Journal of Physical Education and Sport ® (JPES), Vol 19 (Supplement issue 2), Art 62, pp 420 - 426, 2019
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Changes in disjunctive reaction time of soccer goalkeepers in selected training load zones

MARCO OBETKO[1], MATEJ BABIC[2], PAVOL PERÁČEK[3]
[1,2,3]Department of Sports Games, Faculty of Physical Education and Sports, Comenius University in Bratislava, SLOVAKIA

Published online:Februry 28, 2019
(Accepted for publication January 30, 2019)
DOI:10.7752/jpes.2019.s2062

Abstract
In our research, we tried to find out if there are changes in the disjunctive reaction time in selected training load zones of soccer goalkeepers. We expanded our knowledge of the training load and its influence on the disjunctive reaction speed, which is one of the limiting factors of the individual game performance of goalkeepers. There was an assumption of changes in the disjunctive reaction time of goalkeepers from different age categories in the selected training load zones. The research group was formed by eight elite soccer goalkeepers (n = 8) from U15, U16, U17 and U19 categories. The disjunctive reaction time was evaluated by means of the FiTRO Agility Check test that provided us with the values of the disjunctive reaction time of every goalkeeper involved. The POLAR heart rate monitor was used to evaluate the heart rate and the loading zones of goalkeepers were determined using a program called POLAR Team2. Subsequently, the obtained data were evaluated by using the Wilcoxon Signed-Rank Test and Cohen´s „r“ (effect size). We found out a statistically significant relationship between the value of the disjunctive reaction time by the observed goalkeepers in the calm zone (50-59 % HR_{max}) and in the 90-100 % HR_{max} zone.
Key Words: soccer, goalkeeper, disjunctive reaction time, training load zones

Introduction

The reaction speed shows itself by the means of the reaction time and belongs to the category of physical abilities which are genetically conditioned. It means that training has not a great influence on them. This statement is also emphasized by Goméz-López et al. (2017) who found out that the relative age has an impact on the noticeable and considerable differences between two sportsmen born in the same calendar year. According to the stimuli number we can divide the reaction time into two main groups:

- simple reaction time – response only to one stimulus,
- complex/disjunctive reaction time – a choice response, different responses to multiple stimuli.

The peripheral part of the visual system functions as a receiver of the electromagnetic wave from visible light. The perception and processing of the visual stimuli are one of the major functions of the human nervous system (Skyba et al. 2017). Response to a certain stimulus is expressed by the summation of its receiving and processing time, the evaluation of the right solution and the time that one need to make a certain move (Kozina et al. 2017). The minimum time that the retina in the back of human eye needs to receive an information and transform it through synapses (gaps between neurones whose overcoming requires several miliseconds) into the primary visual cortex in the back of the brain and then the brain to send this message to the spinal cord that will set in motion the muscels, is 200 miliseconds. At a speed of 160 km/h of baseball pitchs and 210 kilometers of tennis serves it is too slow. A typical pitch travels about three metres in just 75 miliseconds, which is the time that the retina needs just to confirm that a ball is in her visual field. The entire flight of the baseball ball takes just 400 miliseconds (Adair 2002; Land & McLeod 2000).

Accordingly, one can say that the reaction time is an important part of individual game performance, not only in other sports games but also in the soccer. This issue is discussed in the studies of Junge et al. (2000), Senel & Eroglu (2006), Zemková et al. (2005), Foroghipour et al. (2013), Horníková & Doležajová (2018) or Horníková, Doležajová & Zemková (2018).

Sports games have a positive and significant impact on the level of simple and disjunctive reaction time. This claim was bore out by Ando et al. (2001) who studied in their work the speed of disjunctive reaction time on the visual stimulus in the central and temporal area of visual field. They found out that soccer players, who had been tested, had in the contrast to the ordinary people a shorter disjunctive reaction time in the central and also peripheral area. This statement is also supported by Foroghipour et al. (2013) They measured the simple and disjunctive reaction time of people who don´t do any sport. After focused the experimental programme

Corresponding Author: MATEJ BABIC, E-mail: matej.babic@uniba.sk

on volleyball and it was discovered that volleyball training had a significant effect on shortening of the reaction time of those people who were tested.

Senel & Eroglu (2006) did not find any significant relationship between the reaction speed and running speed when observing the multiple sample of elite Turkish soccer players (n = 104). But they found out that there is a significant difference in reaction time length to the acoustic and visual stimulus. Players´ response to the acoustic stimulus was significantly shorter.

