Measuring the physical parameters of match and training performance in relation to age groups, positions and contextual variables among elite youth and adult footballers

Abstract of PhD Thesis

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1. INTRODUCTION

Football is the world's most popular and dynamically developing sport, which requires players to be perfectly prepared technically, tactically, mentally and physically. This requires more systematic training, selection processes and a new sports science approach from professionals, who are showing increasing interest in the long-term development of athletes. To this end, it is advisable to use the most realistic method of measuring players, i.e. their performance during matches, which is why match analysis is a useful tool for assessing the physical requirements of footballers. In recent decades, the use of GPS systems based on different sampling frequencies has become the accepted technology for analysing the movement patterns of footballers and determining their physical requirements, as it allows running performance to be quantified and provides feedback on the physical demands of matches and training. Over the past two decades, the external load of matches has been studied in depth, which has contributed to our understanding of the evolution of football and trends. Locomotor and mechanical parameters have been

analysed, which are generally related to the distances covered by players in different intensity zones, and running performance has clearly improved, especially in terms of high-intensity actions.

The development of the above mentioned technology and the increasing training load prove that performance analysis by sports science professionals is essential in order for players to be optimally prepared for the high-intensity demands of matches. Understanding these is fundamental for coaches when planning training programmes.

2. OBJECTIVE

Research objectives

The aim of my research is:

- ✓ to present the locomotor and mechanical parameters of players in Hungarian youth and adult football in their respective positions, and to identify the parameters that distinguish between age groups;
- ✓ to present the training load values of youth footballers, i.e. to establish a team average based on the number of days before a match;
- ✓ to show how contextual variables affect the measured variables in league matches in both youth and adult football, and how they influence the training days before the match;
- ✓ to present the most intense periods of matches among professional footballers in terms of the measured variables, and to explore the differences and similarities between match periods;
- ✓ Based on my results, draw conclusions about which variables make the difference between hungarian and

foreign footballers, and what makes the difference and similarity in weekly training load.

Hypotheses

Hypotheses related to match load:

(H_1): I assume that in youth football, U21 footballers playing in NB III perform significantly better in all locomotor parameters than footballers in the U19, U17 and U16 age groups;

(H_2): I hypothesise that players in the NB II league perform more high-intensity running (19.8-25.1 km/h) and sprinting (>25.2 km/h) than U21 footballers playing in NB III;

(H_3): I assume that the locomotor and mechanical performance of central midfielders and forwards differs;

(H_4): I assume that in all age groups, the team's total high-intensity running (>19.8 km/h) accounts for 6-8% of the total distance covered.

Hypotheses related to training load:

(H_5): I assume that the volume and intensity of training days continuously decrease for all variables as the match day approaches;

(H_6): I assume that the volume and intensity of training days before winning matches (MD-1) were lower than before losing or drawing matches;

(H_7): I assume that the match does not represent the greatest load within the microcycle for all variables.

Hypotheses related to contextual variables:

(H_8): I assume that there is a significant difference between the teams' performance in terms of the measured variables depending on the location of the match;

(H_9): I assume that there is a statistically significant difference in the measured variables with regard to the opponent's position on the table;

(H_{10}): I hypothesise that in lost matches, there is a significantly higher level of high-intensity running, sprinting, acceleration and deceleration across all age groups, than in drawn and won matches;

(H_{11}): I assume that there is a statistically significant difference in volume and intensity between the first and second half in terms of positions among adult footballers; (H_{12}): I assume that performance is not lower in all variables in terms of positions between the 75'-90' period than in the 60'-75' period.

3. METHODS

First sample examined

The data for the players participating in the first sample was collected during the 2018-2019 season from August to June. The data was provided by 70 elite youth footballers from four different age groups (U16-U21). A total of 114 league matches were analysed during the league year (U16: n=28; U17: n=28; U19: n=28; NB III: n=30). As a result, we were able to make 574 observations. The teams used a 4-4-2 diamond formation, so we classified them into the following categories: centre back (CB), full-back (FB), midfielder (MF), forward (F).

Second sample examined

The second sample consisted of 19 hungarian U17 youth footballers. The data on the participating players was collected from January to June during the 2022-2023 season. We analysed a total of 22 weeks, and in addition to the weekly training load, the team participated in the 2022-2023 championship announced by the Hungarian Football Association. To ensure the reliability and validity of the study, we only observed weeks that met certain criteria. Then the examined data from 13 weeks, during which there were a total 52 training sessions and 13 saturday league matches. Based on previous studies, we analysed the training load data based on the number of days before the match.

Third sample examined

In the third sample, we collected data on the participating players during the 2022-2023 season, from July to June. The study included 20 players who participated in the hungarian second division (NB II) championship organised by the Hungarian Football Association. We analysed 38 league matches, during

which we made 201 individual observations. In line with previous studies, we examined the players according to their position on the pitch: centre back (CB), full-back (FB), central midfielder (CM), winger (W) and striker (S).

