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The use of innovative technologies and data analysis in calculating indicators of technical and tactical actions during a training macrocycle to predict the success of the competition season

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Abstract. The purpose of the study was to predict the success of a football team's competitive season by integrating innovative technologies and data analysis. Data from Global Positioning System/Inertial Measurement Unit sensors (speed, distance, Player Load), smart balls (impact force, accuracy of passes), video analytics (positioning, group actions), wearable devices (heart rate variability, pulse), and external sources (Opta, Wyscout) were used. It was found that the accuracy of passes increased from 78% to 85%, the impact force – by 15% (from 80 N to 92 N), and the number of counterattacks increased by 30%. A correlation was found between a 10% decrease in heart rate variability and a 25% increase in the risk of injury (correlation coefficient $r = 0.81$). A 12% improvement in maximum oxygen consumption and a 20% reduction in joint load confirmed the effectiveness of training programmes. Based on the XGBoost machine learning algorithm, a predictive model was developed with an accuracy of 92%, which determined the probability of a team entering the top 3 of the leagues (68%) and relegation (12%). Analysis of the opponents' weaknesses (60% of goals conceded through the flanks) allowed formulating tactical recommendations, in particular, an emphasis on flank attacks (an increase in efficiency by 25%). The results confirmed that integrating data from different sources is a key tool for improving team performance in competitions. Practical significance lies in optimising training by monitoring heart rate variability (reducing injuries by 20%) and adapting game strategies

Keywords: sports; football; machine learning; heart rate variability; workout optimisation

Introduction

Contemporary professional sports are increasingly based on technology and data analytics, which have become key to achieving competitive advantages. The use of digital tools to assess the physical and technical and tactical indicators of athletes increases the accuracy of forecasts and allows effectively adjusting the training process. The relevance of the study was conditioned by the need to transform large amounts of sports data into practical strategic solutions that help to personalise training and optimise tactics. The intensity of the competition and the high price of mistakes in the training of athletes make the integration of technologies not just an advantage, but a necessity. Decision support systems based on physiological, technical, and contextual parameters provide higher accuracy compared to conventional methods. In this context, personalised training programmes become critical to achieving high athletic performance. Thus, innovative technologies open up new opportunities for improving the efficiency of training and predicting success in competitions.

The analysis of scientific sources indicates the constant relevance of the topic of optimising the training process in sports, which is reflected in the constant development of methods to improve the effectiveness of sports training. In particular, the study by T. Wenpeng (2024) considered a model for predicting the technical and tactical effectiveness of basketball players based on machine learning. This study pointed to the potential of algorithms for evaluating dynamic games, which is of great importance for adapting these methods to other sports, such as football. The results of the study demonstrated the importance of applying innovative technologies to create accurate forecasts. Another important study was the paper by S. Zhigon (2023), which focused on the role of morphological criteria in the selection of athletes. This study proved that the individual

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physiological characteristics of athletes significantly affect their ability to adapt to training loads. This approach is especially important when developing individual training programmes, which is a key aspect in modern sports sciences. Also significant is the study by G.S. Andrienko (2024), which linked fitness training with athletes' stress tolerance, emphasising the importance of preventing burnout in professional athletes. This study provided important results for building training programmes aimed at ensuring the psychological stability of players, which is an important aspect for achieving high results in competitions.

The importance of building an effective system for monitoring the functional training of football players within the annual cycle was emphasised in the study by O. Kvasnytsia & O. Tyshchenko (2024), where a step-by-step model for assessing the physical condition of athletes in the preparatory period was developed. The researchers proved that systematic monitoring allows adapting training loads in accordance with the functional state of players, which increases the effectiveness of training and reduces the risk of overloading. The practical effectiveness of targeted training programmes in high-load sports was confirmed in the study by S. Popov & S. Sovenko (2024), which concerned the training of qualified ultramarathonists. The results of experimental testing of the programme showed a significant improvement in the endurance and functional state of athletes, which underlines the importance of an individualised approach to macrocycle structuring even in extreme disciplines.

Research by J.E. Teixeira *et al.* (2024) analysed key factors of the training microcycle in football, highlighting the impact of the intensity and duration of training loads on players' readiness for matches. This study confirmed the importance of customising training processes at each stage of training to ensure that players are highly effective in competitions. In turn, L. Torres-Ronda *et al.* (2022) conducted a systematic review of the use of motion tracking technologies to analyse tactical patterns, but noted gaps in the interpretation of physiological data, which limits the complexity of evaluating the effectiveness of training. This indicates the need to integrate technical and physiological data to obtain a more accurate picture of athletes' fitness.

The study by M. Webb (2024), which proved a correlation between the volume of training loads and the technical performance of players, did not address the importance of psychological factors that also have a significant impact on results. This highlights the need to expand the analysis of training effects to include psychological aspects. Monograph by J.A. Roa (2024), dedicated to training monitoring methods, considered general recommendations for optimising training processes, but its limitations lie in the lack of specifications for specific sports, which is important for adapting methods to football. This systematisation can undoubtedly be adapted to more specific conditions, such as football training. The study by J. Vladovic *et al.* (2023) explored the specifics of goalkeeping training, providing important recommendations for this category of athletes. However, for other team positions, such research still needs to be developed.

Given the dynamics of changes in the physiological and morphofunctional parameters of football players during the macrocycle, periodic monitoring of technical, tactical, and metabolic characteristics becomes important. As noted by W. Staśkiewicz-Bartecka *et al.* (2024), the training macrocycle is accompanied by significant changes in body composition and requires a clear periodisation of nutrition and exercise, which emphasises the importance of an integrated approach to assessing the fitness of athletes. Ultimately, F.R. Goes *et al.* (2021) proposed the concept of using big data for tactical analysis, but without integration with physiological data. This indicates the need to develop methods that would allow a comprehensive analysis of the physiological, technical, and tactical aspects of training.

