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A Research on Mathematical Thinking Skills: Mathematical Thinking Skills of Athletes in Individual and Team Sports

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Abstract

The aim of this research is to examine the mathematical thinking skills of licensed athletes engaged in individual and team sports. The research is designed as a survey model. The sample of the research is composed of 59 female and 170 male licensed athletes (n = 229) and (aged 14 to 52) licensed who do the sports of shooting, billiards, archery, tennis, basketball, football, volleyball in various clubs in Turkey. The "Mathematical Thinking Scale" developed by Ersoy (2012) has been employed in the research. Individual sports athletes are more likely to have higher mathematical thinking scores than team athletes. In sports types; those who play billiards and archery have higher scores of mathematical thinking skills compared to other sports types. According to the type of sports the lowest scores of thinking skills were obtained by basketball players. These differences are valid for higher-level thinking tendencies, reasoning, mathematical thinking skills and problem-solving skills, which are sub-dimensions of the mathematical thinking scale.

Keywords: thinking skills, mathematical thinking, individual and team athletes, high-level thinking skills, problem-solving, reasoning.

1. Introduction

Thinking involves critical and creative aspects of the mind. In our thinking process, there are a lot of reasoning works in mind. These are named according to the operations performed; problem solving, decision-making, critical thinking, reflective thinking, creative thinking, reasoning and so on. These are the reasons for creating thought. In the process of thinking, the individual must use the thinking process in an effective and meaningful way. At this stage, the individual needs to construct his thinking system in a good way (Fisher, 2005, Ersoy & Basar, 2012, Gunes, 2012). Thinking, unlike feelings, impressions and designs, is defined as the independent and unique state of the mind, its ability to comprehend, separate, merge, as well as to connect and understand forms (TDK, 2005).

Mathematics is always a topic at all levels of education, from primary school to university. Mathematical properties are different from those of other sciences (Baykul, 2005, s.33, Husnaeni, 2016). Mathematics is one of the most important branches of science that develop thinking. Mathematics is a discipline that requires a certain way of thinking, is associated with many fields, and can develop to a certain degree (Maddox, 2002). The ability to think, which is the most important feature that distinguishes man from other living things, means being able to make deductions from the experienced events; to interpret and rearrange them from its own point of view. For these reasons, mathematics education constitutes one of the most important building blocks of basic education. Mathematics education provides important skills such as thinking in life, establishing relationships between events, reasoning, estimating, problem solving apart from gaining calculation skills and teaching numbers and mathematical operations (Umay, 2003). These skills are learned, develop and support each other as they are used, mathematical skills are the skills that are used to make meaningful or develop one another (Olkun & Toluk, 2006). A mathematical thinking style is the way in which an individual prefers to present, to understand and to think through, mathematical facts and connections by certain internal imaginations or externalized representations (Ferri, 2015).

According to Cotton (2010), everyone can think mathematically; mathematical thinking can be improved by reflection; mathematical thinking evokes contradiction, tension, and excitement; mathematical thinking is supported by the atmosphere of questioning, difficulties and reflection; mathematical thinking helps us understand ourselves and the world. Physical, mental, and emotional connections are seen as requirements that provide mathematical thinking (Hudson, Henderson & Hudson, 2016). In mathematical thinking, there is an effort to reach a product by moving from our perceptions, as in every thinking. There may be individual differences in approaches used during this effort (Alkan & Bukova, 2005). It can be said that mathematical thinking is a form of thinking that is realized not only in cases with numbers and abstract mathematical concepts but also in daily life (Yesildere & Turnuklu, 2007). Mathematical thinking involves all important skills such as logical and analytic thinking as well as quantitative reasoning (Devlin, 2012).

Developing mathematical thinking is the main goal of mathematics education. In today's information-based society, it is desirable to develop process skills such as innovative ways to find a solution to a problem. As for the extent to which mathematical thinking is effective, it is important to have the proficiency to mathematical processes of questioning; to understand the content and areas of application of mathematics; to cope with emotional and psychological situations, and to be confident to use the adverse situations to one’s own advantage. In certain situations, mathematical and statistical thinking develop creative and critical thinking (Mason, Burton, & Stacey, 2010, Isoda & Katagiri, 2012).

