Contents lists available at Islamic World Science Citation Center (ISC)

International Journal of Motor Control and Learning (IJMCL)

Journal Ho me pa ge: htt p:/ / www.ij mc l .c om

Effect of Motor Imagery and Self-Talk Combined with Physical Exercise on Motor Memory Consolidation in Adolescents

Sajjad Heydaripour [a], Behrouz Abdoli [b], Parvaneh shamsipour Dehkordi [c,*], Yannis Theodorakis [d]

[a] Department of Motor Behavior, Faculty of Sport Sciences, Shahid Beheshti University, Tehran, Iran. Email: Sajjadheydaripour@sbu.ac.ir
[b] Department of Motor Behavior, Faculty of Sport Sciences, Shahid Beheshti University, Tehran, Iran. Email: behruzabdoli@sbu.ac.ir
[c] Associate Professor, Department of Motor Behavior, Faculty of Sport Sciences, Alzahra University, Tehran, Iran. (corresponding author). Email: p.shamsipour@alzahra.ac.ir
[d] Department of Physical Education and Sport Sciences, University of Thessaly, Thessaly, Greece. Email: theodorakis@pe.uth.gr

A R T I C L E I N F O

Article history:

Received: 2022/04/29
Accepted: 2022/11/24
Available online: 2022/12/16

Keywords:

Adolescence
Cognition
Memory
Mental Practice
Motor Learning

A B S T R A C T

Background: Consolidation in motor memory depends on various factors. The present study aimed to investigate the effect of physical exercise (PE) combined with motor imagery (MI) and self-talk (ST) on motor memory consolidation in adolescents.
Method: The participants were 45 unskilled right-handed young males (13 ± 1.8 years), randomly divided into three groups of PE, ST + PE, and MI + PE. After the pre-test participants practiced fingers overhead passing and forearm passing for 3 sessions on three consecutive days. The acquisition test was performed immediately after the last training session and the retention one a week after that.
Results: The results of ANOVA with repeated measures indicated that all three groups had experienced consolidation. We found that better performance means of the combined ST+PE group with that of the MI+PE one and the PE group (P = 0.005). Comparing motor performance indicated that the combined ST group, more than the other two groups, and the combined MI group experienced more enhancements in consolidating their motor memory than the PE group (P = 0.005).
Conclusion: Overall, these findings indicated the importance of ST in improving motor memory consolidation.

1. Introduction

Adolescence is the transitional phase of human physical and mental development that occurs between childhood and youth (Orben, Tomova, & Blakemore, 2020). This stage includes biological, social, and psychological changes (Christie & Viner, 2005; Orben et al., 2020). Teenage athletes, like their adult counterparts, learn and develop their sports skills by exercising. Then, they are asked to use these skills in the competition (e.g., AFC U-16; or Youth Olympic Games) (Chroni, Perkos, & Theodorakis, 2007). Preparing teenage athletes and bringing them to high levels of skill becomes one of the most interesting topics for coaches. However, qualifying in doing every skill requires intense exercise and coaches are helping the athlete to reach this level of competence (Camiré, Forneris, Trudel, & Bernard, 2011; Weinberg & Gould, 2014).

Many coaches focus mainly on helping the athletes to gain skills by physical exercises (PE) and sometimes the mental skills are totally ignored (Camiré et al., 2011; Weinberg & Gould, 2014). However, some researchers emphasized the cognitive strategies as appropriate interventions to improve the performance of athletes (Debarnot, Abichou, Kalenzaga, Sperduti, & Piolino, 2015; Hatzigeorgiadis, Zourbanos, Latinjak, & Theodorakis, 2014; Thelwell & Greenlees, 2001; Theodorakis, Chroni, Laparidis, Bebetsos, & Douma, 2001; Van Yperen, 2009). A large number of studies have been conducted in this regard, which demonstrated that psychological skills and performance improvement are positively interrelated (Debarnot et al., 2015; Smith, Spooner, Higgins, & Hoffman, 2021; J. Yang et al., 2019).