During the ontogeny is the disjunctive reaction time changing. It is shortening with age. Brychta et al. (2012) tried to confirm this knowledge in their study. They found statistically significant shortening of disjunctive reaction time in boys between the ages of 10 and 15. Disjunctive reaction time was getting shorter with higher age.

Soccer is an intermittent sport characterised by large amounts of low-intensity activities which are interspersed with short distances and performed with a submaximal or even maximal intensity (Sonderegger et al. 2016). Many analyses focusing on amount and intensity of the players´ physical load during match or training employed mostly various locomotor activities such as walking, trotting, sprinting or running. Not many authors dealt with the quantification of acceleration and deceleration of locomotor actions, which are characteristic for soccer. That´s why many of these works overlooked the large number of distances overcome with maximal intensity as the acceleration of motion has very short duration and no one noticed it. However, there has been tendency to put emphasis on observation of the acceleration and deceleration lately. The main approach is to be able to quantify player´s physical load in intermittent sports such as soccer more precise and realistic and therefore improve game analyses.

Sonderegger et al. (2016) defined the acceleration as very short distance performed with maximal intensity, even in the case that the player is walking or trotting. They claim that observation of acceleration within the game analysis is significantly important, because acceleration requires high physical demands and therefore is a not negligible part of game requirements for bio-energetic ensuring of player´s game performance.

Bio-motor skills are the basis of an individual player´s ability to give a performance. Kanniyan et al. (2012) state that among these bio-motor skills are strength, endurance, speed, flexibility and coordination. Furthermore, they claim that soccer player´s physical condition cannot be determined by only one of these parameters. Soccer makes high demands on the players within their physical, mental and psychological abilities. According to them is an involvement of bio-energetic systems in individual soccer game performance determined by two fundamental factors:

1. proportionality of particular bio-energetic systems on game performance in terms of the specificity of a given sport,
2. level of improvement of individual skills according to the amount of participation in a particular game performance in a given sport.

In comparison with the functions of other soccer players in a match, uses a goalkeeper completely different movement patterns. However, there are such game situations during a match when goalkeepers´ intensity is changing from maximal to submaximal with different changes of movement directions in a short period of time when they are performing specific motor activities characteristic for a goalkeeper (Rebelo-Goncalves et al. 2016).

This claim is confirmed by Di Salvo et al. (2008) who analysed the movement of goalkeepers in the English Premier League. They did not find any statistically significant differences in distances covered between the first and second half, while the average total volume of external load was ranging from 5 to 6.2 km. It has been concluded that goalkeepers covered distance in range from 30 to 90 meters at high intensity during match-play and ran at maximal intensity on average distance about 10 meter per match-play. The average number of game performances, in which the goalkeeper used submaximal or maximal intensity was in the range from 5 to 16 of game situations per match, with the total volume at interval from 0 to 40 metres. The submaximal and maximal intensity load comprised only 2 % of total load volume. Although, he adds that those 2 % at high intensity could have such a high impact on the final result of the match. Babic, Holienka a Mikulič (2018) agree with the claim that in external load there are short, high-speed actions at high intensity too.

Some of the most significant and specific goalkeeper´s motor activities are according to the Rebelo-Goncalves et al. (2016) the diving saves and jumps. In their study they refer to the study of Suzuki et al. (2011) who claims that the most talented or more experienced goalkeepers can performance the diving save faster than less experienced goalkeepers.

Pažítka (2017) find out in his study that a goalkeeper performs in a match about 11 defensive game activities of an individual. The diving saves represent on average from 3 to 5 actions per match. Holienka, Babic & Smoleňák (2017) also analysed two goalkeepers in the European Championship 2016. They found out that catching and batting of shots represented 57 % within defensive game activities by the first goalkeeper and by the second it was even 63 % during all observed matches. On these given examples we show that this movement specific for goalkeepers (catching of ball in diving or its batting) is noticeably and quite often included within the individual game performance.