When looked at the studies on mathematical thinking, it is evident that the studies on mathematics education are more common. (Alkan & Bukova, 2005; Yesildere & Turnuklu, 2007; Arslan & Yildiz, 2010; Ersoy & Baser, 2012; Tataroglu, Celik & Erduran, 2013; Ersoy & Guner, 2014; Gibney, 2014; Herlina, 2015; Saragih & Napitupulu, 2015; Hudson, Henderson & Hudson, A, 2016). The authors emphasize the need for continuous improvement of mathematical thinking in mathematics education.

Looking at the neurophysiology of learning in recent years, it is seen that studies conducted in certain areas such as physical activity, physical education, and sports make important contributions to thinking skills. These studies focus more on thinking skills and different types of intelligence (Bozkurt, 2004; Hosgor & Katrancı, 2007; Tekin, 2009; Coskuner, Gacar & Yanlic, 2010; Certel, Catikkas & Yalcınkaya, 2011; Hekim & Tokgoz, 2012; Cinkılıc & Soyer, 2013; Kucuk & Oncu, 2014; Kiremitci & Canpolat, 2014; Holmes, Liden & Shin 2013, Shalar, Strikalenko & Ivaschenko, 2013; Chatzipanteli, Digelidis, Karatzoglidis & Dean, 2014; Furley & Memmert, 2015; Singh, Singh & Singh, 2015; Jakovljevic, Pajic & Gardasevic, 2015; Gogoi, 2016).

Team sports contribute to improving the individual's ability to socialize, communicate well with other people, win and lose together, do teamwork and help. Individual sports, on the other hand, enhance the individual's ability to develop his will to go beyond his potential, to challenge himself, and to acquire self-confidence (Salar, Hekim & Tokgoz, 2012). Determining what level of mathematical thinking is important for individual and team athletes, which has a very important place in thinking skills, has been a subject worth studying. In this study, we examine the mathematical qualities that affect performance of athletes. Our research questions are:

1. Do individual and team athletes differ in mathematical thinking skills?

2. Do the athletes differed in mathematical thinking skills according to the type of sports they do?

2. Method

2.1 Research Model

The aim of this research is to examine the mathematical thinking skills of licensed athletes engaged in individual and team sports. The research has been designed as a survey model. Survey models are a type of research, which aim to describe the past or present events as they exist. The case, person or object to be studied is defined as they exist and in their own conditions. No attempt is made to alter or influence them (Karasar, 2009).

2.2 Participants

The sample of the research were composed of 59 female and 170 male licensed athletes (n = 229) and (aged 14 to 52) who do the sports of shooting, billiards, archery, tennis, basketball, football and volleyball in various clubs in Turkey. 97 of the athletes participating in the survey are individual athletes and 132 are doing team sports. Of these athletes; 60 are football, 29 are basketball, 43 are volleyball, 13 are tennis, 6 are billiards, 17 are shooting and 61 are archery athletes.

2.3 Data Collection Instrument

The "Mathematical Thinking Scale" developed by Ersoy (2012) has been employed in the study. Mathematical thinking scale consists of the sub-dimensions of higher-level thinking tendencies, reasoning, mathematical thinking skills and problem-solving skills. It is a 25-item likert-type scale covering a total of 25 items 20 positive and 5 negatives. As a result of the analysis conducted, the reliability of the scale is calculated 0.78. The highest point scored on the scale is 125 and the lowest score is 25.

2.4 Implementation Process

The "Mathematical Thinking Scale" was taken to the licensed athletes in various clubs and it was requested that the questionnaire is filled in mostly as a result of face-to-face interviews by the researchers. After the questionnaires were filled they were returned to the researchers so that they were meticulously answered.

2.5 Data Analysis

The data were analyzed using the SPSS software (IBM SPSS Statistics Version 21). Before the analyses, data was screened and prepared for the analysis. Primarily tested using the Kolmogorov-Smirnov normality test for the related research variables. A normal distribution wasn’t observed. Therefore, the Mann-Whitney U and Kruskal-Wallis tests, a nonparametric techniques, were used for examining the mathematical thinking skills of licensed athletes engaged in individual and team sports.

