



Cognitive functions of female open skill sport athletes, closed skill sport athletes and nonathletes

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Abstract

Introduction. The cognitive functions usable in the sports performance are for example an ability to anticipate, perception and speed of movement reactions, decision-making ability or attention. These abilities or functions apply differently to different sports. It means that open skill sports such as team sports, require the coordination of complex bodily movements and adaptation to continually changing task demands. The aim of this study is to identify differences in the level of female's cognitive functions regarding the chosen open skill sports and closed skill sport disciplines. **Material and Methods.** The research group consisted of 84 women aged 22.70 ± 1.71 years. Women were divided into three groups in terms of sport discipline into: female engaged in closed skill sport disciplines ($n=26$), in open skill sport disciplines ($n=19$) and not engaged in any sport activity ($n=39$). We used standardized S-test to determine the level of cognitive functions. It is a test of spatial orientation and concentration of attention with accentuated demands on the pace of activity. **Results.** The results have shown that female engaged in open skill sport disciplines have shown higher level of cognitive functions than female engaged in closed skill sport disciplines ($p=0.04$) and also as nonathletes ($p=0.02$). There was no difference in cognitive function between female engaged in closed skill sport disciplines and nonathletes. **Conclusions.** Our results confirm the theory of different involvement of cognitive functions from the point of view of different types of sport disciplines.

Keywords: concentration of attention, spatial orientation, individual sport disciplines, team sport disciplines

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INTRODUCTION

From a cognitive-psychological perspective, physical exercise and sports are an interesting tool for improving people's cognitive abilities [1]. Cognitive functions are defined as a person's ability to participate in, recognize and plan responses to both external and internal stimuli. They also include executive functions, which mean the ability to plan and schedule an activity, focus on task-related information, and perform multiple activities simultaneously. Core executive functions include inhibition response and interference control, working memory and cognitive flexibility [2-4].

The basic cognitive functions that research in sport area focuses on include mostly attention and its selected functional attributes (such as intentionality, selectivity, concentration), memory and cognitive pace (speed of stimulus processing, speed of response) [5]. Currently, several benefits of sport activity in relation to cognitive functions are known. It can stop decreasing the level of cognitive functions or improve them, because physical exercise is a protective factor for neurodegeneration [6]. Also, physical activity can be an appropriate tool for improving cognitive and executive functions [7]. We may categorize sports into two types – open skill and closed skill sports [8]. In open skill sport disciplines athletes are required to react in a dynamically changing, unpredictable and externally-paced environment (e.g., basketball, tennis, football and etc). Those sport disciplines may develop some cognitive function, specifically visual attention, decision making or action execution. On the other hand, closed skill sport disciplines are relatively highly consistent, predictable, and self-paced for athletes (e.g., running, swimming) [9-11].

The role of aerobic sport activities (such as cycling, swimming, running or some other sport disciplines like this) in area of improving cognitive function is also often discussed. For example, according to authors [8], aerobic exercise training is related with higher level of some cognitive function as well, namely it is associated with modest improvements in attention, processing speed and executive function. Also, many cross-sectional and longitudinal intervention studies have shown a relationship between a sports activity and cognitive functions [13-15].

Due to this mentioned diversity of open skill sports and closed skill sports in the area of cognitive functions, we can assume, that they set different demands on the involvement of cognitive functions. Some team sports (e.g. volleyball, basketball or football) may be considered as an open skill sport. The reason why is that playing well in these kinds of sport disciplines means choosing the right course of action at the right moment and performing that course of action efficiently and consistently throughout the match. Due to continuously changing conditions, goal-directed behaviours need to be repeatedly adjusted and corrected. So executive functions are crucial for the athletes' success. One of the most important executive functions is the ability to continuously switch between two different tasks being required in a random sequence. Those abilities are even more essential in open skill sport disciplines [16-19].