Psychological skills such as motor imagery (MI) are among the cognitive parameters in a sport that assist in teaching technical skills to athletes by activating a number of psychological mechanisms. Imagery may be defined as using one's senses to create or recreate an experience or visual image in the mind that at times may seem to be as real as seeing the image with our physical eyes (Cox, 1998; Kilteni, Andersson, Houborg, & Ehrsson, 2018). It is a kind of simulation similar to the real sense of experience, which takes place in the mind (Batula, Mark, Kim, & Ayaz, 2017; Weinberg & Gould, 2014). MI processes are similar to those that are active during the actual motion (Batula et al., 2017). In fact, the neural networks involved in MI are overlapping with the actual motion (Batula et al., 2017; O'Shea & Moran, 2017). MI should be used as a complementary for PE, not as its replacement (Ladda, Lebon, & Lotze, 2021; Mulder, 2007). Some believe that combining mental and PE is more effective than only PE (Ladda et al., 2021). The problem has been raised by the researchers that both the ability to perform or simulate a skill involves same neuro-cognitive processes (Debarnot et al., 2015) and neural network (Bonassi et al., 2020; Ladda et al., 2021). Due to the fact that physical performance and

Corresponding author. Parvaneh shamsipour Dehkordi, Associate Professor, Department of Motor Behavior, Faculty of Sport Sciences, Alzahra University, Tehran, Iran.
E-mail addresses: p.shamsipour@alzahra.ac.ir

simulation of skill are similar in terms of mental processes(Al-Saegh, Dawwd, & Abdul-Jabbar, 2021; Van Meer & Theunissen, 2009), some researchers demonstrated that physical activity leads to the enhancement of consolidating motor memory (Iranmanesh, Saberi Kakhki, Taheri, Shea, & Fazilat-Pour, 2020; Krakauer & Shadmehr, 2006; Schmid, Erlacher, Klostermann, Kredel, & Hossner, 2020). According to Stickgold & Walker (2007) and Jannati et al (2018), memory consolidation defined as automatic and unintentional processes occur after encoding memory, through which the created memory trace is consolidated or improved. It is expected that MI affects the consolidation of memory, in addition to PE. Memory processes such as comparison and response selection are totally dependent on encoding and retrieval processes(Crowley, Bendor, & Javadi, 2019; Kantak & Winstein, 2012)). To the best of our knowledge, few studies have been conducted on the impact of MI on memory consolidation. Debarnot, Maley, De Rossi, and Guillot (2010) concluded that retroactive interference in the MI such as those physically performed fails to change the consolidation process. In another study, Debarnot et al. (2015) indicated that MI improves performing and consolidating memory. Guillot and Collet (2008) acknowledged that consolidating memory does not take place solely through PE, but MI plays a significant role in occurring or failing memory consolidation. Some reported that MI is a reliable supplement for PE in enhancing cognitive function and consolidation of motor memory (Debarnot et al., 2015; Debarnot, Creveaux, Collet, Doyon, & Guillot, 2009).

In addition, self-talk is another mental skill that affects motor performance and cognition (Hardy, Comoutos, & Hatzigeorgiadis, 2018). This skill is defined as an overt or covert personal dialogue in which the athlete interprets perceptions, feelings, and convictions and gives himself reinforcement and instructions (Hardy et al., 2018), which may affect individual consciousness and assessment process leading to behavioral and motor regulation (Wallace et al., 2017). According to Craik and Lockhart (1972), the level of processing involves the memory of an event which is closely related to the processing depth and variables such as the amount of attention devoted to the event, its adaptation to the analytical structure, and the available time for processing. Information is encoded in the form of real or expressive knowledge during the first stage of learning a skill (Anderson, 1982). During this stage, a learner may continuously retrieve the provided information in order to preserve working memory for subsequent interpretations. The obvious symptoms of this retrieval may include muttering, internal monologue, or moving the lips (Alderson-Day & Fernyhough, 2015; Rose & Christina, 1997) Vigotsky (2012) believed that children and adolescents have an internal monologue for emotional self-regulation and self-leadership. Language helps children think about their behavior and plan their actions(Alderson-Day & Fernyhough, 2015). Vigotsky believes that ST is the basis for all cognitive processes including attentional control, memory, planning, problem-solving, and reflection. The theory of ST function to guide the person and solve the problems is significantly supported (Vigotsky, 2012). Wallace et al. (2017) conducted research on the effects of motivational ST on endurance performance in the heat and finally concluded that motivational ST could improve endurance and also improve executive function and working memory as cognitive functions.

Several researchers confirmed that these psychological skills may promote the physical and cognitive function of young athletes (Hatzigeorgiadis, Zourbanos, Goltsios, & Theodorakis, 2008; Hatzigeorgiadis et al., 2014). To the best of our knowledge, no study has examined and compared the effect of these two skills on the consolidation of motor memory; however, some studies have examined only the impact of imagery on motor memory consolidation (Debarnot et al., 2015; Debarnot et al., 2009). Thus, by reviewing the literature of research in the field of memory consolidation, ST, and MI, the main question is whether the consolidation of motor memory occurs by using MI as much as PE and if using ST instructions can affect the memory consolidation or not. If the answer to these two questions is positive, another question raised by researchers is to know which of these two techniques is more effective in consolidating individuals to succeed in improving their performance and motor memory in a shorter time.