Knopp et al. (2013) characterise goalkeeper´s actions in the defensive game phase, especially when the goalkeeper has to choose proper defensive game activity (dealing with shots of opponent and 1vs1 game situation) as typically explosive, short term and technically demanding. In the context of the soccer goalkeeper´s movements, they are also highlighting "agility" as one of the major motor skills of a modern goalkeeper. Shepard & Young (2006) had already characterized "agility" as a rapid movement of whole-body with change of speed and direction in response to a stimulus or new game situation. According to Knopp et al. (2013) one have to take into account the quality of power abilities, ability to react quickly and the specific neuromuscular processes that take place in goalkeeper´s organism during individual game performance either in training or match-play. The ability of a goalkeeper to react quickly and change his action on the basis of game situation is considered also by Lamas et al. (2018) to be necessary. There are many different points of view and possibilities how to solve a game situation. It is very complicated to make the right decision and that´s why they highlight goalkeepers´ ability to react quickly to new game situations and the opponent´s activity and to adapt their next action to it.

Another reaction to the new game situation is also an efficiency of action implementation. Yang et al. (2017) dealt with this issue in their research and found out that a goalkeeper can react more efficiently if he is able to get the core of body to the flight path of a shot.

Material & Methods

The aim of this research was to find changes in disjunctive reaction time of soccer goalkeepers in the calm zone 1 (50-59 %) and in selected training load zones.

Research hypotheses:

We assume significant changes in the disjunctive reaction time of goalkeepers in selected training load zones. We assume that the disjunctive reaction time of goalkeepers will be significantly shorter in the calm zone (zone 1) than in the zone 5 (90-100 % HR_{max}).

We assume that the disjunctive reaction time of goalkeepers will be significantly shorter in the calm zone (zone 1) than in zone 4 (80-89 % HR_{max}). We assume that the disjunctive reaction time of goalkeepers will not be significantly shorter in the calm zone (zone 1) than in the zone 3 (70-79 % HR_{max}).

Research tasks:

1. Determination of the goalkeeper´s disjunctive reaction time in the calm zone and in selected load zones by means of the FiTRO Agility Check device for measurement of disjunctive reaction time.
2. Evaluation and comparison of changes in the goalkeeper´s disjunctive reaction time on the basis of the measurement results.

The research group consisted of eight elite youth goalkeepers. These goalkeepers are members of soccer academy teams, whose teams play in the highest youth soccer competitions. During the research was the average age of this group about 16.7 ±1.7 year. Goalkeepers in a training microcycle participate during the main period in 5 or 6 trainings.

The main method used to get the research data was measurement of the disjunctive reaction time using the FiTRO Agility Check device.

The heart rate (HR) was measured with POLAR sport-testers and by Polar Team^2 program.

The maximal heart rate of goalkeepers was measured with the test created by Hipp (2007). It is repeating of certain running distances until the runner switches from the basic slow trotting to the running at highest speed and then to the running at individual maximal intensity.

This test consists of:

The field width run

- run at a low intensity (a short run to warm up) – 6 times,
- run at a moderate intensity – 6 times,
- run at a submaximal intensity – 6 times,
- run at a maximal (subjective) intensity – once.

Table 1 Basic data and training load zones of the observed goalkeepers

Goalkeeper	**D.T.**	**P. U.**	**M. M.**	**I. R.**	**J. S.**	**D. K.**	**D. Ž.**	**A. M.**
Age	19.2	18.8	17.2	16.9	16.2	16.1	14.7	14.2
Height [m]	1.95	1.98	1.85	1.82	1.82	1.79	1.73	1.73
Weight [kg]	85	96	84	74	73	70	65	57
HR_{max} [beats.min^{-1}]	198	198	199	200	200	200	206	206
90-100 % HR_{max}	178-198	178-198	178-199	180-200	180-200	180-200	185-206	185-206
80-89 % HR_{max}	158-177	158-177	158-177	160-179	160-179	160-179	165-184	165-184
70-79 % HR_{max}	139-157	139-157	139-157	140-159	140-159	140-159	144-164	144-164
60-69 % HR_{max}	119-138	119-138	119-138	120-139	120-139	120-139	124-143	124-143
50-59 % HR_{max}	99-118	99-118	99-118	100-119	100-119	100-119	103-123	103-123

We used the POLAR Team PRO program to process and evaluate the gained data.

The Wilcoxon Signed-Rank Test was used to evaluate the statistical significance. Afterwards we found out the value of Cohen´s "r" (effect size). The selected level of statistical significance was $p < 0.05$.

RESULTS

The measured values of goalkeepers´ disjunctive reaction time in selected training load zones are stated in the table No.2 below.

