Contents Lists is Available Online
International Journal of Motor Control and Learning (IJMCL)
Journal Homepage: www.ijmcl.com

Comparison of the Moderating Effect of Mental Rotation Ability on the Amount of Learning by Mental Exercise Method in a Motor Skill

Mohammad Taghi Aghdasi[a], Nahideh Rahmani[b]*

[a]Professor, Motor Behavior Department, Faculty of Sport Sciences, Tabriz University, Tabriz, Iran
[b]M.S, Motor Behavior Department, Faculty of Sport Sciences, Tabriz University, Tabriz, Iran

Keywords

Mental Rotation Ability
Mental Exercise
Forehand Table Tennis Skill

Nahideh Rahmani,
Email: nahidehrahmani@ymail.com

Received: 2020/01/16
Accepted: 2020/04/30
Published: 2020/05/20

Abstract

Background: There are few researches on teaching people about mental rotation skills. The first step in this field is to determine which educational programs help individuals improve their performance.
Introduction: The purpose of this study is to compare the moderating effects of mental rotation ability on the amount of learning by mental exercise method in a motor skill (table tennis forehand).
Method: For this purpose, a semi-experimental method and a pre-test and post-test research design were used. Firstly, all subjects were evaluated by mental rotation test and then, according to the test scores, they were divided into two groups each consisting of 15 individuals (a mental exercise group with high mental rotation ability) and (a mental exercise group with low mental rotation ability). Duration of intervention in this research was 4 weeks, 3 sessions per week and each session lasted for 20 minutes. After completion of exercises, acquisition, retention (immediate and delayed) and transfer tests were taken from both of the groups. Mental rotation ability of the subjects was assessed using MRT mental rotation test. In addition, the level of their mental imagery was evaluated by a movement imagery questionnaire- 3 and forehand table tennis skill was assessed by a hit accuracy test. For analysis of the data, repeated measure test was performed using SPSS software.
Results: The results of intra-group comparison for high and low mental rotation variable showed that four weeks of mental exercise intervention caused a significant difference compared to the pre-test.
Conclusion: There is a difference between acquisition, retention and transfer of forehand table tennis skill in individuals with high and low mental rotation in mental exercise group.