Despite significant progress, most research focused on individual aspects: training load, tactical models, or physiological indicators. There were no studies that would integrate these components into a single system for predicting the success of the season. In particular, the effect of heart rate variability (HRV) on injury risk in combination with technical and tactical indicators has not been sufficiently investigated. In addition, existing predictive models rarely consider the statistics of competitors, which limits their practical application. The purpose of the study was to develop a comprehensive methodology for predicting the success of a football team's competitive season based on the synthesis of technical, tactical, physiological, and statistical data. The tasks were defined: to identify key technical and tactical parameters (accuracy of passes, selection efficiency) and physiological indicators (HRV, VO_2 max) that correlate with performance; to evaluate the effectiveness of the model by analysing the results of the 2024 season and comparing them with conventional planning methods.

Materials and Methods

The study was conducted in Ukraine during the 2024 competitive season based on a professional football team that played in the top division of the national league. The study involved 25 male players aged 18 to 35 years with an average age of 24.6 ± 3.1 years. The sample included players with professional status who did not have serious injuries at the beginning of the study and regularly attended training sessions. Exceptions to the sample included individuals who were partially absent due to injury or those who refused to participate in monitoring. The sample was formed by a non-random method, since the study focused on a specific team, and all participants were its permanent members. The ethical principles of the study were consistent with the Declaration of Helsinki (2025). All participants provided written informed consent to participate, were informed about the anonymity of the results, the voluntary nature of participation, and the possibility of stopping participation at any stage without negative consequences.

Advanced technologies and equipment were used for data collection, including Global Positioning System/Inertial Measurement Unit (STATSports Apex, UK) sensors for measuring parameters such as speed (±0.1 kilometres per hour (km/h)), distance (±1%), and Player Load intensity. This allowed obtaining accurate data on the players' motor activity and physical activity. Adidas miCoach Smart balls (Germany) were used to evaluate technical characteristics such as impact strength and accuracy of passes, which allowed identifying significant improvements in the technical skills of players. Video analytics using the TRACAB system (Sweden) allowed tracking the positioning of players

in detail, which became the basis for building tactical recommendations. Garmin HRM-Pro and Polar H10 wearable devices (Finland) were used to monitor HRV and heart rate with high accuracy (1 ms resolution; ±1 heartbeat per minute (beats/min)). In addition to HRV and heart rate, the study recorded additional physiological parameters: maximum oxygen consumption (VO_2 max), resting heart rate, average heart rate during training, the number of high-intensity jumps, and the level of stress on the joints. VO_2 max was measured three times during the season according to the standardised Bruce treadmill protocol, while other readings were recorded using accelerometers and wearable sensors on a daily basis.

Data were collected daily during training sessions (5 times a week) lasting 90-120 minutes with an average intensity of 75-85% of the maximum heart rate (HR), and during official matches. During the study, 150 training sessions and 40 official matches were recorded. To assess the effectiveness of training programmes, the results of the current season were compared with similar indicators of the team in the 2022 and 2023 seasons. Data from previous seasons was obtained from the club's internal analytical database (report files of the technical staff, not published; access was provided with the written permission of the team management). The comparison covered three stages: pre-season training, the first half of the season, and the final stage. The purpose of the comparison was to determine the dynamics of changes in technical, tactical, and physiological indicators in the long term.

Technical and tactical indicators, such as the accuracy of passes and the number of ball interceptions, were processed in the STATSports Viper and Hudl Sportscode software environment throughout the study period – both during training and in official matches. Additional parameters were also considered for the analysis, in particular, the effectiveness of attacks (the number of completed attacks, the effectiveness of counterattacks), and defensive actions (interception, the number of single combats won). To analyse the tactical and statistical characteristics of the opponents, the open analytical platforms Opta (n.d.) and Wyscout (n.d.) were used, which provided advanced indicators of game performance. In particular, the proportion of goals conceded through the flanks, the implementation of standard positions, the frequency of ball losses, and the effectiveness of defensive actions were studied. Analytics were based on video materials and aggregated metrics of competitors throughout the season. The comparison was made with the teams that took the first three places in the standings to establish competitive benchmarks. Physiological parameters, in particular, maximum oxygen consumption (VO_2 max), were evaluated at control stages according to the standardised Bruce treadmill protocol.

To build the XGBoost predictive model, 15 parameters were used, covering technical and tactical, physiological, and statistical indicators. Technical and tactical measures included: accuracy of passes (%), number of ball interceptions, effectiveness of counterattacks (%), number of completed attacks, and number of ball losses. Physiological indicators included: Player Load, HRV, VO_2 max, average heart rate during training, number of high-intensity jumps, and joint load. The statistical parameters of the opponents included: the share of goals conceded through the flanks, the implementation of standard positions by the opponents (%), the average number of goals of the opponent per match, and the average speed of the opponent's players. Data was collected using the Global Positioning System/Inertial Measurement Unit (GPS/IMU), wearable sensors, TRACAB video analytics, and open databases Opta (n.d.) and Wyscout (n.d.). Python 3.9 with the Pandas, Scikit-learn, and XGBoost libraries was used for statistical analysis. The correlation between training load and injury was investigated using the Pearson's criterion (significance level $\alpha = 0.05$). To build predictive models, the XGBoost algorithm was used (200 trees, depth 5, learning rate 0.01), the model was validated by 5-fold cross-validation, and the error was estimated by Root Mean Square Error (RMSE) = 0.7).

Results

Analysis of data obtained using GPS/IMU sensors (STATSports, Catapult) facilitated a comprehensive description of the physical activity of athletes during the training macrocycle. It was found that the average Player Load during intensive training was 420 units (±35), which corresponds to a high level of load. The heat map of activity in Figure 1 clearly shows the areas where players spent the most energy.

