroids, classification, and recognition of experimental conditions
V	Full factorial experiment (2^k) with regression and discriminant analyses	Integrated system	How can the factor space and outcome system be structured simultaneously?	Integration of factor–outcome models with multivariate classification
VI	Series of interconnected experiments and a research programme	Managed process	How can mathematical models be used for planning, monitoring, and modifying the process?	Selection of optimal conditions, programming, pedagogical monitoring, and system-level management

Table 5. Methodological Trajectories of Multifactorial Experimental Designs and Their Analytical Outcomes

Methodological trajectory	Object being structured	Primary analytical outcome	Boundary of cognitive capability
Group × time	Temporal dynamics of experimental groups	Differences in changes between groups	The internal structure of the intervention remains unexplored
Randomized factorial experiment	Combinations of two interventions	Individual and combined effects of intervention components	Primarily limited to comparisons of implemented conditions without modelling the factor space
Two manipulated factors	Factor interactions	Main effects and interactions	Mathematical modelling of the process is not essential
Full factorial experiment (2^k) with regression modelling	Controlled factor space	Mathematical models of individual outcome variables	Describes only a local region of the factor space; the multivariate structure of outcomes may remain unexplored
Full factorial experiment (2^k) with discriminant analysis	Outcome variable space	Recognition and classification of experimental conditions	Does not identify the coordinates of untested local optima
Full factorial experiment (2^k) with regression and discriminant analyses	Factor space and outcome system	Mathematical modelling combined with multivariate selection of optimal conditions	Full management requires integration into a broader programme of subsequent actions
Research programme	Integrated educational or training process	Programming, monitoring, and management based on an integrated system of models	Highest confirmed level of cognitive and constructive realization

of their functions—from identifying experimental effects to mathematical modelling, programming, and model-based management (Table 4).

The proposed hierarchy describes the general logic underlying the functional evolution of experimental design. At the same time, the analysis of the specialized methodological corpus demonstrated that these capabilities are realized through different methodological trajectories, which differ in the object being structured, the nature of the analytical outcomes, and the limits of their cognitive capabilities.

Analysis of the specialized methodological corpus demonstrated that these methodological trajectories represent different ways of realizing the cognitive potential of experimental design. The simplest trajectory is the group × time design, which enables the evaluation of changes between experimental conditions but does not reveal the internal structure of pedagogical or training interventions.

Randomized factorial experiments and studies involving two manipulated factors expand analytical possibilities by examining main effects and interactions; however, their conclusions remain limited to the experimental conditions that have actually been implemented.

A qualitatively new stage is achieved through the application of the full factorial experiment (2^k). The combination of full factorial experiments with regression modelling provides a mathematical description of the factor space, whereas discriminant analysis enables the investigation of the multivariate structure of outcomes and the classification of experimental conditions. The integration of these approaches substantially expands the cognitive capabilities of experimental design, although the complete realization of its constructive potential requires the subsequent application of mathematical models within a unified research programme.

The highest level of methodological realization is achieved when the results of interconnected experiments are integrated into a system of mathematical models used for programming pedagogical processes, organizing pedagogical monitoring, and supporting management decisions. Under these conditions, experimental design acquires a constructive function and becomes an instrument of model-based management of educational and training processes.

Overall, the identified methodological trajectories should not be regarded as alternative classifications of experimental designs but rather as successive stages in the expansion of their methodological functions—from identifying experimental effects to constructing integrated systems of mathematical models that support model-based programming and management of educational and training processes. This pattern provided the conceptual foundation for the model of the functional evolution of experimental design presented in the following section.

Functional Evolution of Experimental Design

The comparative analysis of the main main bibliometric corpus and the specialized methodological corpus demonstrated that the traditional classification of experimental designs according to the number of factors, the structure of the experimental design, or the statistical methods employed does not adequately reflect the evolution of their methodological functions. The integration of the findings from the bibliometric and systematic methodological analyses made it possible to formulate a functional interpretation of the evolution of experimental design.