Introduction

Learning in general and motor learning in particular, are defined as learning dexterous behaviors in different ways (Shmidthe & Lee, 2005). One of the important features of motor learning is that all individuals go through certain stages to learn skills (Magil,1394). In other words, learning process requires time and practice, and in order a beginner person become a skilled one, goes through separate and sequential stages that, along with progress in different stages of learning, changes are made to execute and executer (Kakar, 1389). One of the main goals in motor learning, is to identify the variables that are involved in maximizing learning (Shojaei et al, 1394). Undoubtedly, many factors influence learning motor skills, including observation, feedback, physical exercise, mental exercise (Anaraki et al, 1391). But it can be argued that learning is obtained as a result of exercise; whether physical or mental exercises. In general, one of the features of learning motor skills is its emphasis on the benefits of organizing exercise (Shmidthe & Lee, 2005). There are several ways to train and exercise motor skills; Since most skills include physical and cognitive factors; As a result, it has been suggested that, in addition to physical exercise, cognitive interventions such as imagery, observational exercise can also facilitate learning of skills (Magil, 2004). Although, motor learning is obtained by execution and practical exercise (Weinberg & Gould), but there are also methods that are considered by coaches as a complement to physical exercise in order to learn skills better and faster; One of these methods is mental exercise (Kakar, 2010). There are several types of mental exercise, But the most common form of mental exercise is mental imagery (Weinberg & Gould, 2015). MC Morris (2004) states that mental imagery, like physical exercise, creates a model of skill in the central nervous system. Imagery involves visualization or cognitive browsing of motion without physical execution. mental exercise is used in two ways; in first case, mental exercise is used in order to be prepared for execution which may occur immediately; In this type of use, mental exercise is a tool for action preparation. The second mental exercise approach combines the characteristics of both acquisition and execution positions, which is created by facilitating memory storage and retrieving it (Magil, 2004). The findings of Teymouri (1391) indicates that using both mental and physical exercises increase learning of both components of a motion program and a tracking skill parameter significantly; and also mental exercise can be a good alternative to physical exercise during rehabilitation and learning two parts of the generalized motion program and the tracking motor skill parameter; specially when a person can't use her/ his body to perform physical activity and exercise (Teymouri, 1391). Studies of the effectiveness of mental exercise in acquiring motor skills, compare the conditions of physical exercise and mental exercise with controlled group without (Magil, 2004). the findings of research (Plates & Landers,1983; Hirde &Thimas & Hooran) generally indicates that physical exercise is better than other conditions and mental exercise is better than a state without exercise. These findings are important even on their own, since it shows that mental exercise is helpful in acquiring skills. The effect of using a combination of mental and physical exercises is also more interesting than this. Several factors seem to affect the level of effectiveness of imagery on performance improvement (Weinberg & Gould, 2015). These factors should be considered in order to increase the effectiveness of imagery: the nature of the assignment, ability to imagery, The skill level of executer (Weinberg & Gould, 2015). Most of the researchers know that intelligence consists of a combination of attributes and talents that are not directly visible (Atkinson & et al., 2014). According to Spearman 1904, intelligence is a unitary cognitive ability, which he called it overall intelligence factor. In his opinion, the overall intelligence factor enables reasoning, problem solving and obtaining good results in all cognitive fields. In other words, if a person's overall intelligence is high, so could achieve a good success in most of the areas; but in the opposite case, the result will be poor. Cattel's theory of intelligence factors is such that; the overall intelligence factor is divided into two factors: fluid intelligence and crystallized intelligence. Fluid intelligence is the basic ability of reasoning that depends primarily on the neural structure and is caused by inheritance. Crystallized intelligence grows through the use of fluid intelligence in various learning experiences (Cattel, 1974). Various researchers provided different definitions of spatial abilities, but the definition that most researchers agree on (Scotte, 1999; Earls & evans & Jonson & Louis wang, 2001; Cooper & Reagan, 1981) is the definition of Lin and Patterson (Poal & Lehman, 2004). They divide spatial abilities into three categories: A) spatial perception: the ability to infer the direction of an object with regard to one's own direction. B) mental rotation: the ability to visualize the rotation of a visual actuator or based on the definition of Just and Carpenter (quoted from Voyer, Bryden, 1995) it is the ability to produce a mental representation of a two- or three-dimensional structure, and then the evaluation of features of that representation. C) spatial imagery: It's a bit more complicated, and is the ability to manipulate provided spatial information (Earls & et al, 2001; Paol & et al, 2004). Spatial abilities are a key component of fluid intelligence and include cognitive processes consisting of visualization, position detection, and mental rotation (Lin & Petterson, 1985). Among these factors, mental rotation ability is an important factor. Mental rotation assignments are widely described as exercises requiring mental multi positioning of a two-dimensional or three-dimensional object (Dehghanizadeh et al., 1395). Higher motor performance activates involved areas in similar activities in the cortex of the brain which can be considered as an advantage for recovery and recognizing the position in the mental rotation ability of individuals; more harmonious spatial attention in athletes is an example of these differences. Whenever, spatial development for athletes who coordinate in sports that require spatial cognition and perception such as tennis, football or golf. This coordination of spatial attention in active individuals, helps focus attention on spatial ability and increasing the level of accuracy in gaining activities that need attention (Dehghanizadeh & et al., 1394). Therefore, the spatial attention and higher precision of active individuals when solving the mental rotation assignment (as a spatial attention) can lead to more favorable results by these individuals. Mental rotation ability interacts with Cognitive and motor variables (Adams, 1394). A review of the literature reveals that factors such as motor experience (Johnson, 2013), music (Pietsch & Johnson, 2012), computer games (Cherney, 2006) sex (Voyer & Bryden, 1995), age (Carthy, 2010), and even hormone levels such as testosterone (Martin & et al, 2008) could affect the optimal performance of mental rotation ability. It has been accepted for ages that mental browsing is helpful in learning and executing. However, most of scholars believe that mental browsing should only be done with physical review. Research has shown that people who use mental browsing with physical exercise, learn sooner than those who use only physical browsing. One of theories that confirms the benefits of using mental exercise is that, by thinking of our skills, we create an image or model of how to perform gained skill in CNS (Mc Mouris, 1393). As mentioned before; researchers recommend that, in order to accelerate the amount of one's learning in a motor skill, mental browsing along with physical exercise should be included; this research seeks to find out that whether mental rotation ability as one of the components of intelligence (a cognitive factor) and mental exercise (cognitive intervention) increases the amount of learning a skill or not. However, so far no studies have been reported on the moderating effect of mental rotation ability on the factor and mental exercise (imagery). The present study further reveals the importance and necessity of this issue and seeks to answer the question of whether mental exercise, along with the mental rotation ability affects the amount of learning a motor skill or not.

