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Analysis of the Mathematical Thinking Levels of Individual and Team Athletes in Terms of Different Variables

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ABSTRACT

This study was carried out to examine athletes' mathematical thinking levels who do individual and team sports in different variables. The study was conducted with a relational screening model, which is one of the general screening models. The data were collected by a survey method. "Mathematical Thinking Scale" was used to determine the mathematical thinking levels of athletes. The research population was composed of licensed athletes studying in high schools and universities in the 2020-2021 academic year in Turkey, while 459 licensed athletes determined among these students by a simple random method made up the sample group. The Independent-Samples T-Test was applied to determine the differences between the participants' gender, education and branch variables, and their mathematical thinking level. The Pearson Correlation test was applied to determine the relationship between age, sports year, and mathematical thinking levels. As a result of the analysis, a significant difference was observed favouring female participants in the gender variable and mathematical thinking skills sub-dimension. Additionally, it was determined that there was a significant positive relationship between the sports year and the reasoning sub-dimension. As a result, it is thought that the more inclusion of individual or team sports types in education programs will contribute to an individual's mathematics and academic success.

Keywords:
Individual athletes, team athletes, mathematical thinking

1. Introduction

Thinking is an individual's ability to create mental abilities by analysing and comparing information and reasoning to reach a conclusion (TLA, 2020). Thinking can also be defined as all of the mental behaviours deliberately performed to eliminate the events that lead to psychological and physical imbalances if the individual is disturbed by various external or internal factors (Kazancı, 1989). Thinking is an effective, functional, and targeted action (Rogoff, 1990). According to contemporary psychologists, thinking starts with a problem. The individual takes the problem's solution as a goal, which directs the individual's thinking. Thus, a thinking process starting with a problem is performed (Kalaycı, 2001). Mathematics comes to the fore where there is problem-solving and thinking.

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Mathematics is given to all students to gain logical, analytical, systematic, critical, and creative thinking skills and the ability to collaborate (Sukmadewi, 2014). Although numbers are the first to come to mind, mathematics is also used without numbers while thinking about a significant part of the day. While solving a problem, a person examines the results of the solutions they have found by starting from what they have and tries to reach a result shortly. Of course, not every way of thinking is mathematical, but the contribution of mathematical thinking in problem-solving cannot be denied (Umay, 1996). Mathematical thinking defines how an individual prefers to understand, think, and present mathematical facts and connections with certain internal images or externalised representations (Ferri, 2015). In other words, mathematical thinking is the inquiry process that one goes through while solving problems (Baroody, 2003). It includes important mathematical thinking, reasoning, logical and analytical thinking skills (Devlin, 2010). According to Cotton (2010), every individual can think mathematically, which can be developed through mathematical thinking and reflection. In this context, mathematical thinking is a feature that helps us to understand ourselves and the world.

Mathematical thinking is not just a way of thinking specific to mathematicians. Individuals may have to solve problems at home, work, or school (Biltzer, 2003). This means that every individual will need mathematical thinking at various stages of their life. Studies on the necessity of developing mathematical thinking (Ersoy & Başer, 2013; Ersoy & Güner, 2014; Taşdan, Çelik & Erduran, 2013) supports this. According to the National Council of Teachers of Mathematics (1989) report, the primary goal of mathematics education is developing reasoning, problem-solving, and communication, which are the basis of mathematical thinking. Therefore, using these skills in problematic situations in daily life leads us to conclude that it is not a way of thinking used only in mathematics lessons. Therefore, it is possible to see mathematical thinking in all areas of life. With this feature, mathematical thinking can be easily associated with sports, which has an important place for human health and different fields. Although sports and mathematics seem like two very distant disciplines, sports also have mathematics (Akyüz & Gündüz, 2019). For example, situations such as constructing the offensive organisation on semi-circles in handball or passing to each other in a narrow area by forming a triangle in football express the relationship of sports with mathematics in a simple way (Arslantaş, Malbeleği, & İnan, 2018).

