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The effect of mental imagery on muscle strength and balance performance in recreational basketball players

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Abstract. The purpose was to study the effect of mental imagery on muscle strength and balance performance in recreational basket ball players. *Material and Method*. Thirty male collegiate recreational basketball ball players, randomly assigned into two groups, were the participants of the study. Group 1 subjects underwent strength and balance training and group 2 subjects underwent strength, balance and mental practice. Training was given for six weeks, three sessions per week, and one session lasting for one hour for each subject. The study design was repeated measure experimental design. The outcome measures were modified star excursion balance scores, strength of quadriceps and ankle plantar flexors assessed through 1 RM. Assessment was done before the training and after the completion of training. *Results*. The anterior direction, posteromedial direction, posterolateral direction and composite score showed a significant interaction between programme type (group) and time with p=0.00, p=0.041, p=0.001, p=0.001 and for main effect for time with p=0.001, in all direction and composite score of the balance measure. There was significant interaction between programme type (group) and time, p=0.001 for knee extensors and p=0.018 for ankle plantarflexor strength. There was a significant main effect for time p=0.001 for both knee extensors and ankle plantarflexors strength in both group. The main effect for group comparing the two type of intervention was significant for knee extensor strength, p=0.023. *Conclusion*. There is significant interaction for time ×group for balance and strength, so it can be concluded that there is effect of mental imagery on strength and balance,
Key words: *athletic performance, learning, motor skill, practice*.

Introduction

Mental imagery (MI) is the imagining of an action without its physical execution and motor imagery is a subtype of MI, which refers to the internal reproduction of a specific motor action without any overt motor output (1). Mental practice is a training method by which MI is used with the intention of improving performance, in other words it is the imagined rehearsal of a motor act with the specific intent of learning or improving that act (2). MI is known to improve motor task performance, combination of mental and physical practice being more efficient than, physical practice alone (3). Moreover mental practice combined with physical practice has been found to promote the learning of motor skills and to maintain the level of performance of athletes when physical practice is not possible (4).
Motor imagery in sports plays a very important role in improving arousal, motivation, confidence, skill learning performance, strategies and problem solving, pain management and rehabilitation. In fact, athletes from most sport attribute at least part of their success to their use of imagery (5).
Professional teams today often utilize mental training programs for their athletes, and some have suggested that mental strength training should receive as much emphasis as physical training (6).
Motor imagery had shown to improve muscle strength compared to no practice at all (3). On balance control, it seems that practicing motor imagery or motor execution produces similar benefits in terms of motor learning and performance and there are commonalities in the neural behavioral and physiological responses between the 2 conditions, mental imagery techniques had shown positive effects among the elderly population, in improving static balance (7). Balance is a vital component in athlete's abilities (8). In basketball players its recommended that balance training is necessary for injury prevention (9). There is a strong relationship between muscle strength and balance. There is not much information available how mental imagery along with balance and strength training contribute to improvement in

balance performance in basket ball players. So, this study tries to find out the role of mental imagery in strength and balance training in basket ball players.

Material and Method

A sample of convenience of 30 male collegiate basketball ball players was recruited from different colleges of University of Delhi and Jamia Millia Islamia, New Delhi, India. Subjects included were recreational male basketball players, not involved in programmed training sessions (strength or balance) for last 2 months and with score 4 in movement imagery questionnaire-revised second version scale (MIQ-RS) (10). The mean $\pm$ SD of age, height, weight, limb length and MIQ-RS score of both groups is summarized in table I.

The consent of the subject was obtained and after the recruitment they were randomly assigned, through a random number generator into either group 1 or group 2 with 15 subjects in each group. All identifying information was kept confidential by assigning a number to each subjects. No restriction was placed on the subject's activity level except their participation in any resistance training and mental imagery protocols. Subjects in group 1 underwent strength and balance training and group 2 subjects underwent strength, balance and mental practice.

The study design was repeated measure experimental design and the study was approved by institutional ethical committee of Jamia Millia Islamia, New Delhi, India.

The instruments used in the study were, EN-Tree (Enraf–Nonius) pulley 24 kg system, leg press equipment and balance board. To estimate pre and post training strength of the subjects, software based equipment was used (EN-Tree pulley system) and leg press equipment was used for strengthening of lower limb muscles.

The movement imagery questionnaire-revised second version scale (MIQ-RS) was used as a screening tool which is reported to be a reliable and valid tool for assessing the mental imagery ability (10).

They were asked to read each statement carefully and then they had to actually perform the movement as described. They had to perform the movement a single time. Return to the starting position for the movement just as if they were going to perform the action a second time. Then, they were are asked to do, either (i) form as clear and vivid a visual image as possible of the movement just performed, or (ii) attempt to feel yourself making the movement just performed without actually doing it. Scoring was done according to the individual perception of the images (10).

