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## Football coach replacement – short-term effect on performance

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### Zmiana trenera piłki nożnej – krótkoterminowy wpływ na wyniki sportowe

#### Streszczenie

Wynik sportowy to jeden z najważniejszych aspektów funkcjonowania klubów piłkarskich, a niezadowolający poziom wyników często owocuje zwolnieniem trenera. Sama motywacja osób zarządzających klubami piłkarskimi do zmiany na pozycji pierwszego szkoleniowca sugeruje, że wpływ takiej zmiany na wyniki klubów uzyskiwane w perspektywie krótkoterminowej jest korzystny. Celem artykułu jest ustalenie, w jaki sposób zmiana na pozycji pierwszego trenera w klubie piłkarskim wpływa na osiągnięte rezultaty sportowe. Dokonano analizy statystycznej dla określenia różnicy w osiągniętych przez drużyny wynikach w analogicznych okresach dziesięciu meczów poprzedzających zmianę szkoleniowca oraz dziesięciu meczów po zatrudnieniu nowego trenera w ligach Premier League oraz La Liga, w trzech pełnych sezonach od 2018 do 2021 r. Przeprowadzona analiza pozwoliła wykazać, że w większości przypadków taka zmiana wywiera pozytywny

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wpływ na wyniki zespołu – drużyny krótkoterminowo uzyskują więcej punktów ligowych. Efekt ten jednak w szybkim tempie zanika. Ostatecznie skumulowana liczba punktów uzyskanych przez drużyny pokazuje, że „terapia szokowa”, jaką jest zmiana trenera, na ogół działa i przynosi oczekiwaną poprawę wyników. W związku z powyższym, kiedy wyniki nie są satysfakcjonujące, rotacja na tej pozycji powinna być rozważana jako potencjalny sposób na poprawę rezultatów.

**Słowa kluczowe:** piłka nożna, wynik sportowy, zmiana trenera, Premier League, La Liga.

## Abstract

Sporting performance is undoubtedly one of the key aspects of the way in which professional clubs operate. Insufficient results often result in coach turnover. The initial motivation to replace the coach suggests that improvement should come after the change. This paper aims at determining how the rotation on the coach position influences football clubs' short-term sporting performance. The material for analysis consists of ten games before and ten games after each coach replacement in Premier League and La Liga in the past three seasons from 2018 to 2021. A statistical analysis is conducted to determine and highlight the difference in performance in respective time frames before and after the turnover. The analysis helped to understand that coach replacement does in fact come with a performance booster in most cases – the teams generally benefit short-term. Drawing conclusions from the analysis, it needs to be noted that this positive effect quickly wears off. Eventually, however, accumulated data is an indicator that the shock-therapy, which coach turnover is, works. When the performance regresses, rotation on coaches' chair should be considered as a possible solution.

**Keywords:** football, results, coach turnover, Premier League, La Liga.

## Introduction

Undoubtedly, the core of sport clubs' existence is their performance. Ultimately, the results are what attracts fans, sponsors, as much as they create a general positive perception of the club. The determinants of the aforesaid performance are a subject of multiple cross-discipline research describing different factors influencing it. While they are often revolving around economical aspects of football clubs' functioning [1], [17], they can also be based on more purely sport-related determinants such as players' quality and match stake [24] or in-game achievements (such as possession, passes or shots taken) and their contribution to the final match result [27].

Apart from the leading actors of every football match – the players – the responsibility for results is concentrated on the 1<sup>st</sup> team staff member, especially the coach. They are the club workers closest to the playing field – except for the players themselves – so club managers usually see them as the reason of promising or disappointing performance. Therefore, when the results worsen and club owners are considering their options to improve them in a short-term period, it is often easier and more convenient to let one coach go instead of replacing a bigger part of the team. This is the reason why the dilemma between

two ways of acting usually ends similarly – with a coach turnover. Post-season changes appear to be more thoughtful. Dissatisfaction with the final result provided by one coach drives the change with hopes for long-term improvement. Different motives cause mid-season changes. In these cases, very often replacement comes after a sudden significant form of regress, resulting in a poorer performance [6], [17], [19].

Is this approach correct? Can a short-term booster of performance and results be really expected? The case is not only interesting for football-oriented researchers but is also a subject of many studies on other sports disciplines such as basketball [21] or baseball [10], [17].