In team sport games, anticipation, perception and the decision to solve the game situation as well as the number of hours devoted to specific sport disciplines exercises in childhood are a strong predictor of success [20,21]. That is why those sports are defined as an open skill sport disciplines. This finding is also confirmed by the fact that perceptual abilities improvement is based on experience [22] and perceptual-cognitive training approach may be useful as an integral component of athletic training [23]. This implies that, this ability can be trainable under the appropriate conditions and situations. Moreover, this finding was confirmed by research [24] also, which showed that elite athletes have higher level of cognitive performance than sub-elite athletes or novice manifested in sport specific situations.

Similarly, according to the study of Heppe et al [25], elite athletes engaged in different team sports performed better in sustained attention tests, compared to recreational athletes. Those findings point to the fact that the level of sport activity is also an important aspect in the cognitive function area.

In this context, we can see wide potential of physical activity in area of cognitive functions – namely it may support cognitive functions of children, adults as well as individuals with disabilities [26]. Except the field of sport activity, the processes of attentional control and executive function are critical for operating efficiently in everyday life as well. Deficits in these core processes have serious consequences [27].

Considering the benefits of team sport disciplines in the field of cognitive function, we assume that athletes engaging in those sport disciplines demonstrate an elevated level of monitored cognitive function in compare to individual sport athletes and nonathletes as well. At the same, with respect to the benefits of sport activity in general, we assume that athletes engaging in individual sport disciplines demonstrate an increased level of monitored cognitive function in compare to nonathletes.

MATERIAL AND METHODS

Participants

Ensuring a research sample of young women engaged in open skill sport and closed skill sport disciplines was crucial for meeting the goal of our study. Thus, our research sample consist of 84 woman in age 22.70 ± 1.71 years. This group was divided into three subgroups in terms of sport activity, respectively in terms of sport disciplines. The first group consisted of women engaged in closed skill sport disciplines ($n=26$). In this research, closed skill sports are represented by individual sport disciplines, specifically swimming, running and cycling. The second group consisted of women engaged in open skill sport disciplines ($n=19$). These disciplines are open skill sport disciplines, specifically basketball, football a volleyball. The basic criterion for the inclusion of the participants in the group of athletes was the condition of carrying out sports activities at least three times a week, continuously during at least the last year. The third group consisted of women not engaged in any sport activity ($n=39$).

Measures

To determine the level of cognitive functions we used standardized S-test – recognition of segments [26]. This test is a test of spatial orientation with accentuated demands on the pace of activity in the “pen-paper” form. There are four unambiguous, complete figures in the template, while each of them consists of two different intersecting lines – parallel lines. The test section contains of 300 incomplete figures based on four original figures. The task of the respondent is to determine that complete figure, on which is every incomplete figure based.

Procedures

Data were collected from May 2019 to September 2019. The questionnaire (cognitive test) was distributed in paper form. All of the respondents were informed ahead of time of the purpose of the research finding and assured of their anonymity and any questions were answered directly before their participation in the research. The authors of this study participated in collecting the data and all were instructed in the proper manner of doing so. None of the respondents had experienced this cognitive task before. This study was approved in advance by the Ethics Committee of the Faculty of Physical Education and Sport, Comenius University (No. of decision 10/2019).

Statistics

The statistical analysis was carried out through the IBM SPSS statistical program (Version 23 for Windows, IBM). The Shapiro-Wilk test was used for testing data normality. We used the nonparametric Kruskal-Wallis test followed by post hoc test Mann-Whitney U-test to identify differences between the two independent research samples. We reviewed statistical significance level at $p < 0.05$. To calculate effect size we used the coefficient r ($r \geq 0.9$ – very strong relation; $r = 0.7 - 0.9$ – strong relation; $r = 0.5 - 0.7$ – medium strong relation; $r = 0.3 - 0.5$ – weak relation; $r \leq 0.3$ – very weak relation) [27].