3. Findings

Findings were organized by research questions. The first research question in our study was whether "individual and team athletes differ in mathematical thinking skills". Table 1 shows the data pertaining to this question.

Table 1. Comparison of the total points scored in the mathematical thinking scale according to the sports type variable (individual-team)

Group	N	Rank av.	Rank Total	U	p
Individual	97	137,48	12999,0	4221,0	,000
Team	132	98,48	13336,0		

Statistically, the difference in the level ($p < 0.05$) favors the athletes who do individual sports (Table 1). Participants who were engaged in individual sports came to the conclusion that they were more successful in terms of mathematical thinking.

The second research question was whether or not the athletes differed in mathematical thinking skills according to the type of sports they were doing. As seen in (Table 2) the ability to think according to the type of sports was statistically different ($p < 0.05$).

Table 2. Differentiation of the athletes' mathematical thinking skills scores in terms of sport types.

Group	N	Rank av.	Chi-Square	p
Football	60	111,03		
Basketball	29	62,53		
Volleyball	43	105,21		
Tennis	13	119,73	34,09	,000
Billiards	6	172,08		
Shooting	17	123,82		
Archery	61	141,67		

It has been found that the scores of the athletes who do the sports of billiards and archery are significantly higher than those of other types of sports. According to the type of sports the lowest scores of thinking skills were obtained by basketball players (Table 2).

According to the sub-dimensions of mathematical thinking skills scale (Table 3), the skills of “higher level thinking”, “reasoning”, “mathematical thinking”, “problem-solving” have differed according to the type of sports that each athlete does ($p <.0.05$).

Table 3. Differentiation in the athletes' mathematical thinking ability sub-dimensions scores in terms of sport types

Dimension	Group	N	Rank av.	Chi-Square	p
Higher-Level Thinking Tendency	Football	60	109,3	29,43	,000
	Basketball	29	69,6		
	Volleyball	43	99,6		
	Tennis	13	134,9		
	Billiards	6	150,5		
	Shooting	17	139,2		
	Archery	61	138,2		
Reasoning	Football	60	115,5	22,07	,001
	Basketball	29	66,9		
	Volleyball	43	115,4		
	Tennis	13	128,6		
	Billiards	6	164,2		
	Shooting	17	129,3		
	Archery	61	125,2		
Mathematical Thinking Skills	Football	60	109,6	22,14	,001
	Basketball	29	73,9		
	Volleyball	43	109,7		
	Tennis	13	112,9		
	Billiards	6	150,7		
	Shooting	17	118,0		
	Archery	61	139,6		
Problem-Solving Skills	Football	60	120,59	17,35	,008
	Basketball	29	80,8		
	Volleyball	43	107,2		
	Tennis	13	106,7		
	Billiards	6	174,5		
	Shooting	17	104,7		
	Archery	61	129,9		

Athletes who do the sports of billiards and archery have higher scores on all sub-levels of mathematical thinking skills scale than other athletes (Table 3). When we look at the skills in all sub-dimensions, basketball players got the lowest scores for mathematical thinking skills.

4. Discussion and Conclusion

In this study, in which we tried to determine the mathematical thinking in the cases of individual and team athletes, it is examined how mathematical thinking differs according to types of sports.

According to the results of the research, there is a statistically significant difference in favor of individual athletes among the participants who do individual and team sports. We have come to the conclusion that participants who do individual sports are more successful in terms of mathematical thinking skills. Shalar, Strikalenko & Ivaschenko (2013), in their research where they studied the individual characteristics of tennis players according to their playing style, came to the conclusion that the emotional and mental characteristics of the players differed according to their playing styles. It was determined that the athletes employing cautious playing style had higher intellectual capacity.

Chatzipanteli, Digelidis, Karatzoglidis & Dean (2014), in their research where they studied the effectiveness of the tactical game model in improving primary school children’s higher order cognitive behaviors, concluded that the tactical game approach could improve higher order cognitive behaviors in primary school physical education classes. In our study, participants in individual sports have been found to have higher mathematical thinking skills. In a study by Gogoi (2016), where he researched on the emotional intelligence of athletes doing team sports, it is argued that the athletes of football, hockey, basketball, and volleyball have similar types of emotional intelligence.