Table 2 Values of goalkeepers´ disjunctive reaction time in the training load zones

	Calm zone (50-59 % HR_{max})		**70-79 % HR_{max}**		**80-89 % HR_{max}**		**90-100 % HR_{max}**	
	time [ms]	**%HR_{max}**	**time** [ms]	**%HR_{max}**	**time** [ms]	**%HR_{max}**	**time** [ms]	**%HR_{max}**
D. T.	1201	55 %	1169	74 %	1376	86 %	1265	91 %
P. U.	1210	53 %	1180	75%	1671	81 %	1284	91 %
M. M.	1272	54 %	1275	75 %	1290	82 %	1294	92 %
I. R.	1129	55 %	1153	75 %	1092	85 %	1106	92 %
J. S.	1255	55 %	1280	73 %	1330	84 %	1295	91 %
D. K.	1086	53 %	1170	72 %	1280	84 %	1218	92 %
D. Ž.	1419	55 %	1447	76 %	1634	85 %	1759	91 %
A. M.	1415	54 %	1286	76 %	1327	83 %	1494	91 %
M	1249	54.3 %	1245	74.5 %	1375	83.8 %	1313	91.4 %
s	113	0.8 %	93	1.3 %	179	1.6 %	177	0.5 %

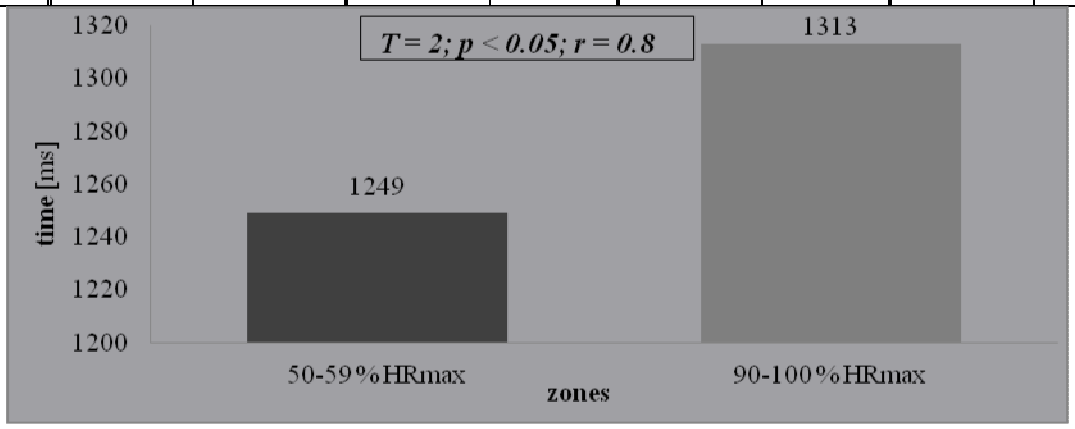

Fig. 1 Average reaction time of goalkeepers in the calm zone and 90-100 % HR_{max} zone

We compared and studied changes in the disjunctive reaction time of goalkeepers in selected training load zones. In comparison to the calm zone we noticed a statistically and significantly worse reaction time ($T = 2$; $p < 0.05$; $r = 0.8$) in the 90-100 % HR_{max} zone.

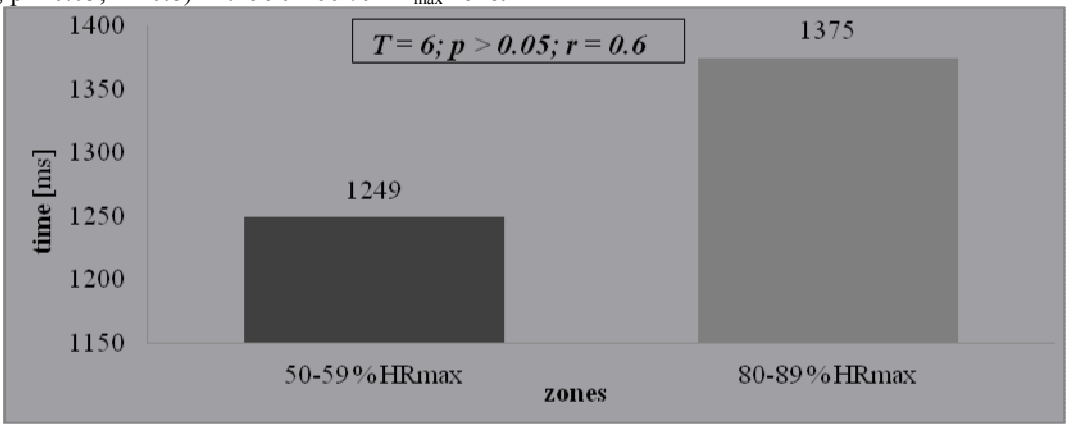

Fig. 2 Average reaction time of goalkeepers in the calm zone and 80-89 % HR_{max} zone