It is known that sports have various benefits. Sport is a good socialiser that effectively changes an individual's behaviour (Özbek & Ercan, 2014). Additionally, it has positive effects on the individual, including effects on psychological factors such as anxiety, depression, and problem-solving skills (Akyüz & Gündüz, 2019; Canan & Ataoğlu, 2010; Küçük & Koç, 2004). In addition to these, it is known that physical exercise also affects cognitive functions in children (Ellemberg & St-Louis-Deschênes, 2010). Sports can be grouped as team sports or individual sports according to the way they are performed. Team sports are an important recreational activity in many societies; they attract their participants to compete or watch and enable them to benefit from such branches commercially. Team sports are often performed by groups that share a common purpose and aim to attack or defend together. Football, basketball, and ice hockey are team sports examples (Gudmundsson & Horton, 2017). Team sports help the individual strengthen communication with people, socialise, and develop their qualities such as winning or losing together, acting together with the team, and helping each other. However, unlike team sports, individual sports are generally done without the need for mutual interactions and usually consist of competitions in which an athlete participates (Jones, 2013). Boxing, wrestling, tennis, swimming, and skiing can be given as examples of individual sports. Individual sports also contribute to developing self-confidence, development of will and self-transcendence (Salar, Hekim & Tokgöz, 2012).

It is also possible to come across studies in the literature on the relationship between sports and mathematical thinking. As a result of a meta-analysis conducted on studies examining the relationship between physical activity and cognitive functioning, it was concluded that there was a positive relationship between physical activity and cognitive functionality in children (Sibley & Etnier, 2003). Additionally, most studies show that physical activity positively affects academic achievements and mathematics performance (Lubans et al., 2018; Howie & Pate, 2012; Castelli et al., 2007). Hillman, Erickson, & Kramer (2008) state that exercise helps improve physical health and academic performances. Since students' physical activity during school days does not negatively affect maths performance and may increase it, it is recommended to add various physical activities during school days (Sneck et al., 2019). Similarly, Phillips, Hannon & Castelli. (2015) concluded that participation in physical activities facilitates math performances. Studies conducted in Turkey also focused on different types of intelligence and thinking skills, and it was observed that sports contributed significantly to these skills (Tekin, 2009; Certel, Çatıkkaş & Yalçınkaya, 2011; Çinkılıç & Soyer, 2013).

Therefore, it is thought that examining the effects of sports on mental skills will be beneficial for the literature. In the light of these data, individual and team sports, which are thought to contribute significantly to thinking skills, and mathematical thinking skills, which are so involved in life, have also been found worth researching. Furthermore, the sample group's aimed to be reached in this study would be selected from larger branch groups compared to previous studies increases the study's importance. As a result, this study aims to contribute to the literature to examine the differences between athletes' mathematical thinking levels who do individual and team sports in terms of various variables. For this purpose, the study tried to answer the following questions:

Q1. To what extent do the mathematical thinking levels of individual and team athletes differ?

Q2. To what extent do the mathematical thinking levels of the athletes differ according to their gender?

Q3. To what extent do the mathematical thinking levels of the athletes differ according to their education?

Q4. To what extent do the mathematical thinking levels of the athletes differ according to their age?

Q5. To what extent do the mathematical thinking levels of the athletes differ according to the year they began to exercise?

2. Methodology

2.1. Research Model

This study was conducted with the relational screening model, one of the general screening models that can be conducted on the whole population or on a certain sample group to make a general judgment about a large population. The "questionnaire" technique, which is frequently preferred in quantitative research, was used to collect data (Karasar, 2009). Participants: The research population was composed of licensed amateurs or professional athletes studying in high schools and universities in the 2020-2021 academic year in Turkey. Whereas, 459 (+ -0.05 sampling error, 95% confidence level) licensed athletes determined among these students by the simple random method formed the sample group (Yazıcıoğlu & Erdoğan, 2004). Information about the sample group is presented in Table 1 below.

Table 1. *Distributions Regarding the Personal Information of the Athletes in the Research Group*

Features	Groups			n	(%)
Gender	Female			211	46.0
	Male			248	54.0
Education	High School			325	70.8
	University			137	29.2
Branch	Team Sports	Football	141	267	58.2
		Basketball	16		
		Volleyball	71		
		Handball	29		
		Rowing	8		
		Field hockey	2		
	Individual Sports	Bicycle	63	192	41.8
		Athletics	16		
		Martial arts	48		
		Swimming	9		
		Wrestling	21		
		Weightlifting	13		
		Tennis	6		
		Badminton	5		
		Mountaineering	5		
		Archery	6		

Total	16	459	459	100

According to Table 1 above, 46% (n = 211) of the athletes participating in the study were females and 54% (n = 248) were males. Considering their educational status, it is seen that 70.8% (n = 325) of the athletes were high school students and 29.2% (n = 137) were university students. When the findings are examined, it is seen that 58.2% (n = 267) of the athletes were interested in team sports and 41.8% (n = 192) in individual sports branches.