Finally, in the current study, we used ST and MI to examine the effect of PE combined with MI and ST on motor memory consolidation. The results from the literature reviewed were used to infer how the use of ST and MI would affect motor memory consolidation. Our hypotheses concentrated on the Positive effects of these two interventions and their particular influence on motor memory consolidation. We posited that both of these two interventions (ST and MI) have different positive effects on memory consolidation.

2. Materials and methods

2.1. Subjects

The participants were N= 45 young male students with no experience in volleyball skills (M-age = 13 ± 1.8 years, Range = 11 to 15 years) who participated voluntarily in this research, randomly selected from students who are interested in participating in volleyball training classes based on inclusion and exclusion criteria. They were randomly divided into three groups: ST with PE, MI with PE, and PE (n = 15 for each group). The inclusion and exclusion criteria included the ability to MI, no experience in volleyball skills, no use of sleeping pills, painkillers, or stimulant drugs, which may alter the level of consciousness. At first, parents were asked about participants' volleyball training experiences, if the students had any previous experience, they were excluded from the study. Also, we asked the participants' parents to let us know about their children's medications, if participants used sleeping pills, painkillers, or stimulant drugs were also excluded from this study. The parents of all participants were given information about the study and signed a consent form before letting their children participate in the research. Ethical approval for the study was received from the Institute of Iran Ministry of Science Research and Technology (IR.SSRI.REC.1398.664).

2.2. Task and apparatus

The quality and rate of participants' sleep and their MI were measured by the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989) and Movement Imagery Questionnaire-Revised (MIQ-R) (Hall & Martin, 1997). PSQI consists of seven dimensions: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction (Buysse et al., 1989). Responses within each domain were scored from 0–3 and the total PSQI score varies from 0 to 21, also higher scores demonstrate more sleep disorders. We used a cut-off score of 8 or higher in PSQI to sieve for poor sleep quality and one of the exclusion criteria. The results of the PSQI are given in Table 1. The MIQ-R measures the kinesthetic and visual imagery abilities of the individuals. This questionnaire includes eight separate movement items that were performed initially and then were asked to be imagined. Participants were asked to rate the easiness or hardness of imagining movement from 1 to 7 (higher scores indicate more easiness, maximum score = 56). The results of the MIQ-R are given in Table 1. One of the inclusion criteria in our research was to obtain at least a score of 32 in the MIQ-R.

Brady Volleyball Skill Test (1945) was used to assess the participants' forearm and fingers overhead passing skills in the pretest, acquisition, and retention tests. Brady's volleyball test measures skill and accuracy under time limits. In this test, the athletes were standing at a distance of one meter from the wall and attempting to hit continuously into a 153 cm square at 3.5 meters above the ground (they must hit the wall within the boundaries of the target) for 60 seconds (30 seconds for fingers overhead passing and 30 seconds for forearm passing skill). The modified 2.5-meter height was used in this study (Boubouki & Perkos, 2014).

Table 1.
Descriptive statistics of PSQI and MIQ-R

group	PSQI (mean± SD)	MIQ-R (M ± SD)	n
ST	2.53 ± 1.92	43.73 ± 4.76	15
MI	2.87 ± 1.81	42.07 ± 3.86	15
PE	2.67 ± 1.88	41.60 ± 5.38	15
Total	2.69 ± 1.83	42.47 ± 4.69	45

Table 2 .
Descriptive Statistics (M ± SD) for the Baseline Measures for scores of Brady Volleyball Skill Test

Groups	Pre-test	Acquisition	Retention score	n
PE	12.6 ± 4.11	16.8 ± 4.49	17.26 ± 3.69	15
ST	11.33 ± 4.4	26.67 ± 7.31	25.86 ± 6.49	15
MI	10.2 ± 3.44	23.33 ± 5.05	23.87 ± 4.85	15

Note: PE = physical exercise group, ST + PE = self-talk with physical exercise group, MI + PE = motor imagery with physical exercise group

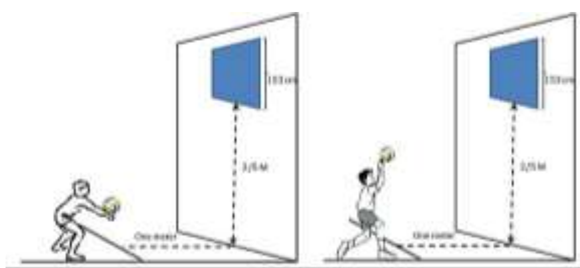

Figure 1. *Brady volleyball skill test*

2.3. Procedure

The overhead and forearm passing skills were taught after the participants were selected based on inclusion and exclusion criteria and divided randomly into three experimental groups. In the next step, they performed these skills in two blocks of 30 seconds as pretest. The three experimental groups equaled in their physical efforts during the training period. MI and ST were considered as interventions. All participants in these three groups performed the same PE with the same trainer in the same training location.

