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The Effect of Mental and Physical Practice on Muscle Electrical Activity in Force Production Task

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Abstract: The aim of this study was to compare the effects of mental and physical exercises on muscle electrical activity in force production task. This research is fundamental in nature and in terms of methodology it is quasi-experimental. For executing this research, different exercise methods (physical, "clear - vague" mental practice and integrative) in 10 kg force values, at acquisition, retention and transfer stages, against a hand grip task, were studied. Results showed that physical practice and clear mental practice, integrative practice at 10 kg force significantly caused electromyography changes at acquisition stage. None of physical practice, clear mental practice, vague mental practice and integrative practice groups caused significant changes in electromyography at retention stage, at 4 kg and 8 kg forces. Thus, physical practice, clear mental practice and integrative practice had significant effects on electromyography changes in transfer stage at 10 kg.

Key words: Mental Practice · Mental Imagery · Ability imagery · Psych Neuro Muscular · Electromyography

INTRODUCTION

Despite the fact that several decades have passed from the date of introduction of mental practice as one of the effective methods of motor learning development, day after day new findings are reported in this field of study and new aspects of mental practice are dealt with. The researches done in the past decades not only have shown that mental practice, like physical practice, develops motor skills [1-4], but also have proved that the learning mechanisms that contribute in physical practice are activated in mental practice tool [5-9]. Some researchers [10-12] have shown that mental practice, like physical practice, is effective in motor skills learning but some others.

Emphasize that the role of mental practice in motor learning is less than that of physical practice [13-15]. Some other researchers believe that mental practice has no bearing on motor learning [16-19]. In the latter case Hall (1992) holds that the inefficacy of mental practice on motor learning is due to incorrect mental practice. He believes that a false imagination of an activity results in negative effects rather than positive ones [20- 24].

Imagery orients individual's activities towards development. Motor sequence, objectives and different solutions require cognition prior to a physical response [25,26,25]. A gymnast's stop at the horse is a good example of the theory. The jumper reviews all the events at his/her mind cognitively before any further action. The time of stop is different depending on the type of jump and the jumper selects the best status for the jump mentally before taking any step.

Almost all the authorities agree on the usefulness of mental imagery but the amount of usefulness and the method of practice are in dispute. Thus, mental imagery is held to be a completely cognitive process and not much is known about the role of the process in muscle force increase [26-29].

The results of the studies show the positive effect of mental practice on muscle power increase.

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However, in that decade many aspects of mental practice such as number of sessions, duration of each session, type of perspective used in the practice and the like were unknown [30,31].

Thus, the studies were relatively incomplete in terms of knowledge of mental imagery. yue and Cole (1992) showed that both mental and physical practices similarly increased muscle power [57]. This research proved that mental practice had a noticeable effect on muscle power improvement [57].

On the other hand, Landers (2002) in several studies showed that the physical improvement of the subjects that practiced a special task mentally was less than that of the subjects that had physical practice and more than the control group that had no practice at all. Overall, he found that mental practice facilitates performance [32- 36, 38].

Demonstration of muscular activity during motor imagery practice dates back to the middle of the 20th century, when lotz (1999) reported that during imagery weight lifting, electromyographic (EMG) activity of forearm muscles increased linearly with the magnitude of the weight. Similar observations have since been made by other investigators [37-39]. Recently, a subliminal activation level in the biceps brachii muscle was observed when participants performed imagery lifting of a 4.5- or 9-kh dumbbell, as compared with the activation level of the same muscle in the passive arm. Furthermore, the increase in EMG activation level during the imagery lifting of 9 kg was higher than was the level during imagery lifting of 4.5 kg [40,41]. The prevalence of higher EMG activity in the biceps brachil and triceps brachil muscles of an arm that is engaged in the performance of an imagery motor task was further corroborated by slade, Landers and Slad (2002), although the pattern of EMG activity during imagery movements was not found to exactly mirror the EMG pattern characterizing the equivalent real movements [49].