RESULTS

Our results showed a significant differences between all monitored groups [$H(2)=5.97, p=0.05$]. Data analyses showed, that the highest level of cognitive function is registered in the group of female open skill sport athletes, on the contrary, the lowest level of cognitive function we noticed in the group of nonathletes. Paired analysis found a difference significant at 5% level of significance between

female open skill sport athletes and nonathletes ($U=230.50$; $p=0.02$; $r=0.30$). Open skill sport athletes dispose with a level of cognitive function corresponding to 126.21 ± 24.83 points, while nonathletes 107.82 ± 26.88 points. It also does not exist a difference in the level of cognitive functions between closed skill sport athletes and nonathletes ($U=497.00$; $p=0.89$; $r=0.02$). Closed skill sport athletes dispose with a level of cognitive functions corresponding to 110.23 ± 19.28 points. It means, that female athletes generally (regardless of engaging to the open skill sport or closed skill sport disciplines) do not dispose with higher level of cognitive function in compare to female nonathletes.

We also looked at the difference between groups of athletes – closed skill sport disciplines and open skill sport disciplines. Our results showed, that it does exist a difference between those groups – at 5% level of statistical significance ($U=159.00$; $p=0.04$; $r=0.30$).

DISCUSSION

The aim of this research was to determine the level of chosen cognitive function of female in late adolescence. Our study has shown a higher level of monitored cognitive function among athletes engaged in open skill sport disciplines compared to athletes of closed skill sport disciplines and nonathletes as well. So it may turns out that open skill sport disciplines (team sport games) have some potential to increase the level of cognitive function of woman. At the same time, according our results, closed skill sport disciplines do not increase the level of chosen cognitive function of young woman.

Some authors categorize cognitive functions into a subgroup called executive function and point to a close connection between these two terms. For example, according the authors Friedman et al. [30] we can say that recent psychological and neuropsychological research suggests that executive functions are the cognitive control processes and they are multifaceted. The different types of executive functions are correlated but separable. Executive functions are generally used as a term to describe the cognitive processes that regulate thought and action, especially in nonroutine situations [30]. And just athletes engaged in open skill sport disciplines are facing these situations very often and they must be prepare to solve unexpected, fast and nonroutine moments in the match.

As mentioned above, the executive functions are thus important in order to capture and discriminate among information in decision-making, especially during time constraints. In open skill sportslike football, basketball or volleyball, there are large amounts of information for the athletes to consider in every new moment. The successful player must constantly assess the situation, compare it to past experiences, create new possibilities, make quick decisions to action, but also quickly inhibit planned decisions [31]. This may explain that open skill sport athletes performed better in cognitive tasks than closed skill sport athletes in the study of authors Voss et al [10]. We have also found higher level of cognitive function in open skill sport athletes in compare to closed skill sport athletes. But there is also evidence that athletes of open skill sport disciplines do not dispose with higher level of cognitive functions. According to the study of authors Memmert, Simons and Grimme [32], team sport athletes did not perform better in any of attention tasks in compare to non-team sport athletes, both on expert level of sporting.

Also, research of Vestberg et al. [31] shows that general executive functions are important in sport game and can even predict a future success in sport game players. Authors have reevaluated cross-sectional test on executive and they have found that the open skill sports athletes (football players) in the high division had significant better results than open skill sport athletes (football players) in the lower division. Moreover, both groups of athletes dispose with higher level of executive functions than the general population. This finding is linked with another result in our study, namely, open skill sport athletes have a higher level of cognitive functions than nonathletes.

On the other hand, from the point of view of assessing the level of cognitive or executive functions regarding the level of sport activity, the research results vary. According to studies [14, 33], there are any differences in simple cognitive processes such as reaction time or basic attentional tasks between elite and semi-elite team sport athletes (specifically football players).