In PE, the participants were warmed up for seven minutes under the supervision of the instructor at the beginning of the training sessions. Then, they performed forearm and fingers overhead passing skills in 16 blocks of 15 trials which lasted from 40 seconds to one minute. They rested for 20 to 30 seconds based on each individual's request to avoid fatigue. The fingers overhead passing was practiced in one block while the forearm passing was used in the second block. PE in ST and PE groups lasted 25-30 minutes per session for each group. The entire intervention period was 3 training sessions on three consecutive days. The combined MI group performed two 4-blocks MI before and after PE in the same place and performed passing skills in 8 blocks of 15 trials between two steps of imagining trials. They were asked to visualize the exercises that should be performed physically in that session. Both forms of imagery, internal perspective, and external perspective, were used in this study. The use of these two perspectives is shown in Figure 3. The length of the imagery was divided into 4 episodes, dedicated to forearm and fingers overhead passing skills (two parts to motor image the skill of forearm passing and two others to fingers overhead passing) which were separated by 20 seconds rest periods. On the basis of previous research (Debarnot, Castellani, Valenza, Sebastiani, & Guillot, 2011; Debarnot et al., 2009) the main content of the skill, which should be visualized, is described by the practitioner for individuals through the recorded voice for each session and more movement patterns were added to their exercises with a sense of movement. For example, the person was asked to do a hand motion pattern without a ball during visualization when the overhead skill was visualized.

The combined ST group used six expressions that included 2 motivational and 4 instructional ones during the training session. Two instructional expressions "Pull your hand" and "Ball against the forehead" as well as two others "Fix your elbow" and "Behind the ball" were used. Also, the expression "that's great" was used as motivational self-talk once for overhead and once for the forearm passing skills. Before performing overhead and forearm passing, self-talk was demanded. The acquisition test was conducted after the end of the last training session.

The participants in the retention test used the Brady Skill Test in order to test the finger's overhead pass and accordingly the forearm pass skill compared in pre-test, acquisition, and retention tests in order to measure the consolidation of motor memory.

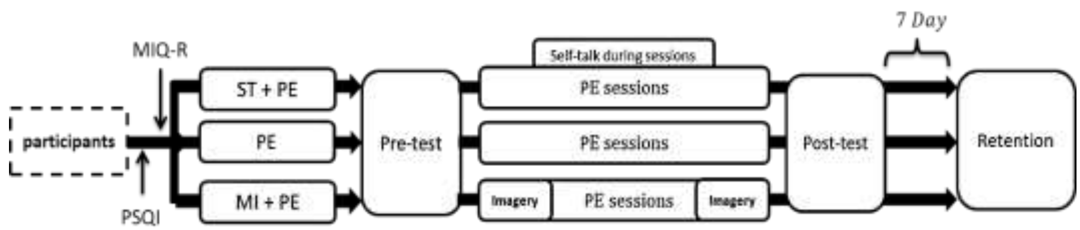

Figure 1. *Experimental procedure*

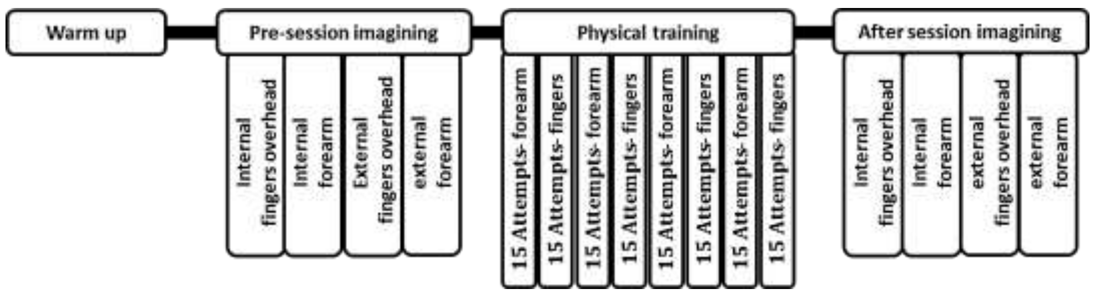

Figure 2. *MI Group training procedure*

2.4. Data analysis

Mixed analysis of variance (ANOVA) with repeated measures was used to compare differences among groups in the 3 phases of evaluation (pre-test, acquisition, and retention test). One-way ANOVA with repeated measures was used to determine differences. Normal distribution and the homogeneity of variance were performed using Shapiro -Wilk and Leven't test, respectively. All significance levels were set at $P < 0.05$ and all statistics were performed using the IBM SPSS/22.