The results indicate that the development of experimental design is determined not so much by the increasing structural complexity of experimental designs as by the progressive expansion of the functions they perform in scientific inquiry. At the initial stage, experimental design serves primarily to test statistical hypotheses and establish causal relationships between the investigated factors. The subsequent stage is characterized by the use of experimental data to develop mathematical models that describe the factor space, quantify factor interactions, and predict outcomes within the investigated domain.

A further stage in the evolution of experimental design is marked by the transition from explaining empirical relationships to their practical application. At this level, mathematical models become instruments for selecting optimal educational or training conditions, programming pedagogical processes, organizing pedagogical monitoring, and supporting management decision-making. Consequently, the functional evolution of experimental design is characterized by a gradual transition from experimental analysis to model-based programming and management of pedagogical systems.

Within this evolutionary framework, the full factorial experiment (2^k) occupies a pivotal methodological position. The analysis demonstrated that it provides the methodological foundation for the transition from statistical analysis to mathematical modelling by enabling the construction of an orthogonal factor space, quantitative estimation of main effects and factor interactions, and the development of regression models. However, the realization of its constructive potential is determined not by the factorial design itself but by the integration of experimental data with mathematical modelling techniques and by the subsequent use of these models for programming and managing educational and training processes.

Accordingly, the evolution of experimental design should be interpreted as a functional rather than a purely structural process, in which its methodological role progressively expands from statistical hypothesis testing to mathematical modelling, programming, and model-based management of pedagogical processes. This functional perspective complements the traditional structural classification of experimental designs by emphasizing not only how experiments are organized but also what methodological functions they perform in the generation, modelling, and application of scientific knowledge.

The Full Factorial Experiment as a Methodological Hub in the Evolution of Experimental Design

The detailed analysis of the specialized methodological corpus demonstrated that the methodological application of the full factorial experiment (2^k) is heterogeneous. Even among studies in which the use of a full factorial experiment was explicitly confirmed, substantial differences were observed in the subsequent analytical approaches and in the extent to which experimental findings were translated into practical applications (Table 6).

The largest group of publications (40.0%) employed full factorial experiments to develop regression models describing individual outcome variables. In these studies, mathematical modelling was primarily used to quantify the relationships between manipulated factors and outcome variables, thereby enabling the identification of local optima and prediction of responses within the experimental factor space.

A separate group of studies (20.0%) combined full factorial experiments with discriminant analysis. Rather than modelling individual outcome variables, these investigations focused on discriminating and classifying experimental conditions on the basis of multiple outcome characteristics, thereby extending the analysis from univariate relationships to multivariate evaluation of pedagogical or training interventions.

The most methodologically advanced approach was identified in studies integrating regression and

Table 6. Structure of the Sports Pedagogy Cluster of Full Factorial Experiment Studies

Analytical branch	Application of the full factorial experiment	Publications (n)	%
Full factorial experiment with regression or mathematical modelling	Development of mathematical models describing the relationships between manipulated factors and individual outcome variables	6	40.0
Full factorial experiment with discriminant analysis	Multivariate discrimination and classification of experimental conditions	3	20.0
Full factorial experiment with regression and discriminant analyses	Simultaneous modelling of the factor space and the outcome structure	4	26.7
Full factorial experiment with insufficiently described analytical branch	The full factorial design was confirmed, but the subsequent analytical model could not be identified from the title, abstract, or keywords	2	13.3
Total		15	100.0

Note. This classification represents a conservative distribution based exclusively on information reported in publication titles, abstracts, and author keywords. The absence of explicit reference to regression or discriminant modelling in the abstract does not necessarily indicate that these methods were not applied in the full text.

discriminant analyses within a single experimental design (26.7%). The combination of these analytical methods enabled simultaneous modelling of the factor space and the multivariate outcome structure, thereby providing the methodological basis for multicriteria selection of optimal educational or training conditions. This group of studies most fully realized the constructive potential of the full factorial experiment.

