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“PERFORMANCE ANALYTICS FOR COMPETITIVE INTELLIGENCE IN AEROBIC GYMNASTICS: EVALUATING INTEGRATED CORE AND PLYOMETRIC TRAINING”

ANÁLISE DE DESEMPENHO PARA INTELIGÊNCIA COMPETITIVA NA GINÁSTICA AERÓBICA: AVALIAÇÃO DO TREINAMENTO INTEGRADO DE CORE E PLIOMÉTRICO

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ABSTRACT (Resumo estruturado em inglês)

Purpose: This paper investigates the purpose of performance analytics as a competitive intelligence instrument in aerobic gymnastics, the impact of integrated core and plyometric training on multi-dimensional performance results.
Methodology/approach: A quantitative quasi-experimental design was used in which 36 competitive aerobic gymnasts (15-22 years) were randomly grouped as experimental and control groups and they followed an 8-week intervention period. Pre- post testing was used to test performance variables including core stability, jump height, balance, execution score and endurance. The statistical tests were paired and independent t-tests, percentage change, effect size (Cohen d), and correlation analysis.
Originality/Relevance: The research combines performance analytics and competitive intelligence where the traditional outcome-driven approach of assessment is replaced by the data-driven, strategic decision-making framework in sport.
Key findings: The results showed the significant improvement in all variables ($p < 0.01$), and the great effect sizes of jump height ($d = 1.34$) and execution ($d = 1.26$). Balance and execution ($r = 0.81$) and core stability and power ($r = 0.71$) were found to have strong correlations, which are indicative of interactions between systemic performance.
Theoretical/methodological contributions: The paper suggests a theoretical framework that converts performance data to competitive intelligence, which serves as the basis of training optimization based on evidence and future research related to the field of sports analytics.
Keywords: Performance analytics; Competitive intelligence; Aerobic gymnastics; Plyometric training; Core stability; Integrated training; Decision-making

RESUMO (Estruturado)

Objetivo: Este artigo analisa o objetivo da análise de desempenho como instrumento de inteligência competitiva na ginástica aeróbica, bem como o impacto do treino integrado de core e plicométrico nos resultados multidimensionais de desempenho.
Metodologia/abordagem: Abordagem: Foi utilizado um desenho quantitativo quase experimental, no qual 36 ginastas aeróbicos competitivos (15–22 anos) foram randomizados em grupos experimentais e de controlo, submetendo-se a um período de intervenção de 8 semanas. Foram realizados testes pré e pós para avaliar variáveis de desempenho, incluindo estabilidade do core, altura de salto, equilíbrio, pontuação de execução e resistência. Os testes estatísticos incluíram testes t pareados e independentes, alteração percentual, tamanho do efeito (Cohen d) e análise de correlação.
Originalidade/Relevância: A investigação integra a análise de desempenho e a inteligência competitiva, substituindo o tradicional modelo de avaliação orientado para resultados por um enquadramento de tomada de decisão estratégica baseado em dados no desporto.
Principais conclusões: Os resultados revelaram uma melhoria significativa em todas as variáveis ($p < 0,01$), com grandes tamanhos de efeito na altura de salto ($d = 1,34$) e na execução ($d = 1,26$). Verificou-se uma forte correlação entre equilíbrio e execução ($r = 0,81$) e entre estabilidade do núcleo e potência ($r = 0,71$), indicando interações entre o desempenho sistémico.
Contribuições teóricas/metodológicas: O artigo propõe um quadro teórico que transforma dados de desempenho em inteligência competitiva, servindo de base para a otimização do treinamento com base em evidências e para futuras pesquisas no campo da análise desportiva.

Palavras-chave: Análise de desempenho; Inteligência competitiva; Ginástica aeróbica; Treinamento plicométrico; Estabilidade do núcleo; Treinamento integrado; Tomada de decisão

1 INTRODUCTION

Aerobic gymnastics has become the practice of a very technical and performance-oriented discipline in the wider context of competitive gymnastics, which consists of continuous high-intensity movement sequences in a precise, coordinated and aesthetic performance. The sport has grown out of the old school of aerobics of the 1980s into a structured competitive sport with standardized scoring systems judging performance based on execution, challenge and artistry. The current-day practices require aestheticism in addition to the extraordinary measures of muscular endurance, explosive strength, body balance, and neuromuscular coordination. Training A typical training ranges of approximately 15 hours a week, which is long, and athletes are often training more than 15 hours a week, extending to over 20 hours a week, because of the mounting physical and technical demands of elite competition. With the ever-increasing competitive standards, competitive success can be decided by marginal gains in the performance, thus requiring increasingly advanced methods of designing and evaluating training (Yang, 2026).

Recent studies of aerobic gymnastics emphasize the difficulty of performance adaptation. There is longitudinal evidence that the conventional training can improve balance, flexibility, and muscular endurance but cannot significantly improve explosive power and anaerobic capacity unless specific measures are implemented (Li & Chen, 2023). This shortcoming highlights the necessity to include specialized training modalities, in particular, those ones that train rapid force production and neuromuscular efficiency. One of them, plyometric training, has become an essential aspect since it can utilize the stretch-shortening cycle and enhance explosive strength, jump performance, and agility. Empirical research also supports the fact that plyometric training produces a considerable effect on lower-limb power and leads to long-lasting performance in the athletic population (Gencay Çüce, 2021; Rodriguez-Redondo, 2025). Equally, a combination of plyometric and high-intensity interval training has shown better results regarding enhancing aerobic and anaerobic capacities among the gymnasts (Ma et al., 2024).

Whereas these results support the physiological utility of high-level training programs, they also indicate that there is a necessary shift towards unconventional approaches to performance assessment. Performance analytics has, in this respect, become a popular new tool of sports science. Performance analytics denote the systematic gathering, processing, and interpretation of performance-related information to support the training choices and maximize the results. Modern sport uses more and more information-based knowledge to assess the condition of athletes, determine performance trends, and anticipate the results in the competition. Analytical methods help coaches and practitioners to transition their understanding of decisions that are based on intuition to the ones that are founded on evidence, thus improving the efficiency

of the training and lowering the uncertainty levels.

The increased use of analytics in sport is consistent with the overall trend of integration of competitive intelligence, an idea historically based on business and strategic management. Competitive intelligence is a process whereby information is collected and analyzed systematically to aid the process of making strategic decisions as well as gaining a competitive edge. In sport, such paradigm is implemented in more and more directions such as athlete performance, optimization of training, and analysis of opponents (Gencay Çüce, 2021). With the right analysis, the performance data could be used as an intelligence tool, with coaches being able to recognize the strengths, weaknesses, and potential areas of improvement. This shift suggests a broader shift in the sporting arena toward knowledge based competition where an individual cannot simply excel due to physical prowess but through the ability to reason and apply information in the way that is more advantageous to him or her.

In the context of aerobic gymnastics, the issue of the integration of performance analytics and competitive intelligence is particularly relevant. The scoring system of the sport is multifactorial in the fact that the sportsmen are forced to maintain the balance between the technical performance, the artistic performance and the physical performance simultaneously. A keen understanding on the relationship between different variables to create an impact on overall performance should therefore inform decision on training. These interactions can be provided through the frameworks of analysis so that the most appropriate training strategies could be identified (Lesinski et al., 2015). To illustrate, the outcomes of the integrated core and plyometric training could be provided as performance indicators through which the degree of improvement of the specific intervention leading to the jump execution, balance and consistency of the routine could be estimated.