Method

The research method is semi - experimental with pre-test and post-test design. In order to investigate the moderating effect of mental rotation ability along with mental exercise on the amount of learning of a motor skill test, we divide the samples according to the scores obtained from mental rotation test and mental imagery ability in 2 groups of 15 individuals (mental exercise + high mental rotation ability), (mental exercise + low mental rotation ability) and from each group, acquisition, final acquisition (immediate retention), delayed retention and transfer tests, as well as mental imagery questionnaire from the mental exercise group were taken separately. Also, the choice of people based on this test is such that; people who score 12 upwards in the high mental ability group and those who score 12 to the bottom will be classified into a low mental rotation group. At the end of sessions 6 and 12, participants were asked to explain the nature of mental images, follow the pilot design guidelines and whether or not they used visual imaging outside of the training sessions. Finally, the quality of the images they were able to illustrate was determined. In the 6th session, both groups received the acquisition test and its scores were recorded. At the end of the session, 12 final acquisition tests (immediate retrieval), after one day, the delay test was performed on the subjects of both groups and their scores were recorded. Also, after 2 days, the test was transferred and the rates were recorded by changing the conditions of the training place of the subjects (transfer of table tennis to another place, the presence of classmates and teachers, changing the ambient light and temperature conditions).

Statistical population and sample of the research

The statistical population of this study is female students of Misag non-profit high school of Tabriz (first year high school), 30 qualified volunteers with lack of familiarity with skills, right handed, healthy, without any physical defects, without any defect in the visual system were selected as a sample and after performing mental rotation test and imagery ability questionnaire and according to the scores that each subject received in tests, they were randomly assigned to two groups of 15 individuals with high mental rotation or low mental rotation; then they were categorized equally and homogeneously in two groups of 15 (mental training + high mental rotation ability) (mental training + low mental rotation).

Tools and method of data collection

1. **movement imagery questionnaire**

(Williams & et al., 2012**) -** This questionnaire is a revised version of movement imagery (Hall & Marin, 1997) made by Williams and et al (2012). The questionnaire measures movement imagery, external visual imagery and internal visual imagery. In general, this questionnaire contains 12 questions, each subscale has four questions. How to score this questionnaire is based on the seven-value Likert scale from very difficult to very easy range. Before the participants begin to complete the questionnaire, a definition of external visual imagery, internal visual imagery, and movement imagery, was provided that made the participants more aware of the questionnaire.

Starting status: Pair your feet and stand up, and then put your hands on both sides.

Doing motion: Bend your right knee as far as you can and then bring up. Now lower your right foot and again stand on two feet. Do this slowly.

Mental activity: Imagine that you're in the starting status. Try to feel this motion without doing it. Now evaluate difficulty or ease of feeling this mental activity.

Table 1. An example of the questions of mental imagery questionnaire.