According to the data obtained, the scores of participants who do the sports of billiards and archery are significantly higher than the other groups. Participants with the lowest scores are those who play basketball. Jakovljevic, Pajic & Gardasevic (2015), in their research where they studied the effects of 48 professional basketball players' cognitive abilities on shooting performance and overall performance, found that the cognitive abilities needed to be improved in order to improve the overall performance of basketball players. The results of their research that basketball players need to improve their cognitive abilities supports the low level of mathematical thinking skills of athletes playing basketball, which has been found in this research. Mathematical thinking skill is also a cognitive skill. The failure to train a sufficient number of athletes among professional basketball players at national level reveals the necessity to focus on these cognitive skills and the activities related to the training of mathematical thinking skills.

Among those who do team sports, there is a statistically significant difference in favor of those who play football and volleyball sports in terms of the total scores they have gotten on mathematical thinking scale. We came to the conclusion that the participants who play football and volleyball are more successful than basketball players in terms of mathematical thinking. In the study of Furley & Memmert (2015), the relationship between the memory capacity of professional footballers and the creativity specific to the field was examined. The results show that memory capacity is not related to football-specific creativity. Bozkurt (2004), in his research on creativity and multi-intelligence in relation to creativity in football in terms of skill and game intelligence, did not find a significant relationship between variables of "football fluency" and "football originality", and "multiple intelligence fields", which form football field measurements. It has been found that there is a significant relationship between the variables of "football fluency" and "football originality", and the "form creativity" skills of footballers. Singh, Singh & Singh (2015) found, in their studies where they compared mental skills of volleyball and football players playing for the school and college teams or clubs, that the mental skills of football players at the school level are better than the mental skills of volleyball players. There is no significant difference between football players and volleyball players at the college and club level. This result can be attributed to the fact that the skills in some team sports have not yet developed in the school years. Holmes, Liden & Shin (2013), in their study where they examined the relation between children's thinking styles, and their game preferences for and their school performance, detected a meaningful correlation between children's thinking styles and game preferences; between game preferences and academic performance; between thinking styles and academic performance; between their way of thinking and the cultural environment. Among the athletes who do team sports, participants who play football and volleyball are more successful in mathematical thinking in all sub-dimensions in terms of the scores they got from sub-dimensions of mathematical thinking scale.

According to the results of the studies in the literature and of this study where we have examined the athletes who do individual and team sports in terms of their mathematical thinking skills, the activities for all dimensions of thinking skills should be diversified and increased in both sports classes at schools and training programs at sports clubs. Similar studies can be conducted on types other than selected sports types in this survey. It is hoped that further studies in this field will make important contributions to education, coaching institutions, students enrolled in physical education teacher training program, athletics clubs and sports in the developing countries.

References

Alkan, H., & Bukova-Guzel, E. (2005). Ogretmen adaylarında matematiksel dusunmenin gelisimi. *Gazi Universitesi Egitim Fakultesi Dergisi*, *3*, 21-236.

Arslan, S., & Yıldız, C. (2010). Reflections from the experiences of 11th graders during the stages of mathematical thinking. *Education and Science*, *35*(156), 17-31.

Baykul, Y. (2005). *Ilkoğretimde matematik ogretimi (1-5. Sınıflar)*. Ankara: PegemA Yayıncılık.

Borromeo, F. R. (2015) Mathematical thinking styles in school and across cultures. In: Cho S. (eds) *Selected Regular Lectures from the 12th International Congress on Mathematical Education*. Springer, Cham. https://doi.org/10.1007/978-3-319-17187-6_9

Bozkurt, S. (2004). *Yaratıcılık ve coklu zekânın futbolda yaratıcılıkla iliskisinin incelenmesi*, Marmara Universitesi, Yayınlamamıs Doktora Tezi, Saglık Bilimleri Enstitusu, Istanbul.

Bukova, G. E. (2008). Yapılandırmacı Ogrenme Yaklasımının Matematik Ogretmen Adaylarının Matematiksel Dusunme Sureclerine Olan Etkisi. *Journal of New World Sciences Academy*, (4).