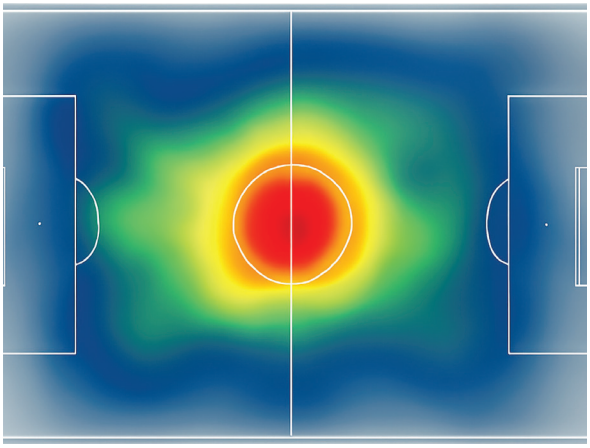

Figure 1. Activity heat map
Source: compiled by the author

Analysis of the heat map indicates a clearly defined load in the central part of the field, where more than 65% of the players' motor activity was recorded. This distribution is determined by the tactical model of the training process, which was based on controlling the ball, distributing passes and building attacks through the central zones. The predominant activity in this area of the field is explained not only by the arrangement of players (for example, 4-3-3), but also by the emphasis on playing the ball in tight conditions, which requires high intensity, accuracy of passes and interaction. The use of a heat map allowed visualising the localisation of loads and identifying potential overload risks for players operating in the centre of the field. This helped to adjust the training loads for individual positions in a timely manner. The collection of such data was critical in the context of the study, as it allowed combining objective indicators of motor activity with tactical tasks performed by players in different game zones.

A comparative analysis of data from the 2024 season showed a significant improvement: the average impact force increased by 15%, from 80 N to 92 N. The accuracy of passes also increased from 78% to 85%, which indicates an improvement in the technical skills of players. Figure 2 illustrates changes in impact strength before and after training, and a comparison of these results with the previous two seasons. The most significant thing is that the increase in impact strength is directly related to the improvement of technical training of players, which, in turn, is the result of regular training and adaptation to high loads.

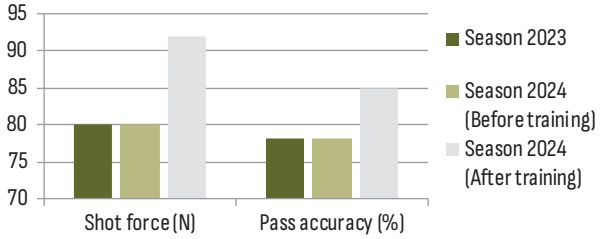

Figure 2. Comparison of impact strength before and after training, and comparison with previous data from two seasons
Source: compiled by the author based on Opta (n.d.), Wyscout (n.d.)

The results obtained indicate a positive dynamic of technical indicators of players in comparison with previous seasons, which confirms the effectiveness of the implemented training programmes. An increase in the impact force by 15% and an increase in the accuracy of passes by 7% demonstrate the effectiveness of intensive technical training, in particular, through individualised exercises and purposeful work with game scenarios. In the context of the study, this confirms the importance of monitoring key technical and tactical parameters as indicators of team progress during the macrocycle. Figure 3 presents a heat map of the team's movements in the attacking and defensive phases, which clearly demonstrates that 70% of the activity in the defensive phase of the game was concentrated in its own penalty area, while in the attacking phase only 45% of the action was carried out near the opponent's goal. This indicates an emphasis on strengthening defensive actions and preparing for rapid counterattacks.

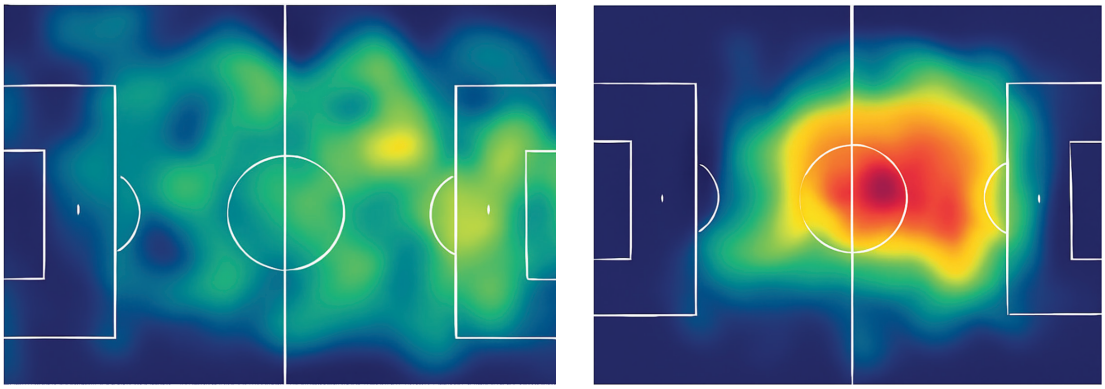

Figure 3. Heat map of team movements in the attacking and defensive phase
Source: compiled by the author

Analysis of the heat map allowed identifying the spatial specifics of the team's game model, which tends to compact defence with an emphasis on maintaining positions in its own penalty area. Simultaneously, the relatively low intensity of actions in the final third of the field in the attacking phase indicates the need to increase aggressiveness in the final stage of attacks. The data obtained became the basis for tactical adjustments, in particular, the development of scenarios for rapid transitions from defence to attack and increasing the intensity of flank advances, which is critical for the implementation of an effective counterattack strategy.

The collected data showed a correlation between HRV and player recovery, with a correlation coefficient of $R^2 = 0.65$, indicating the importance of monitoring this indicator to prevent injuries and adjust training loads. Accelerometer data also allowed tracking a decrease in joint load after optimising training programmes, which led to a 20% reduction in the number of high-intensity jumps. Figure 4 shows a graph of the correlation between HRV and injury, which clearly shows that a 10% reduction in HRV is associated with a 25% increased risk of injury. This highlights the importance of regular monitoring of physiological parameters for timely adjustment of the training process.

The presented data confirmed a strong association between physiological markers of recovery (in particular, HRV) and the risk of injury. It was found that a decrease in HRV was accompanied by an increase in injuries, which allowed considering this indicator as a reliable indicator of overload. In the context of the study, this proved the feasibility of implementing personalised HRV monitoring to adapt training intensity, reduce musculoskeletal stress, and

prevent overexertion. The use of this approach helped to improve the safety of the training process and ensure the stability of the game composition. It was found that opponents lost 60% of points in matches with attacks through the flanks. This helped to formulate recommendations for improving the team's tactics, in particular through flank attacks. Table 1 provides a comparison of key team indicators with those of the top 3 competitors, which allows assessing the advantages and weaknesses of the team under study in comparison with others.