7	6	5	4	3	2	1
It was very easy to feel	It was easy to feel	It was a little easy to feel	Neutral (neither hard nor easy)	It was a bit hard to feel	It was hard to feel	It was very hard to feel

Forehand hit accuracy test

The task of this forehand hit accuracy test research was carried out on a standard table of 274 cm, 152.5 cm wide, 76 cm high and 15.25 cm height of the tour. The accuracy of this skill is evaluated using forehand hit accuracy test as follows. 50×50 squares are plotted on the table, there are three small squares of 25 × 25 in these squares. For each person, 20 balls will be sent (close and challenging), and each person receives points according to the area that returns the ball. Sending a ball to 1th zone, had 3 points; to 2th zone, 2 points; other areas,1 point; and inaccurate hit will not be pointed. individual's score in each block is calculated and the mean of the blocks is recorded as the score of each individual.

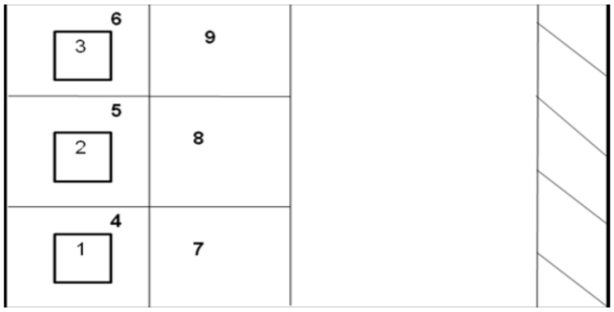

Figure 1. Tennis table scores for hit accuracy test.

Mental rotation test

This test consists of the numbers provided by Shepard and Metzler (1978), and in fact, it comes from the AutoCAD mapping version and the Vanderberg and Kios's mental rotation test. Mental rotation test is in 2 forms: 1. V form which is comprised of 20 questions, 2. k form which is comprised of 24 questions. The mental rotation test used in this research will be a set of 24 questions. Each question includes a target shape on the right and four moving shapes on the left. Two shapes of four moving shapes, are rotated form of the target shape and the other two shapes can't be identical with the target shape. The test consists of a researcher-made checklist of personal information, an introduction (page 1 and 2) to get acquainted with the test and pages 3 to 6 covering the main test. In introduction part, the method of scoring and conducting the test, along with several similar examples to the original test are presented. The main test has 24 problems, which will be taken as 12-problems tests. The duration of each test is 4 minutes with a rest period of 2 minutes between the two tests. There are two ways to score this test. The first is to record 1 score for each correct answer and deduct 1 score for each wrong answer. In this case, the maximum score is 48. However, in this study a more common scoring method was used, for 2 correct answer, 1 score was recorded and no scores were recorded for 1 correct answer (1 score is considered only for 2 correct answers). This means that the maximum score in this test is 24. A proper description of the mental rotation performance and its processes can be found in the Voyer's work (Voyer & Bryden, 1995) and special information for the revised k and v tests, as described here, can be found in Peters & Chisholem & Leang (1995); Peters & et al. (1995). Also, how to choose people based on this test is that those who gain higher than 12 will be classified into the high mental rotation group and those whose score is below 12 will be classified into the low mental rotation group.

Information analysis method

In this research for statistical analysis, mean and standard deviation were used as descriptive statistics. Before examining the data, the Shapiro Wilk test was used to examine the natural distribution, ANOVA test with repeated measurements of repetitive data on the mental rotation test was used to examine the between-group and within -group differences in the pre-test, acquisition, immediate retention, delayed retention and transfer. Also, repeated tests were used based on the estimation of marginal means to determine the position of differences for between -group and within -group factors. One-way analysis of variance (ANOVA) was used to unify the groups in the pre-test and analysis stages in the acquisition, immediate retention, delayed retention and transfer. Data analysis was performed using SPSS version 22.

Results

In Table 1, information about the descriptive statistics of the sample, including number, mean, and standard deviation of mental rotation in the pre-test and post-test, are presented.

As mentioned above, Shapiro Vilk test was used to examine the distribution of data in the pre-test scores which confirmed the assumption of the natural distribution of data. Therefore, a parametric analysis of variance analysis with repeated measurements can be used to observe the effect of exercise (Table 2, 3).

The results of intra-group comparisons for the variable of high mental rotation ability showed that four weeks of mental exercise intervention (p <0/0001) caused a significant difference compared to the pre-test stage.

