THE ANALYSIS OF CHANGES OF HANDBALL GOALKEEPERS' EFFECTIVENESS DURING THE EUROPEAN MEN'S HANDBALL CHAMPIONSHIP BETWEEN 2000 AND 2016

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Abstract:
Introduction: A goalkeeper in a handball team should be cool-headed, courageous, well prepared physically and psychologically, focused and resistant to physical pain. The success of the entire team depends on his good performance. The object of the work is a research of the change of the efficiency of handball goalkeepers during the European Men's Handball Championships held in the period between 2000 and 2016, with the use of statistical tools. **Material and methods**: The gathered material included elements of the effectiveness of handball goalkeepers such as: general defence, penalty throw saves, 6-metre throw saves and wing throw saves, and defending from interception and fast breaks. In order to determine the changes of the level of the efficiency of players in the researched period, basic statistical measures, segmental regression model and one-base indices were employed, which are a measure of the dynamics of the changes of time series. **Results:** The result of the conducted analysis is that the goalkeepers reached the highest efficiency in respect of saves of wing throws. The segmental model employed in the research was characterised by a good compatibility with the data in the case of the general efficiency of the defence and wing throw saves. The analysis of the dynamics of the change in the goalkeeping's effectiveness allowed to observe variations in calculated values of indices for researched variables corresponding to elements of said effectiveness. **Conclusions:** On the basis of the results, it was concluded that the general level of successful saves of goalkeepers decreases in the whole researched period. The high effectiveness of goalkeeping was observed for wing throws. The segmental model proved that since 2010 there has been a rise of the effectiveness of the element of saves of penalty throws and goal area throws at the expense of the effectiveness of the saves of wing throws and fast breaks.

INTRODUCTION

A goalkeeper usually plays the role of a 'conductor' of a handball team, being the last obstacle when facing an opponent on his own. The victory depends often on cool-headedness, high concentration, foresight and determination. A well-disposed goalkeeper constitutes 50% of an entire team. The success of an entire team depends on a goalkeeper's good performance [Kamiński 1990].

The traits of a good goalkeeper are: cool-headedness, courage, being well prepared physically and psychologically, the ability to focus, resistance to physical pain. He is characterised by a good knowledge of techniques and tactics of the handball. A goalkeeper must often be self-sufficient, and can only count on his own skills. A goalkeeper intervenes

without participation of his defence partners when it comes to 70% of throws made at the goal [Kamiński 1990].

The modern handball requires a great physical and mental effort, great fitness, courage and intelligence from a goal keeper. His tasks during a match are so varied and so have such an impact on the final result of the match that in order to perform them well he must possess a number of technical and tactical skills and a sufficient level of coordination capabilities. Somatic aptitudes (the height of the body, the length of the limbs etc.) and experience acquired throughout years of training and playing have a great influence on the effectiveness of a goalkeeper's performance [Spieszny et al. 2011].

Every goalkeeper, regardless of his abilities, makes an effort to foresee in any way at which part of the goal the ball is directed at the moment of a throw. Obviously making the choice depends on the existing situation at the court. As of today, we can state without a doubt that the best goalkeepers in the word are players who are older than 30. The observation and quick analysis ability, resulting from their experience, are their main asset. Every throw brings additional information. The trajectory of a thrown ball most often depends on the direction of the movement of the thrower, the alignment of the hand in relation to the ball and the presence (or lack) of defenders. The last information impacts upon blocking in the central sector when for second line throws, and in the presence and a method of intervention of a defender for wing throws, enables the goalkeeper (even forces him) to make proper decisions, which is related to an effective intervention [Nowiński 2000]. Defenders make an effort to make an intervention easier for a goalkeeper, through their individual actions or teamwork.

Creation of match statistics and their analysis is a vital tool employed by coaches of many sports, among other things to replay the course of a match, collect data on the effectiveness of players, etc. Those data may be used for optimization of the training process [Castellano et al 2012]. Among numerous research papers using match statistics as a research material subject to analysis, there are also papers concerning the handball. An analysis of the match statistics of handball players participating in the European Men's Championships and the Olympic tournament in the period between 2004 and 2010 was carried out by, among others, Bilge (2012). In another research paper [Espina-Agulló et al. 2016], the effectiveness of handball players, participating in 32 finals of the highest ranked world and European tournaments (1982-2012), was researched in relation to throws at the goal from various zones of the court. Considering the above, this research paper analyses goal statistics.