This paper aims at determining how the rotation on the coach position influences football clubs' short-term sporting performance. A statistical analysis will be conducted to see the impact coach turnovers had on Premier League and La Liga football teams in three full seasons – from 2018/19 up to 2020/21.

The frequency of the turnovers was a springboard to many studies on that matter in the first decade of the 21<sup>st</sup> century. Not only are they based on data from earlier seasons in this rapidly changing world of football, but also the research articles on that subject were inconclusive and often contradictory. For example, a study proved the results to decline over the first two months in Belgium [3], which is not considered the country with top football performance, whereas a similar result is also pointed out in a study regarding English Premier League, one of the two leagues analyzed in this paper. A Spanish study on La Liga (also analyzed here) suggested an immediate positive effect, though flattening over time [19].

Other researchers did not notice any improvement in performance [5], [22], [23], however their research was based on a longer time frame, while this paper aims to find the short-term shock reaction's immediate effect on performance. It is suited for cases when the need of short-term improvement is crucial and is the main driver for the change in the coaching position.

Coaching performance in team sports focuses on four core factors having a direct effect on the team as a unity [18]:

- Selecting and engaging adequate players who bring along a specific ability of game performance as well as other desirable traits for a successful team,
- Forming and leading individual players as well as a team,
- Planning and regulation of training,
- Game strategy and match governance.

A coaching competence scale may consist of five different dimensions of coach competencies: 1) Creating the relationship, 2) Communication attending skills, 3) Communication influencing skills, 4) Making the responsibility clear, and 5) Facilitating for learning and results [20]. Coach competencies may be a stim-

ulus for organizational learning; some of their dimensions are related to learning culture [20].

## Material and methods

The general motivation for a turnover implies the hypothesis that coach turnover influences the results of a football team positively in a short-term perspective. Considering how often football clubs seek improvement by rotation on the first coach chair, it is justified to inquire how the sporting performance differs in respective short time frames before and after the turnover. Are the results of new coach's first games better than his predecessor's?

### Data

Verification of the hypothesis is based on data regarding coach changes retrieved from transfermarkt.de [26] and the prior to and post change results obtained from flashscore results database [11]. As these web portals are among the most popular, commonly used, trusted and respected databanks in football industry, they were selected as the most reliable sources for data to the research. Therefore, the risk of mistakes or wrongly documented data was minimized. The data covers mid-season coach replacements in two currently highest ranked (uefa.com [9]) football leagues in Europe – Premier League and La Liga. The validity of the data was ensured by selecting the most recent results, i.e. the last three full seasons – from 2018/2019 to 2020/2021. In-between seasons coach changes were not observed, as the layover might be reducing the researched influence. However, if a new coach was appointed with fewer than ten games to the end of a season, his ten games observation span was extended to his next-season games. Respectively, if a coach was changed sooner than ten games into new season, his previous performances from the last season were also included in the ten games span. An exception to this rule is when a team was relegated – the results were standardized to a top tier playing level in a given country (Premier League in England and La Liga in Spain) and results from a tier below could not be included. Also, caretaker coaches were observed, however only if they managed the team for ten games. In case when a caretaker coach was turned over sooner, the last ten games of the previous coach were analyzed in relation to the first ten games of a new permanent coach with the assumption that this was a change initially desired by club authorities. In total, there were 43 coach change observations within 847 games, as listed in Table 1.

**Table 1.** Number of mid-season coach changes and games observed

League	Mid-season coach replacements	Games
Premier League	17	332
La Liga	26	515

Source: FlashScore database (2021).

## Procedures

Collected data was structured and sequenced in match day periods from -10 up to 10, from the first analyzed game of a replaced coach up until the last analyzed game of his successor. A comparison test was conducted to determine and highlight the difference in performance in respective time frames before and after the turnover. A determining factor was the average point per game ratio for three set periods: 1, 3 and 10 corresponding match days before and after the change. This part of the research corresponded to the methods used by Lago-Peñas (2011).

$$(1) \text{ Avg}(PG1) - \text{Avg}(PG-1)$$

$$(2) \text{ Avg}(PG1,PG2,PG3) - \text{Avg}(PG-1,PG-2,PG-3)$$

$$(3) \text{ Avg}(PG1,PG2,PG3,\dots,PG10) - \text{Avg}(PG-1,PG-2,PG-3,\dots,PG-10)$$

Consequently, a scatter plot was generated in statistical software to graphically depict progress that teams made after a given change. It was based on absolute point difference for each analyzed coach replacement that was calculated.