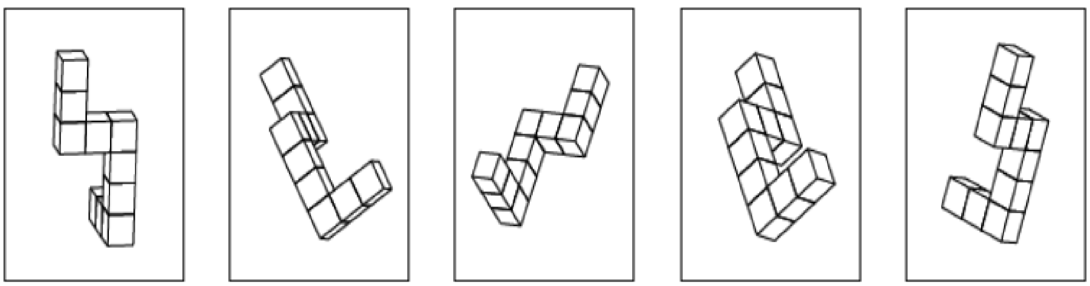

Figure 2. an example of mental rotation test (Peters et al, 1995).

Table 2. descriptive statistics of high and low mental rotation ability variable in mental exercise

THE VARIABLE OF DESCRIPTIVE STATISTICS					
STAGE	*Pre-test*	*Acquisition*	*Immediate retention*	*Delayed retention*	*Transfer*
NUMBER	*15*	*15*	*15*	*15*	*15*
MEAN	*66/47*	*79/89*	*88/80*	*96/60*	*102/80*
STANDARD DEVIATION	*1/767*	*2/278*	*10/213*	*9/425*	*1/944*

Table 3. results of repeated ANOVA for intra group differences of high mental rotation ability in mental exercise group.

Source of change	*Total squares of deviation from the mean*	*Degree of freedom*	*Average squares of deviations from the mean*	*F value*	*significance*
***within** group differences*	*12262/480*	*4*	*3065/620*	*117/463*	*0/0001*
***within** group error*	*1461/520*	*56*	*26/099*		

The results of intra-group comparisons for the variable of low mental rotation ability showed that four weeks of mental exercise intervention (p <0/0001) caused a significant difference compared to the pre-test stage.

Table 4. results of repeated ANOVA for intra group differences of high and low mental rotation ability in mental exercise group

Significance	Error deviation mean	Mean difference	stages	group
0.0001	1.87	13.40	Pre-test_ acquisition	high mental rotation + mental exercise
0.0001	2.85	22.33	Pre-test_ immediate retention	
0.0001	2.64	30.13	Pre-test_ delayed retention	
0.0001	2.62	36.33	Pre-test_ transfer	
0.0001	1.43	8.93	Acquisition_ immediate retention	
0.0001	1.34	16.73	Acquisition_ delayed retention	
0.0001	1.44	22.93	Acquisition_ transfer	
0.0001	0.68	7.80	immediate retention_ delayed retention	
0.0001	1.37	14	_immediate retention transfer	
0.0001	0.96	6.20	_delayed retention transfer	
Significance	Error deviation mean	Mean difference	stages	group
0.0001	0.55	4.40	Pre-test_ acquisition	Low mental rotation + mental exercise
0.0001	0.77	9.80	Pre-test_ immediate retention	
0.0001	0.79	16.56	Pre-test_ delayed retention	
0.0001	0.84	21.93	Pre-test_ transfer	
0.0001	0.37	5.40	Acquisition_ immediate retention	
0.0001	0.67	12.16	Acquisition_ delayed retention	
0.0001	0.82	17.53	Acquisition_ transfer	
0.0001	0.80	7.89	immediate retention _ delayed retention	
0.0001	1.28	13	immediate retention _ transfer	
0.0001	0.87	5.89	_Delayed retention transfer	

The results showed that the pattern of changes between different stages of learning, varies in high and low mental rotation ability (p=0/0001). Also, in general, there is a difference between high and low mental rotation ability (p=0/005), regardless of the effect of learning stages in the mental exercise group.