Compared to the calm zone we did not find any significant changes in the goalkeepers´ disjunctive reaction time ($T = 6$; $p > 0.05$; $r = 0.6$) at the 5 % level, however a critical value for $T_W(8) = 5$ means almost significant changes with a great effect (Cohen´s „r").

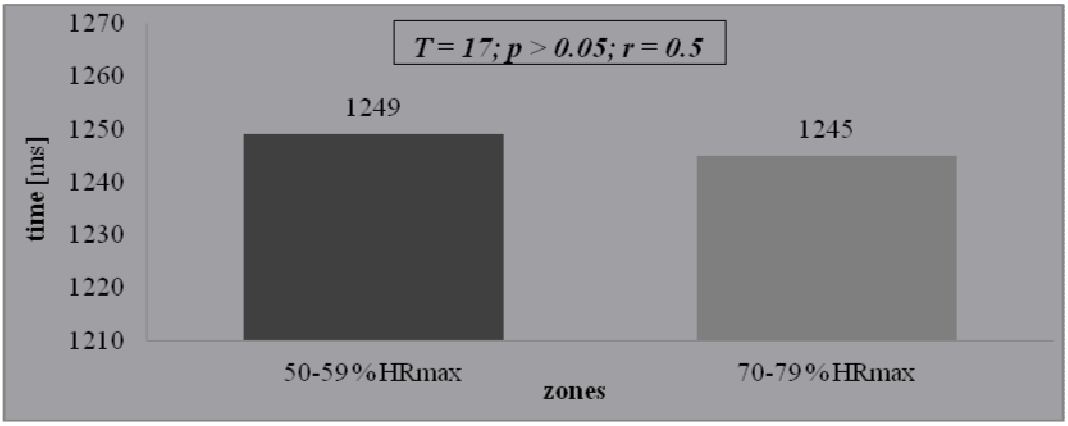

Fig. 3 Average reaction time of goalkeepers in the calm zone and 70-79 % HR_{max} zone

In comparison with the calm zone (T = 17; p > 0.05; r= 0.1) we did not find any statistically significant changes in the 70-79 % HR_{max} zone neither.

Discussion

The basis of a successful solving of game situation is to make right and quick decisions. Goalkeeper is during the match in the maximal loading zone (90-100 % HR_{max}) just minimally. According to Di Salvo et al. (2008) it is only 2 % of the game time. Such a game action lasts on the average no more than 5 seconds. However, these situations, which are called also critical game situations, can have a considerable impact on the final result of the match. Peráček et al. (2017) state that current soccer trends– training load intensification of players in a match – do not indicate only external load of player in a match, but especially there is a demand on goalkeepers to react quickly to more frequently changing game situations. Starkes (1987) proved that tests of simple reaction time as a selected criterion are not a good determinative factor in deciding who will be the best goalkeepers or forwards. According to her research the simple reaction time may not be a precondition for anything. When she was testing women field hockey players, she got the same result as by volleyball women players. Elite field hockey players were able to determine whether the ball was in their visual field or not faster than you can blink. They managed to exactly reconstruct the game situation on the field, even after just a momentary glimpse. This can be applied to all sports games. The question is how important these capabilities are for the elite sportsmen and whether it has something to do with genes or not. (Starkes & Deakin 1984; Starkes 1987; Abemethy et al. 2008; Mann et al. 2010).

We succeeded in confirmation of the first hypothesis at the 5 % level of statistical significance. On average, the reaction speed got worse by 64 ms, however the reaction time of goalkeeper I. R. wasn´t worse than in the calm zone. It can be caused by the fact that he is a left-hander. Al Awamleh et al. (2013) found that sportsmen who are left-handers have an advantage over the right-handers. The observed sample consisting of handball women players preferred to use their left hand. The research showed that they had a shorter reaction time than the players who preferred to use their right hand.