Lastly, a graphic depiction of a total number of points accumulated for teams was created. The first figure visualizes total progress achieved by teams after the coach change. The second figure visualizes separate total point values for separate match days in order to highlight the exact corresponding match day's contribution to the very total.

## Results

Since the first post-change match day teams have proven to improve their results to a similar extent in both analyzed leagues. Spanish teams tended to have worse results before making the decision to replace the coach during the season and for them the immediate results improvement is therefore slightly more significant. Per match day a team can collect 0, 1 or 3 points depending on the result (lose, draw or win), and these points will be the dependent variable. The biggest improvement for both leagues came during the second analyzed period, that is after the 3<sup>rd</sup> match day. Over this period the average of collected points per game was more than double compared to corresponding results in

the last three games before the shift on the coach position. Again, Spanish teams were the ones with the most noticeable positive change, improving by over 112%. The progress significantly flattens over the last analyzed period – full ten match days (table 2).

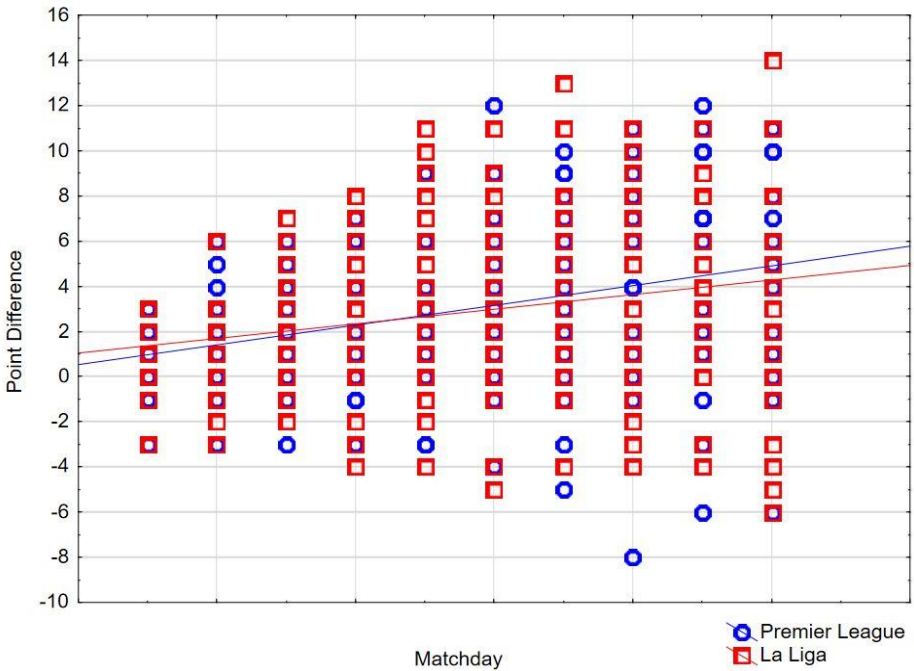
**Table 2.** Average points per game

League	1 game prior to coach change	1 game after coach change	Difference	3 games prior to coach change	3 games after coach change	Difference	10 games prior to coach change	10 games after coach change	Difference
Premier League	0.65	1.18	+0.53	0.60	1.19	+0.59	0.83	1.27	+0.44
La Liga	0.54	1.19	+0.65	0.62	1.32	+0.70	0.95	1.26	+0.31
Total	0.58	1.19	+0.61	0.61	1.27	+0.66	0.92	1.27	+0.35

Source: own studies utilizing data obtained from FlashScore database (2021).