The results of the study of authors Krenn et al. [34] say about the importance of executive functions in elite sports and, at the same, they demonstrate that athletes vary in executive functions regarding their individual sports. These results also suggest that the development of executive functions might be favored by the deliberate practice of strategic sports, and/or that executive

functions may play a more important role in strategic sport disciplines. In the present, we can assume that sport activity has potential to improve cognitive functioning and change structural and functional aspects of the human brain [35-37]. Results of the research realised by authors Alesi et al. [13] have found that team sport activity can help to increase the level of executive functions. According to this study there were significant differences between group of athletes and sedentary group in executive functions after the football exercise program. The team sport athletes (football players group) at post-test showed significantly larger gains than the sedentary group on measures of agility, visuo-spatial working memory, attention, planning and inhibition.

However, our research has not confirmed our assumption that individual sport disciplines athletes will dispose with a higher level of cognitive functions than nonathletes. Thus, this finding is not consistent with findings of Martin et al. [7]. According these authors is physical activity (as a only intervention) a good tool for improving cognitive, executive function. We can explain this by finding of Best [38], that says that executive functions have been found to be more sensitive to physical activity than other types of cognitive functions. Also results of the study of Jacobson and Matthaues [39] have showed that athletes outperform nonathletes on tests of such executive functions domains as inhibition and problem solving. Moreover, authors say that different types of athletic experience may correlate with higher levels of particular executive functions domains. Our findings are consistent with the results of this study only when compared the difference in the level of cognitive function of open skill sport athletes and nonathletes.

Despite this study's interesting findings in the area of cognitive functions on the difference between athletes engaged in open skill sport disciplines, athletes engaged in individual sport disciplines and nonathletes, it has several limitations that should be acknowledged. Firstly, the size of the research group of athletes and nonathletes of our research was relatively small. These findings may reveal the extent to which a specific sports activity such as open skill sport disciplines can influence cognitive functions.

Regardless of the research limitations, we can say that young female athletes participating in open skill sport disciplines have higher level of cognitive functions in comparison to young female athletes engaged in individual sport disciplines and young females who do not participate in any sports activity.

CONCLUSION

Our study confirmed the knowledge of different involvement of cognitive functions in different types of sport disciplines, and consequently a higher level of cognitive functions of women engaged in open skill sport disciplines, in compare to women engaged in individual sport disciplines and female nonathletes as well. However, we could not prove the higher level of monitored cognitive function of female engaged in individual sport disciplines compared to females not engaged in any sport activity.

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REFERENCES

1. Sebrì V, Savioni L, Triberti S, Mazzocco, K, Pravettoni G. How to Train Your Health: Sports as a Resource to Improve Cognitive Abilities in Cancer Patients. *Front Psychol* 2019; 10: 2096. doi: 10.3389/fpsyg.2019.02096
2. Nemcek D, Simon A. Effect of 3-months home-based exercise program on changes of cognitive functioning in older adults living in old people's home. *AFEPUC* 2016; 56(1): 16-29. doi: 10.1515/afepuc-2016-0002
3. Diamond A. Executive functions. *Annual Review of Psychology* 2013; 64: 135-168.
4. Ward J. *The student's guide to cognitive neuroscience*. London, United Kingdom: Psychology Press; 2006
5. Powell T. Poškození mozku: Praktický průvodce pro terapeutu, rodinné příslušníky a pacienty [Brain Damage: A practical guide for therapists, family members and patients]. Praha: Portal; 2010.