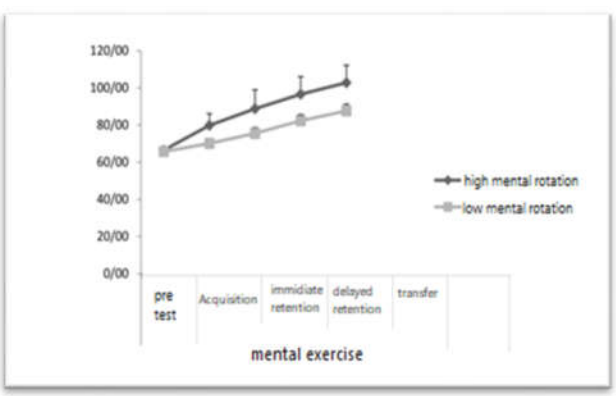

Diagram 1. Changes of mental exercises in individuals with high and low mental rotation ability before and after mental exercise intervention.

Discussion and Conclusion

These findings were similar to Dehghanizadeh et al. (1393, 1394, 1395). Also, based on the findings of this hypothesis, we didn't find any inconsistent study with this. Dehganizadeh et al. (1395), in their research entitled "The impact of working memory exercises and physical exercise on mental rotation", found that aerobic exercise and working memory exercise affect mental rotation ability; findings indicate that cognitive abilities are facilitated by cognitive and motor interventions.

This finding was also consistent with the results of Dehghanizadeh et al (1394). Dehghanizadeh et al., In their research entitled "The impact of motor and cognitive experience on boys' mental rotation ability " there was no significant difference between mental rotation of wrestling group (motor experience) and computer games group (cognitive experience). These findings show the positive effects of motor and cognitive experience on cognitive development of individuals (mental rotation). This finding was consistent with the results of Dehghanizadeh et al (1394). Dehghanizadeh and et.al (1394) conducted a research entitled "the impact of moderate-intensity aerobic exercise on working memory and mental rotation". The results of multivariate analysis of variance analysis showed that moderate-intensity aerobic exercise has an effect on the performance of working memory and mental rotation ability. In other words, moderate-intensity aerobic exercise facilitates working memory and improves mental rotation ability. In fact, the present research reveals the interaction and the connection between motion and cognitive processes more than before. This finding was consistent with the results of Dehghanizadeh et al (1393). Dehghanizadeh and et al. conducted a research entitled "Comparing the mental rotation of active and inactive students." The findings showed that, there is a significant difference between mental rotation performance of physical education students and human sciences students. In general, results indicate the superiority of active female students and there was a significant difference between them and male students in mental rotation ability. Since physical activity increases the mental rotation, it can be assumed that physical activity also increases other cognitive areas and this case is worth to run in education process.

Mental rotation ability is as an important and examined factor. Mental rotation tasks are widely described as exercises requiring mental multi positioning of a two or three-dimensional object (Dehghanizadeh et al, 1395). Higher motor performance actives involved parts in similar activities in the cortex of the brain; A more coherent spatial attention in athletes is an example of these differences. Whenever, spatial development for athletes who coordinate in sports that require spatial cognition and perception such as tennis, football or golf. This coordination in spatial attention on active people helps focus attention on spatial ability and increase the level of accuracy in acquiring activities that require attention (Dehghanizadeh et al, 1394). Therefore, spatial attention and higher precision of active people when solving the mental rotation task (as a spatial ability) can lead to gain more favorable results by these individuals. Mental rotation ability interacts with cognitive and motor variables (Adams, 2014). A review of the literature indicates that factors such as motor experience (Johnson, 2013), music (Pietsch & Johnson, 2012), computer games (Cherney, 2006), sex (Voyer & Bryden, 1995), age (Carthy, 2010), And even hormone levels such as testosterone (Martin & et al, 2008) could affect optimal functioning of mental rotation ability. Among these factors, physical activity has the greatest effect on mental rotation ability (Dehghanizadeh et al, 1395).