Buyukozturk, S. (2006). *Sosyal bilimler icin veri analizi el kitabi*, Ankara: Pegem A Yayincilik

Certel Z., Catıkkas F., & Yalcınkaya M., (2011). Beden egitimi ogretmen adaylarının duygusal zeka ile elestirel dusunme egilimlerinin incelenmesi, *Selcuk Universitesi Spor Bilim Dergisi*, *13*, 74-81.

Chatzipanteli, A., Digelidis, N., Karatzoglidis, C., & Dean, R. (2016). A tactical-game approach and enhancement of metacognitive behaviour in elementary school students, *Physical Education and Sport Pedagogy*, *21*(2), 169-184. https://doi.org/10.1080/17408989.2014.931366

Cinkilic, İ., & Soyer, F. (2013). Beden egitimi ogretmen adaylarının coklu zekâ alanları ile problem cozme becerileri arasındaki iliskinin incelenmesi. *Spor Yonetimi ve Bilgi Teknolojileri Dergisi*, *8*(1), 4-16.

Coskuner, Z., Gacar, A., & Yanlıc, N. (2012). Beden egitimi ve spor ogretmen adaylarının dusunme stillerinin degerlendirilmesi. *Spor ve Performans Arastırmaları Dergisi*, *3*(1). https://doi.org/10.17155/SPD.68777

Cotton, T. (2010). *Understanding and teaching primary mathematics*. Pearson Education Limited. Harlow: England.

Devlin, K. (2012). *Introduction to mathematical thinking*. Keith Devlin-Palo Alto. ISBN-13: 978-0615653631

Ersoy, E. (2012). *Ust duzey dusunme becerilerinin probleme dayali ogrenme surecinde duyussal kazanımlara etkisi*. Doktora Tezi. Dokuz Eylul Universitesi Egitim Bilimleri Enstitusu. Izmir.

Ersoy, E., & Baser, N. (2012). Matematiksel dusunme olceginin gelistirilmesi. *Kastamonu Egitim Dergisi (Ozel Sayı).* Cilt:21 No:4. 1471-1486

Ersoy, E., & Guner, P. (2014). Matematik ogretimi ve matematiksel dusunme. *Egitim ve Ogretim Arastırmaları Dergisi*, *3*(2), 102-112.

Fisher, R. (2005). *Teaching children to think*. Nelson Thornes. Cheltenham: United Kingdom.

Furley, P., & Memmert, D. (2015). Creativity and working memory capacity in sports: working memory capacity is not a limiting factor in creative decision making amongst skilled performers. *Frontiers in Psychology*, *6*, 115. https://doi.org/10.3389/fpsyg.2015.00115

Gibney, J. (2014). Provoking mathematical thinking: experiences of doing realistic mathematics tasks with adult numeracy teachers. *Adults Learning Mathematics*, *9*(2), 97–115.

Gogoi, D. (2016). Comparison of emotional intelligence among selected team games, *International Journal of Applied Research, 2*(2), 18–19.

Gunes, F. (2012). Ogrencilerin dusunme becerilerini gelistirme. *Turkluk Bilimi Arastırmaları.* Istanbul.

Herlina, E. (2015). Advanced mathematical thinking and the way to enhance IT. *Journal of Education and Practice*, *6*(5), 79–89.

Holmes, R. M., Liden, S., & Shin, L. (2013). Children's thinking styles, play, and academic performance. *American Journal of Play, 5*(2), 219-238.

Hosgorur, V., & Katrancı, M. (2007). Sınıf ve Beden Egitimi ve Spor Ogretmenligi Ogrencilerinin Baskın Zeka Alanları (Kırıkkale Universitesi Egitim Fakultesi Ornegi). *Ondokuz Mayıs Universitesi Egitim Fakultesi Dergisi*, (24), 33–42.

Hudson, B., Henderson, S., & Hudson, A. (2015). Developing mathematical thinking in the primary classroom: Liberating students and teachers as learners of mathematics. *Journal of Curriculum Studies*, *47*(3), 374–398. https://doi.org/10.1080/00220272.2014.979233

Husnaeni. (2016). The enhancement of mathematical critical thinking ability of aliyah madrasas student model using gorontalo by ınteractive learning setting cooperative model. *Journal of Education and Practice*, *7*(8), 159–164.