The object of the paper is an analysis of selected elements of effectiveness of handball goalkeepers during the European Men's Handball Championships held in the period between 2000 and 2016. The analysis was carried out with the use of basic statistical measures, segmental regression model and designated values of one-base indices.

MATERIAL AND METHODS

The research material includes data concerning the level of effectiveness of defences of the handball players from teams qualified to semi-final of European Men's Handball Championships held within the period from 2000 to 2016. The database used in the analysis was created thanks to databases made available by the European Handball Federation [EHF 2017]. The material includes data on the overall defence, penalty throws, 6-metre throws, wing throws and fast breaks in relation to effective goal defences in each of the elements of the play.

In the analysis of tendencies and changes of the level of effectiveness of handball goalkeepers, indices with a fixed base $i_{t/k}$ were employed (one-base indices). Fixed base indices allow us to observe the dynamics of the change of the level of the research phenomenon within a given period in relation to the level of the phenomenon in the base

period [Maszczyk 2013]. Values of one-base indices were calculated according to the equation 1.

$$i_{t/k} = \frac{y_t}{y_k}, \qquad (1)$$

where: y_t – the extent of the phenomenon in the researched period, y_k – the extent of the phenomenon in the base period (the mean level of effectiveness of defences of the goalkeepers from the European Men's Handball Championship of 2000).

A segmental regression model was employed to characterise changes in the level of effectiveness of goalkeepers in the researched period. It is a model employed in non-linear estimation, which is used when a linear model fails to sufficiently reflect correlations between variables. In a segmental regression, an independent variable is divided into segments, and then in each designated segment a linear model is adjusted for a dependent variable [Biecek 2014; Ryan, Porth 2007; StatSoft 2006].

A segmental regression model is for example used in a paper of Dziadek (2016) to characterise changes of final results reached by the best decathlonists from Poland and the world competing in the period between 1985 and 2015.

Statistica 12 software and the R programming language with additional packages were used for the analysis of the data [StatSoft 2014; R Core Team 2016].
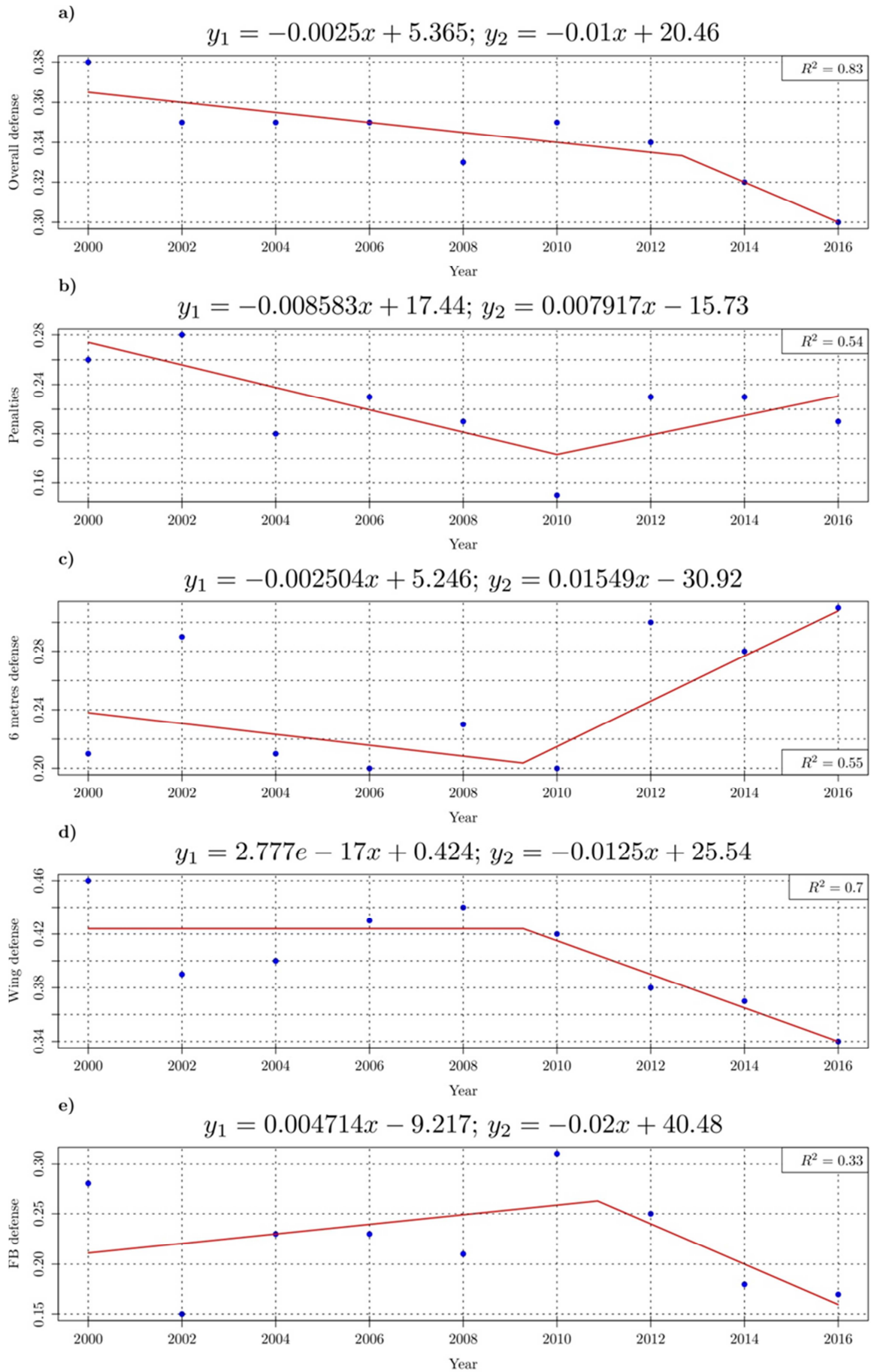
RESULTS