Despite the developed importance of analytics and advanced training practices, there is a gap that is essential in the literature. Physiological outcomes, such as strength, endurance and power have been of primary concern in the available literature without adequate correlations of such outcomes to the strategies of strategic decision-making. Also, there has not been the development of the application of competitive intelligence models in sporting spaces particularly in those sports which are niche such as aerobic gymnastics. Though research has been conducted regarding the effectiveness of plyometric training and the interventions based on intervals, there has been very little research conducted regarding how the performance data can be intelligible translated to actionable intelligence to coaches and practitioners. The lack of knowledge is augmented by the fact that there exist no integrated models that combine training science, and also analytical decision-support systems.

There is also a tendency to separate training interventions as the recent studies are conducted but joint training modalities should be treated synergistically. As an example, despite plyometric training being traditionally known to enhance explosive power, when used together with core stability training, which is required to maintain the posture and control of the intricate routine, there has not been much study conducted on a theoretical platform. Lack of these integrative practices restricts the capacity to see the contributions of various training components to the competitive performance wholly. Moreover, most of the studies are either descriptive or experimental in nature without reflecting on the predictive or prescriptive analytics and thus limit their applicability in real-life settings in decision making.

Considering these constraints, the gap between sports science and competitive intelligence requires a research methodology that would fill the gap. This approach, in addition to assessing the effectiveness of training interventions, must also be able to convert the performance data into the strategies that can be used in decision-making. It can be concluded that by placing the performance analytics as the source of competitive intelligence (McGarry, 2009), one can develop the strategic aspect of training, allowing coaches to make more knowledgeable and focused interventions.

Hence, the main aim of this research is to discuss the use of performance analytics as a competitive intelligence tool in aerobic gymnastics, in particular, integrated core and plyometric training. The research will (1) assess the effect of integrated training on the key performance measures, such as power, balance, and quality of execution; (2) examine performance measures in order to predict the pattern and relationship that can be applied to competitive success; and (3) formulate an analytical framework to aid in making evidence-based judgments in training design. In meeting these goals, the study aims to make contributions to the theoretical and practical knowledge of how data-based strategies can be used to improve the competitive performance in aerobic gymnastics.

Finally, this research contributes to the idea that the modern sports optimization of performance is not the work of the physical training only, but of the analytical ability as well. Performance data intelligence creation and use is a vital factor of success in an increasingly competitive environment. This study, combining

performance analytics and competitive intelligence, will provide a new approach to the optimization of training, which coaches, athletes, and sports organizations that want to acquire a competitive advantage should understand.

2 THEORETICAL FRAMEWORKS

The theoretical basis of this research is based on the intersection of the performance analytics, competitive intelligence, and innovative training methodologies. Although each of the mentioned domains developed in recent years, they have not been integrated yet, and it is still quite hypothetical. It is a critical review of the literature available and it will help to show the overlapping of concepts, limitations of methods applied and the tension in the literature that needs introduction of an integrated analytical framework in the field of aerobic gymnastics.

The performance analytics theory in sport refers to a theory that serves as a method to analyze the sport and enhance the performance of the participants.

2.1 Performance Analytics

Performance analytics is one of the main paradigms of modern sport because of the emergence of data collection technologies, artificial intelligence, and computational modeling. In the simplest definition, performance analytics involves transformation of raw performance data into information that is practical and which can be used to maximize training as well as facilitate competitive choices. The contemporary models are concerned with multi-dimensional combination of information, including physiological, biomechanical, and tactical information, to create a complex picture of the athletic performance.

The latest studies emphasize the change brought about by analytics in sport. As an example, Cossich et al. (2023) observe that the performance of athletes and athletes can be constantly monitored and analyzed using newer technologies, i.e., wearable sensors, machine learning algorithms, and real-time feedback systems, which allows improving the process of making decisions (Cossich et al., 2023). Similarly, Munoz-Macho et al. (2024) demonstrate that the use of AI-based analytics can manage a complex performance and health variable, which would allow predictive modelling and injury prevention (Munoz-Macho et al., 2024). The improvements make performance analytics not a tool to describe but a tool to predict and prescript that can be applied to training practices.

However, the literature shows that, despite such developments, there are certain severe limitations. First, some of the analytical paradigms are reductionist in nature and do not underline the dynamics of interaction of physical, technical and contextual factors. This issue is particularly sharp in the individual sports where the outcomes of performance are predetermined by the complex interdependence that can hardly be quantified. Second, it has a chronic disconnect between data creation and decision making. There is a discrepancy between the acquisition of large amounts of data and their conversion into practical insights, which is sometimes because of an absence of theoretical basis.

Moreover, the available studies are more inclined towards technological innovation than conceptual clarity. The adoption of AI in sport has been fast by far compared to the theoretical frameworks to explain the way analytical outputs are supposed to be used in decision-making processes (Zhou et al., 2025). Such an imbalance leads to a disjointed body of knowledge, with the implementation of analytical tools that do not have a clear interpretation of the strategic implications. Performance analytics, as we know it, therefore, tends to be more of a technical operation as opposed to a strategic capacity.

2.2 Competitive Intelligence Theory

Competitive intelligence (CI) has its roots in strategic management and can be considered as the methodological process of gathering, analyzing, and sharing information in order to aid decision-making and build competitive advantage. CI focuses on situational zing, interpreting, and strategic implementation, unlike conventional data analysis. It converts information into intelligence through connecting data to organizational goals and dynamics in the environment.

At the sporting level, CI has become a topic of growing interest as a paradigm through which the data available on performance can be used to achieve a competitive advantage. According to van den Berg et al. (2020), sport performance analysis is in itself indicative of CI processes because coaches and analysts are constantly gathering and processing information regarding their own athletes and their rivals to make strategic decisions (van den Berg et al., 2020). According to this opinion, performance analytics and CI are not two different spheres; instead, they are complementary parts of a greater decision-support system.

The empirical research as of today also supports the strategic value of CI. Indicatively, Souaifi et

al., (2025) indicate that information and analytical skills of high quality are important in attaining sustainable competitive advantage especially in uncertain and rapidly evolving environments (Souaifi et al., 2025) Likewise, the study by Rein & Memmert et al. (2016) highlights the importance of CI in improving the organizational learning and performance, proving that intelligence processes contribute to a more adaptive and informed decision-making process Rein & Memmert (Rein & Memmert, 2016).

The use of CI in sport is underdeveloped, although its theoretical strength is strong. The majority of research is centered on the organizational situation, and little attention is paid to the decision-making at the level of athletes. Furthermore, the current literature tends to consider CI as a one-dimensional process, including data collection, data analysis, and data dissemination, without considering the dynamic and cyclic nature of the decision-making process in sport. This weakness is especially applicable in highly performance settings where decisions need to be made quickly and they need to be made in circumstances of uncertainty ((Yu et al., 2024).

The other gap that is significant is the absence of the integration between CI and performance analytics. Although both fields focus on making decisions using data, they are working on different levels of abstraction. Performance analytics is concerned with measuring and evaluating performance and CI is concerned with interpreting and strategy. Lack of a single framework also means that there is no linkage between strategic decisions and the outputs of the analysis, which constrains the success of the two methods.

2.3 Core Training Literature

Core training has become a commonly known ingredient of athletic performance especially in the kind of sport that entails stability, balance and coordination. Core musculature is an essential and vital part of force distribution, posture, and efficiency of movements because it is the key connection between the upper and lower body functions. In aerobic gymnastics, where they use intricate patterns of active motions, core stability is also needed to ensure harmony and achieve expertise and skills with accuracy (Sun, 2022).