6. Mandolesi L, Polverino A, Montouri S, Foti F, Ferraiolli, G, Sorrentino P, Sorrentino G. Effects of physical exercise on cognitive functioning and wellbeing: Biological and psychological benefits. *Front Psychol* 2018; 9: 509. doi: 10.3389/fpsyg.2018.00509.
7. Martin A, Booth JN, Laird Y, Sproull J, Reilly JJ, Saunders DH. Physical activity, diet and other behavioural interventions for improving cognition and school achievement in children and adolescents with obesity or overweight. *Coch Dat Syst Rev* 2018; CD009728. doi: 10.1002/14651858.CD009728.pub4
8. Wang Ch-H. Open vs. Closed Skill Sports and the Modulation of Inhibitory Control. *PLoS One* 2013; 8(2): e55773
9. Di Russo F, Bultrini A, Brunelli S, Delussu AS, Polidori L, et al. Benefits of Sports Participation for Executive Function in Disabled Athletes. *IJNT* 2010;27: 2309–2319. doi: 10.1089/neu.2010.1501
10. Voss MW, Kramer AF, Basak C, Prakash RS, Roberts B. Are expert athletes' expert in the cognitive laboratory? A meta-analytic review of cognition and sport expertise. *Appl Cognitive Psych* 2010; 24: 812–826. doi: 10.1002/acp.1588
11. Taddei F, Bultrini A, Spinelli D, Di Russo F. Neural Correlates of Attentional and Executive Processing in Middle-Aged Fencers. *MSSE* 2012; 44: 1057–1066. doi: 10.1249/MSS.0b013e31824529c2
12. Smith PJ, Blumenthal JA, Hoffman BM, Cooper H, Strauman TA, Wels-Bohmer K, Browndyke JN, Sherwood A. Aerobic exercise and neurocognitive performance: A meta-analytic review of randomized controlled trials. *Psychosom Med* 2010; 7(3): 239-252. doi: 10.1097/PSY.0b013e3181d14633
13. Alesi M, Bianco A, Luppine G, Palma A, Pepi A. Improving children's coordinative skills and executive functions: The effects of a football exercise program. *Percept Motor Skill* 2016; 122: 27–46. doi: 10.1177/0031512515627527
14. Huijgen BCH, Leemhuis S, Kok NM, Verburgh L, Oosterlaan J, Elferink-Gemser MT, Visscher C. Cognitive functions in elite and sub-elite youth soccer players aged 13 to 17 years. *PLoS ONE* 2015; 10(12): e0144580. doi: 10.1371/journal.pone.0144580
15. Ishihara T, Sugawara S, Matsuda Y, Mizuno M. Relationship of tennis play to executive function in children and adolescents. *Eur J Sport Sci* 2017; 17: 1074-1083. doi: 10.1080/17461391.2017.1334831
16. Montuori S. et al. Executive functioning profiles in elite volleyball athletes: Preliminary results by a sport-specific task switching protocol. *Hum Movement Sci* 2019; 63: 73-81. doi: 10.1016/j.humov.2018.11.011.
17. Grehaigne JF, Godbout P, Bouthier D. The teaching and learning of decision making in team sports. *Quest* 2001; 53(1): 59-76. doi: 10.1080/00336297.2001.10491730.
18. Javier Sanchez-Sanchez, Alejandro Rodriguez, Cristina Petisco, Rodrigo Ramirez-Campillo, Cristian Martínez and Fábio Y. Nakamura. Effects of Different Post-Activation Potentiation Warm-Ups on Repeated Sprint Ability in Soccer Players from Different Competitive Levels. *J Hum Kinet* 2018; 61: 189–197.
19. Zuzana Gonosova, Petr Stastny, Jan Belka, Lucia Bizovska and Michal Lehnert. Muscle Strength Variations of Knee Joint Muscles in Elite Female Handball Players after Pre-Season Conditioning. *J Hum Kinet*, 2018; 63: 105–115.
20. Sowden PT, Davies IR, Roling P. Perceptual learning of the detection of features in X-ray images: a functional role for improvements in adults' visual sensitivity? *J Exp Psychol: Hum Percept Perform* 2000; 26(1): 379-390. doi: 10.1037//0096-1523.26.1.379
21. Roca A, Williams AM, Ford PR. Developmental activities and the acquisition of superior anticipation and decision making in soccer players. *J Sport Sci* 2012; 30(15): 1643-1652. doi:10.1080/02640414.2012.701761
22. Ste-Marie DM, et al. Observation interventions for motor skill learning and performance: an applied model for the use of observation. *International Rev Sport Exerc Psychol* 2012; 5(2): 145-176. doi: 10.1080/1750984X.2012.665076
23. Faubert J, Sidebottom L. Perceptual-cognitive training of athletes. *J clin sport psychol* 2012; 6(1): 85-102. doi: 10.1123/jcsp.6.1.85
24. Mann DT, Williams AM, Ward P, Janelle CM. Perceptual-cognitive expertise in sport: a meta-analysis. *J Sport Exerc Psychol* 2007; 29(4): 457–478. doi: 10.1123/jsep.29.4.457
25. Heppel H, Kohler A, Fleddermann MT, Zentgraf K. The relationship between expertise in sports, visuospatial, and basic cognitive skills. *Front Psychol* 2016; 7: 904. doi: 10.3389/fpsyg.2016.00904
26. Varekova J, Dadova K. Pohybová aktivita a kognitivní funkce [Physical activity and cognitive functions]. *Medicina Sportiva Bohemica et Slovaca* 2014; 23: 210–215.
27. Hopfinger JB, Slotnick SD. Attentional Control and Executive Function. *Cogn Neurosci* 2020; 11(1-2): 1-4. doi: 10.1080/17588928.2019.1682985