The gathered research material was subjected to a basic statistical analysis where mean values and standard deviations were designated for particular elements of the effectiveness of the defence. The results are presented in table 1.

Tab. 1: The basic descriptive statistics regarding the effectiveness of defences of handball goalkeepers during the European Men's Handball Championships within the period from 2000 to 2016.

| Year of the European Championship	Efficiency of defence [%]				
	Overall defence	Penalty shots	6-metre shots	Wing shots	Fast breaks
	$\overline{x} \pm sd$	$\overline{x} \pm sd$	$\overline{x} \pm sd$	$\overline{x} \pm sd$	$\overline{x} \pm sd$
2000	0.38±0.02	0.26±0.05	0.21±0.07	0.46±0.14	0.28±0.13
2002	0.35±0.02	0.28±0.08	0.29±0.08	0.39±0.07	0.15±0.09
2004	0.35±0.04	0.20±0.10	0.21±0.04	0.40±0.07	0.23±0.04
2006	0.35±0.04	0.23±0.09	0.20±0.07	0.43±0.07	0.23±0.07
2008	0.33±0.04	0.21±0.08	0.23±0.06	0.44±0.09	0.21±0.09
2010	0.35±0.03	0.15±0.04	0.20±0.04	0.42±0.08	0.31±0.04
2012	0.34±0.04	0.23±0.07	0.30±0.08	0.38±0.05	0.25±0.04
2014	0.32±0.02	0.23±0.08	0.28±0.10	0.37±0.07	0.18±0.06
2016	0.30±0.02	0.21±0.06	0.31±0.05	0.34±0.06	0.17±0.07
Mean	0.34±0.03	0.22±0.07	0.25±0.07	0.40±0.08	0.22±0.08

The next step of the analysis consisted in drawing up graphs presenting the mean level of the effectiveness of handball goalkeepers in the selected elements of the play with the use of a segmental regression model.