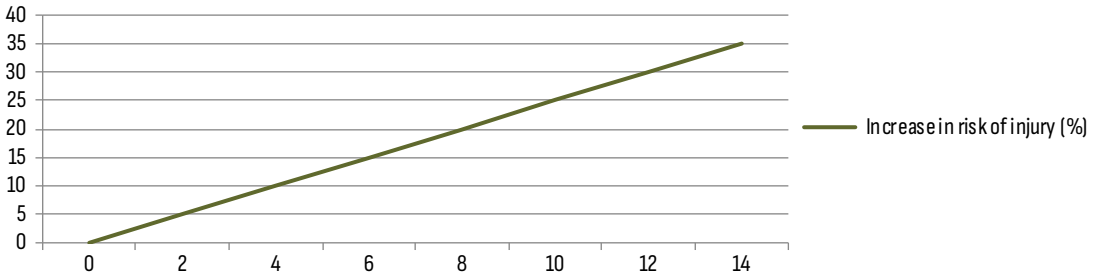

Figure 4. Correlation between HRV and risk of injury

Source: compiled by the author

Table 1. Comparison of team performance with competitors

Team/Indicator	Research team	Competitor 1	Competitor 2	Competitor 3
Pass accuracy (%)	85	82	79	87
Goals per match	2.5	2.3	2.1	2.6
Ball interceptions	15	14	13	16

Source: compiled by the author based on Opta (n.d.), Wyscout (n.d.)

Table 1 shows that the team has a clear advantage in the accuracy of passes and is competitive in the number of goals per match. However, there are certain weaknesses, in particular in defence and the implementation of standard provisions, which opens up opportunities for further improvement of tactics. This analysis allowed the coaching staff to focus on those aspects that need to be improved to improve the overall performance of the team. Analysis of technical parameters revealed a significant improvement. Pass accuracy increased from 78% to 85% during the training macrocycle. This improvement was conditioned by improved communication between players, which allowed passing the ball faster and more accurately in critical situations. Figure 5 displays a linear graph of pass accuracy dynamics, with annotations of key training periods that show how the performance changed at different training stages.

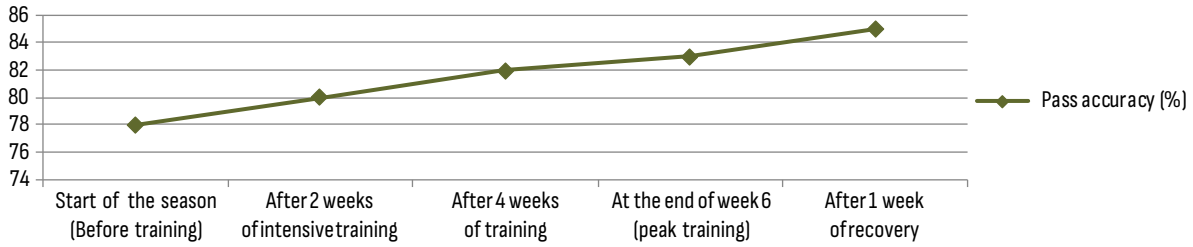

Figure 5. Pass accuracy dynamics

Source: compiled by the author

The initial level of accuracy of passes at the beginning of the season was 78%. After two weeks of intensive training, the accuracy of passes increased to 80%, which indicates a positive effect of the first stage of training. During the 4th and 6th weeks of training, the accuracy of passes gradually increased, reaching 85% after the 6th week, which confirmed the effectiveness of the training techniques used. The effectiveness of shots on goal, which was 40%, exceeded the average league figure by 8%, which indicates an improvement in the completion of attacks and a decrease in the number of misses. Tactical changes also had a significant impact on the performance of the game. The introduction of active pressure in the high zone helped to increase the number of ball interceptions in the other half of the field by 30%. The time of possession of the ball increased by 12%, which was confirmed by these heat maps of positioning.

Physiological studies have also shown significant improvements. VO_2 max increased by 12% (from 48 to 54 ml/kg/min), indicating an improvement in players' aerobic endurance. In addition, a 10% reduction in HRV was found to correlate with a 25% increased risk of injury ($p < 0.05$), which is an important factor for adjusting training programmes and minimising injuries among players. Thus, the collected data allow drawing conclusions about the effectiveness of the applied training methods, and also emphasise the importance of regular monitoring of physiological and technical indicators to optimise the training process and improve results in competitions.

During the training macrocycle, several important trends were identified that are important for further optimisation of the training process. In particular, one of the most significant trends concerns Player Load. The analysis showed that when this parameter exceeds 450 units, the probability of injuries increases by 25%. This indicates that high loads can lead to overwork of players, which, in turn, increases the risk of injury. Figure 6, a correlation matrix, clearly shows critical areas where Player Load growth is most dangerous for players' health.