3. Results

Participants' performances in all three groups were reported in table 1. The results of the Shapiro- Wilk normality test indicated the normal distribution of the data (P> 0.05). The results of one-way ANOVA revealed no significant difference between the average performance of volleyball skills in the three groups in the pre-test ($F_{(2, 42)} = 0.826$, P = 0.44). The findings of mixed ANOVA indicated that the main effect of the phases of evaluation on performance were significant ($F_{(1, 84)} = 396.94$; P < 0.001; η^2= 0.91). The results of the post hoc test showed that there is a significant difference between the pre-test (M = 11.20) with that of the acquisition (M= 22.27) and retention (M = 22.33) tests (P < 0.001). Further, no significant difference was observed between the acquisition and the retention test (P = 0.99).

The main effect of the group was significant ($F_{(2, 42)} = 6.07$; P = 0.005; η^2= 0.22). The results of the Bonferroni post hoc test indicated no significant difference between the mean performance of the ST group (M= 21.29) and the MI (M= 19.13) one (P = 0.65). Furthermore, no significant difference was observed between the mean performance of the MI group with the PE (M=15.38) one (P = 0.10). The mean performance in the ST group and the PE group is significantly different (P = 0.004). Comparing the means revealed that ST groups and MI ones had higher mean motor performance than the PE group, respectively. The interaction effect of the group and phases of evaluation was significant ($F_{(4, 84)} = 38.31$, P =0.001, η^2= 0.59). The results of one-way ANOVA test with repeated measures showed that the mean of motor performance of participants in phases of evaluation (pre-test, acquisition and retention) was significantly different for combined ST ($F_{(2, 28)}$ = 57.134; P = 0.001), combined MI ($F_{(2, 28)}$ = 261.44; P = 0.001), and PE ($F_{(2, 28)}$ = 55.75; P = 0.001) groups. The mean motor performance of the participants for each group in the acquisition and retention tests was higher than that of the pre-test based on the Bonferroni post hoc test.

Furthermore, a significant difference was reported between the mean motor performance of the combined ST group and MI group with the PE group in acquisition and retention tests. The mean of motor performance of the PE group in the acquisition test (M = 16.8) and retention test (M=17.27) was lower than that of the combined ST group in the acquisition test (M= 27.67) and retention test (M= 25.87), and combined MI group in the acquisition (M= 23.33) and retention test (M= 23.87), however the difference between MI group and ST group in acquisition and retention were not significant (Figure 4, Table 3).

International Journal of Motor Control and Learning (IJMCL) 2022; 4(4) 12-18

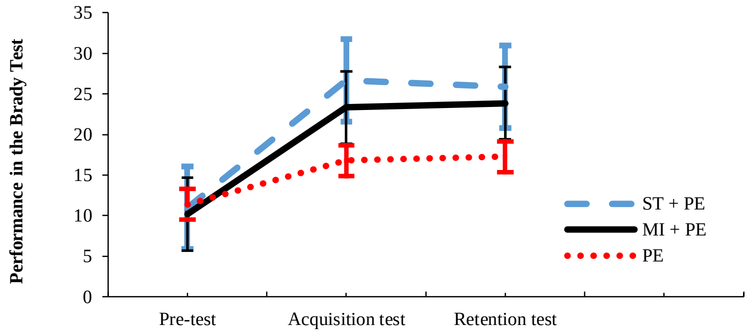

Figure 4. *The mean of the experimental groups in pretest, acquisition, and retention tests*

Table 3.
Bonferroni Pairwise comparison results for acquisition and retention.