Recent studies have been done to determine the effects of core training on performance outcomes. Research published in the journals like Journal of Strength and conditioning Research and Sports biomechanics show that core-oriented interventions enhance balance, trunk stability and movement efficiency thus improving overall performance. The literature however indicates a number of inconsistencies in the extent and transferability of these effects (Kayantaş & Genç, 2024).

The variation in training protocols is one of the limitations. Core training takes place in a very broad pool of exercises starting with the static stability, through to the dynamic and functional movement which makes the comparison of the results among studies to be hard. Further, the majority of the studies rely on the individual performance results, such as plank endurance or trunk strength and these results may not be true as far as the performance in the sport is concerned. This disillusionment makes one wonder how ecologically sound core training research is.

Besides, there is controversy over core stability and performance. Although there is a few studies that have documented considerable gains in athletic performance, others have claimed that core training effects are only effective in preventing injuries and postural control. This indistinctness underscores the necessity of more integrative methods which put into account the interaction of core training with other performance variables (Cabrejas et al., 2023).

Analytically, core training research has been mostly disregarding the contribution of data-driven assessment. The majority of studies use pre- post experimental design without having advanced analytical tools, e.g., predictive modeling or multi- variable analysis. Consequently, the fact that the analysis of training core effects can be optimized through performance analytics is an understudied issue.

2.4 Plyometric Training Literature

Plyometric training is very popular as it has been considered to be one of the most efficient ways to acquire explosive power, speed and neuromuscular efficiency. According to the stretch-shortening cycle, plyometric exercises help athletes to produce maximum force within the shortest period of time, and thus they are especially applicable in sports that involve quick and dynamic actions.

Recent systematized reviews and meta-analyses have also unanimously shown the efficacy of plyometric training in enhancing jump performance (Rodriguez-Redondo et al., 2025), sprint speed, and agility in different sporting groups. These results are confirmed by the results of the works in high impact journals like Sports Medicine and European Journal of Sport Science that point to the physiological processes of plyometric adaptations, such as higher recruitment of the motor units and better tendon stiffness (Ma et al., 2024).

Nevertheless, the plyometric training literature is not without constraints although this method is widely used. Firstly, short-term interventions have mostly been studied and little has been done to examine the long-term adaptation and sustainability. Second, the findings are generalized to other sports, without considering the specific needs of a sport (Li & Chen, 2023). The relevance of conventional plyometric training in the setting of aerobic gymnastics is still unclear, as the exercises there involve explosive strength as well as accuracy.

The other pressing concern is the fact that there is a gap between plyometric training and the other forms of training. Although plyometric training has been commonly used together with strength training or endurance training, not many studies have empirically investigated the interaction between these two aspects. This gap specifically applies in matters pertaining to the impact of integrated training methods on performance outcomes (Sun, 2022).

In terms of methodological perspective, there is also a lack of application of advanced analytics in the research of plyometric training. Though the performance improvement is well documented, the internal patterns and associations among the variables are not often investigated with the help of data-driven approaches. This is a limitation that hinders the development of prediction models and the optimization of training plans.

2.5 Integration of Core and Plyometric Training: Toward an Analytical Intelligence Framework

The combination of core and plyometric training is a prospective but understudied field of research. In theory, a combination of these modalities will be able to improve stability and power to meet the two-fold needs of aerobic gymnastics. The basis of postural control and force transmission is created through core training whereas explosive capabilities are developed through plyometric training. The combination of the two can yield more than the sum of the effect of each modality individually (Cabrejas et al., 2023).

Nevertheless, the literature shows that there are no in-depth frameworks of knowing this integration. The majority of studies focus on the core and plyometric training separately with little consideration to the effectiveness of the training when it is combined. In addition, the current literature is usually descriptive in nature since it considers the final performance but not the mechanisms or interactions (Aslam et al., 2025).

This loophole explains why an analytical intelligence framework based on the unified integration of performance analytics and competitive intelligence is needed. This type of framework would allow training interventions to be evaluated in a systematic way, with the performance data associated with strategic decision-making. It is possible to determine patterns, predict the results, and optimize training strategies by using multi-dimensional data analysis.

Notably, the combination of analytics and intelligence resolves the shortcomings mentioned in the foregoing sections. It is the linkage of measurement and strategy that converts the performance data to actionable insights. In addition, it offers a conceptual base of comprehending the interaction of various elements of training to affect performance ((Ma et al., 2024).

Such frameworks are still underdeveloped even though they have potential. The available literature focuses on technological potential, but it does not integrate the concepts. As it has been mentioned in the recent AI and analytics in sport reviews, more holistic strategies that incorporate data analysis with information on domain specific knowledge and strategy need to be developed.

2.6 Synthesis and Research Implication.

In short, the literature shows that there are major improvements in performance analytics, competitive intelligence and training practices. Nevertheless, these fields are rather unrelated and cannot have a significant cumulative effect on performance optimization. Performance analytics offers the means of analyzing data and does not integrate strategy. Competitive intelligence provides a decision-making model that is not fully used in sport. The studies of core and plyometric training show performance improvements yet do not include analytical aspects.

This fragmentation serves to emphasize the fact that an integrated approach is what is required; a strategy that incorporates analytical rigour and strategic insight. When placing the role of performance analytics as a part of competitive intelligence, one can make the training interventions more effective and help to make informed decisions (van den Berg et al., 2020). This gap is the gap that the present study tries to fill as it aims to create a framework that would accommodate such domains though particular emphasis is made on aerobic gymnastics.

This approach not only contributes to the development of theoretical knowledge, but also has practical consequences, i.e., it can be used by coaches, athletes, and sports organizations. In a highly data-

driven world, the capacity to create and use intelligence based on performance data is an important source of competitive advantage.

In accordance with the above theoretical presentation, this paper assumes a hybrid approach according to which core and plyometric training are theorized as complementary performance variables that have an impact on the main athletic performance indicators, such as power, balance, and quality of execution. These performance variables are not considered as independent constructs but as a part of a related system. Moreover, the performance analytics is posed as a mediating process through which raw performance data is converted into competitive intelligence, which can be acted upon. This model gives the theory underpinning the study of how the training interventions may be logically analyzed to enhance strategic decision-making in aerobic gymnastics.