Another para-analytical study found mental practice very fruitful in facilitating learning tasks requiring much attention (such as throwing a ball) or in motor performance (such as dribbling a ball). It was emphasized that mental practice wouldn't be effective in improving motor performance and precision unless two factors were included: first, the subject should be somehow skilled before practicing mentally and second, the fruitful effects of mental practice appear only when physical practice accompany mental practice [4,42,44].

Meanwhile, there are different theories about imagery one of which is mental-neural-muscular theory that draws in mental and motor aspects of mental imagery. On the basis of this theory, mental imagery facilitates motor skills learning. Clear images of events and behaviors result in neural-muscular responses like those created by physical experiences and actions. The images imageried in the mind stimulate the muscles contributing in the skill like physical movements although such stimulations are so limited that no tangible movement may be generated. Therefore, by stimulating neural paths, similar to real stimulations, we plan for muscles and get ready for real performance [45,46].

The researches done in 1998 and 2005 ignored the subjects' abilities to imagery (mental imagery efficacy factor) [47]. Study of imagery ability and its effect on motor learning is the focus in this research. The other question dealt with in this research is that whether the will power of the subjects increases with mental practice or not. This question is still unanswered. The limited literature on these two questions and the existing disputes call for further research.

This research aims at studying the effect of physical practice and mental practice on force generation by measuring and electrical activity of finger's muscle contraction in grabbing movement.

MATERIALS AND METHODS

Participants: This is a fundamental research and in terms of method it is semi-experimental. Data was gathered in the laboratory. Five groups (4 experimental groups and one control group) participated in the research including practice intervention, pre-test, acquisition test, retention test and transfer test.

The subjects included 75 female students selected from the population through simple random sampling method. The subjects had no experience in the task and were unaware of the research objectives before participation in the practical task. All the subjects were right-handed. All the participants filled out questionnaires including individual information (age, height, weight, etc.), medical information (record of illness, pain, surgery in shoulders, wrists and elbow, damages to muscles due to grabbing and also mental and muscular diseases) and sports record.

The participants were randomly divided into 4 groups: physical group (15 persons), integrative group (15 persons), control group (15 persons) and the remaining 30 persons were divided electively and purposively into vague mental practice group (15 persons of the participants with the lowest scores in the tests) and clear mental practice group (15 persons with the highest scores in the tests).

Measurement Tool: Individual, medical and sports questionnaire The participants filled out questionnaires including individual information (age, height, weight, etc.), medical information (record of illness, pain, surgery in shoulders, wrists, elbow, damages to muscles due to grabbing and also mental and muscular diseases) and sports record.

Movement Imagery Questionnaire (MIQ-R): Revised Motor Imagery Questionnaire was used to evaluate motor sense and sight imagery ability. Knowledge-Smirnov alpha of the questionnaire was 0.89. Revised Motor Imagery Questionnaire has 8 sections: 4 sections related to visual imagery ability and 4 sections related to kinetic imagery shown in the form of a numerical score.

Vividness of Visual Imagery Questionnaire and Vividness of Movement Imagery Questionnaire were used to evaluate clarity of images. Digital hand dynamometer A Japanese dynamometer was used to measure muscular force.

Procomp Infiniti System: The Procomp Infiniti System with SA7500 used in the research was manufactured in Canada. The device was a package with various components including central sections, sensors, electrodes, connectors, software, instruction, etc. all with their own applications. The device had 8 output canals rendering data on EMG, SCL, EEG, EKG, etc.).

Practice Protocol

Physical Group: The participants warmed up with several extension exercises in the hand muscles and other muscles contributing in grabbing.

The group repeated grabbing exercise attempts for 4 weeks, 3 sessions a week, 18 times a session, in two blocks of 10 kg in 10 seconds using dynamometer. The duration of rest between blocks was 4 minutes. At the end of the week EMG of the Flexor Digit rum Superficial is muscle was recorded.

Mental Practice Group (Vague and Clear): The participants rested in chairs with hand rests and relaxed. The participants were asked to close their eyes and breathe deeply and relax all their muscles for 4 minutes. Then, at the command of the researcher, the participant mentally imageries 10 kg concentration for 10 seconds and at the command of the researcher rested for 10 seconds. Mental contraction repeated alternatively. Muscles contributing in grabbing were free of stress and contraction during the practice and the researcher controlled these factors. At the end of the week EMG activity of Flexor Digitorum Superficialis muscle was measured.