	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.
Acquisition	ST	MI	3.33	2.09	0.360
		PE	9.86*	2.09	0.001
	PE	MI	-6.53*	2.09	0.010
Retention	ST	MI	2.0	1.87	0.879
		PE	8.60*	1.87	0.001
	PE	MI	-6.60*	1.87	0.003

Note: * = significant at P ≤0.05

4. Discussion and conclusion

The present study aimed to investigate the effect of exercise types (physical activity, physical exercise combined with MI and ST) on motor memory in male adolescents. The results indicated the improvement of experimental groups in the acquisition and retention test occurred in all three groups, compared to the pre-test consolidation, but ST led to more memory consolidation. The findings of the present study are consistent with those of Hanshaw and Sukal (2016) and Wallace et al. (2017). Wallace et al. (2017) investigated the effect of motivational ST on endurance and cognitive function in heat. The findings proved that the participants who used motivational ST showed better cognitive function than those with no interventions. Hanshaw and Sukal (2016) examined the influence of ST and MI on the reaction time of skilled martial arts athletes. The group that used ST performed better in reaction time than the group that used MI.

In the present study, the group that used ST experienced more consolidation than the other two groups. The MI group showed more memory consolidation than the PE one. This finding is in line with that of Debarnot et al. (2009), who showed that MI is an effective factor in memory consolidation. In addition, these results are consistent with the findings of Batson, Feltman, McBride, and Waring (2007), which demonstrated the usefulness of combined MI with PE compared to PE only. One of the useful reasons for combining MI with PE might be due to the fact that the neuromuscular junction activates the actual real-time movement in the individual's mind during MI (Al-Saegh et al., 2021; Kilteni et al., 2018). This factor prepares the muscles involved in the movement better, which is effective in planning and learning efficient movement. That mental training may lead the threshold of muscular activity more closely to perform and learn the activities better. Richardson (1967) psych neuromuscular theory states that impulses transmitted from the brain to the muscles during the movement are in accordance with those sent from the brain to the muscles during MI. It is worth noting that the dual coding theory proposed by Paivio (2013) proves that images are effective in learning. Based on this theory, there are two cognitive subsystems, one specialized for the representation and processing of nonverbal objects/events (i.e., imagery), and the other specialized for dealing with language. For example, if we store both the word ball and its image, we can retrieve the ball either as a word or as an image. Similarly, it is possible to learn the sequence of movements both verbally and visually.

The significant finding in this study is the superiority of the ST group in memory consolidation, compared to the other two groups. Memory processes are entirely based on encoding and retrieval processes, as well as reviewing the strategies, which are considered another way of consolidating memory (Rose & Christina, 1997; Schmid et al., 2020; X. Yang et al., 2022). Both of these processes can be provided by ST. In this regard, Hall (2015) demonstrated that most of the sensory experiences before storing in the brain and before processing for other mental purposes are converted into language equivalents. For example, when we read a book, we do not store the printed words, but the words or transitive concepts in language form. The brain has a tendency to hear new information especially if they are noteworthy(X. Yang et al., 2022) Therefore, the significant features of the sensory experience during this period are gradually stored in the memory.

Further, ST directly influences behavior and levels of motivation (Hardy et al., 2018). Motivation facilitates the process of recovery and affects the processes of recall and recognition through encoding. Moreover, motivation helps focus attention on content by reducing the focus on marginal details, which are being encoded in a motivated state(Bowen & Spaniol, 2017). From a neuroscience point of view, the amygdala plays an essential role in the processing of emotions. The neural communication with the cerebral cortex can facilitate the processing of provided stimuli provided when the amygdala is activated (Gothard, 2020; McIntyre, Power, Roozendaal, & McGaugh, 2003). The data are more readily stored with more motivation when the amygdala is activated (Gothard, 2020). The limitations of this research was, the lack of simultaneous participation of girls and boys and the small number of retention tests. in addition, the participants' physical and cognitive activity could not be accurately controlled outside the laboratory.

Based on the findings, it can be recommended that coaches and physical education teachers use ST as a technique for promoting the consolidation of motor memory and as complementary to PE. However, these two psychological approaches are different by nature and need to be compared in other cognitive aspects by using ST as an alternative for MI when the goal of mental training is to improve motor memory and the person fails to visualize. According to Hardy et al. (2018) and Shamsipour et al. (2014) an individual's perception could affect the level of ST, which suggests that these effects may be influenced by the personal characteristics of the participants. Therefore, this factor could be further examined in future studies by using larger statistical communities and methods that have the ability to neutralize the effects of individual characteristics. It is suggested that the impact of different psychological approaches such as types of MI and ST be compared by focusing on different age ranges (from children to elders).

Acknowledgment:

We need to express our special thanks to all the students who participated in this research.

Conflict of interest

The authors declared no conflict of interest.

References

Al-Saegh, A., Dawwd, S. A., & Abdul-Jabbar, J. M. (2021). Deep learning for motor imagery EEG-based classification: A review. *Biomedical Signal Processing and Control, 63*, 102172.