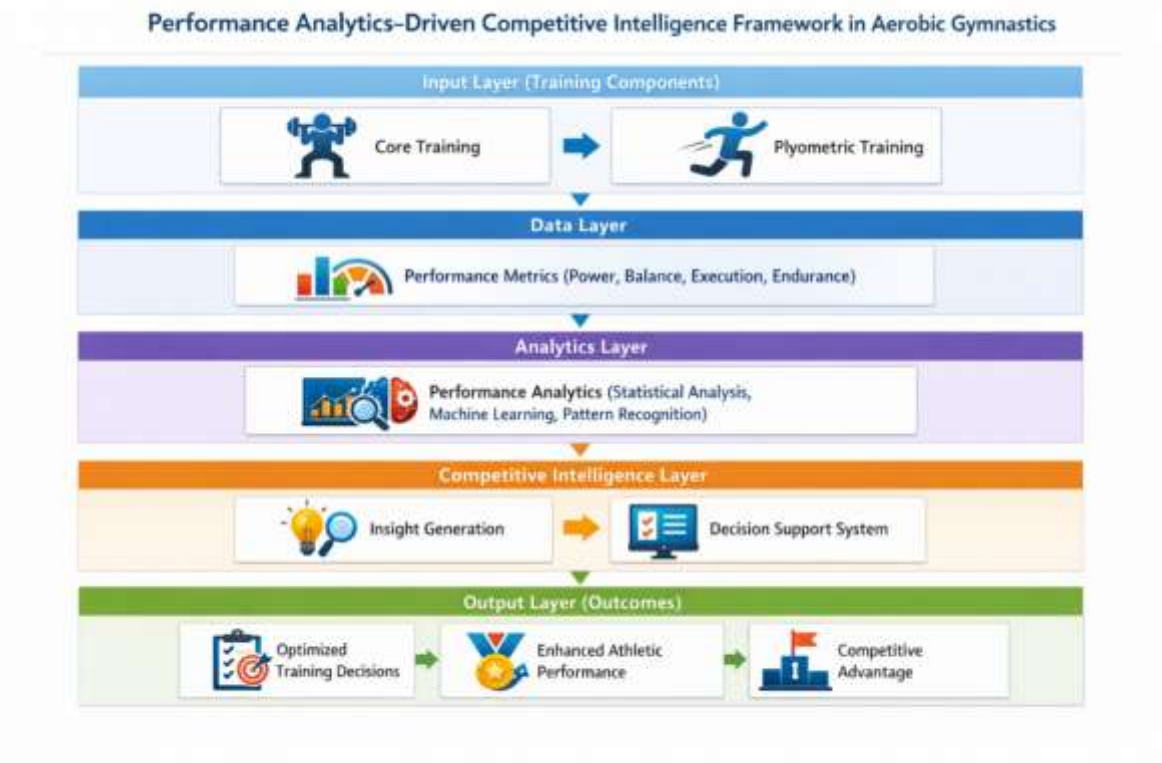

Figure 1.Performance Analytics–Driven Competitive Intelligence Framework in Aerobic Gymnastics

This theoretical framework informs the methodological design of the research, which empirically tests the connections among the variables of integrated training, the results of the performance, and the process of analytical intelligence.

3 METHOD

The paper will use quantitative and experimental research design to investigate how performance analytics as a competitive intelligence tool is relevant in aerobic gymnastics particularly integrated core and plyometric training. The methodological decisions are informed by the requirement to produce objective, measurable, and analytically solid evidence that can be used in the process of assessment of performance as well as strategic decision-making. Since it has the dual focus on physiological results and analytical interpretation, the design combines the conventional experimental implementation with the methods of performance analytics.

3.1 Research Design

A quasi-experimental pretest- posttest pretest experimental design was utilized. The design is typical of the research conducted in the sphere of sports science to determine the effectiveness of training interventions under real-world conditions when complete randomization may not be possible (Impellizzeri and Marcora, 2020). The reason to select this design is that it could be used to determine causal relationships between the

training interventions and the performance outcomes as well as be ecologically valid in a sportive environment.

Unlike purely observational research, an experimental research design offers the advantage of the control over manipulating the variables, which in this case are the combination of core and plyometric training, and it can, therefore, be more stringently evaluated the effects of training. In the meantime, the quasi-experimental approach considers the practicality of the situation in sports settings, such as the composition of the teams and the coaching regimes, which tend to be obstacles to random allocation (Halperin et al., 2018). It is this sacrifice of control and realism that makes the difference between the generation of scientifically sound and practically relevant findings.

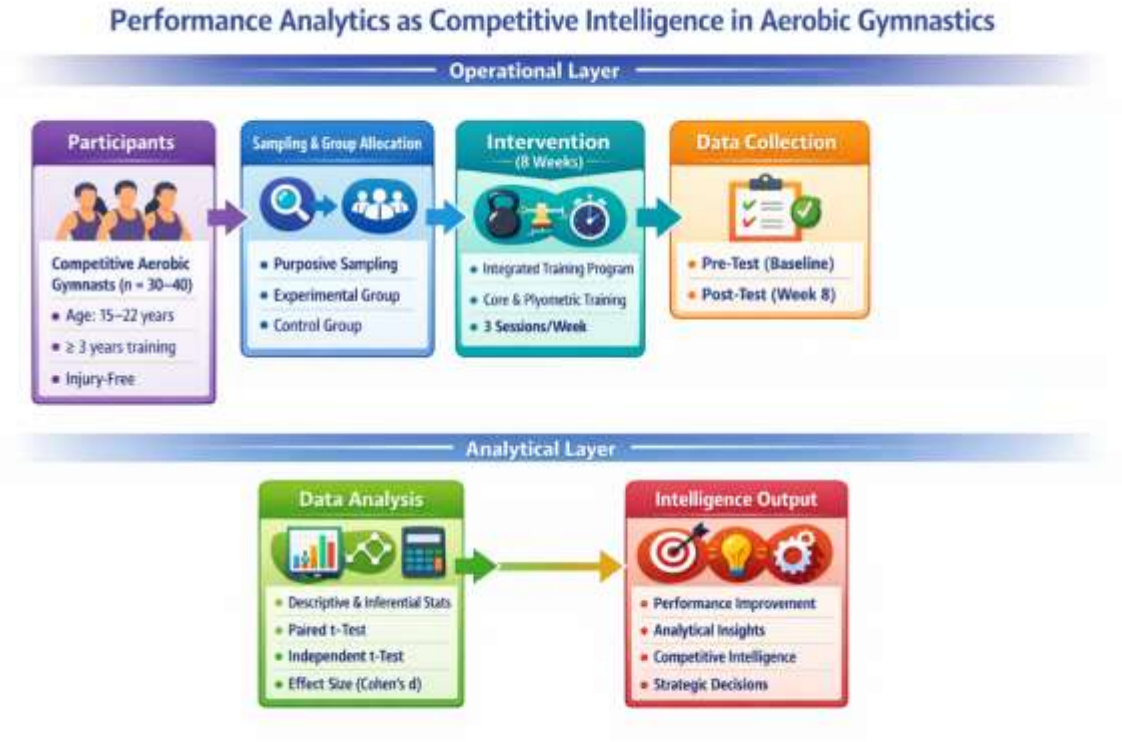

Figure 2. Performance Analytics as Competitive Intelligence in Aerobic Gymnastics."

3.2 Participants

In this study, 36 competitive aerobic gymnasts (n = 30-40) with the ages 15-22 years were recruited through regional training centers and sports academies. The following inclusion criteria were used to select participants: (1) three years of continuous training experience in aerobic gymnastics, (2) the active participation in competitive events, and (3) no injury in the past six months.

The use of trained sports people as opposed to beginners is of paramount importance in making results of such a study relevant in high performance settings. Past studies show that the adaptations of training are quite different in novices and trained individuals, and more specific and specialized interventions are necessary among experienced athletes to gain performance (Grgic et al., 2020). Thus, competitive athletes improve the external validity of the research and is consistent with the goal of creating competitive intelligence knowledge.

The study was deemed not applicable for ethical approval by the [Institutional Research Ethics Committee / University Name] and followed the Declaration of Helsinki in the course of the research procedures. Written. Written informed consent was obtained by all participants before participation and in the case of participants who were below 18 years old, their legal guardians participated.

3.3 Sampling Technique

Purposive sampling strategy was used to find the participants that will fit into the performance and experience requirements necessary in the study. This is suitable in the research of the sports science when the population

of interest is specialized and cannot be easily identified using a random sampling technique (Etikan & Bala, 2017).

The respondents were separated into two categories:

- Experimental group: Got integrated core and plyometric training.
- Control group: Went on with regular training regimes.