Table 2: *Arithmetic Mean and Standard Deviation Values for Athletes' Age and License Duration Variables*

	$\bar{x}$	Lowest	Highest	sd	Total
Age	17.27	13.00	30.00	3.48	459
Sports Year	6.33	1.00	21.00	3.41	459

The arithmetic mean, standard deviation, lowest and highest values regarding the age and sports year variable of the athletes participating in the research are given in Table 2 above. When Table 2 is examined, it is seen that the average age of the athletes was $\bar{x}$ = 17.27, the lowest age value was 13, and the highest age value was 30, the sports year average was $\bar{x}$ = 6.33, the lowest period of license value was 1 year, and the highest period of license value was 21 years.

2.3. Data Collection Tools

The data collection tools used in the study consists of three parts. The first section contains information about the research, and the section prepared to obtain participants' consent that they voluntarily participated in the study. There is a "Personal Information Form" prepared to collect information about the athletes' age, gender, educational status, sports year, and sports branch in the second part. In the third part, the "Mathematical Thinking Scale" is included in determining athletes' mathematical thinking levels.

Mathematical Thinking Scale (MTS): MTS developed by Ersoy & Başer (2013) was used to determine athletes' mathematical thinking levels. The measurement tool consists of 25 items, 20 of which are positive and 5 are negative (negative items = item 7, item 15, item 16, item 20, item 22). The highest score to be obtained from the scale is 125, and the lowest score is 25. The measurement tool is a 5-point Likert-type scale and is rated as "1 = totally disagree", "2 = disagree", "3 = undecided", "4 = agree", and "5 = totally agree". As the scores obtained from the scale increase, the level of mathematical thinking increases, and as the scores decrease, the level of mathematical thinking decreases. MTS consists of 'Higher-order disposition', 'Reasoning', 'Mathematical thinking skill', and 'Problem-solving' sub-dimensions. The original scale's reliability (Cronbach's Alpha Coefficient) was calculated as 0.78 (Ersoy & Başer, 2013). Information about the Cronbach's Alpha reliability coefficients of the measurement tool and the skewness and kurtosis values are presented in Table 3 below.

Table 3: *Reliability and Normality Values of the Mathematical Thinking Scale*

Dimensions	α (Original)	α (Research data)	Skewness	Kurtosis
High Level Thinking Disposition			-0.41	-1.43
Reasoning			-0.39	0.96
Mathematical Thinking Skill	0.78	0.75	-0.22	-0.27
Problem Solving			-0.08	1.22
Total Scale	0.78	0.75	-0.16	0.50

When Table 3 above is examined, it is seen that the data obtained from MTS provided the assumption of normality and the reliability coefficient was at an acceptable rate. For normality test in social sciences and studies using the Likert type scale method, kurtosis and skewness measures are also evaluated. The distribution is accepted as 'normal' if the skewness and kurtosis values are within ± 2 (George & Mallery, 2019; Kalaycı, 2006).

2.4. Analysis of Data

Before analysing the research data, descriptive statistical calculations were made for the data obtained from the personal information form to determine the participant group's characteristics. The data obtained from MTS in the third part of the data collection form were transferred to the SPSS program, and the arithmetic averages of the scores obtained for each dimension were taken. Independent-Samples T-Test (Q1, Q2, Q3) was conducted to determine the differences between the participants' gender, education and branch variables, and mathematical thinking levels. Finally, the Pearson Correlation test (Q4, Q5) was applied to determine the relationship between the participant's age, sports year, and mathematical thinking level.

2.5. Ethical

Before the data collection process, written permission was first obtained from the researcher who developed the measurement tool. Afterwards, the data collection tool prepared by the research team was submitted to the Sinop University Ethics Committee, it was evaluated in session number 10 on 18.12.2020, and its compliance was approved with the official letter numbered 2020-134. Research data were collected using the "Online forms" technique due to the COVID-19 pandemic, and the participants participated in the study voluntarily.