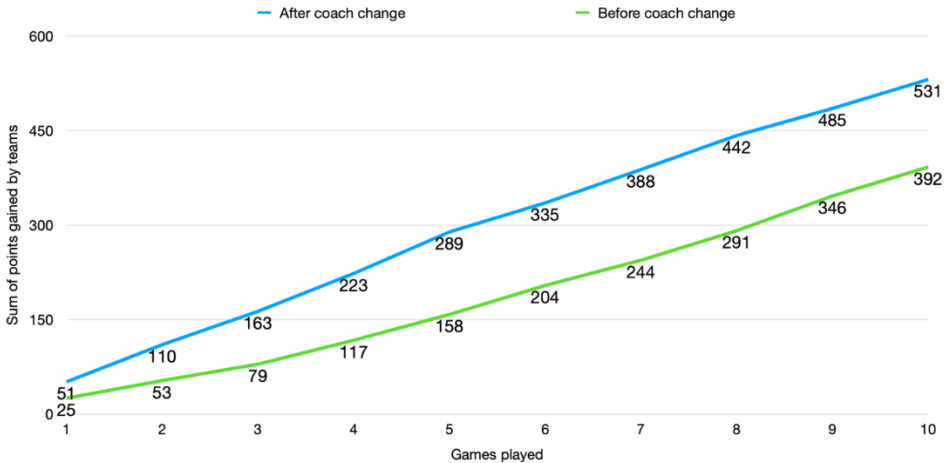
A scatter plot is a tool to visualize these data in a more detailed way – with higher regard of teams' individual performances. It broadens the idea of collective progress being just a combination of all the individual efforts. Each red square represents a Spanish La Liga team, whereas blue circles are Premier League representatives (Figure 1). Most of the teams benefited from the change and the trend line also suggests so. Initially the progress for La Liga teams is more noticeable, however, in the end English teams were the ones to have progressed the most. The results do not vary significantly, which seems to be an indication that a steady progress is to be usually expected from top level teams replacing their coaches. The scatterplot reveals each individual team contributing to this generally positive outcome. The spread is wide, and we see that ultimately two teams (one from each league) gained as many as six points less than they did in a respective period of ten games before replacing the coach. One of the teams from English Premier League reached the lowermost spot at eight points behind on match day 8, compared to the number of points gained in last eight games of the previous coach in charge.

The total number of points is also clearly showing how much of a positive impact on team performance the coach shifts have on average, without considering the insights we can see in the scatterplot (Figure 2). A steady increase is visible since match day one up until match day 10, with a slight decrease on match day 9, however not influencing the general progress.



**Figure 1.** Point difference for every team after each analyzed match day

Source: own studies utilizing data obtained from FlashScore database (2021).

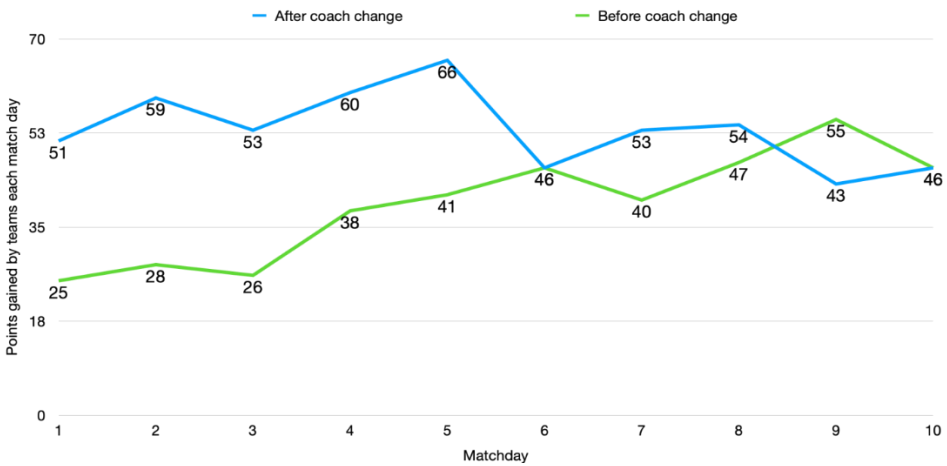


**Figure 2.** Accumulated point differences for all teams combined

Source: own studies utilizing data obtained from FlashScore database (2021).