Group assignment was done such that there was baseline equivalence in terms of age, training experience and level of performance. In small and specialized samples, purposive allocation may be more useful in controlling confounding variables due to the internal validity, whereas in large, population-based samples, randomization is a better approach because it improves internal validity. This is especially crucial with performance studies; as individual variation may have a strong impact.

3.4 Intervention Protocol

The intervention program involved an 8-week integrated training program, which involved core stability exercises mixed with plyometric exercises. The training sessions were done thrice a week, about 60 minutes, and were integrated into the routine of the training of the athletes.

The fundamental training element.

Dynamic stabilization exercises, such as:

- Planks (variations)
- Rotations of medicine balls.
- Stability-based movements

Plyometric Training element.

Exercises were focused on explosive power, such as:

- Jump squats
- Bounding drills
- Box jumps

The combination of these elements can be theoretically explained with references to the compensatory functions of stability and power in sport. Core training increases the postural control and force transmission, and plyometric training increases the rapid force production with the use of the stretch-shortening cycle. The synergistic effect is likely to occur with the combination of these modalities, which are justified by recent training studies, focusing on multimodal interventions (Ramirez-Campillo et al., 2021).

The length and the frequency of the intervention were chosen in accordance with the existing guidelines that state that 6-8 weeks of organized plyometric training is adequate to achieve the performance changes that could be observed among trained athletes (Chaabene et al., 2019). Also, the intervention itself can be incorporated into the current training practices to guarantee ecological validity and reduce the impact of the intervention on the training cycles of the athletes.

3.5 Data Collection

The data on performance were measured at two times, and these are: pre-intervention (baseline) and post-intervention (week 8). To have a multidimensional view of the performance of aerobic gymnastics, several performance indicators were quantified:

- Explosive strength: vertical jump height (tested with the help of jump mat systems)
- Core stability: Plank test and dynamic balance test.
- Quality of execution: Evaluation of certified judges under the set standard of competition criteria.
- Endurance: Aerobic capacity tests that are based on repetition.

The need to prove the complexity of the performance requirements of aerobic gymnastics explains the combination of the indicators. Single measures that focus on variables are not adequate to understand the relationship between strength, coordination, and technical execution. Thus, a multidimensional approach will increase validity and depth of analysis (Moreno-Ortega et al., 2026).

The data collection was done in standardized protocols to provide reliability. Also, digital instruments and performance tracking systems were employed to increase the accuracy of measurements and simplify further analytical processing. The use of objective measurement instruments is in line with the current trends in sports analytics, which underline the significance of correct and high-quality data in evaluating performance.

3.6 Reliability and Measurement Validity

Standardized testing protocols were used in all the assessment sessions to guarantee the reliability and validity of the measurements. All the performance tests were done in the same environmental conditions and monitored by the same evaluators to reduce inter-rater variability.

Pilot testing was done to determine test-retest reliability before the actual process of data collection and the reliability coefficients (interclass correlation coefficient, ICC > 0.85) were high in all the performance variables. Also, measurement instruments and procedures were chosen according to their validity in sports performance research and allowed measuring core stability, power, balance, execution, and endurance correctly and consistently.

3.7 Statistical Analysis

The statistical analysis was done by means of the use of statistical software (e.g., SPSS or R), applying both descriptive and inferential statistics.

Descriptive Statistics

- Mean, Standard deviation and percentage change.
- It is used to present the trends in the performance and give a preliminary picture of the outcomes.

Inferential Statistics

- Paired t-tests: To determine in-group differences (pre vs. post).
- Independent t-tests: To test the differences between the experimental and control groups.
- Effect size (Cohen d): To assess the strength of the training effects.

T-tests are suitable in the analysis of the differences in small samples and are commonly used to conduct research in sports science (Hopkins, 2019). Nevertheless, statistical significance does not give us the whole picture of practical relevance. Thus, there are measures of effect sizes to evaluate the practical significance of the intervention, and this is an issue that has been used to criticize performance research.

Performance Analytics Integration.

In addition to traditional statistics, the research uses the aspects of performance analytics, such as:

- Pearson correlation analysis.
- Pattern recognition between performance indicators.

Such approaches may facilitate a deeper perception of the interplay between different performance factors, which may be applied to transform the data into feasible intelligence. This level of analysis is essential to ensure that the research adheres to the principles of competitive intelligence since it does not only focus on analyzing the result, but a strategic analysis.

3.8 Rigor and Methodology Justification.

The choice of the methodology may be regarded as the deliberate effort to resolve the issue of having to strike a balance between the scientific rigor and the usability. The causal inference is supported by the design of the experiment, whereas the analytical integration increases the interpretative value of the findings. This is enhanced by employing trained athletes and sport-specific measures thereby improving the ecological validity of results and making sure that results are applicable to actual competitive situations.

Moreover, the combination of statistical and analytical methods fill the existing gap in the literature, as most studies have conducted only an outcome measurement, but have not investigated the patterns. This research is an extension of the conventional methods of conducting research and it aids in the process of the creation of intelligence-based training systems by adding performance analytics to them.

Overall, the methodology will not only be used to assess the success of integrated training but will also be used to illustrate how the performance information can be effectively analyzed to facilitate the process of making decisions that are competitive. This two-fold approach puts the research within the scope of both the sports science and the competitive intelligence areas, as part of the overall research objectives.

4.1 RESULT

The findings indicate statistically significant and clinically significant changes in all of the variables measured after the 8-week combination training program. The findings directly reflect the study objectives in that they indicate that, (1) integrated core and plyometric training improves performance, (2) performance variables have high levels of interdependency and (3) the analytical interpretation can be used to convert data

into competitive intelligence.

The greatest changes were in explosive power and quality of the execution meaning that the neuromuscular adaptations were the main contributor to the performance improvement. The significance of core stability and balance also is enhanced by the enhancement of the postural control and coordination in aerobic gymnastics. Endurance, on the other hand, showed relatively moderate improvements, indicating that metabolic adjustments did not take the center stage as the result of the intervention.

4.2 Performance Outcomes

In order to measure such changes, Table 1 shows the post-pre-test performance results, as well as inferential statistical analysis.

Table 1. Pre–Post Performance Outcomes and Statistical Analysis

Variable	Pre-test Mean ± SD	Post-test Mean ± SD	% Change	t-value	p-value	Effect Size (d)
Core Stability (s)	82.4 ± 10.2	98.7 ± 9.5	+19.8%	6.12	<0.001	1.21
Jump Height (cm)	38.5 ± 4.3	45.9 ± 4.8	+19.2%	7.04	<0.001	1.34
Balance (score)	7.1 ± 0.8	8.4 ± 0.7	+18.3%	5.76	<0.001	1.08
Execution Score	7.5 ± 0.6	8.9 ± 0.5	+18.7%	6.48	<0.001	1.26
Endurance (reps)	42.3 ± 6.1	47.6 ± 5.8	+12.5%	3.92	0.002	0.74

All the variables showed significant improvement ($p < 0.01$) and the effect size ($d > 1.0$) of most performance indicators was high as demonstrated in Table 1. But the important critical analytical observation is the allocation of these effects. The greatest effect size was reported in jump height ($d = 1.34$), which proves that the plyometric training is effective in developing explosive capacity. However, the almost equal positive change in the execution score ($d = 1.26$) suggests that these positive gains were effectively converted to the outcomes of functional performance.

It can be seen further through the analysis of the graphical trends. Figure 1a depicts the corresponding proportional variation in the variables in the bar chart and the variables that have been improved are power and execution that are quite parallel. This implies that the performance improvement is not a solitary process, but it is systematically incorporated, which justifies multi-dimensional assessment.