There occurred a worsening in disjunctive reaction time when they compared the calm zone with the 80-89 % HR_{max} zone. However, this change was not statistically significant. The second hypothesis was thus not confirmed. There were some individuals among the goalkeepers who managed to have a better time in this load zone than in the calm zone, as their level of training experience and ability of the organism to cope with the load is slightly higher than that of the other observed goalkeepers. Although, it is a one-off phenomenon and we think that with increasing of the group it would be possible for us to confirm this hypothesis too.

When comparing the calm zone and the 70-79 % HR_{max} zone, we achieved our goal and confirmed the last hypothesis. It means that there was no statistically significant worsening of the disjunctive reaction time in this zone, when compared to the calm zone. However, the results of the comparison of these two zones are interesting, but on the other hand not statistically significant. The average value of the disjunctive reaction time was in the 70-79 % HRmax zone shorter than in the calm zone. It is probably because the load in this zone functions as some kind of warm-up (at appropriate intensity), which (if it is appropriately chosen in the terms of length and complexity) is shortening also the disjunctive reaction time. Adapting the visual function of the player to the load is showing itself by the balance of extraocular muscles, improvement of vision in the dark, improvement of the visual motor reaction, as well as widening of the visual field.

Conclusions

This research showed that in terms of ontogeny is the disjunctive reaction time shortening (according to the disjunctive reaction time results of our research group composed of young junior and youth players). Ability to react quickly and right, and be able to decide properly under pressure (movement discomfort) is for a goalkeeper very important. It is important especially in critical game situations which can influence,

or more precisely will influence the course of the match. Disjunctive reaction time is an appropriate criterion for selecting talented soccer goalkeepers.

Acknowledgements

This study is part of research VEGA 2/0154/19: Subliminal brain concussions as a risk factor for chronic traumatic encephalopathy.

References

Al Awamleh, A.A., et al. (2013). Handedness differences in eye-hand coordination and, Choices, simple reaction time of international handball players. *Journal of Physical Education and Sport*, *13*(1), 78-81. ISSN 2247–8051.

Abernethy, B., et al. (2008). Expertise and attunement to kinematic constraints. *Perception, 37*(6), 931-948. ISSN 1468-4233.

Adair, R.K. (2002) The physics of baseball. 3rd edition. New York, NY: Harper Perennial. ISBN 978-00-60-08436-3.

Ando, S., et al. (2001). Central and peripheral visual reaction time of soccer players and nonathletes. *Perceptual and Motor Skills*, *92*(3), 786-794. ISSN 0031-5125.

Babic, M., Holienka, M., & Mikulič, M. (2018). Internal load of soccer goalkeepers during the improvement of selected game activities. *Journal of Physical Education and Sport*, *18*(3), 1731-1737. ISSN 2247-8051.

Brychta, P., et al. (2012). Disjunktivní reakční rychlost dolních končetin u chlapců staršího školního věku. [Multi-choice reaction speed of the lower limbs of older school-aged boy]. *Česká Kinantropologie, 16*(4), 103-110. ISSN 1211-9261.

Di Salvo, V., et al. (2008). Activity profile of elite goalkeepers during football match-play. *Journal of Sports Medicine and Physical Fitness*, *48*(4), 443-446. ISSN 0022-4707.

Foroghipour, H., et al. (2013). Comparison of simple and choice reaction time in tennis and volleyball players. *International Journal of Sport Studies, 3*(1), 74-79. ISSN 2251-7502.

Gómez-López, M., et al. (2017). Relative age effect in handball players of Spain. *Journal of Physical Education and Sport*, *17*(2), 705-711. ISSN 2247-8051.

Hipp, M. (2007). *Futbal: Rozvoj vybraných pohybových schopností, diagnostika a strečing v družstve vrcholového futbalu*. Bratislava: SPN. ISBN 978–80-10–01146-9.

Holienka, M., Babic, M., & Smoleňák, S. (2017). Hodnotenie herného výkonu brankárov v zápasoch ME 2016 vo futbale. [Assessment performance goalkeepers in football matches on the EURO 2016]. *Žiak, pohyb, edukácia. Vedecký zborník 2017*. Bratislava: Univerzita Komenského, pp. 81-93. ISBN 978-80-223-4370-1.

Horníková, H., & Doležajová, L. (2018). Vplyv veku na úroveň vybraných koordinačných schopností stolných tenistov. [Effect of age on the level of selected coordination abilities of table tennis players]. *Studia Sportiva, 12*(2), 212-219. ISSN 1802-7679.