Another figure was created to supplement the generally positive accumulated number of points gathered by all the teams (Figure 3). It graphically sup-

ports the general outcome of the previous calculations – positive impact on team performance coming with the new coach is immediate and progresses even more up to match day 3. Up until match day 6, the teams still collected significantly more points than they had in a respective period before coach turnover. The figure also indicates that the novelty effect brought on by the new coach, however significant, quickly wears off. From match day 6 on, the progress seems to have remarkably declined, with the abovementioned match day 9 being the only one from the analyzed period on which the teams did not manage to obtain at least as many points as on respective match day – 9.



**Figure 3.** Point differences in separate match days

Source: own studies utilizing data obtained from FlashScore database (2021).

## Discussion

Just the number of mid-season coach turnovers in top European leagues indicates how important their effects may be to team performance. In hope for this improvement clubs decide to proceed with a new team coach, especially in circumstances of high pressure to stay in the top division and maintain the revenue source associated with it.

When the turnover comes, it must be noted that permanent improvement is unlikely to happen. Just like in case where a longer-term effect was the basis for research [5], [22], [23], our research discovered that results stabilize and go “back to normal” after a short novelty period. The effect is also highlighted because the change comes after a sharp decrease in obtained points in league tables. Another research argued that this factor is the main driver for coach turnover [10], [17], [19] and this point of view proved to be the case in this paper.



The performance preceding the turnover was very poor and declining. However, this does not fully explain the motivation standing behind club's managers who decide to change the head coach. It turns out that the decline in results could be forgiven more eagerly when no relegation threat occurs. American Major League Soccer is a perfect example of this trend: there are no relegations from the league, and this has significantly lowered the total number of coach dismissals over the last years [25]. What is important to notice is the fact that contrary to MLS, Premier League and La Liga do relegate teams each season. Moreover, they are two leagues of the highest TV revenue split each season among all the teams [12]. Therefore, the threat not only occurs, but it is also scarier than anywhere else, which significantly contributes to the importance of the research.

Current research suggests that performance change does not stem from the physical aspects of coaches' influence on the players and has more to do with a new coach's tactical abilities [16]. That is an important observation for determining whether it is time for a turnover and even though it was not a basis for our research it needs to be addressed.

The post-turnover positive effect is present and lasts for about six match days. Even though it does not seem to be permanent, it cannot be ignored that teams do perform better. This stands contrary to some of the other research conducted in this field. A Belgian study proved that performance declined in the first two months after the turnover [3]. This difference between observed results possibly stems from a different general performance level in these respective leagues – the Belgian top division occupies the 13<sup>th</sup> place in the UEFA ranking led by Premier League and La Liga. This general performance inequality influences the threat of being relegated and possible consequences that are basically incomparable between those leagues, therefore the Belgian one could and should be considered separately. However, it needs to be noted that positive short-term impact is, in fact, conditional. In the Brazilian top division, it takes about 7 games to see a slight increase in performance [13], whereas in Premier League and La Liga the effect seems to be wearing off by that time. The Brazilian top division holds the 12<sup>th</sup> place in FIFA ranking, also led by leagues researched in this paper, which again might be an explanatory factor for this different outcome. As in evidence from Belgian football, positive effect is lower in the league of a lower status. It is worth mentioning that another study on Brazilian football, which undertakes different methodology, i.e. the probability of winning, losing or drawing is introduced, proves that the probability of winning at least two games on the first 6 match days following the coach turnover increases by 30% [4].

A recent study that cross-analyzed top divisions in Europe [14] over a longer time frame concludes that, contrary to conventional wisdom, getting acquainted with the organizational standards does not help the coach enhance the results, as from match day 10 improvement in results is nowhere to be found.

Our study also confirms those findings, shortening the novelty time even further – to about match day 6. This, however, does not disrupt the general outcome of both studies and even highlights the short-term improvement. Research on top four European leagues, which includes a dataset closest to the one from this paper, along with their 2<sup>nd</sup> tiers corroborates these results, proving further that after coach dismissal teams experience a small, but statistically important increase in performance for about 6 match days [9]. Then, their performance declines somewhat over games 7-15. A general impression is that whenever top divisions are subject to research, the novelty effect of a coach change is always the same.

## Conclusive remarks

Firing the coach mid-season in leagues of the highest European level remains risky and can have various results. The distribution of point ratios gained by teams on ten consecutive match days after rotating on the coach position is wide and different outcomes must be expected.