3. Findings

Table 4: *T-Test Results between Individual and Team Athletes and MTS Sub-Dimensions*

Sub-dimensions	Groups	n	$\bar{x}$	SD	df	*t*	p
Reasoning	Team	267	4.01	0.54	457	0.465	0.642
	Individual	192	3.99	0.51			
High Level Thinking Disposition	Team	267	3.87	0.59	457	0.439	0.661
	Individual	192	3.85	0.51			
Mathematical Thinking Skill	Team	267	3.55	0.38	457	1.830	0.068
	Individual	192	3.48	0.36			
Problem Solving	Team	267	3.51	0.46	457	1.391	0.165
	Individual	192	3.45	0.42			

According to Table 4 above, no significant differences were found between individual and team athletes and MTS sub-dimensions. But all mean scores for team athletes in each sub-domain is higher than that for individual athletes.

Table 5: *Results of the T-Test between the Athletes' Gender Variable and MTS Sub-Dimensions*

Sub-dimensions	Groups	n	$\bar{x}$	SD	df	*t*	p
Reasoning	Female	211	4.01	0.50	457	0.398	0.691
	Male	248	3.99	0.55			
High Level Thinking Disposition	Female	211	3.84	0.58	457	-0.563	0.574
	Male	248	3.87	0.55			
Mathematical Thinking Skill	Female	211	3.59	0.39	457	3.538	**0.000***
	Male	248	3.46	0.35			
Problem Solving	Female	211	3.52	0.45	457	1.664	0.097
	Male	248	3.45	0.44			

According to Table 5 above, apart from the mathematical thinking skill sub-dimension ($t = 3.538$; $p = 0.000$), no significant differences were found in other sub-dimensions. The arithmetic mean between the subgroups was examined to determine which group favours the significant difference in the sub-dimension of mathematical thinking skills. When the values were examined, it was determined that female participants' arithmetic means was significantly higher than that of males in the sub-dimension of mathematical thinking skills (female $\bar{x}$= 3.59, male $\bar{x}$= 3.46).

Table 6: *Results of the T-Test Between the Education Variable of the Athletes and the MTS Sub-Dimensions*

Sub-dimensions	Groups	n	$\bar{x}$	SD	df	*t*	p
Reasoning	High School	325	3.98	0.55	457	-1.122	0.262
	University	134	4.05	0.47			
High Level Thinking Disposition	High School	325	3.87	0.58	457	0.322	0.747
	University	134	3.85	0.52			
Mathematical Thinking Skill	High School	325	3.53	0.39	457	0.422	0.673
	University	134	3.51	0.34			

Problem Solving	High School	325	3.50	0.45	457	1.037	0.300
	University	134	3.45	0.44			

According to Table 6 above, no significant differences were found between the education variable and MTS sub-dimensions. But mean scores for high school students in high-level thinking disposition, mathematical thinking skills, and problem-solving sub-domain are higher than those for university students.

Table 7: *Correlation Table between Age Variable and MTS Sub-Dimensions*

	Age	Reasoning	High Level Thinking Disposition	Mathematical Thinking Skill	Problem Solving
Age	1	-.003	-.037	-.061	-.078

When Table 7 above is examined, it is seen that there are no significant relationships between the age variable and mathematical thinking scale sub-dimensions.

Table 8: *Correlation Table between The Sports Year Variable and MTS Sub-Dimensions*

	Sports Year	Reasoning	High Level Thinking Disposition	Mathematical Thinking Skill	Problem Solving
Sports Year	1	**.111***	.013	.042	.002

When Table 8 above is examined, it is seen that there is a low level of positive correlation between the sports year and reasoning sub-dimension ($p<0.05$; $r=0.111$). Thus, it can be said that reasoning sub-dimensions are significantly correlated with sports year.

4. Conclusion and Discussion

This study was conducted to examine individual and team athletes' mathematical thinking levels regarding different variables (gender, educational status, age, and sports year). Findings suggest that the mathematical thinking levels of participants who played individual and team sports were compared in the sub-dimensions of reasoning, higher order thinking disposition, mathematical thinking skills, and problem-solving (Q1). As a result of the analysis, it was determined that there was no statistical difference between individual and team athletes' mathematical thinking levels. When past studies were examined, it was seen that there were findings contrary to the results of this study. When the studies conducted were examined, it was emphasised that there is a significant relationship between doing team sports and problem solving, which is a sub-dimension of mathematical thinking skills (Önal, İnan & Bozkurt, 2017; Canan & Ataoğlu, 2010; Singh, Singh & Singh, 2015). However, in some studies, it was emphasised that there is a significant relationship between individual sports and mathematical thinking skills or problem-solving, which is a sub-dimension of mathematical thinking (Özdemir, Güreş & Güneş, 2012; Yönal, 2018). It is possible that the different results obtained in studies were related to the characteristics of the sample groups studied. In this study, it is thought that this result was obtained because a large sample group from different sports branches was obtained. Therefore, the results obtained in previous studies explain the result that there are no statistical differences between individual and team athletes' mathematical thinking levels. The fact that there is a relationship between physical activity and cognition (Esteban-Cornejo, 2015) concludes that doing individual or team sports affects the level of mathematical thinking.