28. Miglierini B, Vonkomer J. S-test: testová príručka – pokyny pre administráciu a interpretáciu testu S-test. [S-test manual – instructions for administration and interpretation of the S-test]. Bratislava: Psychodiagnostika, a.s.; 2007.
29. Pett MA. Nonparametric statistics for health care research: Statistics for small samples and unusual distributions. Thousand Oaks, CA: Sage; 1997.
30. Friedman NP, Miyake A, Young SE, DeFries JC, Corley RP, et al. Individual differences in executive functions are almost entirely genetic in origin. *J Exp Psychol Gen* 2008; 137: 201–225. doi: 10.1037/0096-3445.137.2.201
31. Vestberg T, Gustafson R, Maurex L, Ingvar M, Petrovic P. Executive Functions Predict the Success of Top-Soccer Players. *PLoS ONE* 2012; 7(4): e34731. doi: 10.1371/.0034731
32. Memmert D, Simons DJ, Grimme T. The relationship between visual attention and expertise in sports. *Psychol. Sport Exerc* 2009; 10: 146–151. doi: 10.1016/j.psychsport.2008.06.002
33. Verburch L, Scherder EJ, van Lange PA, Oosterlaan J. Executive functioning in highly talented soccer players. *PloS One* 2014; 9(3): e91254. pmid:24632735
34. Krenn B, Finkenzeller T, Würth S, Amesberger H. Sport type determines differences in executive functions in elite athletes. *Psychol Sport Excerci* 2018; 38: 72-79. doi: 10.1016/j.psychsport.2018.06.002
35. Kramer AF, Erickson KI. Capitalizing on cortical plasticity: Influence of physical activity on cognition and brain function. *TICS* 2007; 11: 342–348. doi: 10.1016/j.tics.2007.06.009
36. Szerla M, Wasik J, Ortenburger D, Gwara M, Trybulec B. Optimization of quality of functional improvement – aspects of psychomedical treatment. *Medical Studies* 2016; 32(2):150-156.
37. Wasik J, Ortenburger D, Góra T, Mosler D, Wodarski P, Michnik R. The influence of gender, dominant lower limb and type of target on the velocity of taekwon-do front kick. *Acta of Bioengineering and Biomechanics* 2018; 20(2):133–138.
38. Best JR. Effects of physical activity on childrens executive function: Contributions of experimental research on aerobic exercise. *Develop Rev* 2010; 30: 331-351. doi: 10.1016/j.dr.2010.08.001
39. Jacobson J, Matthaeus L. Athletics and executive functioning: How athletic participation and sport type correlate with cognitive performance. *Psychology of Sport and Exercise* 2014; 15(5): 521-527. doi: 10.1016/j.psychsport.2014.05.005