However, contrary to some of the previous findings from English Premier League, a significant positive trend is present in both leagues as well. The wearing-off period comes after about 6 match days of reliable progress. Then the results flatten and become almost indistinctive from the corresponding results preceding the turnover.

The final outcome of the study could serve as a practical piece of advice for management staff of football clubs struggling with performance, as the wear-off effect is clearly present. The immediate shock therapy seems to really make an impact on a given team's performance. When it is on the verge of being relegated, this quick improvement is necessary and it may be a smart strategic move to replace the coach. However, with thorough long-term planning, it seems to be just a positive spark to be noted, and nothing more. A further study on a longer-time perspective would be an important complement and an indicator whether the positive effect permanently flattens or maybe fluctuates in certain patterns over time. Provided that enough data is available on high-achieving teams, some differentiation between them and teams struggling to avoid relegation could also be introduced and researched to gain an understanding on whether the influence depends on a team's status within the league, making the results more meaningful for certain scenarios a given team faces when they consider coach replacement. Furthermore, it also needs to be mentioned that coach turnovers usually exceed the expenditure of the club significantly. Weighting beneficial sporting results against the aforesaid increased costs could also be a basis for useful, practical further research. Lastly, an in-depth profes-

sional football analysis could be conducted on scouted performance to determine what the factors are that, in fact, influence the change in play and in performance after coach turnovers. Understanding what that new thing is that coaches bring to the game, which positively affects the results could be beneficial for club managers so that they are able to reach the best decision for their teams at any given time.

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#### References

- [1] Andreff W., Scelles N. (2021): *Economic determinants of sport performance*. [in:] E.C.K. Pike (ed.): *Research Handbook on Sports and Society*. Edward Elgar Publishing, pp. 69–82; <https://doi.org/10.4337/9781789903607.00012>.
- [2] Audas R., Dobson S., Goddard J. (2002): *The impact of managerial change on team performance in professional sports*. *Journal of Economics and Business*, vol. 54(6), pp. 633–650; [https://doi.org/10.1016/S0148-6195\(02\)00120-0](https://doi.org/10.1016/S0148-6195(02)00120-0).
- [3] Balduck A., Buelens M., Balduck A., Buelens M. (2007): *Does sacking the coach help or hinder the team in the short term? Evidence from Belgian soccer*. Working Papers of Faculty of Economics and Business Administration, vol. 430(7); <https://doi.org/10.2139/ssrn.3475379>.
- [4] Barbosa D.A.C. (2020): *Should he stay or should he go? Head coaches turnover in brazilian football 2014–2019*. Pontificia Universidade Católica Do Rio De Janeiro Departamento De Economia; [http://www.econ.puc-rio.br/uploads/adm/trabalhos/files/Daniel\\_Adriano\\_Carvalho\\_Barbosa\\_Mono\\_20.1.pdf](http://www.econ.puc-rio.br/uploads/adm/trabalhos/files/Daniel_Adriano_Carvalho_Barbosa_Mono_20.1.pdf).
- [5] Besters L.M., van Ours J.C., van Tuijl M.A. (2016): *Effectiveness of In-Season Manager Changes in English Premier League Football*. *Economist* (Netherlands), vol. 164(3), pp. 335–356; <https://doi.org/10.1007/s10645-016-9277-0>.
- [6] Bruinshoofd A., ter Weel B. (2003): *Manager to Go? Performance Dips Reconsidered with Evidence from Dutch Football*. *European Journal of Opera-*