a)
$$y_1 = -0.0025x + 5.365; \quad y_2 = -0.01x + 20.46$$

b)
$$y_1 = -0.008583x + 17.44; \quad y_2 = 0.007917x - 15.73$$

c)
$$y_1 = -0.002504x + 5.246; \quad y_2 = 0.01549x - 30.92$$

d)
$$y_1 = 2.777e - 17x + 0.424; \quad y_2 = -0.0125x + 25.54$$

e)
$$y_1 = 0.004714x - 9.217; \quad y_2 = -0.02x + 40.48$$

Fig. 1: Segmental regression analysis

Figure 1 shows the mean level of the effectiveness of defences of handball goalkeepers within the period from 2000 to 2016 along with the used segmental regression model. For all researched elements of the defence of goalkeepers, two linear segments were designated, along with linear function formulas describing each of them, and values of the coefficient of determination R^2 were calculated. Comparing the measured values of the coefficient of determination R^2, it was observed that the best model match was reached for the general level of defence, which reached the level of 0.83, and for effective interventions for wing throws. The smallest match was determined for the model describing the effectiveness of defence of goalkeepers against fast breaks of the opposing team, where $R^2 = 0.33$. On the basis of figure 1(a) depicting the general effectiveness of defence of goalkeepers in the researched period, it was observed that the highest mean effectiveness of goalkeepers, i.e. 38% was in 2000. In the following years the proportion of saved goals in a match to the number of throws at the goal falls in the whole period and reaches the 30% (European Men's Handball Championship 2016). In the case of penalty throws (figure 1(b)) the highest mean effectiveness of the goalkeepers was observed in 2002 (28%), the lowest value was noted in 2010, at the level of 15%. After 2010, during European Men's Handball Championship, there is a visible increase of the effectiveness of saves of penalty throws. While researching the effectiveness of saves of throws made from the distance of the goal area (figure 1(c)), a low effectiveness of the goalkeepers was observed in years 2000, 2004, 2006 and 2010 where it was below 22%. For the other moments of the researched period, the number of successful saves in relation to throws increased and in 2016 reached 31%. While analysing the wing throws of handball players (figure 1(d)), it was observed that the effectiveness of the goalkeepers in this aspect was at the highest level in relation to the other researched elements of the effectiveness of the defence. Until 2010, the effectiveness had been at the level (0.39;0.46), and then began to fall. After an interception of the ball by the enemy, a fast break and a throw (figure 1(e)), the goalkeepers reached the highest effectiveness during the European Men's Handball Championships of 2000 and 2010, when it reached 28 and 31% respectively. The lowest effectiveness of the defence in the above-mentioned element of play, lower than 20%, was noted in 2002, 2014 and 2016.

The analysis of the dynamics of the changes of the effectiveness of the handball goalkeepers playing during European Men's Handball Championship between 2000 and 2016 was carried out with the use of one-base indices (indices with a fixed base). The values of calculated indices are presented in figure 2. The high dynamics of the changes of the level of the effectiveness of goalkeepers in relation to the adopted base period was observed for elements of defence such as penalty throws, goal area throws and fast breaks. Graphs in figure 2(a, d) were characterised by relatively low dynamics. In figure 2(a) you may notice a continuous decrease of the value of indices in relation to the base period. The largest decrease of the effectiveness was identified for 2016, when it reached 21%. During the research of the values of indices for the element of penalty throw save (figure 2(b)), decreases were identified for the level of effectiveness throughout the majority of the researched period, while in 2010 the decrease was at 42%. The only increase in the value of fixed base index was determined in 2002 and reached 8% in relation to 2000. While analysing the graph (figure 2(c)), which shows the dynamics of the changes of the effectiveness of the defence of the goal area throws, it has been pointed out that the highest values of the measures of the dynamics were reached in 2002 (growth by 38%), 2012 (43%) and 2016 (48%). In the years 2006 and 2010, there was a 5% fall of index values. The general fall of the level of the effectiveness of wing throw saves in the whole researched period was illustrated in figure 2(d). The largest fall of index values in relation to the adopted base level for the above-mentioned element of the goalkeeper's play was noted in 2016 and reached 26%.
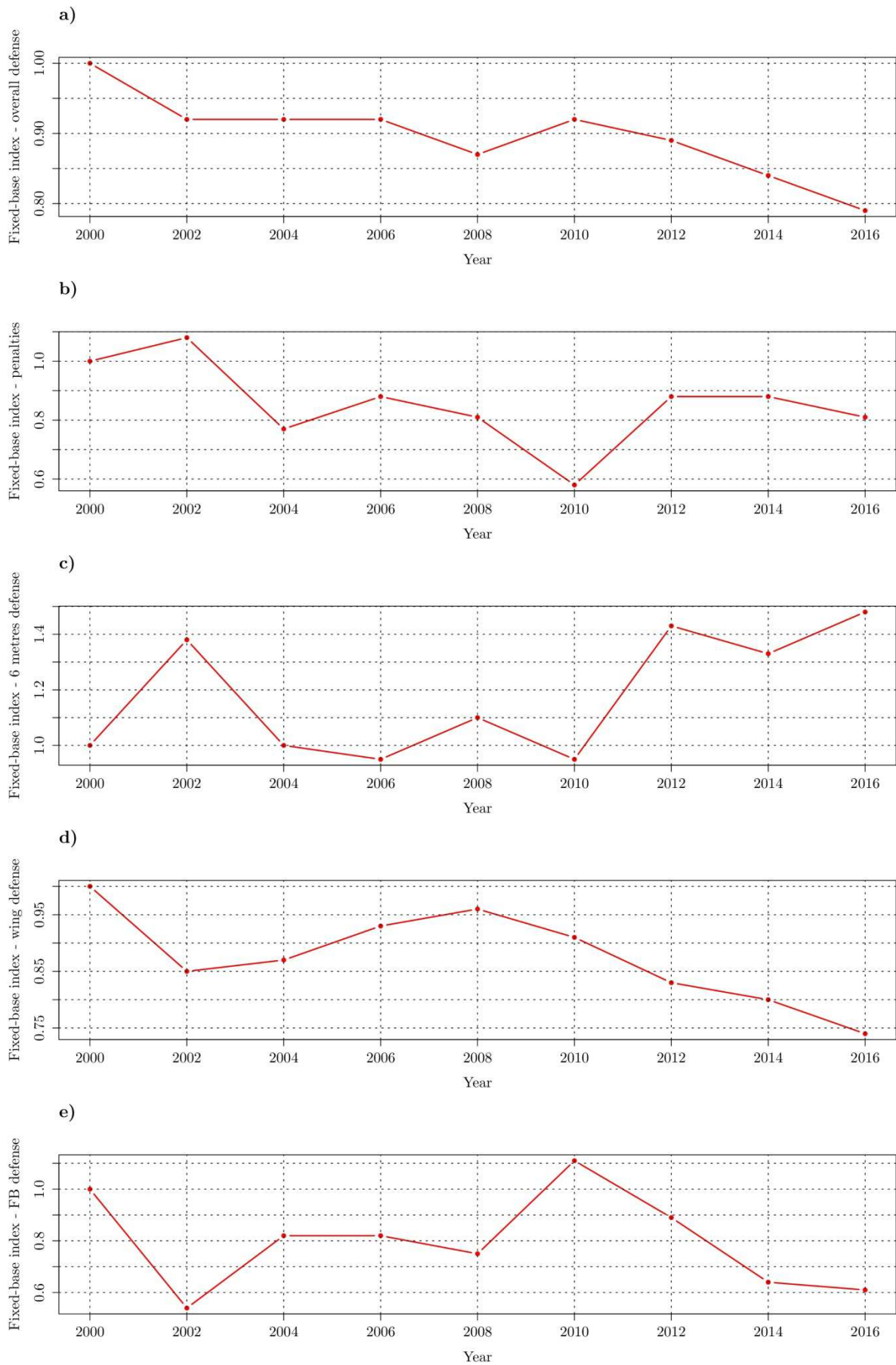
Fig. 2: Indices with a fixed base