Alderson-Day, B., & Fernyhough, C. (2015). Inner speech: development, cognitive functions, phenomenology, and neurobiology. *Psychological bulletin, 141*(5), 931.

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological review, 89*(4), 369.

Batula, A. M., Mark, J. A., Kim, Y. E., & Ayaz, H. (2017). Comparison of brain activation during motor imagery and motor movement using fNIRS. *Computational intelligence and neuroscience,*

Bonassi, G., Lagravinese, G., Bisio, A., Ruggeri, P., Pelosin, E., Bove, M., & Avanzino, L. (2020). Consolidation and retention of motor skill after motor imagery training. *Neuropsychologia, 143*, 107472.

Bowen, H. J., & Spaniol, J. (2017). Effects of emotion and motivation on memory dissociate in the context of losses. *Learning and Motivation, 58*, 77-87.

Brady, G. F. (1945). Preliminary investigations of volleyball playing ability. *Research Quarterly. American Association for Health, Physical Education and Recreation, 16*(1), 14-17.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry research, 28*(2), 193-213.

Camiré, M., Forneris, T., Trudel, P., & Bernard, D. (2011). Strategies for helping coaches facilitate positive youth development through sport. *Journal of sport psychology in action, 2*(2), 92-99.

Christie, D., & Viner, R. (2005). ABC of adolescence: Adolescent development. *BMJ: British Medical Journal, 330*(7486), 301.

Chroni, Perkos, S., & Theodorakis, Y. (2007). Function and preferences of motivational and instructional self-talk for adolescent basketball players. *Athletic Insight, 9*(1), 19-31.

Cox, R. H. (1998). *Sport psychology: Concepts and applications*: McGraw-Hill.

Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of verbal learning and verbal behavior, 11*(6), 671-684.

Crowley, R., Bendor, D., & Javadi, A.-H. (2019). A review of neurobiological factors underlying the selective enhancement of memory at encoding, consolidation, and retrieval. *Progress in neurobiology, 179*, 101615.

Debarnot, U., Abichou, K., Kalenzaga, S., Sperduti, M., & Piolino, P. (2015). Variable motor imagery training induces sleep memory consolidation and transfer improvements. *Neurobiology of learning and memory, 119*, 85-92.

Debarnot, U., Creveaux, T., Collet, C., Doyon, J., & Guillot, A. (2009). Sleep contribution to motor memory consolidation: a motor imagery study. *Sleep, 32*(12), 1559-1565.

Debarnot, U., Maley, L., De Rossi, D., & Guillot, A. (2010). Motor interference does not impair the memory consolidation of imagined movements. *Brain and cognition, 74*(1), 52-57.

Gothard, K. M. (2020). Multidimensional processing in the amygdala. *Nature Reviews Neuroscience, 21*(10), 565-575.

Guillot, A., & Collet, C. (2008). Construction of the motor imagery integrative model in sport: a review and theoretical investigation of motor imagery use. *International Review of Sport and Exercise Psychology, 1*(1), 31-44.

Hall, C. R., & Martin, K. A. (1997). Measuring movement imagery abilities: a revision of the movement imagery questionnaire. *Journal of mental imagery*.

Hall, J. E. (2015). *Guyton and Hall textbook of medical physiology e-Book*: Elsevier Health Sciences.

Hardy, J., Comoutos, N., & Hatzigeorgiadis, A. (2018). Reflections on the Maturing Research Literature of Self-Talk in Sport: Contextualizing the Special Issue. In: Human Kinetics Champaign, Illinois, USA.

Hatzigeorgiadis, A., Zourbanos, N., Goltsios, C., & Theodorakis, Y. (2008). Investigating the functions of self-talk: The effects of motivational self-talk on self-efficacy and performance in young tennis players. The Sport Psychologist, 22(4), 458-471.

Hatzigeorgiadis, A., Zourbanos, N., Latinjak, A., & Theodorakis, Y. (2014). Self-talk. Routledge companion to sport and exercise psychology: Global perspectives and fundamental concepts, 372-385.

Iranmanesh, H., Saberi Kakhki, A., Taheri, H., Shea, C., & Fazilat-Pour, M. (2020). The Role of Sleep in Children's Motor Memory Consolidation in a Motor Sequence Task. Journal of Cognitive.