Training protocol was given for six weeks, three sessions per week, and one session lasting for one hour for each subject. The components of training were balance training, strength training and mental imagery.

Balance training was done on balance board. Exercises program include were 1) maintaining double-leg stance while rotating the balance board; 2) maintaining a side to side balance on board with eyes open and closed; 3) and performing functional sport activities while in single-leg stance on the board for 10 minutes and each trial was done for 3 times (11).

Leg press was the exercise used to strengthen the lower limb muscles and the protocol used was daily adjustable progressive exercise technique (DAPRE) (12,13). Four set of exercise were performed by each muscle group. The first two set of exercise performed against 50% and 75% of previously established working weight(working weight is the amount of weight a person can lift in individual session and optimal working weight would be equal to person's 6RM)the full working weight was used in third set and the subject performed as many repetition as possible. The number of repetition performed in third set used to determine the adjusted weight for fourth set. Maximal repetition was performed in fourth set, and the number performed used to determine the working weight for the next day. Warm up was done for quadriceps, calf and hamstring by stretching in warm up session. Quadriceps strengthening was done by subjects in sitting position on the leg press machine with knees at 90° of flexion while pushing the weight within 10° of full knee extension and the position for strengthening of plantar flexors (gastrocnemius and soleus) knees were in full extension with the midfoot on the foot plate doing full range of plantarflexion and dorsiflexion at the ankle against the resistance.

Mental imagery was done after strengthening training and after balance training for ten minutes each. Subject and therapist were sitting in a quiet room. For the first two minutes subject were asked to do deep breathing for relaxation after that he was asked to image the strength and balance exercise which was actually done by him in training session and each task was imagined for 3

times with rest interval of one minute in between (14).
Balance was measured by modified star excursion balnce test (mSEBT), done in three directions that was anterior, posteromedial and posterolateral. Reliability measure ranging from 0.86 to 0.95 was reported for this test and it's also a predictor lower limb injuries in basket ball players (15,16). Before starting, their dominant leg was determined by asking the subject that which leg he used for kicking the ball. If right leg was dominant, the test would be counter-clockwise; on the contrary, if the left one was dominant, the test would be clockwise. Participants stood on the dominant leg on a center of Y-junction shape surface. While maintaing the single leg stance, the player was asked to reach with the free limb in the anterior, posteromedial and posterolateral direction in relation to the stance foot. Point was marked with chalk or pencil and subject return to the starting position after each trial. Distance was measured with the measuring tape. The trail was void if the subject was unable to maintain single-limb stance, the heel of the stance foot did not remain in contact with the floor, weight was shifted onto the reach foot in any of the 3 directions, or the reach foot did not return to the starting position prior to reaching in another direction and the trial was then repeated. Test was performed in all the 3 directions and average of 3 trials was taken for each direction and divided by leg length to normalize the data. (Distance covered/leg length x 100). Also, the greatest reach distance from each direction was summed to yield a composite reach distance for analysis of overall performance on the test (15,17).
Strength testing. 1repetion maximum (RM), was measured by EN-Tree pulley (Enraf Nonius), which is a software based machine and the reliability of the machine was found to be good (18,19). 1 RM method for assessing muscle strength was found to be valid method (20). The software of the equipment calculates 1RM according to the number of repetitions and weight. For quadriceps strength testing subject had to sit on the stool in front of the machine, pulley was attached to the subjects leg just below the medial malleolus. Subject had to do full knee extension followed by knee flexion as many times as he can against the weight. Instructions were given that exhale during extension and inhale during flexion (18). For ankle plantar flexors, seated calf raise were performed. For this subject had to sit in front of machine, foot was placed on a wedge with dorsum of the wrist placed on knee with subject holding the weight attached to the pulley in hand (18). They had to exhale during the upward movement and inhale during the downwards movement.
Statistical Analysis. Demographic characteristics of subjects between the groups such as of age, weight height, limb length MIQ-RS scores and pre training scores of balance and strength were analyzed by independent t-test. Group comparison was done by mixed model analysis of variance to determine the effect of training. Both the groups were assessed for mSEBT (composite score and individual direction) and for knee extensors and ankle plantar flexors. Statistical analysis was conducted in SPSS version 16.0, statistical significance was established a prior at $p \leq 0.05$.