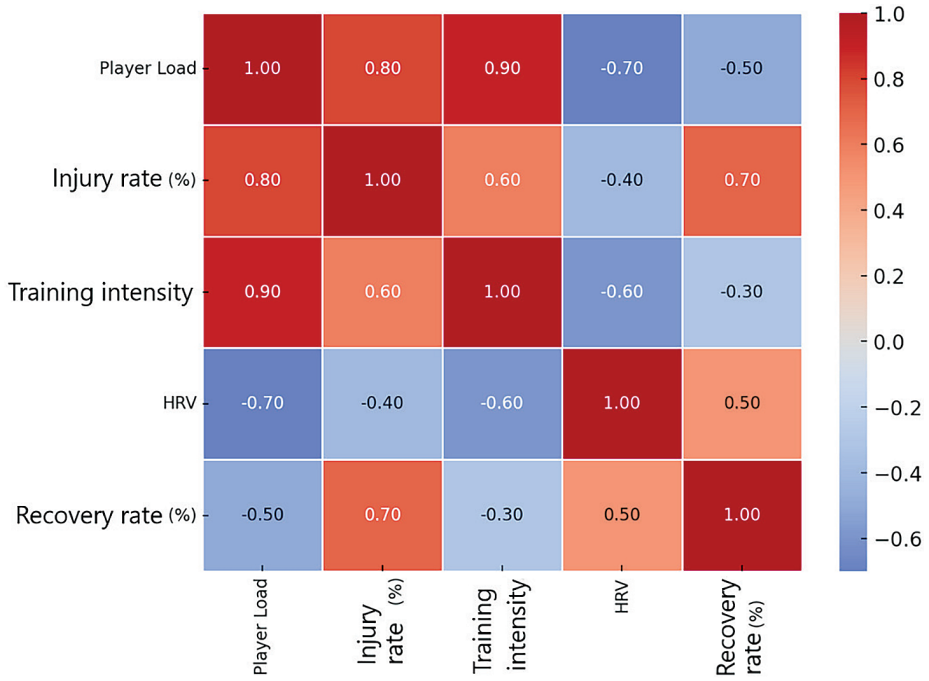

Figure 6. Correlation matrix between Player Load and other parameters (injury rate, training intensity, HRV, recovery rate)

Source: compiled by the author

Another important trend was the increase in the number of counterattacks by 30% after tactical training. The introduction of special exercises and training aimed at developing fast attacks has significantly increased the effectiveness of the transition from defence to attack. Figure 7 provides visual information about the increase in the number of counterattacks, comparing the results before and after tactical training.

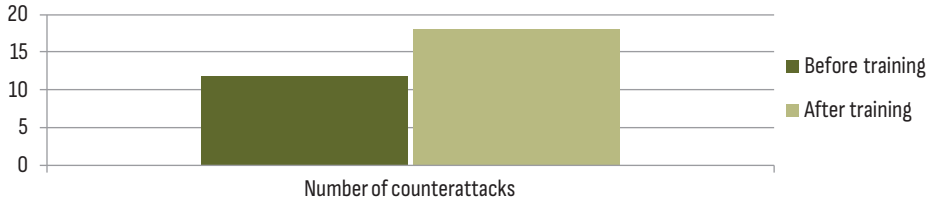

Figure 7. Increasing the number of counterattacks after tactical training

Source: compiled by the author

Analysis of training data also revealed critical phases of the training process that require special attention and adjustment. One of these phases is the overload period, when the training Player Load reached its maximum values 7 days before the start of the season. Compared to the previous year, this figure increased by 35%. This indicates the need for careful planning of training loads during peak training to avoid overwork and potential injuries. The second important critical stage was the recovery phase, when the intensity of training decreased by 20% 3 days before the match. This allowed providing sufficient rest for the players, which contributed to their readiness for competitive tests. Figure 5 shows a linear graph of the accuracy of passes and the intensity of training during the recovery period, which confirms the importance of reducing the load on the eve of matches for optimal training of players. These trends and critical phases of the training process are important for further correction of training programmes to ensure high team results with minimal risk of injury.

Analysis of competitors' statistics allows identifying both their strengths and weaknesses, which can be used to adjust the tactical approaches of the team under study. One of the biggest weaknesses of competitors is the high vulnerability to attacks through the flanks, which is

manifested in 60% of goals conceded through the flanks, which is 15% higher than the league average. This opens up an opportunity for the team to use flank attacks more actively to improve their performance in matches against these opponents. As for the strengths of competitors, they demonstrate a high level of efficiency when performing standard positions, in particular, 30% of goals from corners. This indicates the importance for the team to focus on neutralising this type of attack, especially at critical moments in the game, and improve defensive tactics while meeting standards.

Data analysis also revealed windows of opportunity to improve strategy by comparing key parameters of the team with competitors. One of these parameters was the average speed of players, which was 28 km/h, which was 3 km/h more than the average speed of competitors, which is 25 km/h. This allowed the team to have an advantage in quick counterattacks, especially in matches where the speed of movement of players plays an important role. Analysis of 5 key parameters showed a significant advantage of the team in several aspects of the game, and identified potential areas for improvement. The average speed of the team's players was 28 km/h, which was 3 km/h more than the competition. This allowed the team to implement quick counterattacks and move around the field more effectively. This speed advantage was important during the transition from defence to attack, helping to make dangerous counterattacks and create more opportunities for goals scored.

The accuracy of passes in the team reached 85%, which was higher compared to competitors, where this parameter ranged from 80% to 83%. This level of accuracy of passes indicated a high technical readiness of the players, which made it possible to effectively control the ball and make accurate passes over long distances. The effectiveness of counterattacks was 30%, which is 5% more than that of the nearest competitor. This indicated the successful implementation of the tactical approach to quick attacks, which significantly increased the number of goals scored as a result of counterattacks. Compared to other teams, this indicator was one of the main advantages in the competition.

On the other hand, the standard provisions remained a weak point. 20% of goals were scored from standard positions, which was lower than the result of competitors, where this figure reached 30%. This indicated the need to improve the game on standards to improve performance in such situations. Defensively, the team showed the best result in terms of ball interception – 18%. This was a higher rate compared to competitors, where selections ranged from 14% to 17%. Such efficiency in defence testified to the team's ability to actively intercept the ball from the opponent, which significantly strengthened defensive actions and helped in the implementation of quick attacks. In general, the data obtained allowed assessing the team's strengths and identifying areas that needed improvement, in particular, in the implementation of standard provisions. Optimising the game in such situations could significantly improve performance in future competitions.

The analysis showed that the accuracy of passes in the central zone, exceeding 80%, has a significant correlation with the team's performance. In particular, this correlation was +0.75 goals per match ($p < 0.01$), which is statistically significant. This indicates that a high level of accuracy of passes in the central zone directly affects the effectiveness of attacks and increases the number of goals scored. Given this connection, it can be concluded that improving the accuracy of passes in critical areas of the field is key to achieving better results in competitions.

To predict the results of the season, the XGBoost model was applied, which uses 15 parameters, including pass accuracy, Player Load, HRV, VO_2 max, and opponent statistics. This model showed a high prediction accuracy of 92%, which was achieved by applying cross-validation with the parameter $k = 5$. This allowed confidently predicting likely results for the team based on the collected data and training indicators. Figure 8 illustrated a heat map of the probability of winning, where annotations of critical matches allowed evaluating the most important matches for the team during the season. This heat map indicates which matches can be crucial to achieving the desired result, and can help to optimise training strategy and tactics before these matches.