In two publications (13.3%), the application of a full factorial experiment was confirmed; however, the information presented in the titles, abstracts, and author keywords was insufficient to determine the subsequent analytical approach. These findings indicate that the mere use of a full factorial experiment does not, by itself, characterize the level of realization of its methodological capabilities and that evaluation of its methodological role requires consideration of the complete analytical workflow.

Overall, these findings indicate that the methodological significance of the full factorial experiment is determined not by the factorial design itself but by the extent to which experimental evidence is integrated with mathematical modelling and subsequently translated into model-based programming and management of educational and training processes. Accordingly, the full factorial experiment should be regarded not simply as a statistical design but as the methodological hub linking experimental research with mathematical modelling, pedagogical programming, and evidence-based management.

Realization of the Constructive Potential of the Full Factorial Experiment

Analysis of the confirmed core of publications demonstrated that the constructive potential of the full factorial experiment (2^k) is realized not through the factorial design itself but through the mathematical processing of experimental data. The integration of full factorial experiments with regression and discriminant analyses provides a sequential transition from experimental planning to mathematical modelling, multicriteria evaluation of experimental conditions, and evidence-based decision-making (Khudolii et al., 2019; Ivashchenko, 2020).

The analytical process begins with the construction of an orthogonal factorial matrix, which ensures systematic variation of manipulated factors and provides the basis for quantitative analysis of their effects. At this stage, the full factorial experiment determines the structure of experimental conditions but does not yet produce a mathematical model of the investigated process (Box & Wilson, 1951; Montgomery, 2020).

Regression analysis subsequently generates mathematical models describing the relationships between manipulated factors and individual outcome variables. These models quantify main effects and factor interactions and enable prediction within the investigated region of the factor space (Myers et al., 2016; Khudolii et al., 2019).

Discriminant analysis complements regression modelling by focusing on the multivariate structure of experimental outcomes. It generates canonical functions, identifies centroids of experimental conditions, and classifies multivariate outcome patterns, thereby enabling multicriteria comparison of alternative pedagogical or training interventions (Khudolii et al., 2019; Ivashchenko, 2020).

The integration of regression and discriminant analyses completes the analytical workflow. Regression models describe quantitative relationships within the factor space, whereas discriminant functions support multicriteria selection among experimentally implemented conditions. This methodological sequence is clearly illustrated by the study of Ivashchenko et al. (2018), in which a full factorial experiment was combined with regression modelling to identify optimal experimental conditions and subsequently with discriminant analysis to determine the most appropriate pedagogical regime. Consequently, experimental design evolves from explaining empirical relationships to supporting programming, pedagogical monitoring, and model-based management of educational and training processes.

The methodological framework presented in Table 7 demonstrates that the realization of the constructive potential of the full factorial experiment requires the integration of complementary analytical approaches. The factorial design provides the experimental structure, regression analysis models quantitative relationships within the factor space, and discriminant analysis supports multicriteria evaluation

Table 7. Methodological Framework for Realizing the Constructive Potential of the Full Factorial Experiment (2^k)

Analytical component	Analytical space	Principal question	Analytical outcome
Full factorial experiment	Space of manipulated factors	Which combinations of factor levels should be implemented?	Orthogonally organized system of experimental conditions
Regression modelling	Relationships between factors and an individual outcome variable	How do manipulated factors and their interactions influence a specific outcome?	Mathematical model describing the local factor space
Discriminant analysis	Multivariate outcome space	Which variables best discriminate among experimental conditions?	Canonical functions, centroids, and classification of experimental conditions
Integration of regression and discriminant analyses	Factor space and outcome system	Which experimental condition is optimal when multiple outcomes are considered simultaneously?	Multicriteria selection among implemented experimental conditions
Research programme	Integrated educational or training process	How can the system of mathematical models be applied to planning and monitoring?	Programming, pedagogical monitoring, and management