Moreover, in Figure 1b (weekly progression), it can be seen that performance gains were not linear. The sharp increase in between weeks 3 and 5 suggest that there is an attainment of a rapid neuromuscular adaptation followed by a plateau during week 6. The trend corresponds to the modern periodization model, which highlights the significance of adaptive stages and diminishing returns (Issurin, 2020). The plateau phase indicates that additional gains in performance would need an alteration in training stimulus, and the significance of adapting training approaches based on analytics.

Figure 3. Multi-Dimensional Performance Trends (a) Pre–Post Bar Comparison (b) Weekly Progression (8

Weeks) (c) Scatter Plot: Core Stability vs Jump Height

4.3 Multi-Dimensional Performance Analytics

Table 2. Correlation Matrix of Performance Variables

Variable	Core	Power	Balance	Execution	Endurance
Core	1.00	0.71	0.76	0.69	0.54
Power	0.71	1.00	0.68	0.74	0.49
Balance	0.76	0.68	1.00	0.81	0.52
Execution	0.69	0.74	0.81	1.00	0.57
Endurance	0.54	0.49	0.52	0.57	1.00

Table 2 has an analytical value because it proves that performance variables do not exist in a vacuum but within a system. Balance and execution (r = 0.81) show the strongest correlation meaning that the technical performance strongly depends on the postural control.

The same relationship is further depicted in Figure 1a, with the performance in balance being closely similar to that of the execution. Nevertheless, more insight is evident in the Figure 1c which reveals that there is a great positive relationship between core stability and jump performance. This indicates that the strength of the core improves the efficiency of passing the force thus increasing the effects of the plyometric training.

On the same note, the execution and power correlation (r = 0.74) shows that explosive capability is a direct contributor to the performance score. This has however been mediated by core stability as there is a strong relationship between core and power (r = 0.71). This validates the idea that the production of forces is not enough but instead, they need to be stabilized successfully, which contributes to the kinetic chain integration idea.

Endurance on the other hand shows lower correlations with variables, which is a strong support to its secondary role in performance determination. This result questions the training paradigm which places too much emphasis on aerobic conditioning and instead promotes an efficiency-focused design of training.

In Figure 1c, the scatter diagram shows that there is a high linear correlation between the stability of the core and the jump performance. This correlation proves that the efficiency of explosive movements improves with the improvement of stability. Notably, the empirical evidence based on this finding presents the integration of core and plyometric training because it explains how one variable enhances the influence of another.

4.5 Competitive Intelligence Interpretation

As Table 3 shows, performance data may be changed into strategic intelligence in a systematic manner. The main contribution is the identification of high-impact variables and giving them priority in the training design.

Table 3. Transformation of Performance Data into Competitive Intelligence

Performance Indicator	Analytical Insight	Strategic Implication	Decision-Making Application
Core Stability	Central integrator of performance	Prioritize stability training	Increase core-focused workload
Jump Height	Strong predictor of execution	Enhance plyometric intensity	Adjust training load dynamically
Balance	Highest correlation with execution	Focus on control-based drills	Integrate balance into routines
Execution Score	Composite performance indicator	Use as primary KPI	Monitor performance trends
Endurance	Limited predictive value	Maintain baseline conditioning	Avoid overemphasis on endurance

As an illustration, the balance and execution correlation is strong indicating that targeted balance training has disproportional returns. In the same vein, predictive value of endurance is not very high, thus showing the possibility that much emphasis on aerobic conditioning can lead to poor allocation of resources.

4.6 Discussion.

The current results are largely consistent with recently obtained empirical and meta-analytical studies that show that integrated training modalities result in better neuromuscular responses than single modalities. As an example, Ramirez-Campillo et al. (2020) note that explosive strength and movement efficiency improved significantly after mixed training programs. Nevertheless, the research at hand develops this body of knowledge by going beyond the validation of outcomes to the level of analytical integration by explicitly exploring the interaction of performance variables in the context of a systemic framework.

A significant difference is presented in comparison of these outcomes with results that separate plyometric training as the primary intervention. This is despite the fact that these studies demonstrate congruent power output improvement, most of them report that they can be of little transferability to more complex performance tasks in which stability and accuracy are required (Zhang et al., 2026). On the other hand, the existing findings suggest that the core training inclusion is the essential transformation in the functional impact of plyometric adaptations, which enables the more efficient power transfer to the controlled sport-specific movement.

The second potential cause of such difference is the location of the force transmission in the kinetic chain. Plyometric training enhances force production capacity but unless adequate core stability this force cannot be successfully transferred through the body parts. This will lead to failure to achieve full profitability. The intervention will enhance the production of the force and the utilization of the force, therefore creating a more rounded-out performance improvement with the inclusion of core training.

In addition, the findings contradict the existing pattern in the sports science in which training interventions are evaluated separately. The high inter-variable relationships in this research study reveal that performance is a multi-dimensional phenomenon, which needs analytical models to reflect such interaction. This view is consistent with the recent demands towards more integrative methodologies of performance research, in which individual variables are replaced by dynamic systems of performance (Trowell et al., 2020).

4.7 Integrated Training Effect

The cooperative interplay between core and plymetric training can be viewed as a key contribution of the present study. The combination of these modalities seems to produce multiplicative gains in performance as opposed to additive gains, which are enabled by three interrelated mechanisms.

In the first place, the neuromuscular coordination is improved greatly by integrated training. The benefits of core exercises are enhanced coordination of the muscle activity patterns, which allows the recruitment of motor units during explosive movements to be more efficient. This increases coordination and minimizes unneeded muscular activity and enhancing movement economy, which leads to both power output and the quality of movement (Souaifi et al., 2025).

Second, there is a significant increase in the effectiveness of force transfer. The core is central to the process of stabilization in the kinetic chain and it aids in transmitting a force produced by the lower limbs to the upper body and vice versa. Unless adequate core stability is present, energy is lost due to compensatory movements decreasing efficiency in general. The positive changes in the results of the jump performance and the execution score indicate that integrated training reduces the loss of such energy to the greatest extent, leading to the more efficient use of force.

Third, the precision of movement is increased by increased postural control and balance. Not only explosive motions are needed in aerobic gymnastics, but also accuracy when performing in dynamic circumstances (Shahid et al., 2025). Core training is associated with more proprioception and proper positioning that allow athletes to be able to control the dynamics of complex sequences. This is the reason why there is a high correlation between balance and execution in the results.

Taken together, these processes indicate that integrated training does not only enhance the individual parts of performance but it reforms the working structure of movement resulting in more effective and efficient performance results. This observation also has significant implications in training design because the sequencing and combination of the training modalities is found to be the key determinant of training performance.

4.8 Competitive Intelligence Performance Analytics.

One of the main contributions of the given work is the conceptualization of performance analytics as a type of competitive intelligence, not a strictly descriptive or evaluative instrument. These findings indicate that actionable information can be generated by the performance data, which can be used in making strategic

decisions when systematically analyzed.

The key performance drivers can be identified with the help of performance analytics as the correlation among such variables as balance, core stability, and execution remains strong. Isolation of these high-impact variables would allow coaches to focus on training interventions that provide the highest ROI. This is a change in generalized training methods to accuracy-focused training methods (Riscart-López et al., 2021).

In addition, the training results can be predicted with the help of the analytical framework. The patterns of the observed weekly progress and inter-variable relationships allow predicting the responses of the athletes to certain stimuli in training. This ability to predict is fundamental to streamlining training programs as well as reducing uncertainty in the performance results.