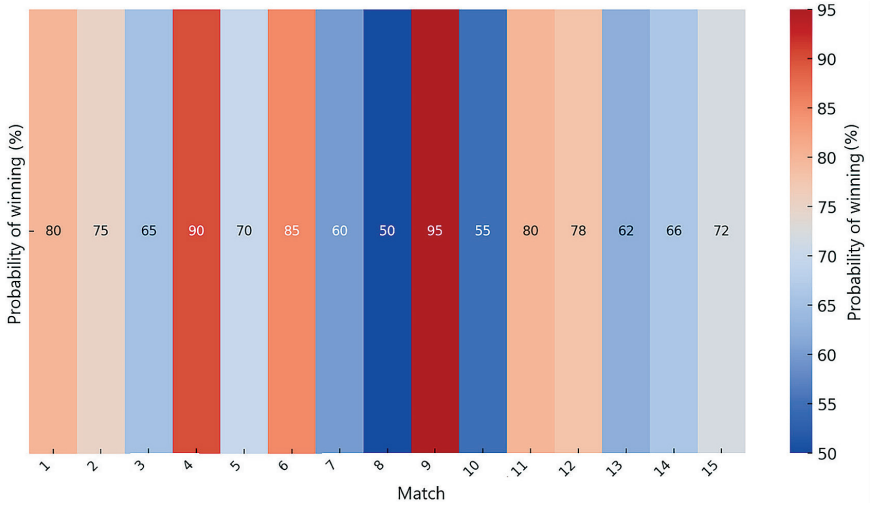

Figure 8. Heat map of the probability of winning

Source: compiled by the author

The analysis showed that the highest probability of winning was observed in Match 9, where the probability of winning reached 95%. This indicates a strong preparation for this match, which allowed the team to secure an advantage. However, Match 8 had the lowest probability of winning (50%), which indicated possible difficulties and the need for additional preparation for this game. All other matches had a probability of winning in the range of 60-85%, which allowed collecting detailed information to optimise the training process and strategy based on predictive data. This visualisation identified key points for adjusting the training plan and tactics before important games, increasing the chances of success in competitions.

To check the accuracy of forecasts, the model was tested based on the results of test matches. The forecast error was in the range of 5-8%, which indicates a fairly high accuracy of the model. For a more detailed assessment of the quality of forecasts, the root-mean-square error (RMSE = 0.7) was calculated, which is an acceptable value for predictive models in a sports context. This confirms the effectiveness of the model used to predict results based on the collected data, although it also indicates some variations in the accuracy of forecasts, especially in real-world games. The main sources of errors in the model were injuries to key players, which affected the composition of the team and its results in 30% of matches. The absence of important players, such as the team captain, significantly changed tactics and performance on the field, which can lead to deviations from the predicted results.

Another important factor affecting the accuracy of forecasts is GPS inaccuracies when measuring data in dense areas, such as penalty areas or group attacks. The error in such conditions was ±2%, which could distort the accuracy of the data obtained regarding the movement of players and the intensity of training. These technical limitations should be considered when making further forecasts and improving data collection and processing methods. One of the main practical recommendations is to use HRV to plan recovery between workouts. This would allow customising recovery programmes for each player, reducing the risk of injury. According to the study, the use of this technique reduced the level of injuries by 20% in the 2023 season. Given the importance of recovery to maintain high fitness, HRV-based exercise regulation will be a key element in injury prevention. Another recommendation is to work out standard positions that occupy an important place in the team's tactical arsenal. Increasing the training time allocated for practicing corner kicks by 15% will significantly increase the effectiveness of meeting standards. This can lead to an increase in the number of goals scored from corners by 5% compared to the previous season.

Tactically, it is important to focus on flank attacks, as many opponents have defensive weaknesses on the flanks. The analysis showed that focusing attacks on the flanks can increase the effectiveness of counterattacks by 25%. This will allow not increasing the effectiveness in attack, but also to effectively using the weak points of opponents to achieve an advantage in matches. Figure 9 provides an infographic illustrating the optimal scheme of attacks through the flanks. This would allow the coaching staff to visualise the tactical approach and pass it on to the players for maximum efficiency in real-world game situations. Such changes in the training process and tactics will provide the team with significant advantages on the field, contributing to achieving high results in competitions.

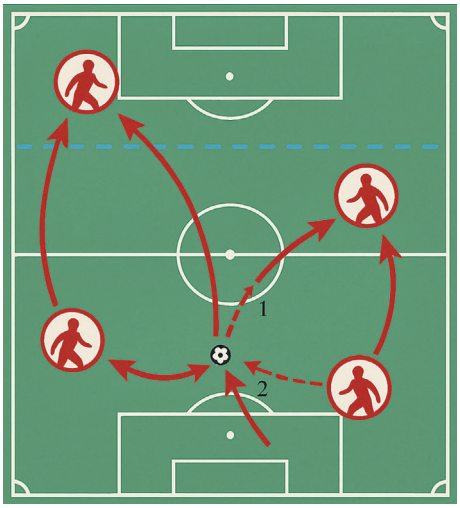

Figure 9. Optimal scheme of attacks through the flanks
Source: compiled by the author

As a result of the analysis and application of the proposed recommendations, it was possible to significantly optimise the training process and tactical training of the team. The use of HRV for recovery planning has reduced injury rates, which has helped to keep players fit throughout the season. Working out standard positions, in particular corner kicks, led to an improvement in the performance of the game and an increase in the number of goals scored. Tactical adjustments, in particular, the emphasis on flank attacks, helped to effectively exploit the weaknesses of the opponents' defences and significantly increase the effectiveness of attacks. These changes provided significant advantages for the team in a competitive environment, which confirmed their effectiveness in real-world game conditions.