Table 8. Levels of Realization of the Constructive Potential of Experimental Design

Level	Mode of realization	Publications	Typical outcomes	Representative publications
I. Local model-based management	Optimization of individual pedagogical or training parameters	7	Selection of repetitions, rest intervals, exercise sequences, local optimization	Ivashchenko et al. (2018); Ivashchenko et al. (2019); Kapkan et al. (2019a,b); Ivashchenko et al. (2020); Khudolii et al. (2020); Zima & Ivashchenko (2022)
II. Programming of educational and training processes	Design of pedagogical processes	1	Allocation of training means, time distribution, pedagogical programming	Ivashchenko (2020)
III. System-level model-based management	Integration of interconnected experiments into systems of mathematical models	3	Programming, pedagogical monitoring, and management of pedagogical systems	Khudolii et al. (2019); Ivashchenko (2020); Khudolii et al. (2026)

of experimental conditions. Together, these components establish the methodological basis for programming and managing educational and training processes.

The final stage of the systematic methodological analysis evaluated the extent to which mathematical models developed from full factorial experiments were applied to practical problems. Analysis of the confirmed core of 11 publicationsdemonstrated that the constructive potential of experimental design is realized at three interconnected levels, differing in the scale of the managed object and the practical application of mathematical models (Table 8).

The first and most common level, represented by seven studies, involved local model-based management, in which mathematical models were used to optimize individual pedagogical or training parameters, such as repetitions, rest intervals, exercise sequences, and other manipulated variables.

The second level, identified in a single study, extended mathematical modelling from optimizing individual interventions to programming educational and training processes, including the allocation of instructional time, selection of training means, and organization of pedagogical structures.

The highest level comprised three studies in which interconnected factorial experiments were integrated into comprehensive systems of mathematical models supporting programming, pedagogical monitoring, prediction, and management of educational and training processes. At this level, individual experiments became components of coordinated research programmes rather than isolated investigations.

Overall, these findings demonstrate that the complete realization of the constructive potential of experimental design remains relatively uncommon. Even within the specialized methodological corpus, most studies employed mathematical modelling primarily for local optimization, whereas the integration of mathematical models into comprehensive systems for programming and management represented the exception rather than the rule. Accordingly, model-based management may be regarded as the highest contemporary level of realization of the constructive potential of experimental design in sports science.

Discussion

Functional Reinterpretation of Experimental Design

Experimental designs are traditionally classified according to their structural characteristics, including the number of factors, randomization procedures, measurement organization, and statistical methods. Such classifications are essential for describing the organization of research but do not fully explain the methodological functions that experimental design performs in scientific inquiry (Goodwin, 2004; Creswell & Creswell, 2018). Contemporary reviews of research designs in sports science likewise classify studies as experimental, quasi-experimental, observational, longitudinal, mixed-methods, and related designs, while paying relatively little attention to the functional use of experimental results (Nicholas et al., 2025).

The bibliometric analysis demonstrated that the contemporary scientific discourse describes experimental studies primarily through their substantive research topics rather than through the methodological characteristics of their designs. The most frequent author keywords referred to research objects, interventions, and outcomes (e.g., exercise, resistance training, physical activity, rehabilitation, athletic performance, and physical education), whereas terminology directly related to experimental design rarely appeared among the dominant descriptors. Likewise, publication titles predominantly referred to experimental studies or quasi-experimental studies, while terms such as full factorial experiment or factorial experimental design were encountered only occasionally. These findings indicate that experimental design is widely applied as a methodological tool but is rarely considered an independent object of methodological investigation.