The group practiced for 4 weeks, 3 sessions a week, 18 grabbing imagery attempts a session, in 2 blocks of 10 kg force during 10 seconds with an intervening 4 minute resting periods.

Integrative Group: The group practiced grabbing on the dynamometer for 4 weeks, 3 sessions a week, 9 attempts a session, at 10 kg and after 9 attempts at 10 kg the participants imageried the practice at the same force for 10 seconds and then rested for 4 minutes.

Statistical Method: Descriptive statistics was used to determine indices, deviation, data display, data categorization in terms of suitable parameters and drawing curves and diagrams. The normality of data was tested using Knowledge-Smirnov test. T-test for independent groups was used to compare the pre-test results and acquisition, retention and transfer tests results. Variance analyses were used to compare the difference in the means of different groups (in terms of significance). Tukey's test was used to determine the difference among the groups and the group with the highest progress.

RESULTS

Data on age, height, weight, arm ambient, wrist ambient and VVIQ, MVIQ and MIRQ are entered in Table 1.

Fig. 1 shows a summary of performance means of the study groups at pretest, acquisition, retention and transfer stages in all the five groups. As Fig. 2 shows the best performance in all the stages is related to physical practice group. On the other hand, vague practice group has an unnoticeable progress similar to that of the control group.

Table 1: Mean (Sd) of Demographic Information and Scores of VVIQ, MVIQ and MIRQ Tests

	Study Group				
Statistical Factor	Control	Physical Practice	Vague Mental Practice	Clear Mental Practice	Integrative
Age	24.53(1.55)	23.93(1.79)	24.73 (2.05)	24.26 (1.83)	23.93 (1.79)
Height	161.53(4.43)	159.93 (4.73)	162.7 (5.59)	163.2 (7.67)	160.7 (5.52)
Weight	55.16(6. 84)	54.86 (5.62)	57.1(9.9)	56 (8.64)	55.66 (6.89)
Arm ambient	23.93 (1.85)	23.23 (1.66)	23.4 (1.75)	24.23 (2.89)	23 (1.97)
Wrist ambient	14.7(1.01)	14.3 (0.87)	14.6 (1.24)	14.93(0.96)	14.4 (0.92)
VVQ Score	47.317)	55.8(9.03)	86.4 (7.48)	41.26 (7.12)	45.06 (7.17)
MVIQ Score	68.26(12.23)	81.33 (10.53)	123.93 (32.13)	56.33 (4.56)	66.66 (7.18)
MIRQ Score	51.6 (3.06)	49.26 (5.22)	32. 2(1.2)	55.53 (0.51)	54.46 (1.18)

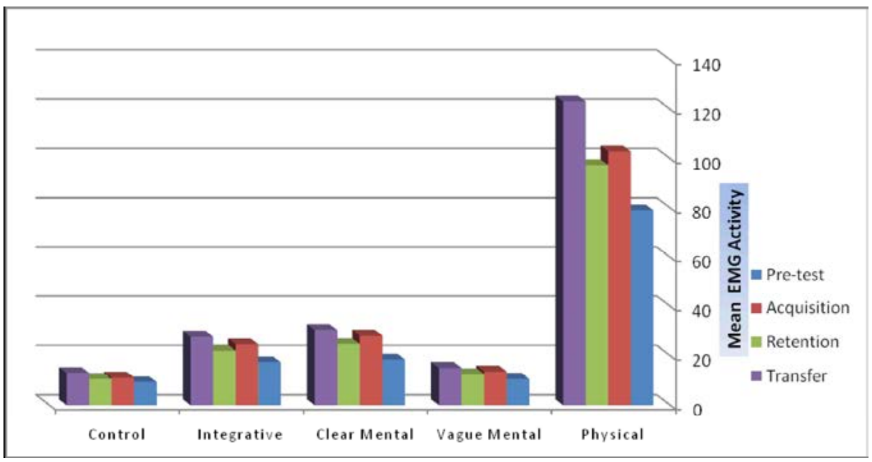

Fig. 1: A comparison of performance means of the study groups at pre-test, acquisition, retention and transfer stages