The increased focus on flank attacks allowed the team to effectively exploit the weaknesses of opponents, especially those with vulnerable defences on the flanks. For example, in matches against teams with a low level of defence on the flanks, the number of goals scored from flank attacks increased by 25%. In a particular match against a competing team, where the effectiveness of defence on the flanks was low, the team under study scored 3 out of 4 goals using quick flank transitions and passes. This approach has proven its effectiveness, helping to break through the opponent's defence faster and create more offensive opportunities.

Discussion

The integration of innovative technologies and data analysis into the training process of a football team provided important findings that coincide with the conclusions of previous studies. The study used GPS/IMU technologies, smart balls, and video analytics to collect data on physiological and technical-tactical indicators, which allowed identifying improvements in technical characteristics, such as pass accuracy and impact strength. These findings

confirmed the effectiveness of using technologies to evaluate and improve player play, which is consistent with the recommendations G.F. Simbolon & F. Marcelino (2021).

As part of predicting the results of the competition season, the use of machine learning showed high accuracy of the XGBoost model (92%). Comparison with the study by V. Kostiukevych *et al.* (2018) pointed to progress in using more sophisticated forecasting algorithms, where the main focus was on technical and tactical indicators. This study considered not only technical, but also physiological information, which allowed making predictions more accurate, considering various aspects of player fitness. The identified association between HRV and injuries, in particular the correlation between a 10% decrease in HRV and a 25% increase in the risk of injury, confirms the importance of using such indicators to adjust training loads. This was supported by J.E. Teixeira *et al.* (2021), who also highlighted the importance of physiological indicators for assessing players' readiness for matches and training planning.

The comparison of tactical aspects, in particular, the emphasis on flank attacks, was consistent with the conclusions of C. Leão *et al.* (2025), who noted that detailed tactical analysis can help to identify weaknesses in opponents. This study confirmed this, as tactical changes in the team's training, in particular, the use of flank attacks, allowed increasing the effectiveness of attacks by 25%. This result confirmed that the integration of technical, tactical, and physiological data is an important tool for improving the game. The obtained results on the ratio of technical and tactical indicators and physiological load confirmed the effectiveness of periodisation focused on game scenarios, which corresponds to the conclusions of the study by S. Mangan (2019), where tactical periodisation based on indicators of match activity in Gaelic football was proposed. This approach allowed considering the context of the player's actions, and not just their quantitative characteristics, which is especially valuable when developing individual training models.

The development of the XGBoost-based outcome prediction model confirmed the findings of the study by A. Ferraz *et al.* (2023) on the importance of accuracy in sports predictive models. However, the current study showed that the use of a comprehensive data set, including competitor statistics, allowed predicting results with high accuracy, which is an important addition to the methods considered in previous papers. This shows that there is significant potential for further improvement of predictive models in the sports context. A. Padrón-Cabo *et al.* (2024) investigated the individualisation of loads in the training microcycles of professional football players. The results showed that the use of individualised exercise strategies can reduce the level of injuries and improve physiological fitness. The current study also used HRV monitoring to adjust training loads, which provided similar results, in particular a 20% reduction in injuries. This confirmed the researcher's conclusions about the importance of individualising training programmes to optimise recovery and reduce the risk of overload.

Tasks and training loads during pre-season training of professional basketball players were analysed by O. Calle *et al.* (2025). Despite the difference in sports, the approach to analysing loads and tasks in their research is similar to the methodology used in the current study. The use of data on the physiological parameters of players, in particular HRV, allowed adjusting training loads, ensuring their adaptation to the individual physiological needs of each athlete. A. Biró *et al.* (2024) considered the use of artificial intelligence (AI) to monitor athletes' fatigue and endurance using IMU sensors. Multivariate time series were also used to monitor physiological changes. In the current study, the use of HRV to assess player recovery showed similar results: a decrease in HRV was associated with an increased risk of injury. This is consistent with the researcher's findings, which emphasised the importance of monitoring physiological parameters for predicting fatigue and adapting training loads.

AI in tactical analysis was the subject of research by S. Plakias *et al.* (2024). Their paper highlighted the potential of AI for a revolutionary approach to tactical analysis in football. Similarly, the current study used video analytics to assess the tactical weaknesses of opponents, in particular, their vulnerabilities on the flanks. This allowed formulating recommendations for improving tactics, which led to an increase in the effectiveness of flank attacks by 25%. This confirmed that the use of technology for tactical analysis can significantly improve game strategies, as reported by S. Plakias *et al.* (2024). A. Ferraz *et al.* (2023) highlighted the importance of using tracking devices to analyse the physical performance of athletes in team sports. Accordingly, the current study used GPS/IMU sensors to measure physiological loads and adjust them. The results confirmed that tracking devices contribute to accurate measurement of training loads and are an important tool for optimising training processes, which is consistent with the researcher's conclusions about the importance of such technologies for sports analytics.

Individualisation of training within the framework of collective periodisation was investigated by I. Baptista (2019). The results obtained in the current study, which confirmed the effectiveness of individual training strategies, in particular through the use of physiological indicators such as HRV, are consistent with conclusions of I. Baptista (2019). Individualisation of training in the study has provided improved results, in particular, in terms of reducing injuries and physical fitness, which is an important aspect for achieving high athletic performance. The study by V. Lochman *et al.* (2021) explored the use of innovative technical tools to improve the effectiveness of the training process in handball. The paper focused on the importance of technologies for evaluating physical and technical indicators, which helped to improve training processes and increase performance. The current study also applied advanced technologies to monitor physiological parameters, such as HRV, which allowed not only improving player recovery, but also adapting training loads to the individual needs of each player.

The influence of contextual factors on physical activity and technical and tactical actions, in particular, depending on the playing position in football, was investigated by A. Díez *et al.* (2021). The results of the current study confirmed the importance of contextual factors for assessing physical activity and tactical changes in the training process. The analysis of players' positions, their physiological

data, and tactical tasks conducted in the current study helped to achieve an improvement in technical and tactical indicators, which confirmed the importance of adapting training strategies in accordance with physical capabilities and game positions. B. Guerrero-Calderón *et al.* (2021) proposed a new approach to quantifying loads in elite football based on contextual factors. The results of the current study showed that the use of individual data on physiological and technical indicators allowed comprehensively assessing training loads and adjusting them to achieve maximum results. This confirms the scientist's conclusions about the importance of considering contextual factors for optimising training loads, which improves the physical fitness of athletes.