The systematic methodological analysis complements these observations. Studies with similar structural characteristics frequently performed fundamentally different methodological functions. In most publications, experimentation concluded with statistical hypothesis testing or the evaluation of factor interactions. Only a limited number of studies extended experimental findings to mathematical modelling, optimization, pedagogical programming, or model-based management of educational and training processes (Khudolii, 2019; Ivashchenko, 2020). These observations are consistent with recent meta-research in sports science highlighting persistent challenges related to experimental design, statistical methodology, reporting quality, and the translation of research findings into practical decision-making (Warmenhoven et al., 2025).

Taken together, these findings support a functional reinterpretation of experimental design. Rather than viewing experimental design solely as the organizational structure of an experiment, it may be regarded as a methodological system whose functions progressively expand according to the objectives of scientific inquiry. Within this framework, experimental design serves not only to establish causal relationships but also to support mathematical modelling, integration of empirical knowledge, pedagogical programming, and model-based decision-making. This interpretation is consistent with contemporary views of scientific methodology emphasizing the transition from isolated empirical findings to integrated systems of knowledge (Khudolii et al., 2026a; Khudolii et al., 2026b).

Accordingly, the proposed functional concept does not replace traditional structural classifications of experimental design but complements them by introducing the methodological functions of experimental design as an additional principle of classification.

From Hypothesis Testing to Model-Based Decision Making

One of the principal findings of the present study is that the evolution of experimental design in sports science is characterized by a gradual transition from statistical hypothesis testing to the use of mathematical models as instruments for practical decision-making. Within the traditional experimental paradigm, the primary objective is to establish statistically significant differences between experimental conditions and estimate effect sizes. Although this approach provides evidence regarding intervention effectiveness, it offers limited guidance for optimizing educational or training processes (Goodwin, 2004; Creswell & Creswell, 2018).

The present findings demonstrate that integration of full factorial experiments with regression and discriminant analyses fundamentally changes the function of experimental design. Experimental data become the basis for constructing mathematical models describing factor interactions, predicting outcomes, and selecting optimal pedagogical or training conditions (Montgomery, 2020).

Importantly, this transition is not simply the result of employing more sophisticated statistical procedures. Rather, it reflects a change in the methodological function of experimental design itself. At the initial level, experimentation primarily provides empirical evidence. At subsequent levels, experimental data are transformed into mathematical models that support pedagogical programming, monitoring, and management. This progression was consistently observed within the confirmed methodological core identified in the present study (Khudolii, 2019; Ivashchenko, 2020).

These findings are also consistent with the epistemological interpretation of modelling as the mechanism linking empirical observations with organized scientific knowledge (Lopatiev et al., 2026). Within this perspective, mathematical models perform not only descriptive and predictive functions but also provide the conceptual basis for evidence-based decision-making.

The Methodological Role of the Full Factorial Experiment

The present findings refine the methodological interpretation of the full factorial experiment (2^k). While traditionally regarded as one of several multifactorial experimental designs (Montgomery, 2020), the present analysis demonstrates that its principal methodological significance lies in establishing the link between experimentation and mathematical modelling.

The constructive potential of the full factorial experiment is determined not by the factorial design itself but by the subsequent mathematical processing of experimental data. Orthogonal factorial matrices provide the structural basis for systematic variation of manipulated factors; however, only the integration of regression and discriminant analyses enables the transition from statistical evaluation of experimental effects to modelling the factor space, multicriteria evaluation of outcomes, and evidence-based selection of optimal pedagogical or training conditions (Khudolii, 2019; Ivashchenko, 2020).

The findings further demonstrate that complete realization of the constructive potential of the full factorial experiment remains relatively uncommon. Even among studies specifically selected for methodological analysis, only a limited number integrated mathematical models into systems supporting pedagogical programming and management, whereas most studies remained focused on statistical significance testing.

Accordingly, the methodological significance of the full factorial experiment is determined not by the factorial design itself but by the extent to which experimental evidence is integrated with mathematical modelling and subsequently translated into model-based programming and management of educational and training processes. In this sense, the full factorial experiment may be regarded as the methodological hub linking experimental research with mathematical modelling, pedagogical programming, and evidence-based management.