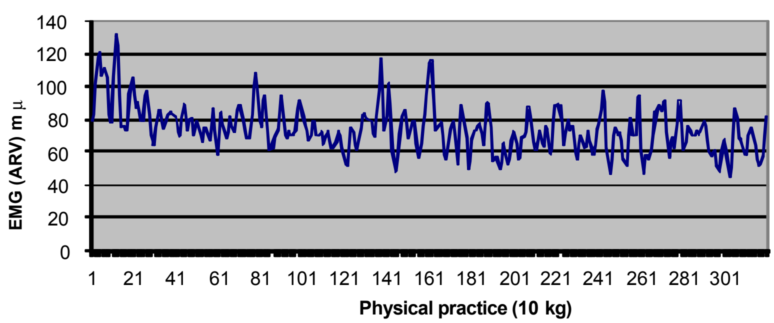

Fig. 2: Shows electromyographic activity of the Flexor Digitorum Superficialis muscle during physical practice 10 kg

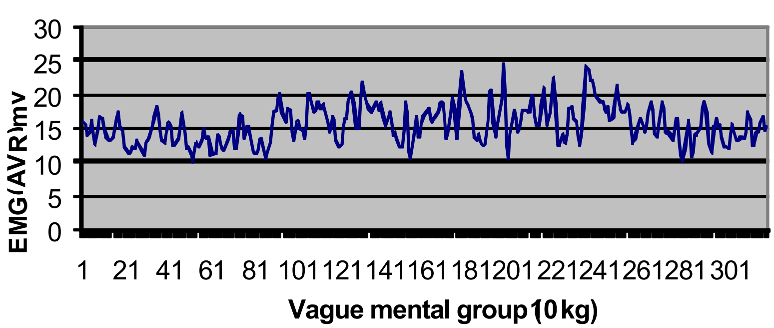

Fig. 3: Shows electromyographic activity of the Flexor Digitorum Superficialis muscle during vague mental practice 10kg

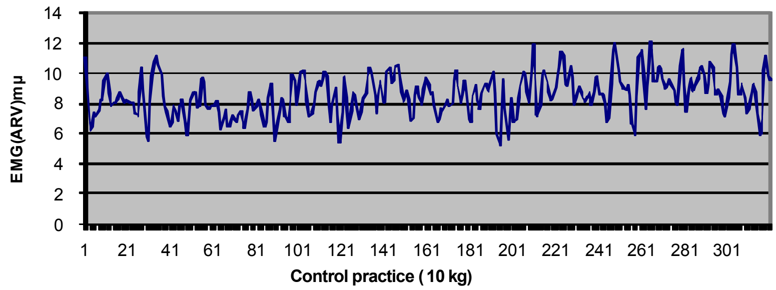

Fig. 4: Shows electromyographic activity of the Flexor Digitorum Superficialis muscle during control practice 10 kg

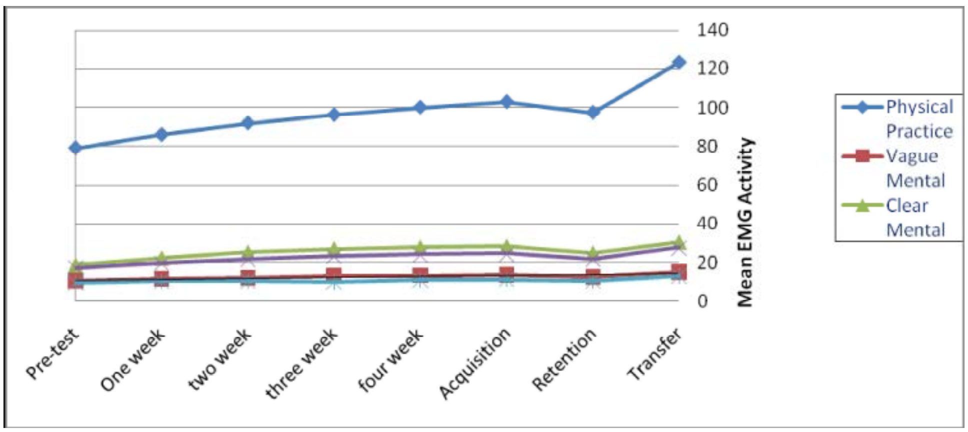

Fig. 5: Comparison of the progress of different groups during the practice period