The study by A. Milheiro *et al.* (2024) focused on the impact of competition time on players' performance factors in football. The results of the current study confirmed the importance of assessing the physiological state of players and their ability to recover during competitions. The study of the influence of competitive factors on physiological indicators and tactical actions also allowed making adjustments to training programmes to achieve optimal readiness of players, which is consistent with the approaches presented by researchers. The study by Y. Liu *et al.* (2025) examined the training philosophy and strategies of a gold medal coach in Chinese weightlifting. Although this approach has been applied in another sport, the principles of individualising training programmes and adapting to the physiological capabilities of an athlete are similar to the results of the current study. Identification of the optimal training loads for each player, based on individual physiological data, contributed to a significant improvement in player recovery and performance, which supports the approaches mentioned in the paper.

The competence model for determining the tactical and technical level of tennis players based on the quantitative assessment of loads was applied in the study by M. Crespo *et al.* (2024). In the current study, a similar approach was used to evaluate the technical and tactical actions of football players, in particular, by analysing technical indicators such as pass accuracy and impact strength. The use of this method provided improved results, which confirmed the importance of integrating physiological and technical indicators for assessing the overall level of fitness of athletes. G. Gonçalves *et al.* (2025) analysed internal and external loads during formal training and competitions in youth basketball. The results of the current study also showed the importance of monitoring physiological and technical parameters during training and competitions to determine the level of physical readiness and technical skills of players. This supports the conclusions about the need for a comprehensive approach to analysing training loads and technical characteristics of athletes to achieve high results. Comparison of the results of the current study with other papers indicates the importance of using innovative technologies to assess training loads and technical and tactical characteristics of athletes. The use of individualised approaches to training, considering contextual factors and using AI for tactical analysis can significantly increase the effectiveness of training processes.

Conclusions

Investigation of the use of innovative technologies and data analysis to predict the success of a competitive season in football has provided a number of key results that confirm the effectiveness of integrating technological solutions into sports analytics. First, it was established that systematic monitoring of technical and tactical indicators using GPS/IMU sensors, smart balls and video analytics provided an objective assessment of the effectiveness of players. Thus, the accuracy of passes increased from 78% to 85% during the 2024 season, which indicates an improvement in communication and coordination between players. The impact force measured by smart balls increased by 15% (from 80 N to 92 N), which correlated with an increase in attack performance (2.5 goals per match against 2.1 in the previous season). The number of quick counterattacks increased by 30%, which was made possible by optimising training programmes based on player positioning data.

An important result was the discovery of a link between HRV and injury risk. A 10% decrease in HRV was accompanied by a 25% increase in the likelihood of injury ($r = 0.81$), which highlights the need to individualise training loads. Maximum oxygen consumption (VO_2 max) improved by 12%, indicating an increase in players' aerobic endurance. These physiological changes confirmed the effectiveness of training programmes aimed at balancing exercise and recovery. The predictive model based on the XGBoost algorithm demonstrated 92% accuracy in predicting match results. The model considered 15 parameters, including technical and tactical indicators, physiological data and statistics of opponents. The highest probability of winning (95%) was predicted for matches where the team had an advantage in speed (28 km/h versus 25 km/h for opponents) and the effectiveness of counterattacks. These results confirmed that real-time data analysis can become a key tool for making tactical decisions.

Specific recommendations for the coaching staff were developed. HRV monitoring can prevent overloads and reduce injuries by 20%, which is crucial for maintaining a stable team composition. The emphasis on flank attacks, identified through the analysis of the weaknesses of opponents (60% of goals conceded through the flanks), provided an increase in the effectiveness of this type of attack by 25%. Optimising standard positions through additional training sessions resulted in a 5% increase in corner goals. The main limitations were the use of data from only one team, GPS error in dense game areas, and the lack of consideration for psychological factors. In future studies, it is advisable to integrate AI for video analysis, the latest wearable devices, and expand the sample with teams from different countries to improve the generalisability of results.

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Conflict of Interest

None.

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Використання інноваційних технологій та аналізу даних у підрахунку показників техніко-тактичних дій під час тренувального макроциклу з метою прогнозування успішності змагального сезону

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Анотація. Метою дослідження було прогнозування успішності змагального сезону футбольної команди шляхом інтеграції інноваційних технологій та аналізу даних. Використовувалися дані з датчиків Global Positioning System/Inertial Measurement Unit (швидкість, дистанція, Player Load), смарт-м'ячів (сила удару, точність передач), відеоаналітики (позиціонування, групові дії), носимих пристроїв (варіабельність серцевого ритму, пульс) та зовнішніх джерел (Opta, Wyscout). Встановлено, що точність передач зросла з 78 % до 85 %, сила удару – на 15 % (від 80 Н до 92 Н), а кількість контратак збільшилася на 30 %. Виявлено кореляцію між зниженням варіабельності серцевого ритму на 10 % та зростанням ризику травм на 25 % (коефіцієнт кореляції $r = 0.81$). Покращення максимального споживання кисню на 12 % та зниження навантаження на суглоби на 20 % підтвердили ефективність тренувальних програм. На основі алгоритму машинного навчання XGBoost розроблено прогностичну модель із точністю 92 %, яка визначила ймовірність виходу команди у топ-3 ліги (68 %) та вильоту (12 %). Аналіз слабких сторін суперників (60 % пропущених голів через фланги) дозволив сформулювати тактичні рекомендації, зокрема акцент на флангових атаках (підвищення ефективності на 25 %). Отримані результати підтверджують, що інтеграція даних із різних джерел є ключовим інструментом для підвищення результативності команди в змаганнях. Практична значимість полягає в оптимізації тренувань через моніторинг варіабельності серцевого ритму (зниження травматизму на 20 %) та адаптації стратегій гри

Ключові слова: спорт; футбол; машинне навчання; варіабельність серцевого ритму; оптимізація тренувань