Results
Comparison of demographic data between two groups showed no significant difference in age, height, weight, limb length and MIQ-RS score ($p>0.05$,table I) The mean $\pm$ SD of pre and post training scores of mSEBT (composite and individual direction scores) and 1RM scores of quadriceps and plantar flexors is given in table III. Pre training mSEBT (composite score and individual direction score) and 1RM score for both muscles studied showed no significant difference between the groups ($p>0.05$, table II).
The anterior direction, posteromedial direction, posterolateral direction and composite score showed a significant interaction between programme type (group) and time with $p=0.001$, $p=0.041$, $p=0.001$, $p=0.001$.
There was a substantial main effect for time with $p=0.001$, in all direction and composite score of the balance measure, with both group showing increase in the score across the 2 time period. The main effect comparing the two type of intervention was not significant, $p=0.118$ for anterior direction, $p=0.169$ for posteromedial, $p=0.303$ for posterolateral and $p=0.22$ for composite score suggesting no difference in the effectiveness of two interventions (table IV).
There was significant interaction between programme type (group) and time, $p=0.001$ for knee extensors and $p=0.018$ for ankle plantar flexor strength.
There was a significant main effect for time $p=0.001$ for both knee extensors and ankle plantar flexors strength in both group showing increase

in the score across the 2 time period. The main effect comparing the two type of intervention was significant for knee extensor strength p=0.023, suggesting statistical difference in the effectiveness of two interventions, while there was no significant difference in ankle palntarflexors strength p=0.052 (table IV).

Table I, Comparison of demographic characteristics of both the groups by independent sample *t* test

Variable	Group 1 (n=15) (mean ± SD)	Group 2 (n=15) (mean ± SD)	*t*	*p*
Age (years)	20.80±2.4	20.53 ±2.2	0.31	0.75
Weight (Kg)	65.35±7.059	69.63 ±8.03	-1.55	0.13
Height (cm)	173.65± 4.9	174.91 ±4.09	-.75	0.45
Limb Length (cm)	79.80 ±16.2	78.53 ±15.46	0.21	0.82
Movement imaginary ability questionnaire (MIQ-RS)	5 ±0.84	5.07 ± 0.91	- 0.2	0.82

Table II. The mean ±SD, of balance and strength scores for group 1 and 2 before and after training

Group	Time of assessment	mSEBT (anterior, cm)	mSEBT (postero medial, cm)	mSEBT (postero lateral, cm)	Composite Score (cm)	Quadriceps strength (1 RM, kg)	Ankle plantar flexors strength (1 RM, kg)
Group 1	Pre training	86.6±21.2	111.01±24	109.4±28.2	102.1±24	34.07±4	28±4.1
	Post Training	93±23.2	120.2±31	115.3±30	110±27.1	38.2±4.1	32±4
Group 2	Pre training	89±20.3	118±29	111.07±28.1	103.2±25	36.4±3.3	30.3±4
	Post Training	117±24.2	140.08±24.1	135.27±30	130.6±25	42.5±4.2	35.33±5

Table III. Comparison of strength and balance between the groups before training

Variable	Group 1(n=15) (mean ± SD)	Group 2(n=15) (mean ± SD)	*t*	*p*
mSEBT(anterior, cm)	86.6±21.2	89±20.3	-0.26	0.79
mSEBT (postero medial,cm)	111.01±24	118±29	-0.68	0.49
mSEBT(postero lateral,cm)	109.4±28.2	111.07±28.1	-0.15	0.87
Composite Score(cm)	102.1±24	103.2±25	-0.12	0.90
Quadriceps strength (1 RM, kg)	34.07±4	36.4±3.3	-1.81	0.08
Ankle planterflexors strenth(1 RM, kg)	28±4.4	30.3±4	-1.60	0.12

Table IV. Summary of mixed model analysis of variance result of effect on balance and strength

Type of analysis	p value/ effect size	mSEBT (anterior, cm)	mSEBT (postero medial, cm)	mSEBT (postero lateral, cm)	Composite Score (cm)	Quadriceps strength (1 RM, kg)	Ankle plantar flexors strength (1 RM, kg)
Interaction [type (group) x time]	*p*	0.001	0.041	0.001	0.001	0.001	0.018
	Partial eta squared (effect size)	0.56	0.14	0.35	0.57	0.31	0.18
Main effect (time)	*p*	0.001	0.001	0.001	0.001	0.001	0.001
	partial eta squared (effct size)	0.76	0.48	0.60	0.80	0.92	0.90
Main effect (group)	*p*	0.118	0.169	0.303	0.228	0.023	0.052
	partial eta squared (effect size)	0.085	0.066	0.038	0.051	0.171	0.128

Discussion

Results of this study for all the tested variable that is strength and balance, showed a significant time x group interaction and main effect (time) that means both the groups were changing differently over the time period and main effect (group) groups was not significant except for knee extensors strength. The mean percentage of change for all the testing variable that is for strength and balance was more for group 2. Mean percentage of change in group 1 and group 2 for knee extensor was 12.1% and 16.8% respectively, and for ankle plantar flexors was 14.3% for group 1 and 16.6% for group 2. Likewise for mSEBT the mean percentage for composite score was

7.7% for group 1 and 26.6% for group 2. The results of the present research are in accordance with the findings of Ranganathan et al., Herbert et al. and Bahari et al. (3,19,20).