- tional Research, vol. 148(2), pp. 233–246; [https://doi.org/10.1016/S0377-2217\(02\)00680-X](https://doi.org/10.1016/S0377-2217(02)00680-X).
- [7] Bryson A., Buraimo B., Farnell A., Simmons R. (2021): *Special ones? The effect of head coach on football team performance*. IZA Discussion Paper, No. 14104; <https://doi.org/10.2139/ssrn.3785068>.
- [8] Bykova A., Coates D. (2019): *Does experience matter? Salary dispersion, coaching, and team performance*. Contemporary Economic Policy, vol. 38, no. 1, pp. 188–205; <https://doi.org/10.1111/coep.12444>.
- [9] *European Leagues Ranking*, www.uefa.com [accessed: December 7, 2021].
- [10] Fabianic D. (1994): *Managerial Change and Organizational Effectiveness in Major League Baseball: Findings for the Eighties*. Journal of Sport Behavior, vol. 17(3), pp. 135–147; <https://doi.org/10.1177/1527002517716972>.
- [11] *FlashScore*, www.flashscore.com [accessed: December 7, 2021].
- [12] *FootballBenchmark*, www.footballbenchmark.com [accessed: April 11, 2022].
- [13] Galdino M., Wicker P., Soebbing B.P. (2021): *Gambling with leadership succession in Brazilian football: head coach turnover and team performance*. Sport, Business and Management, vol. 11(3), pp. 245–264; <https://doi.org/10.1108/SBM-06-2020-0059>.
- [14] Gómez M.A., Lago-Peñas C., Gómez M.T., Jimenez S., Leicht A.S. (2021): *Impact of elite soccer coaching change on team performance according to coach- and club-related variables*. Biology of Sport, vol. 38(4), pp. 603–608; <https://doi.org/10.5114/biolsport.2021.101600>.
- [15] Grusky O. (1963): *Managerial Succession and Organizational Effectiveness*. The American Journal of Sociology, vol. 69(1), pp. 21–31; <https://doi.org/10.1086/223507>.
- [16] Guerrero-Calderón B., Owen A., Morcillo J.A., Castillo-Rodríguez A. (2021): *How does the mid-season coach change affect physical performance on top soccer players?* Physiology & Behavior, vol. 232, 11332; <https://doi.org/10.1016/j.physbeh.2021.113328>.
- [17] Hoffmann R., Chew Ging L., Ramasamy B. (2002): *The Socio-Economic Determinants of International Soccer Performance*. Journal of Applied Economics, vol. 5(2), pp. 253–272; <https://doi.org/10.22004/ag.econ.44292>.
- [18] König S. (2013): *Coaching performance and leadership behaviours in team sports*. German Journal of Exercise and Sport Research, vol. 43(4), pp. 253–263; <https://doi.org/10.1007/s12662-013-0309-5>.
- [19] Lago-Peñas C. (2011): *Coach Mid-Season Replacement and Team Performance in Professional Soccer*. Journal of Human Kinetics, vol. 28(1), pp. 115–122; <https://doi.org/10.2478/v10078-011-0028-7>.
- [20] Moen F., Federici R.A. (2013): *Coaches' Coach Competence and Influence on Organizational Learning*. Organization Development Journal, vol. 31(2), pp. 32–46; <https://doi.org/10.5539/jel.v2n1p240>.

- [21] Pfeffer J., Davis-Blake A. (1986): *Administrative Succession and Organizational Performance: How Administrator Experience Mediates the Succession Effect*. The Academy of Management Journal, vol. 29(1), pp. 72–83; <https://doi.org/10.2307/255860>.
- [22] Paola D. (2008): *The Effects of Managerial Turnover: Evidence from Coach Dismissals in Italian Soccer Teams*. Journal of Sports Economics, vol. 13(2); <https://doi.org/10.1177/1527002511402155>.
- [23] Poulsen R. (2012): *Should He Stay or Should He Go? Estimating the Effect of Firing the Manager in Soccer*. Chance, vol. 13(2), pp. 29–32; <https://doi.org/10.1080/09332480.2000.10542204>.
- [24] Scelles N., Andreff W. (2019): *Determinants of national men's football team performance: a focus on goal difference between teams*. International Journal of Sport Management and Marketing, vol. 19(6), pp. 407–424; <https://doi.org/10.1504/ijsmm.2019.10025974>.
- [25] Semmelroth D. (2022): *Time to Say Goodbye: A Duration Analysis of the Determinants of Coach Dismissals and Quits in Major League Soccer*. Journal of Sports Economics, vol. 23(1), pp. 95–120; <https://doi.org/10.1177/15270025211034820>.
- [26] *Transfermarkt*, [www.transfermarkt.de](http://www.transfermarkt.de) [accessed: December 7, 2021].
- [27] Zambom-Ferraresi F., Rios V., Lera-López F. (2018): *Determinants of sport performance in European football: What can we learn from the data?* Decision Support Systems, vol. 114, pp. 18–28; <https://doi.org/10.1016/j.dss.2018.08.006>.