Probably, the most significant benefit of performance analytics is the optimization of the decision-making process. It will help coaches to make evidence-based informed decisions about training design, load management, and performance evaluation by converting raw data into structured insights. This can be connected to the current thinking in the field of competitive intelligence whereby information is stressed to be strategically valuable in the attainment of competitive advantage.

Here, performance analytics is more of a strategic resource than the measurement tool and allows organizations and athletes to gain a competitive advantage by a better information processing and use.

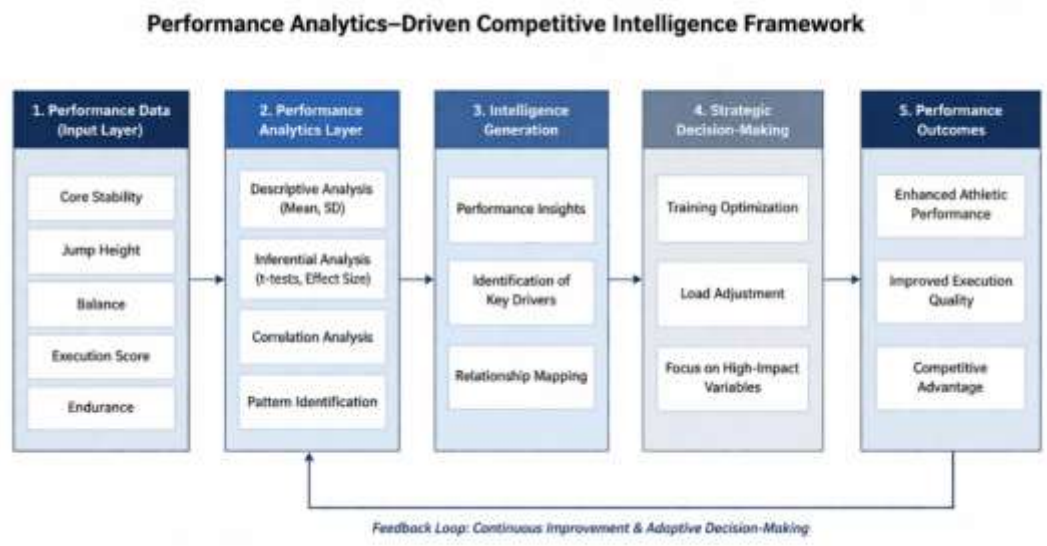

Figure 4. Performance Analytics–Driven Competitive Intelligence Framework

This procedure is the mirror image of competitive intelligence cycle when raw data is converted into consumable knowledge on the basis of systematic analysis and interpretation which underlies strategic decision making eventually.

4.9 Practical Implications

The research findings are highly practical in regards to coaches, athletes, and sports organizations. First of all, the coaches will adopt in-depth, analytics-driven, training designs, which aim at addressing interdependences of the performance variables rather than independence. These data point to the fact that core and plymetric training is superior to the traditional training practices.

Second, athletes are expected to focus on building of power, coordination and stability. The results show that the beneficial outcomes of explosive strength are maximized as the core stability and balance increase (Munoz-Macho et al., 2024). It is an all-inclusive form of training that is required to achieve the best performance of such complex sporting activities such as aerobic gymnastics.

Third, the training programs should include teaching continuous performance assessment with the help of analytics. Rather than developing periodic assessment, the coaches are advised to utilize continuous data gathering and analysis to monitor progress, identify trends and amend training interventions in real-time. This dynamic model of training management makes it flexible and maintains that training should be in line with the performance objectives.

Lastly, the implementation of competitive intelligence principles implies that the decision on training should be informed by strategy prioritization of variables that have high impact. Coaches can make the best use of resources and increase performance using the most important performance determinants.

4.10. Synthesis of key Findings.

Overall, the current research indicates that combined core and plyometric training results in the significant changes in the athletic performance in a pathway of interrelated mechanisms. These gains are more than just additive and they are as a result of the synergies between stability, power and coordination which all lead to improved efficiency of movements and quality of execution.

More to the point, the research confirms that performance analytics is an extremely important linkage between data and decision-making. It allows changing performance data into competitive intelligence that facilitates the transition between reactive and proactive training strategies where the decisions are supported with evidence instead of intuition.

These two contributions help promote the field of sports science and competitive intelligence theory and serve as an excellent example of the value of analytical integration in optimizing performance. With the growing competitiveness of sporting environment, the capacity to create and use intelligence based on performance data is a decisive point in the gaining and maintenance of competitive advantage.

5 CONCLUSIONS

This paper aimed at investigating the potential to use performance analytics as a competitive intelligence-based tool in aerobic gymnastics and, specifically, integrated core and plyometric training. The results give obvious evidence that the enhancement of performance in such situation is not the consequence of solitary physiological changes, but a byproduct of mutual, system-level effects of stability, power, coordination, and execution. The intervention achieved substantial improvements in all of the important variables, although the explosive power and quality of execution were impacted significantly. Such improvements were not just statistically significant but relevant in a practical sense, and proved to be directly relevant to competitive performance.

One of the main lessons learned during the research is that the variables of performance have a high level of interdependence, which is a dynamic system rather than a combination of independent elements. The core stability was found to be one of the core integrative factors, which contributed to both the balance and power, and balance was also a paramount outcome defining the quality of the execution. These associations indicate the shortcomings of conventional training methods that separate performance components. On the contrary, the results are consistent with a holistic and integrative model of the performance, in which the effectiveness of training relies on the compatibility and interplay of various variables.

Theoretically, the research yields to the field of sports science and competitive intelligence literature. It is used in sports science to develop knowledge by showing how combined training works synergistically, especially the importance of core stability in functional implementation of plyometric power. The study has a unique approach to the competitive intelligence field because it places performance analytics in the category of strategic decision-support system. Performance analytics is not a measurement tool but rather it is imagined as a driver of developing viable data driving training design and competitive strategy.

The implications of these findings on practice are far-reaching. The findings, as they relate to coaches and practitioners, are that the implementation of data-based, combined training models should focus on the interplay between the variables of performance. The critical performance driver identification helps to be more specific and efficient in applying the training interventions and eliminates the need to use generalized or intuitive methods of training. In the case of athletes, the outcomes imply that a person must not only work on such physical skills as strength and stamina but also on coordination and stability, which is crucial to transfer physical performance into real performance. On a larger scale, the research proves the importance of the constant monitoring of performance and the evaluation of analytical measures in the optimization of training results.

Although this has been done, it must be noted that there are a number of restrictions. First, the study had a small sample size with a narrow age bracket restricted to competitive aerobic gymnasts thus might limit the applicability of the study to other population groups or athletic conditions. Second, the intervention lasted eight weeks which, despite being a sufficient period of time to achieve significant changes, could not assist in tracking the patterns of long-term adoptions and the sustainability of gains in performance. Third, even though performance analytics were applied, the modes of analysis applied in the study were largely statistical, and the use of more sophisticated methods, such as machine learning or predictive modelling, was not

utilized.

These shortcomings indicate a number of ways of research in the future. To increase generalizability, future research ought to use larger and more heterogeneous samples, that is, athletes of various levels and disciplines of performance. The longitudinal designs are also required to be used to study the sustainability of training effects and the long-term development of performance systems. Also, the further potential is present in terms of the further development of the analytical aspect of the given research with the introduction of more advanced data analytics methods, including artificial intelligence and predictive modelling, to increase the conversion of performance data into competitive intelligence.