Isoda, M., & Katagiri, S. (2012). *Mathematical thinking: how to develop ıt ın the classroom*. Singapore: World Scientific. https://doi.org/10.1142/8163

Jakovljević, S., Pajić, Z., & Gardašević, B. (2015). The ınfluence of selected cognitive abilities on the efficiency of basketball players. *Physical Education and Sport*, *13*, 283–290.

Karasar, N. (2009). *Bilimsel arastırma yontemi*. Ankara: Nobel Yayıncılık.

Kiremitci, O., & Canpolat, A. M. (2014). Beden egitimi ve spor yuksekokulu ogrencilerinin coklu zekâ alanlarının ustbilissel farkındalık ve problem cozme becerilerini belirlemedeki rolu. *Spor Bilimleri Dergisi*, *25*(3), 118–126.

Kucuk Kılıc, S., & Oncu, E. (2014). Beden egitimi ve spor yuksekokulu ogrencilerinin bilisotesi ogrenme stratejileri ve akademik oz-yeterlikleri, *Spor ve Performans Arastırmaları Dergisi*, *5*, 13-22. https://doi.org/10.17155/spd.31708

Maddox, R. B. (2002). *Mathematical thinking and writing : a transition to higher mathematics*. San Diego, Calif: Academic Press.

Mason, J., Burton, L., & Stacey, K. (2010). *Thinking mathematically* (*second edition).* Pearson-Harlow. ISBN: 978-0-273-72891-7.

Olkun, S., & Toluk, Z. (2006). *Ilkogretimde etkinlik temelli matematik ogretimi*. Ankara: Seckin Yayıncılık.

Saclı, F., & Demirhan, G, (2011). Beden egitimi ogretmenligi, antrenorluk ve rekreasyon programlarındaki ogrencilerin elestirel dusunme becerilerinin karsılastırılması. *Hacettepe Universitesi Egitimi Fakultesi Dergisi*, Sayı:41, Sayfalar:372-385,

Salar, B., Hekim, M., & Tokgoz, M. (2012). 15-18 yas grubu takım ve ferdi spor yapan bireylerin duygusal durumlarının karsılastırılması. *Mehmet Akif Ersoy Universitesi Sosyal Bilimler Enstitusu Dergisi*, *0*(6), 123–135.

https://doi.org/10.20875/SB.47129

Saragih, S., & Napitupulu, E. (2015). Developing student-centered learning model to ımprove high order mathematical thinking ability. *International Education Studies*, *8*(6), 104–112. https://doi.org/10.5539/ies.v8n6p104

Shalar, O. G., Strikalenko, E. A., & Ivaschenko, A. N. (2013). Indıvıdual propertıes of personalıty as crıterıon of choıce of style of game of tennıs players. *Physical Education of Students*, 69–73. https://doi.org/10.6084/m9.figshare.156384

Singh, J., Singh, C., & Singh, M. (2015). Mental skills: a comparison between volleyball and football players. *International Multidisciplinary E-Journal*, *4*(3), 122–128.

Tastan Tataroglu, B., Celik, A., & Erduran, A. (2013). matematik ogretmen adaylarinin matematiksel dusunme ve ogrencilerin matematiksel dusunmelerinin gelistirilmesi hakkindaki goruslerinin incelenmesi. *Kastamonu Egitim Dergisi*, *21*(4), 1487–1504.

TDK, (2005). Turkce sozluk, Ankara: Turk Dil Kurumu Yayinlari.

Tekin, M. (2009). Ferdi ve takım sporlarında erkek ve kız sporcuların farklı zeka tiplerindeki seviyelerinin karsılastırılması: *Beden Egitimi ve Spor Bilimleri Dergisi*, *11*(4).

Umay, A. (2003). Matematiksel muhakeme yetenegi mathematical reasoning ability. *Hacettepe Universitesi Egitim Fakultesi Dergisi*, *24*, 234–243.

Yesildere, S., & Turnuklu, E. B. (2007). Examination of students' mathematical thinking and reasoning processes. *Journal of Faculty of Educational Sciences*, *40*(1), 181–213. https://doi.org/10.1501/Egifak_0000000152