Horníková, H., Doležajová, L., & Zemková, E. (2018). Playing table tennis contributes to better agility performance in middle-aged and older subjects. *Acta Gymnica*, *48*(1), 15-20. ISSN 2336-4912.

Junge, A., et al. (2000). Psychological and sport-specific characteristics of football players. *American Journal of Sports Medicine*, *28*(5), 22-28. ISSN 0363-5465.

Kanniyan, A., et al. (2012). The detraining and training effects of different training programs on selected bio-motor abilities of college level football players. *Journal of Physical Education and Sport*, *12*(4), 531-534. ISSN 2247–8051.

Knoop, M., et al. (2013). Evaluation of a specific reaction and action speed test for the soccer goalkeeper. *Journal of Strength and Conditioning Research*, *27*(8), 2141-2148. ISSN 1064-8011.

Kozina, Z., et al. (2017). Comparative characteristics of psychophysiological indicators in the representatives of cyclic and game sports. *Journal of Physical Education and Sport*, *17*(2), 648-655. ISSN 2247-8051.

Lamas, L., et al. (2018). Analytic method for evaluating players' decisions in team sports: Applications to the soccer goalkeeper. *PloS ONE, 13*(2), [1-18]. ISSN 1932-6203.

Land, M.F., & McLeod, P. (2000). From eye movements to actions: How batsmen hit the ball. *Nature Neuroscience*, *3*(12), 340-345. ISSN 1546-1726.

Mann, D.L., et al. (2010). An event-related visual occlusion method for examining anticipatory skill in natural interceptive tasks. *Behavior Research Methods*, *42*(2), 556-562. ISSN 1554-351X.

Pažítka, T. (2017). *Individuálny herný výkon brankára vo vybraných zápasoch Ligy Majstrov vo futbale.*[Individual game performance goalkeeper in selected matches Champions League footbal]. Bratislava. Bachelor thesis. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Sports Games.

Peráček, P., et al. (2017). Selected indicators of an individual game performance of goalkeeper at the European Championship among the 17-year-old elite soccer players. *Journal of Physical Education and Sport*, *17*(1), 188-193. ISSN 2247-8051.

Rebelo-Goncalves, R., et al. (2016). Assessment of technical skills in young soccer goalkeepers: Reliability and validity of two goalkeeper-specific tests. *Journal of Sports Science and Medicine*, *15*(3), 516-523. ISSN 1303-2968.

Senel, Ö., & Eroglu, H. (2006). Correlation between reaction time and speed in elite soccer players. *Journal of Exercise Science and Fitness*, *4*(2), 126-130. 1728-869X.

Sheppard, J.M., & Young, W.B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences*, *24*(9), 919-932. ISSN 0264-0414.

Skyba, O., et al. (2017). Vegetative status of sportsmen depending on the level of their sensimotor reaction. *Journal of Physical Education and Sport*, *17*(2), 748-752. ISSN 2247-8051.

Sonderegger, K., et al. (2016). The challenge of evaluating the intensity of short actions in soccer: A new methodological approach using percentage acceleration. *PloS ONE*, *11*(11), [1-10]. ISSN 1932-6203.

Starkes, J.L., & Deakin, J. (1984). Perception in sport: A cognitive approach to skilled performance. In W.F. Straub & J.M. Williams (Eds)*, Cognitive Sports Psychology* (pp. 115-128). Lansing, NY: Sports Science Associates.

Starkes, J.L. (1987). Skill in field hockey: The nature of the cognitive advantage. *Journal of Sport Psychology*, *9*(2), 146-160. ISSN 2152-0704.

Suzuki, S., et al. (2011). Analysis of the goalkeeper's diving motion. In T. Reilly et al. (Eds.), *Science and Football: Proceedings of the First World Congress of Science and Football Liverpool*, *13-17th April 1987* (pp. 468-475). New York, NY: Routledge. ISBN 978-04-155-0911-4.

Yang, J., et al. (2017). Goalkeeper's position for defending short range shots. *International Journal of Sports Science and Coaching*, *12*(5), 603-610. ISSN 1747-9541.

Zemková, E., et al. (2005). Test agility v diagnostike disjunktívnych reakčno-rýchlostných schopností dolných končatín u basketbalistov. *Zborník vedeckých prác Katedry hier FTVŠ UK* č. 3. Bratislava: Peter Mačura – PEEM, pp. 152-156. ISBN 80-89197-30-2.