Contextual variables

During the data analysis, we took the following contextual variables into account: (i) the location of the match (home or away), (ii) the quality of the opponent (weak-medium-strong), (iii) the outcome of the match (win-draw-loss) (iv) and the individual match periods (half-time and 15-minute intervals). The quality of the opponent was determined by their position on the table at the end of the season. We separated two clusters: higher-ranked (strong opponent – U16-U19 teams ranked 1-4, U21: teams ranked 1-8, while for NB II teams: 1-10) and lower-ranked (weak opponent – U16-U19 teams ranked: 5-8, U21: 9-16, while for NB II teams: 11-20).

The device used for the study

The movements of the players were recorded and evaluated using GPS technology in all three samples.

During the measurement of the first sample, the players wore a fifth-generation GPS tracking system (Catapult OptimEye S5, Melbourne, Australia) with a sampling frequency of 10Hz during football matches. In samples second and third, data was provided by an upgraded version of the device (Vector S7, Catapult. Catapult Sports. Ltd. Melbourne).

Statistics used, data processing

The location of the match (home or away), the quality of the opponent (strong or weak), and the comparison between the two halves (first half and second half) were presented using two sample T-tests. We used the Anova test for all three samples. We used the Tukey post-hoc test in the first sample and the Bonferroni post-hoc test in the second sample in cases of significant differences, while we used the Games-Howell post-hoc test in cases of different variance homogeneity. The Bonferroni post-hoc test was also used in the third sample. The significance level was $p<0.05$ in all cases. All statistical analyses were performed using SPSS Windows 25.0.

4. RESULTS

First sample examined

In terms of high-intensity running, the U21 footballers performed significantly better (520±174 m) than the U16 players (450±111 m; p=0.001), suggesting that the difference between the age groups (η^2 =0.05) is indeed noticeable in terms of match intensity.

In terms of high-intensity running, there was no difference in performance between attackers and full-backs (566±126 m; 540±149 m), but players in both positions differed significantly from centre backs (373±99 m; p<0.001) and midfielders (454±143 m; p<0.001).

There was no significant difference in terms of the location of the match and the opponent's position on the table. In terms of match outcome, players in the U21 age group performed more high-intensity runs in winning matches (p=0.015), a difference that is noticeable but not significant (η^2 =0.062). The outcome of the match has a small effect on running performance, which indicates that in the age groups mentioned, age-specific characteristics

and position-specific roles are more decisive than the final result of the match.

Second sample examined

Among the days with the lowest load, there was a significant difference between MD-5 and MD-1 in the case of the TD and TPL variables ($p<0.001$). There was no significant difference between MD-2 and MD-4 training days in the HSR, SPR and DEC variables, but the load was significantly higher on MD-2 training day in the case of TD and TPL ($p<0.001$).

The most intense training load was on training day MD-4, and the $SPR_{(m/min)}$, $ACC_{(number/min)}$, $DEC_{(number/min)}$ variables differed significantly from the intensity of the match ($p=0.005$; $p<0.001$; $p<0.001$). In the case of $MPP_{(m/min)}$ and $TPL_{(au/min)}$, the match day was the most intense and differed significantly from the training days ($p<0.001$).

Although no significant difference was observed, the MD-2 training day before winning matches was milder in terms of all volume variables than the trainings before the lost matches. In terms of load, the MD-1 training day

was milder in all variables before winning matches, but only $MPP_{(m/min)}$, $HSR_{(m/min)}$, and $TPL_{(au/min)}$ showed a significant difference.

The MD-2 training day was significantly more intense in terms of $MPP_{(m/min)}$, $ACC_{(number/min)}$, $TPL_{(au/min)}$ and $DEC_{(number/min)}$ when the team played against weaker opponents. The MD-4 training day was more intense in terms of HSR, SPR, ACC, and DEC when preparing for stronger opponents, but a significant difference was only observed in the mechanical variables of acceleration and deceleration.

Third sample examined

The wingers excelled in high-intensity running (638±160 m) and sprinting (201±74 m) and performed significantly better than players in other positions in both variables examined. In terms of acceleration, wingers (14.25±3.41 nr.) differed significantly from other positions and also performed the most explosive actions, indicating their dynamic participation in the game.

In terms of high-intensity running, players ran significantly more (487±121 m) in lost matches than in

draws (434±153 m; p=0.016). Furthermore, the metres per minute covered by players (107.87±7.56 m), explosive actions (32.88±9.94 nr.) and acceleration were significantly higher in lost matches than in draws.

In high-intensity running, centre backs ran significantly more in the 1'-15' period (73±28 m) than in the 60'-75' and 75'-90' periods. Furthermore, in 75'-90' period in sprint runnings the full-backs (12±14 m) and forwards (9±10 m) ran significantly less than in the first 15 minutes. In addition, full-backs, centre backs and central midfielders performed significantly better in the first 15 minutes in terms of metres per minute, total player load and total player load per minute than in the other periods of the match.