DISCUSSION

The modern handball changed its character as regards the physical effort. The handball became a more dynamic, faster team sport. This boosts the requirements for the players of the modern handball in regards to motor, fitness, and technical-tactical preparation [Ryguła, Jarząbek 2009]. A similar situation concerns the preparation of the goalkeepers in terms of fitness and technical-tactical aspects. The basic attributes of the fitness preparation for a handball goalkeeper are: speed, agility, jumping ability, as well as divisibility of attention and anticipation of movements of an opponent shooting at a goal [Spieszny, Żak 2000; Massuca, Fragoso 2009; Bilge 2012].

We can select a player for the position of a handball goalkeeper after a long training observation. We must choose a player distinguishing himself with appropriate physical conditions, motor abilities and already acquired skills [Gorostiaga et al. 2005].

The research regarding the analysis of the effectiveness of the play of handball goalkeepers carried out by Bilge confirms the fact that higher effectiveness of the goalkeeper has an impact on the performance of the team. Additionally, in some cases goalkeepers of poorly performing teams reached very high levels of individual effectiveness. Similar correlations regarding the effectiveness of goalkeepers were observed during the analysis of match statistics of the European Men's Handball Championship held within the period of 2000-2016.

An interesting fact is that despite conducting specialist goalkeeper training regimes, the effectiveness of goalkeepers fell by few percent within the last several years. It stems from the fact that handball became a very dynamic sport and the number of throws have practically doubled [Pollany 2006].

While analysing the effectiveness of the goalkeepers' performance within the period between 2000 and 2016, the authors noticed that for years there has been a visible increase of the effectiveness of the performance of the goalkeepers in terms of penalty throws, situational throws and goal area throws (made by a pivot). Sevim et al. (2004) pointed out the same conclusions in their research. To sum up, the results of the research in this publication are close to observations of other authors regarding the analysis of the effectiveness of the performance of goalkeepers during the European Men's Handball Championship in the years 2000 to 2016.