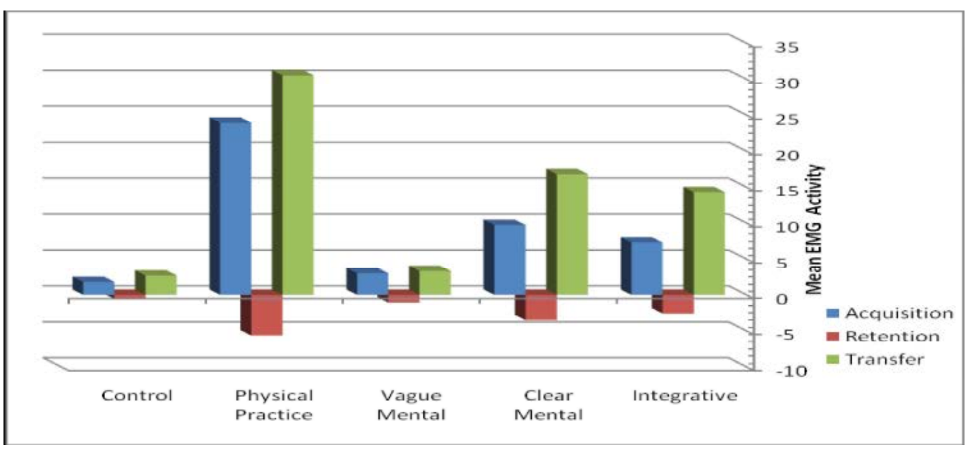

Fig. 6: Mean of differences among research groups (10 kg) at acquisition, retention and transfer stages

Table 2: Tukey's test results at acquisition and transfer stages in order to determine the points of difference in paired groups

groups	Variables	Control	Physical Practice	Vague Mental Practice	Mental Practice	Integrative
Control	acquisition	-	0.002**	0.999	0.6	0.853
	Transfer	-	0.004*	1.000	0.348	0.543
Physical Practice	acquisition	-	-	0.003**	0.083	0.027*
	Transfer	-	-	0.005*	0.371	0.214
Vague Mental Practice	acquisition	-	-	-	0.735	0.934
	Transfer	-	-	-	0.394	0.595
Clear Mental Practice	acquisition	-	-	-	-	0.992
	Transfer	-	-	-	-	0.998
Integrative	acquisition	-	-	-	-	-
	Transfer	-	-	-	-	-

** p<0.01 * p<0.05

Fig. 6 shows the progress of the study groups (10 kg) in consecutive weeks. Except for the control group, all the groups show a tangible drop in progress during exercising weeks till acquisition test and before retention test.

As is shown in the table, physical practice, integrative practice and clear mental practice had significant effects on electromyography changes at acquisition stage ($P<0.05$). Physical practice ($P<0.01$), clear mental practice and integrative practice ($p<0.05$) significantly affected electromyography changes at transfer stage. Also, Physical practice, mental practice and integrative practice not significantly affected electromyography changes at retention stage.

Table 2 includes Tukey test results at acquisition and transfer stages in order to determine the points of difference (the groups are paired). The table shows that the differences between control and physical practice groups at acquisition ($p<0.01$) and transfer stages ($p<0.05$) and between physical practice and vague mental group at acquisition ($p<0.01$) and transfer stage ($p<0.05$) were significant.

DISCUSSION

As mentioned before, practice methods significantly affected the electromyography changes in the selected muscle at acquisition and transfer stages. The results of the present research conform to those found by other studies [48- 52] that have shown similar patterns for the muscles used in mental and physical practice movements using electromyography techniques.