5. CONCLUSIONS

Match load results

I assume (H_1) that in youth football, U21 players playing in NB III perform significantly better in all locomotor parameters than players in the U19, U17 and U16 age groups. My hypothesis is only partially correct, as differ significantly from all age groups in terms of total high-intensity running, sprinting and maximum speed, while in terms of high-intensity running, they differ only from the U16s.

I assume (H_2) that NB II championship players perform more high-intensity running (19.8-25.1 km/h) and sprinting (>25.2 km/h) than U21 footballers in NB III. My hypothesis proved to be only partially correct, as NB II centre backs, wingers and central midfielders performed better in terms of high-intensity running, while U21 footballers playing in NB III ran more in terms of sprinting in all positions.

I assume (H_3) that the locomotor and mechanical performance of central midfielders and forwards differ. My hypothesis is partially correct, as there was no

significant difference in locomotor parameters in all cases, while in terms of mechanical variables, there was no significant difference in the number of high-intensity accelerations, decelerations and explosive actions among adult NB II footballers.

I assume (H_4) that in all age groups, the team's total high-intensity running (>19.8 km/h) accounts for 6-8% of the total distance covered. Since the total distance covered was 5.3% for the U16 age group, 5.6% for the U17 age group, 5.5% for the U19 age group, 6.3% for the U21 age group, and 6.6% for professional adult footballers, my hypothesis was partially proven correct.

Training load results

I assume (H_5) that the volume and intensity of training days continuously decrease for all variables as the match day approaches. My hypothesis was partially confirmed, as this can be observed in the case of high-intensity running, sprinting, acceleration and deceleration parameters, but not in terms of total distance covered and total player load. This suggests that on MD-4 training

days, the physical factors that play a key role in pre-goal situations are given greater emphasis.

I assume (H_6) that the volume and intensity of training days before winning matches (MD-1) were lower than before matches that ended in defeat or a draw. Since all volume and intensity parameters are lower, my hypothesis is correct. There was a significant difference in the total distance covered, the volume of high-intensity running, the intensity of these variables, and the total player load/minute variable. This leads to the conclusion that, with a lower load, the focus was on the result.

I assume (H_7) that the match does not represent the highest load for all variables within the microcycle. Since on MD-4 training day the load was higher in terms of acceleration (volume) and high-intensity running/minute, sprinting/minute, acceleration/minute and deceleration/minute (intensity) that is why, my hypothesis has been partially confirmed.

Results of contextual variables

I assume (H_8) that there is a significant difference between the teams' performance in terms of the measured

variables with regard to the location of the match. Since I found a statistically significant difference only in two cases, my hypothesis was not confirmed. This suggests that the players adapted physically and psychologically in the same way and that they played in the same style at home and away matches.

I assume (H_9) that there is a statistically significant difference in the measured variables with regard to the opponent's position on the table. No significant difference was found for any of the measured variables, so my hypothesis was not proven correct. This suggests that the external load is becoming more stable and maximum performance must be strived for in every match in the competition system.

I assume (H_{10}) that in lost matches, high-intensity running, sprinting, acceleration and deceleration are significantly higher across all age groups than in drawn and won matches. Analysing the measured variables for the U16, U17, U19 and U21 age groups, I found that performance is higher, but there is no significant difference. Among NB II adult footballers, only high-intensity running and acceleration were significantly more

prevalent in lost matches than in draws. Based on the results obtained, I reject my hypothesis.

I assume (H_{11}) that there is a statistically significant difference in volume and intensity between the first and second half in terms of positions among adult footballers. My hypothesis proved to be incorrect, as there is only a significant difference in the metres/minute parameter for all positions, while there was no significant difference in any position for the variables of explosive action, acceleration, deceleration and high-intensity running.

I assume (H_{12}) that performance is not lower in all variables in the 75'-90' period than in the 60'-75' period. My hypothesis was partially confirmed, which suggests that not only fatigue but also game interruptions and match strategies play a major role in the decrease in running performance between match periods.

LIST OF OWN PUBLICATIONS

Kádár, L., Géczi, G., Bognár, J., & Csáki, I. (2023). Movement analysis of match play in U16-U21 youth Hungarian soccer players - the influence of age, position, and contextual variables. *International Journal of Performance Analysis in Sport*, *23*(3), 213–231. https://doi.org/10.1080/24748668.2023.2219490

Kádár, L., Revesz, L., Sáfár, S., Géczi, G., Bognár, J., & Csáki, I. (2024). Elite U17 football players' physical parameters: focus on contextual variables during training and matches. *International Journal of Performance Analysis in Sport*, *25*(4), 753–767. https://doi.org/10.1080/24748668.2024.2444794

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Revesz, L., Stengl, V., **Kadar, L.**, Rado, D., Safar, S., & Csaki, I. (2025). Positional roles, match outcomes, and location: Understanding performance dynamics in second division soccer. *International Journal of Sports Science & Coaching*, *20*(3), 1125–1133. https://doi.org/10.1177/17479541251316160