References

1. Schmidt, Richard, E. (1386). Motor learning and performance, from basic to run, Translated by Mehdi Namazizadeh and Mohammad Kazem Vaez Mousavi, Samt Publications, Tehran, 10th Edition. quoted by Ehsan Khajevi Ravari et al (1393).
2. Schmidt, Richard, E. Dei, Lee, Timothy. Motor learning and control. Translated by Rasul Hemayat talab, Abdollah Ghasemi. Science and Motion Publications. Tehran, Second Edition.
3. Weinberg, Robert s, Gould, Daniel. (2015). Foundations of sport and Exercise psychology" Translated by Mohammad Kazem Vaez Mousavi. Hatmi Publications, Tehran.
4. Kakar, Cheryl A. (1389). "Motor learning and control for users". Translated by Behrouz Abdoli, Mohammad Taghi Aghdasi, Hasan Mohammadzadeh, Shahid Beheshti University Publications, Tehran.
5. MC Morris, Terry (1393). " Acquisition and execution of sports skills". Translated by Rasul Hemayat talab, Abdollah Ghasemi. Bamdad ketab publications, Tehran.
6. Magil, Richard (1394). Motor learning, concepts and applications". Translated by Mohammad Kazem Vaez Mousavi and Masoumeh Shojaei. Bamdad ketab publications, Tehran.
7. Weinberg, Robert S. Gul, Daniel (1394). "basics of sport and exercise psychology". Translated by Mohammad Kazem Vaez Mousavi and Ibrahim Moteshraei. Hatmi publications, Tehran. second edition.
8. Ganji, Hamza. (1386). "General Psychology". Savalan Publications, Tehran. 39th edition.
9. Atkinson, Rita. Atkinson, Richard. Smith, Edward. Bam, Daryl. Hoeksma, Susan (2014). "The field of Hylgard psychology " Translated by Mohammad Taghi Barahani, Behrouz Birshak, Mehrdad Beyk, Reza Zamani, mehrnaz Shahr Aray, Roshd publications, Tehran.
10. Dehghanizadeh, Jalal. Mohammadzadeh, Hasan. Sadat Hoseyni, Fatemeh. (1393). "comparison of mental rotation of active and inactive students". Motor behavior, number 16, p.p: 93 – 106.
11. Dehghanizadeh, Jalal. Mohammadzadeh, Hasan. Sadat Hoseyni, Fatemeh. Fall (1392). "the impact of gymnastics training program on mental rotation". Journal of Cognitive Psychology, 1th period, number 1.
12. Pourmohseni, Fereshteh. Vafaei, Maryam. Azadfallah, Parviz (1383). "the impact of computer games on teenagers' mental rotation ability". New cognitive science. Year 6, number 3, 4.
13. Habibi, Ramin. Farid, Abolfazl. Shaban Basim, Farnaz (1396). " Comparing the Effects of mental rotation and phonological awareness on the accuracy, speed and reading comprehension of students with dyslexia in Tabriz city, In the school year 1394 – 1395". Scientific Journal of Research of Arak university. Year 20, number 2, p.p: 10-21.
14. Dehghani, Mahrokh. Sarvari, Sepideh (1395). " Yoga and mental rotation ability". www.civilica.com.paper:CSFALL01CSFALL01_032
15. Alipour, Ahmad. Baghban Porshokouhi, Alireza (1387)." Lateralization of family and mental rotation ability". New cognitive science. Number 10, p.p: 63-74.
16. Farsi, Alireza. Abdoli, Behrouz. Basiri, Fahimeh. (1394). "the impact of Vision and skill exercises on learning forehand hit in tennis on the table". Motor behavior journal, and sport psychology. Number 12. p.p: 997- 1006.
17. Sohrabi, Mahdi. Farsi, Alireza. Fooladian, Javad. Summer (1389). "determination of validity and reliability of the Persian version of revised movement imagery questionnaire. Institute of Physical Education and Sport Sciences. Number 5, p.p: 13- 24.
18. Moghadam, Amir. Rezaei, Meysam. Saranirad, Mahin. Spring (1393). " the effect of mental imagery with physical exercises on the implementation and learning of free basketball throwing in both right and left handed groups". Motor behavior. Number 15, p.p: 87-100.
19. Anaraki, Maliheh. Zolfaghari, Rashid. Heydarbeyghi, Jalal. Winter (1391). "The effect of self-talk and feedback on increasing the level of motor skills learning on students of mechanic engineering, Islamic Azad University of Roodehen". Journal of Scientific Educational Management Research. Year 4. Number 2. Sequence 4.
20. Teymouri Khorvi, Mostafa. Ahmadi, Ibrahim. Abdoli, Behrouz. Farsi, Alireza (1391). "comparing the impact of mental exercise and physical exercise on Generalized motion program and rotational tracking skill parameter" Volume 8. Number 2.
21. Hojati, Ali. Vaez Mousavi, Seyed Mohammad Kazem. Khabiri, Mohammad (1394). " Features of the Persian version of the movement imagery questionnaire – 3" Quarterly Journal of Sports Psychology Studies. Number 14. Winter (1394). p.p:1-16.
22. Mohammadalinezhad, Ataollah. "learning tennis on table step by step". Publication: Karaj Education