To sum it up, the study is able to prove that the performance optimization within the framework of aerobic gymnastics cannot be reduced to the involvement of the training intensity or volume, but it is the outcome of the critical synthesis and analytical experience. The association of performance analytics and competitive intelligence makes the research a frame of how the data can be converted into actionable knowledge and therefore allow better and informed decision-making. In a more competitive and information-driven sporting context, generation and utilization of such intelligence is a decisive factor of success.

REFERÊNCIAS (exemplos de formatação) (quando a referência tiver DOI, incluir)

1. Aslam, S., Habyarimana, J. D. D., & Bin, S. Y. (2025). Neuromuscular adaptations to resistance training in elite versus recreational athletes. Frontiers in Physiology, 16, 1598149. https://doi.org/10.3389/fphys.2025.1598149
2. Cabrejas, C., Solana-Tramunt, M., Morales, J., Nieto, A., Bofill, A., Carballeira, E., & Pierantozzi, E. (2023). The effects of an eight-week integrated functional core and plyometric training program on young rhythmic gymnasts' explosive strength. International Journal of Environmental Research and Public Health, 20(2). https://doi.org/10.3390/ijerph20021041
3. Cossich, V. R. A., Carlgren, D., Holash, R. J., & Katz, L. (2023). Technological breakthroughs in sport: Current practice and future potential of artificial intelligence, virtual reality, augmented reality, and modern data visualization in performance analysis. Applied Sciences, 13(23), 12965. https://doi.org/10.3390/app132312965
4. Etikan, I., & Bala, K. (2017). Sampling and sampling methods. Biometrics & Biostatistics International Journal, 5(6). https://doi.org/10.15406/bbij.2017.05.00149
5. Gencay Çüce, A. Y. Ö. E. G. A. (2021). The effect of plyometric and Tabata training on jump performance and respiratory function parameters in aerobic gymnasts. https://doi.org/10.15314/tsed.897252
6. Halperin, I., Vigotsky, A. D., Foster, C., & Pyne, D. B. (2018). Strengthening the practice of exercise and sport-science research. International Journal of Sports Physiology and Performance, 13(2), 127–134. https://doi.org/10.1123/ijspp.2017-0322
7. Kayantaş, İ., & Genç, H. (2024). Comparison of the effects of core and plyometric training on flexibility performance in gymnast children. Journal of Recreation, Sport and Tourism Research, 1(1), 14–19. https://doi.org/10.70736/jrstr.5
8. Lesinski, M., Hortobágyi, T., Muehlbauer, T., Gollhofer, A., & Granacher, U. (2015). Effects of balance training on balance performance in healthy older adults: A systematic review and meta-analysis. Sports Medicine, 45(12), 1721–1738. https://doi.org/10.1007/s40279-015-0375-y
9. Li, L., & Chen, Q. (2023). Impact of plyometric training on the lower limb strength of gymnasts. Revista Brasileira de Medicina do Esporte, 29. https://doi.org/10.1590/1517-8692202329012022_0658
10. Ma, D., Silva, R. M., Xu, Q., Wang, K., & Zhao, Z. (2024). Jumping interval training: An effective training method for enhancing anaerobic, aerobic, and jumping performances in aerobic gymnastics. Journal of Sports Science and Medicine, 23(2), 410–417. https://doi.org/10.52082/jssm.2024.410
11. McGarry, T. (2009). Applied and theoretical perspectives of performance analysis in sport: Scientific issues and challenges. International Journal of Performance Analysis in Sport, 9(1), 128–140. https://doi.org/10.1080/24748668.2009.11868469
12. Moreno-Ortega, C., Gonzalez-Garcia, J., & Romero-Moraleda, B. (2026). How can we assess neuromuscular performance in female football players? A systematic review. Scientific Journal of Sport and Performance, 5(2), 170–186. https://doi.org/10.55860/uyba1318
13. Muñoz-Macho, A. A., Domínguez-Morales, M. J., & Sevillano-Ramos, J. L. (2024). Performance and healthcare analysis in elite sports teams using artificial intelligence: A scoping review. Frontiers in Sports and Active Living, 6, 1383723. https://doi.org/10.3389/fspor.2024.1383723

14. Rein, R., & Memmert, D. (2016). Big data and tactical analysis in elite soccer: Future challenges and opportunities for sports science. SpringerPlus, 5(1), 1410. https://doi.org/10.1186/s40064-016-3108-2
15. Riscart-López, J., Rendeiro-Pinho, G., Mil-Homens, P., Soares-Dacosta, R., Loturco, I., Pareja-Blanco, F., & León-Prados, J. A. (2021). Effects of four different velocity-based training programming models on strength gains and physical performance. Journal of Strength and Conditioning Research, 35(3), 596–603. https://doi.org/10.1519/JSC.0000000000003934
16. Rodriguez-Redondo, Y., Carlos-Vivas, J., & León, K. (2025). The effect of plyometric training on gymnasts: A systematic review and meta-analysis. Science of Gymnastics Journal, 17(3), 397–420. https://doi.org/10.52165/sgj.17.3.397-420
17. Shahid, S. A., Gill, M. S. A., Tabassam, R., Riaz, M., Gill, A., Cheachi, C., & Obayashi, T. (2025). Artificial intelligence and performance analytics in Olympic sports. ACADEMIA International Journal for Social Sciences, 4(4), 1825–1835. https://doi.org/10.63056/acad.004.04.1032
18. Souaifi, M., Dhahbi, W., Jebabli, N., Ceylan, H. İ., Boujabli, M., Muntean, R. I., & Dergaa, I. (2025). Artificial intelligence in sports biomechanics: A scoping review on wearable technology, motion analysis, and injury prevention. Bioengineering, 12(8), 887. https://doi.org/10.3390/bioengineering12080887
19. Sun, S. (2022). Physical conditioning and core strength training in female college aerobics gymnastics athletes. Revista Brasileira de Medicina do Esporte, 28(6), 789–791. https://doi.org/10.1590/1517-8692202228062022_0084
20. Trowell, D., Vicenzino, B., Saunders, N., Fox, A., & Bonacci, J. (2020). Effect of strength training on biomechanical and neuromuscular variables in distance runners: A systematic review and meta-analysis. Sports Medicine, 50(1), 133–150. https://doi.org/10.1007/s40279-019-01184-9
21. van den Berg, L., Coetzee, B., & Mearns, M. (2020). Establishing competitive intelligence process elements in sport performance analysis and coaching: A comparative systematic literature review. International Journal of Information Management, 52. https://doi.org/10.1016/j.ijinfomgt.2020.102071
22. Yang, W. (2026). Physical fitness and training factors associated with injury risk in aerobic gymnastics: A systematic review. Frontiers in Public Health, 14, 1803284. https://doi.org/10.3389/fpubh.2026.1803284
23. Yu, X., Chai, Y., Chen, M., Zhang, G., Fei, F., Zhao, Y., & Li, W. J. (2024). AI-embedded motion sensors for sports performance analytics. Proceedings of the IEEE NSENS Conference, 116–119. https://doi.org/10.1109/NSENS62142.2024.10561438
24. Zhang, F., Liu, Y., Liu, J., Yeremenko, O., & Shi, L. (2026). The effects of plyometric training on physical fitness in adolescent team sports: A systematic review and meta-analysis. Frontiers in Physiology, 17, 1760239. https://doi.org/10.3389/fphys.2026.1760239
25. Zhou, D., Keogh, J. W. L., Ma, Y., Tong, R. K. Y., Khan, A. R., & Jennings, N. R. (2025). Artificial intelligence in sport: A narrative review of applications, challenges and future trends. Journal of Sports Sciences. https://doi.org/10.1080/02640414.2025.2518694