Jannati, M., Abdoli, B., Farsi, A., Shamsipour Dehkordi, P. (2018). Effect of Practice Structure and Off- Line Time Period on Consolidation of Motor Memory in Children: An Investigation of Theoretical Foundation for Principles of Practice Variability and Memory Encoding Specificity. J Child Ment Health, 5 (2) :95-106

Kantak, S. S., & Winstein, C. J. (2012). Learning–performance distinction and memory processes for motor skills: A focused review and perspective. Behavioural brain research, 228(1), 219-231.

Kilteni, K., Andersson, B. J., Houborg, C., & Ehrsson, H. H. (2018). Motor imagery involves predicting the sensory consequences of the imagined movement. Nature communications, 9(1), 1-9.

Krakauer, J. W., & Shadmehr, R. (2006). Consolidation of motor memory. Trends in neurosciences, 29(1), 58-64.

Ladda, A. M., Lebon, F., & Lotze, M. (2021). Using motor imagery practice for improving motor performance–a review. *Brain and cognition, 150*, 105705.

McIntyre, C. K., Power, A. E., Roozendaal, B., & McGaugh, J. L. (2003). Role of the basolateral amygdala in memory consolidation. *Annals of the New York Academy of Sciences, 985*(1), 273-293.

Mulder, T. (2007). Motor imagery and action observation: cognitive tools for rehabilitation. *Journal of neural transmission, 114*(10), 1265-1278.

O'Shea, H., & Moran, A. (2017). Does motor simulation theory explain the cognitive mechanisms underlying motor imagery? A critical review. *Frontiers in human neuroscience, 11*, 72.

Orben, A., Tomova, L., & Blakemore, S.-J. (2020). The effects of social deprivation on adolescent development and mental health. *The Lancet Child & Adolescent Health, 4*(8), 634-640.

Rose, D. J., & Christina, R. W. (1997). A multilevel approach to the study of motor control and learning.

Schmid, D., Erlacher, D., Klostermann, A., Kredel, R., & Hossner, E.-J. (2020). Sleep-dependent motor memory consolidation in healthy adults: a meta-analysis. Neuroscience & Biobehavioral Reviews.

Smith, C., Spooner, H., Higgins, A., & Hoffman, R. (2021). 128 Beyond the ride: the use of psychological skills training in equestrian athletes. Journal of Equine Veterinary Science, 100, 103591.

shamsipour Dehkordi, P., Abdoli, B., Ashayeri, H., Namazi Zadeh, M. (2014).The effect of different offline periods on enhancement-based consolidation process in implicit motor memory. J Shahrekord Univ Med Sci; 16 (3) :95-107

Stickgold, R., & Walker, M. P. (2007). Sleep-dependent memory consolidation and reconsolidation. Sleep medicine, 8(4), 331-343.

Thelwell, R. C., & Greenlees, I. A. (2001). The effects of a mental skills training package on gymnasium triathlon performance. The Sport Psychologist, 15(2), 127-141.

Theodorakis, Y., Chroni, S., Laparidis, K., Bebetsos, V., & Douma, I. (2001). Self-talk in a basketball-shooting task. Perceptual and Motor Skills, 92(1), 309-315.

Van Meer, J. P., & Theunissen, N. C. (2009). Prospective educational applications of mental simulation: A meta-review. Educational Psychology Review, 21(2), 93-112.

Van Yperen, N. W. (2009). Why some make it and others do not: Identifying psychological factors that predict career success in professional adult soccer. The Sport Psychologist, 23(3), 317-329.

Vigotsky, L. S. (2012). Thought and language: MIT press.

Wallace, P. J., Mckinlay, B. J., Coletta, N. A., Vlaar, J. I., Taber, M. J., Wilson, P. M., & Cheung, S. S. (2017). Effects of motivational self-talk on endurance and cognitive performance in the heat. *Medicine & Science in Sports & Exercise, 49*(1), 191-199.

Weinberg, R. S., & Gould, D. (2014). *Foundations of Sport and Exercise Psychology, 6E*: Human Kinetics.

Wright, M. J., Schmitter-Edgecombe, M., & Woo, E. (2010). Verbal memory impairment in severe closed head injury: The role of encoding and consolidation. *Journal of clinical and experimental neuropsychology, 32*(7), 728-736.

Yang, J., Lim, T., Kwon, O., & Han, H. (2019). Structural relationship among resilience, psychological skills and performance of taekwondo sparring athletes. *Archives of Budo, 15*, 45-56.

Yang, X., Gong, R., Qin, L., Bao, Y., Fu, Y., Gao, S., . . . Lu, W. (2022). Trafficking of NMDA receptors is essential for hippocampal synaptic plasticity and memory consolidation. *Cell Reports, 40*(7), 111217.