On the other hand, there are other researchers that have reported no muscular electromyographic activity during mental practice [48-51]. The results of the research show that practice methods used in this research don’t have any significant effect on electromyographic changes in the Flexor Digitorum Superficialis muscle at retention state. The results of the present research confirm those of Mulder *et al.* (2004), Jackson *et al.* (2004) [32,41].

Unlike the findings of the present research showing that mental practice has no significant effect on motor skill learning, some researchers such as Gabriele, Hall and Lee (1989), Sanders *et al.* (2004) and weinberg (2003) have reported that mental practice, similar to physical practice, results in motor learning [17, 46, 55]. Yaguez *et al.* (1998), Hall (2002), have shown in separate studies that mental practice develops motor learning [6,17].

The discrepancy can be attributed to the respective tasks. The task in this research was merely kinetic (grabbing) and lack of learning can be attributed to this fact. Based on the literature, mental practice is more effective in cognitive skills learning. Pascaline *et al.* (2010) motor imagery is a cognitive process during which subjects mentally simulate movements without actually performing them [43]. Ryan and Simons (1982) provided experimental evidence in support of the cognitive basis of mental practice efficacy in skill learning. The researchers argue that if mental practice is a cognitive phenomenon it will be more effective in learning such skills that are more cognitive. To test this hypothesis, Ryan and Simons compared a cognitive and a kinetic task and found mental practice more effective in terms of cognitive tasks in comparison with the kinetic ones. The findings of the researchers support the efficacy of mental practice in cognitive tasks [52-54].

Variance analysis prove that the differences among mental practices (clear and vague), physical practice and integrative practice groups and electromyographic changes were significant. Tukey's test results show that at 10 kg there is significant difference between physical group and vague mental group and between physical group and control group. The results show that the effect of physical practice on movement task was more than that in other modes of practice. In other words, physical engagement in the exercises, in comparison with mental (clear and vague) and integrative ones, results in better development in acquisition and transfer. Meanwhile, although the participants that had mental practice only showed development in criteria task and their scores of pretest and acquisition, transfer tests were significantly different, but in comparison with the physical practice group had relatively low progress. May researchers such as Grouios (1992), Kohl *et al.* (1992) and Jackson *et al.* (2004) confirm this finding [32,41]. Regarding electromyographic results muscle force at acquisition and transfer stages improves with physical, mental and integrative exercises. Literature is full of researches that confirm this finding such as yue and Cole (1992), Feltz and Landers (1983) and Vinoth *et al.* (2002). According to the latter scholars mental practice can be used for maintenance and improvement of muscle force. The findings of the present research don’t conform to those found by Kasai (1997), Zehra *et al.* (2000) and Herbert *et al.* (1998) [14,15,35,53,57,58].

The findings of the present research show that clear and vague mental groups are significantly difference at acquisition and transfer stages. In other words, imagery ability affects performance and high mental imagery facilitates learning through mental practice. People with limited imagery ability find mental practice relatively limited in terms of motor skill learning. There are people with high ability of imagery. In these people high mental practice improves their learning performance. People with clear mental imagery, in comparison with those with limited imagery ability, are more successful in mental imagery of motor skills [52- 59]. Thus, it is not logical to expect an individual with weak mental imagery ability to surpass another individual in the control group in performance.

Some researchers [47-51] attribute the inefficacy of mental practice in motor skills learning to the inability of the subject in correct implementation of mental imagery. The literature shows that people with higher imagery ability shall find mental practice more effective [31].

This research in which the effect of mental imagery in acquisition, retention and transfer using electromyography changes in the selected muscle is studied confirms Barr and Hall (1992), Hall (1982) and Harris and Robinson (1986) who confirm the effect of internal imagery in electromyography activity of muscles [2,22,27].

CONCLUSION

With regard to the findings of the present research and other similar researchers, it can be concluded that mental practice improves motor tasks according to electromyography results. Inefficacy of mental practice in retention stage can be attributed to type of motor task. It seems that increase of electromyography changes of the selected skeletal muscle due to mental practice is because of utilization of the motor units.

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