When the mathematical thinking levels of athletes were examined according to the gender variable, which is the second sub-problem of the study (Q2), it was concluded that female athletes got higher scores in the sub-dimension of mathematical thinking skills. Similarly, Fox et al. (2010) found that female participants exhibited more successful academic performances in their study examining the relationship between high school and secondary school students' participation in physical activities, team sports, and academic achievements. However, studies on the subject indicate that predominantly male athletes have higher mathematical thinking skills than female athletes (Arslantaş, Malbeleği, & İnan, 2018; Tekin, 2009). Contrary to these results, there are also studies indicating no statistically significant differences in mathematical thinking levels in terms of the gender variable (Önal, İnan, & Bozkurt, 2018; Temel & Ayan, 2015; McNaughten & Gabbard, 1993).

According to the education variable, the third sub-problem of the study, the athletes' mathematical thinking levels did not differ significantly (Q3). As is known, mathematical thinking can be developed. However, no differences in education levels may be related to whether there is an education in this direction or whether this education is effective or not. Suppose the education in the high schools and universities (where the participants study) was carried out with similar classical methods, which do not develop mathematical thinking; in that case, the findings can be considered compatible. Contrary to this result, Önal, Inan, & Bozkurt (2018) found that the individual and team athletes' total scores on mathematical thinking levels at the primary education level were significantly higher than other education levels. They found that athletes with the lowest scores were also those who continued their undergraduate education. Fox et al. (2010) investigated the relationship between high school and middle school student's participation in physical activities and team sports and their academic achievement. They found a significant relationship between physical activities and academic achievements of high school children's participation in team sports and secondary school students' participation in team sports.

According to the age variable, the mathematical thinking levels of the athletes, which is another sub-problem of the study, did not differ significantly (Q4). Similarly, in a study in which the effect of physical activities on cognitive functions was tested, it was determined that it provided equal benefits in different age groups (Ellemberg & St-Louis-Deschênes, 2010). However, Arslantaş, Malbeleği, & Inan (2018) suggested that as the athletes get older, their mathematical thinking skills also increase. Hillman et al. (2009) stated that medium-intensive aerobic exercises could be an important factor contributing to cognitive development and increase in academic performances in pre-adolescent children. It is thought that this situation may be related to the intensity of the participants taking mathematics courses.

A significant low-level relationship was found between the sports year variable (Q5) and the reasoning skill. According to this finding, it can be said that as athletes' experiences increase, there is an increase or improvement in the level of reasoning skills. Considering the effect of sports on mathematical thinking, it can be expected that the level of mathematical thinking will increase in parallel with the increase of the sports year. The mathematical skills of children who learn mathematics in an environment designed with physical activities and music develop significantly more than children who learn mathematics with joint number activities (Elofsson et al., 2018). Have et al. (2018) enabled primary school children to participate in a 9-month physical activity. They concluded that participation in activities positively affected mathematical achievements and stated that physical activities would contribute to higher academic success. Furthermore, using physical activities in academic courses' teaching contributes to mathematics and writing performances (Mullender-Wijnsma et al., 2016). Therefore, it can be said that as the rate and duration of doing sports increases, the level of mathematical thinking will increase.

As a result, mathematics/geometry and physical activity integrated teaching methods are more effective than traditional teaching methods common in schools today (Hraste et al., 2018). When the results obtained in this study are considered, it is thought that the inclusion of individual and team sports in the education programs will contribute to mathematics and academic success.

5. Recommendations

In new studies, it is recommended to conduct a similar study with more participants, including primary and postgraduate students. Additionally, similar studies can be conducted with different branches other than the types of sports included in this study or with the same branches but with more balanced groups in terms of the number of participants.

6. Conflict of interests

The authors declare that there is no conflict of interests.

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