Department. Department of Education Physical Education, Institute of Science and Sports Publishing. Pages: 5 – 65.

23. Farokhzadeh, Fatemeh. (1395). " Comparison of the effect of mental and physical rotation exercises on the balance and fall of the elderly woman". Master's Thesis. Tabriz University. Thesis Director, Mohammad Taghi Aghdasi.
24. Jansen P, Pietsch S (2010). Physical activity improves mental rotation performance Creative Educ. 1, 58-61.
25. Shepard R N, Metzler J. Mental rotation of three-dimensional objects. Science 1971; 171; 701-703.
26. Linn MC, Peterson AC (1985). Emergence and characterization of sex-differences in spatial ability: A. meta- analysis. Child Development. (56); 1479-98.
27. Cherney ID, London KL (2006). Gender-linked differences in the toys, television shows computer games, and outdoor activities of 5-to 13- year- old children. (54);717-605.
28. Peters M, Laeng B, Latham K, Jackson M, Zaiyouna R (1995). Richardson C. A. Redrawn Vandenberg & Kuse Mental Rotations Test: Different versions and factors that affect performance. Brain and Cognition. .28; 39-58.
29. Pietsch S, Jansen P. (2012). Different mental rotation performance in students of music sport and education. Learning and Individual Differences. 22; 159-63.
30. Jansen P, Titze C, Heil M (2009). “The influence of juggling on mental rotation performance Journal of International Sport Psychology. 40; 351-9.
31. Peters, M., Chisholm, P., Laeng, B. (1995). “Spatial ability, student gender and academic performance". Journal of Engineering Education. 84; (4): 69-73.
32. Peters, M., Laeng, B., Latham, K., Jackson, M., Zaiyouna, R. (1995). “Richardson C. A Redrawn Vandenberg & Kuse Mental Rotations Test. Different Versions and Factors that affect Performance". Journal of Brain and Cognition. 28; 39- 58.
33. Vandenberg, S. G., Kuse, A. R (1978).” Mental rotations, a group test of three- dimensional spatial visualization, Perceptual and Motor Skills “. 47; 599-604.
34. Voyer, D., Voyer, S., Bryden, M.P (1995).” Magnitude of sex differences in spatial abilities: A metaanalysis and consideration of critical variables. Psychological Bulletin”. 117, (2), 250 -270.
35. Mc Carthy, L, A. (2010). “Improving older adult's mental rotation skills through computer training. Thesis of Degree Doctor of Philosophy “. University of Akron; 59-67.
36. Moreau, D., Clerc, J., Mansy-Dannay, A., Guerrien, Alain (2012).” Enhancing spatial ability through sport practice. Evidence for an effect of motor training on mental rotation performance”. Journal of Individual Differences, 33 (2), 83-88.
37. Jansen, P., Lehmann, J (2013).” Mental rotation performance in soccer players and gymnasts in an object-based mental rotation task”. Advances in cognitive Psychology. 9 (2), 92-98.