Implications for Sports Science and Experimental Research

The proposed functional concept has important methodological implications for the planning of future research in sports science. It encourages researchers to consider not only the structural characteristics of experimental designs but also the methodological function that experimental design is intended to perform within a particular study. Under this perspective, experimentation becomes part of a broader research programme directed toward the accumulation of knowledge, development of mathematical models, and support of practical decision-making.

The findings further indicate that full realization of the constructive potential of experimental design requires systematic integration of experimental data with mathematical modelling and pedagogical monitoring. Such integration provides the methodological basis for moving from isolated experiments toward coordinated research programmes in which successive investigations contribute to programming, prediction, and management of educational and training processes. This interpretation is consistent with the conception of physical education as a managed learning process in which pedagogical monitoring becomes regulatory only when integrated into a comprehensive instructional model (Ivashchenko et al., 2026).

More broadly, the proposed functional perspective is consistent with contemporary methodological trends emphasizing the transition from isolated empirical findings toward integrated conceptual frameworks and research programmes (Khudolii et al., 2026a; Khudolii et al., 2026b). The bibliometric findings indicate that although experimental research is widely conducted in sports science, methodological aspects of experimental design remain underrepresented in the scientific discourse. This observation further supports the relevance of the functional approach proposed in the present study.

Accordingly, experimental design should no longer be regarded solely as a framework for organizing experiments but as a methodological system supporting the generation, modelling, programming, and practical application of scientific knowledge. This functional perspective constitutes the principal methodological contribution of the present study and provides a conceptual framework for future methodological research in sports science.

Conclusions

The bibliometric analysis of 1,653 publications and the systematic methodological analysis of a specialized corpus of 244 publications demonstrated that experimental studies in sports science are predominantly classified according to the structural characteristics of experimental designs, whereas the methodological functions of experimental design have received little systematic attention. The bibliometric findings further revealed that contemporary scientific discourse is dominated by subject-oriented terminology, while concepts directly related to experimental design are largely absent from author keywords and publication titles, indicating that experimental design is generally employed as an implicit methodological instrument rather than an explicit object of methodological investigation.

The present study proposes a functional concept of experimental design, according to which its methodological significance is determined not only by the structure of the experimental design but primarily by the level of realization of its cognitive and constructive potential. Unlike traditional structural classifications, the proposed functional perspective interprets experimental design as a methodological system whose functions progressively expand from statistical hypothesis testing to mathematical modelling, pedagogical programming, and model-based management of educational and training processes.

The findings demonstrate that the full factorial experiment (2^k) occupies a central methodological position in this functional evolution by providing the foundation for the transition from experimental analysis to mathematical modelling. Its constructive potential is realized not through the factorial design itself but through its integration with regression and discriminant analyses, enabling mathematical modelling of the factor space, optimization of pedagogical interventions, and evidence-based decision-making.

The systematic methodological analysis identified three hierarchical levels of realization of the constructive potential of experimental design: local model-based management, programming of educational and training processes, and system-level model-based management. Complete realization of this potential was found to be relatively uncommon and occurred only when experimental findings were integrated into interconnected systems of mathematical models supporting pedagogical programming, monitoring, and management.

Overall, the findings extend the current methodological understanding of experimental design in sports science by introducing its functional classification as a complementary methodological framework. This perspective provides a conceptual basis for the transition from isolated experimental studies toward coordinated research programmes integrating experimentation, mathematical modelling, pedagogical programming, and evidence-based management of educational and training processes.

Ethics Approval

Ethical approval was not required for this study because it was based exclusively on the analysis of bibliographic metadata and previously published scientific literature. The study did not involve human participants, animals, or the collection or use of personal data.

Informed Consent

Informed consent was not required because the study did not involve human participants or the collection or use of personal data.

Data Availability Statement

The bibliographic data used in this study were obtained from the Scopus database. The search strategy, eligibility criteria, and the analytical publication corpus developed for this study are available from the corresponding author upon reasonable request.