CONCLUSIONS

The conducted analysis of the gathered research material and acquired results allowed to form the following conclusions:

- the general level of successful saves of the goalkeepers decreased throughout the researched period
- the highest mean effectiveness of goalkeeping was observed for wing throws
- since 2010, there has been a rise of the effectiveness of the element of saves of penalty throws and goal area throws at the expense of the effectiveness of saves of wing throws and fast breaks

REFERENCES

1. Biecek P. (2014) *Przewodnik po pakiecie R*. Gliwice: Oficyna wydawnicza GiS;
2. Bilge M. (2012), *Game Analysis of Olympic, World and European Championships in Men's Handball*, "Journal of Human Kinetics" vol. 35, no. 1, pp.109-118
3. Castellano J., Casamichana D., Lago C. (2012), *The Use of Match Statistics that Discriminate Between Successful and Unsuccessful Soccer Teams*, „Journal of Human Kinetics", vol. 31, pp. 139-147

4. Dziadek B., Iskra J., Przednowek K. (2016), *The development of the sports careers of the best decathletes in the world and in Poland in the years 1985-2015*, "Polish Journal of Sport and Tourism", vol. 23, no. 1, pp. 7-20
5. EHF – *European Handball Federation*, (2017), available at: http://eurohandball.com (access Sep. 2017)
6. Espina-Agulló J.J., Pérez-Turpin J.A., Jiménez-Olmedo J.M., Penichet-Tomás A., Pueo B. (2016) *Effectiveness of Male Handball Goalkeepers: A historical overview 1982-2012*, International Journal of Performance Analysis in Sport, vol. 16, pp. 143-156
7. Gorostiaga E.M., Granados C., Ibáñez I., Izquierdo M. (2005), *Differences in Physical Fitness and Throwing Velocity Among Elite and Amateur Male Handball Players*, "International Journal of Sports Medicine", vol. 26, pp. 225-232
8. Kamiński M. (1990), *Piłka ręczna*, Resortowe Centrum Metodyczno-Szkoleniowe Kultury Fizycznej i Sportu, Warszawa, pp. 52.
9. Massuca L., Fragoso I. (2009), *Success criteria to identify high potential handball athletes*. "EHF Web Periodical", available at: http://activities.eurohandball.com/web-periodicals (access Dec. 2017)
10. Maszczyk A. (2013), *Analysing and predicting the variability of the outcomes achieved by world athletes in athletics events in the years 1946-2011*, AWF Katowice, Katowice
11. Muggeo V.M.R. (2008), *Segmented: An R Package to Fit Regression Models With Broken-Line Relationships*, available at: https://www.researchgate.net (access Oct. 2017
12. Nowiński W. (2000), *Rola Trenera w nowoczesnej koncepcji gry w piłkę ręczną*, COS, pp. 64–65.
13. Pollany W. (2006), *7th Men's European Championship - trend analysis*, "EHF Web Periodical", available at: http://activities.eurohandball.com/web-periodicals (access Nov. 2017)
14. R Core Team. R. (2016) A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, available at: https://www.R-project.org
15. Ryan S.E., Porth L.S. (2007), *A Tutorial on the Piecewise Regression Approach Applied to Bedload Transport Data*, available at: https://www.fs.fed.us (access Jan. 2017)
16. Ryguła I., Jarząbek R. (2003), *Wartość diagnostyczna narzędzi analitycznych w młodzieżowej piłce ręcznej*, „Antropomotoryka", vol. 26, pp. 63-77
17. Sevim Y., Taborsky F. (2004), *EURO 2004 – Analysis 6th Men's European Championship*, "Handball Periodical For Coaches, Referees and Lecturers", vol. 2, pp. 10-27
18. Spieszny M., Tabor R., Walczyk L. (2011), *Piłka ręczna. Technika, Metodyka. Podstawy Taktyki*, AWF Kraków, pp. 107.
19. Spieszny M., Żak S. (2000), *W poszukiwaniu czynników determinujących efektywność szkolenia młodych piłkarek i piłkarzy ręcznych*. [in:] H. Sozański, K. Perkowski, D. Śledziewski (red.): *Efektywność systemów szkolenia w różnych dyscyplinach sportu*, AWF, Warszawa.
20. StatSoft, Inc. (2014) STATISTICA (oprogramowanie do analizy danych), wersja 12, available at: http://www.statsoft.pl
21. StatSoft. (2006) *Elektroniczny Podręcznik Statystyki PL,* available at: http://www.statsoft.pl (access Mar. 2016)