Neuroimaging and psychophysical research on motor control has shown that there are striking similarities between real and imagined movements. These findings had led to a theoretical position termed the simulation hypothesis (21). This hypothesis states that overt movement and motor imagery (covert movement) are essentially based on the same processes. Movement execution, motor imagery and action observation are all driven by the same basic mechanism. The simulation hypothesis is based on two different lines of evidence. First, it has been shown that there are similarities in the behavioural domain. For instance, the time to complete an imagined movement is known to be similar to the time needed for actual execution of that movement; this phenomenon is known as mental isochrony. A second line of evidence for the simulation hypothesis shows that the neural system, used for action control is, indeed, activated during imagination of these actions. An increasing number of brain imaging studies have shown the similarity at the neural level of mental imagery and physical acitivity (21,22). The psychoneuromuscular theory (4) a base for interpreting how of mental training plays a role in movement acquisition and progress of movement skills, explains how mental training of movement causes the activity potential and little contraction of muscles. The movement feedback of this little muscular movement sent to brain centers in turn affects the activity of these areas which lead to improvement in the conformity of neuron-muscular system and causes the movement acquisition (23).

The strength increase may be due to mental training induced enhancement in the central command to the muscles (3) and studies have shown that greater strength is due to stronger brain activity (19,20). It is possible that repeated imagery of contractions will change the maximum energy production in a muscle. These changes may increase the activation of motor neurons or increase the relative levels of activation of agonist and antagonist muscles in a joint (20). There is reports on effect of mental imagery on static balance (23,7). It was found that postural control increased with MI than only with the physical exercise only (24). MI had shown to improve postural control in elderly subjects by reducing postural oscillations in the anterior–posterior axis. Such findings may be explained by focusing attention on the mental image of movement (7). A reduction in explorative movement (reduced sway) may occur during MI because attentional resources are diverted from postural to task performance (25). The studies have reported that mental and physical exercise has similar and common neural mechanisms (26). Brain structures which are activated in movement control, readiness and movement planning of physical movements are activated in mental training too and the structures were secondary movement area, premovement cortex, elementary movement cortex, cerebellum, and parietal lobe (25) the above discussed mechanisms might have contributed to increase in balance performance as well. Other reasons for increase in strength and balance are neuromuscular adapation and specificity of training adaptation (27). Balance training must have lead to task-specific neural adaptations at the spinal and supraspinal levels (28). Improved dynamic balance can also due to strength training of knee extensor and ankle planterflexors. These two muscle groups plays major role in maintaining balance (29, 30).

The training protocol can be used as an adjunct to other physical training to prepare, motivate and enhance the performance of athelets. For maintaining and enhancing dynamic balance one needs better cues of percepting change in direction and speed and mental imagery training may prepare the individual for better acquisition of techniques and skills.

A good neuromuscular control, such as strength and appropriate joint positioning is a prerequisite for performing the balance tests (31). During dynamic balance activity the co-contraction of the quadriceps femoris and hamstring muscles occurs in all directions.It is also established that the quadriceps were most active during the anterior direction in performing mSEBT. During anterior excursions, one must lean backward and the body should be in extension position in order that he/she could control his/her dynamic-balance. In this position, the gravity which acts on the upper body causes high torque of flexion knee and should be controlled by torque of extension (eccentric contraction) which is produced by quadriceps femoris (15). The plantar flexors also play a vital role in dynamic balance. These are the reasons why quadriceps muscle and plantar

flexors were selected to strengthen in this particular study. In present study first person perspective for motor imagery was used as it was found that internal imagery is more efficient than external imagery and had a greater effect on performance (3). Also we used MIQ-RS scale as a baseline measure so that every participant in the mental practice group had same imagery ability. It was taken in consideration because imagery ability has a significant effect on imagery efficiency and a person who is unable to vividly imagine a motor skill is unlikely to benefit from the numerous advantages of mental practice (10).
The limitations of the study were mental imagery were not quantified as perception differs individual to individual, the subject were not optimally aroused during the training as there is no game scenario after the intervention and there may be a possibility of hay wired thought process during the intervention. The size was small and proper sample size calculation techniques were also not used so the result may not be generalized and a study on larger sample size is warranted. In future mental imagery can be used for developing higher motor function such as agility, coordination etc. and mostly athlete uses mental imagery just before the game, its effects can be studied in training phases too.

Conclusion

There is significant interaction for time ×group for balance and strength, so it can be concluded that there is effect of mental imagery on strength and balance, so this technique may be used in situations when the athlete is not actually able to carry out the exercises physically.

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