AI Transparency Statement

The authors used AI-assisted tools to improve the organization of the manuscript, enhance language quality, and improve the readability of the text. All scientific decisions, including the conceptualization of the study, development of the methodology, construction of the analytical publication corpus, analysis and interpretation of the findings, and preparation of the final manuscript, were made exclusively by the authors. The authors reviewed, verified, and approved all AI-assisted outputs and accept full responsibility for the accuracy, integrity, and originality of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Функціональна еволюція експериментального дизайну у спортивній науці: від бібліометричного аналізу до формування функціональної концепції

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 15 с., 8 табл., 1 рис., 28 джерел.

Передумови. Експериментальний дизайн є основною методологічною основою встановлення причинно-наслідкових зв›язків у спортивній науці. Традиційні класифікації описують експериментальні дизайни за їх структурними характеристиками, такими як кількість факторів, процедури рандомізації, організація вимірювань або застосовані статистичні методи. Водночас такі підходи не пояснюють, яким чином методологічні функції експериментального дизайну еволюціонують від статистичної перевірки гіпотез до математичного моделювання, програмування та модельно обґрунтованого прийняття рішень.

Мета. Дослідити функціональну еволюцію експериментального дизайну у спортивній науці, визначити методологічну роль повного факторного експерименту (ПФЕ 2^k) та розробити функціональну концепцію експериментального дизайну на основі бібліометричного та систематичного методологічного аналізів.

Матеріал і методи. Дослідження виконано у два етапи. На першому етапі проведено бібліометричний аналіз публікацій, індексованих у базі даних Scopus (2000–2026 рр.), з метою визначення структури досліджень експериментальних дизайнів та формування аналітичного корпусу документів. Після вилучення дублікатів бібліометричний корпус складався з 1653 публікацій. На другому етапі проведено систематичний методологічний аналіз спеціалізованого корпусу з 244 публікацій для оцінювання рівня реалізації пізнавального та конструктивного потенціалу експериментальних дизайнів. Особливу увагу приділено дослідженням, у яких повний факторний експеримент поєднувався з методами математичного моделювання, регресійного та дискримінантного аналізу.

Результати. Бібліометричний аналіз показав, що сучасна спортивна наука характеризується домінуванням предметно орієнтованої термінології, тоді як методологічні поняття, пов›язані з експериментальним дизайном, рідко представлені серед авторських ключових слів або в назвах публікацій. Систематичний методологічний аналіз засвідчив, що експериментальні дизайни з подібними структурними характеристиками можуть виконувати принципово різні методологічні функції. На цій основі розроблено функціональну концепцію експериментального дизайну, відповідно до якої його методологічне значення визначається рівнем реалізації пізнавального та конструктивного потенціалу. Встановлено, що повний факторний експеримент є методологічною ланкою, яка поєднує експериментальний аналіз із математичним моделюванням. Виділено три рівні реалізації конструктивного потенціалу експериментального дизайну: локальне модельно обґрунтоване керування, програмування педагогічного процесу та системне керування.

Висновки. Запропоновано функціональну концепцію експериментального дизайну, яка доповнює традиційні структурні класифікації. Методологічний внесок дослідження полягає у запровадженні нового принципу класифікації експериментальних дизайнів за рівнем реалізації їх пізнавального та конструктивного потенціалу. Повний факторний експеримент займає центральне методологічне місце в цій концепції, забезпечуючи перехід від статистичної перевірки гіпотез до математичного моделювання, програмування та модельно обґрунтованого керування педагогічними й тренувальними процесами.

Ключові слова: експериментальний дизайн, повний факторний експеримент, спортивна наука, математичне моделювання, регресійний аналіз, дискримінантний аналіз, бібліометричний аналіз, систематичний методологічний аналіз, педагогічне програмування, модельно обґрунтоване прийняття рішень.

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