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Effect of Neuromuscular Training on Selected Coordination Motor Abilities in Adolescent Soccer Players

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Abstract:

Introduction: Soccer is one of the most widely played sports in the world. It is a contact sport and challenges physical fitness by requiring a variety of motor abilities at different intensities. Complex coordinative motor abilities represent one of the key physical abilities which affect the speed of sports performance development. Coordinative abilities are primarily dependent on the motor control and regulation processes of CNS. The neuromuscular training is the ability to produce controlled movement through coordinated muscle activity, and functional stability (dynamic stability) is the ability of the joint to remain stable during physical activity.

Aims and Objectives: The aim of this study was to examine the effect of a six weeks neuromuscular training on selected coordination motor abilities in adolescent soccer players. To evaluate the level of selected coordination motor abilities in adolescent soccer players after neuromuscular training..

Methodology: Eighty-four adolescent soccer players playing at the school level (aged 13 ± 1.5 years) took part in the study. Experimental (neuromuscular) training group underwent the neuromuscular training program in addition to their normal soccer training, while the control group was involved in soccer training only.

Results: The neuromuscular training group enhanced their selected coordination motor abilities statistically significantly ($p < 0.001$) over the short period of time, while the control group also showed slight improvement in their kinesthetic differentiation and orientation abilities after just six weeks of soccer training. The results of present study also showed that selected coordination motor abilities in NMT group of males were more as compared to NMT group of females.

***Conclusion*:** The findings suggest that a 6-week neuromuscular training can significantly improve kinesthetic differentiation, balance, orientation and sense of rhythm in adolescent soccer players.

Key words: Neuromuscular training (NMT), Coordination motor abilities (CMA), Kinesthetic Differentiation, Balance, Orientation, Sense of rhythm

I. INTRODUCTION

Soccer is one of the most widely played sports in the world. It is a sport characterized by short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling. [5] Soccer is classified as a high intensity intermittent team sport. [47] It is a contact sport and challenges physical fitness by requiring a variety of skills at different intensities. Players are divided into different position such as goalkeepers, defenders, midfielders, and attackers. It was noted that goalkeepers have lower level of development of coordination motor abilities than players occupying positions in the field. The role and importance of coordination motor abilities in soccer should be directed at the realization of technical and tactical actions in varied conditions and in constantly changing situations and in tasks of all team formations.[13]Running is the predominant activity involved in playing soccer while explosive type activities such as sprints, jumps and kicks are an important performance factor which requires maximal strength and power of the neuromuscular system. [36]

Coordination motor abilities play a crucial role in the level of the sportsman motor fitness[13]and they set the effectiveness of motor behaviour of an individual.[37] The CMA reflected to the quality of motor performance, the speed of motor learning and the effectiveness, beauty and smooth of movements.[2] These abilities are compound character includes agility, accuracy, reaction, attention and concentration during motor performance, but appear in a complex manner along with mutual relations with other physical qualities such as speed, strength, endurance and flexibility. Due to this complicated combination of the coordination

abilities, the base of sports-specific skills and performance are depends upon the physical and skill qualities.[21] Basic coordination motor abilities[17] are: kinesthetic differentiation, balance, orientation and sense of rhythm.

The kinesthetic differentiation ability is the capability in positioning the body's joints (the spatial component), activating the strength of the involved muscles (the strength component) and the speed of the involved movement (the temporal component).[7] In soccer, kinesthetic differentiation may be indicated as kicking performance in which spatial and strength components are kicking ability and the speed of the ball is temporal component. [35]

Balance is the ability to maintain perfect body position during performance & recover the initial position.[8] Balance is the process of maintaining the position of the body's centre of gravity vertically over the base of support and relies on rapid, continuous feedback from visual, vestibular and somatosensory structures and then executing smooth and coordinated neuromuscular actions.[28] Balance in soccer players often perform single-leg reaching movements outside their base of support during passing, receiving, and shooting.[9] In matters of technique, such as stop-out-of-running, safe stance in kicking, and in one-on-one situations, so that a good balance abilities are crucial in soccer.[25]

Orientation is the ability to determine the position & movements of the body in space and time.[43] The ability to accurately assess of body positioning and its changes with regard to an opponent as well as perform movements in the proper direction are connected with orientation. The capacity of orientation was the substructure of the coordinative capacity allows the modification of the position and the movement of the body in space in relation to a certain field of action.[41] Motor capacities and excellent available for motor orientation, which are components of coordinative abilities, have important aspects for physical-sports achievement ability.[6]

Sense of rhythm is the ability to capture an acquire rhythm from an external source and to reproduce it in movement.[43] It is given by the sensibly equal time intervals that follow one another having the role of landmarks. Making the rhythm is realized via bodily or segmental psycho-motor reactions, being physiologically dependent on the nervous cell's functions.[41]

Coordination motor abilities are primarily dependant on the motor control and regulation process of central nervous system. These enable the sportsman to do group of movements with better quality and effect.[48]

Neuromuscular training encompasses a very broad group of exercises such as multi-intervention programs with a combination of balance, strength, plyometric, agility, and sport-specific exercises. Thus, it is unclear whether a single intervention or the combination of various exercises is primarily responsible for the training effects.[49] The neuromuscular training methods are based on sensorimotor control and achieved compensatory functional stability.[38] Sensorimotor control (also called neuromuscular control) is the ability to produce controlled movement through coordinated muscle activity, and functional stability (also called dynamic stability) is the ability of the joint to remain stable during physical activity.[3]

Neuromuscular training is strongly emphasized in the latest reviews and research.[26,29] Training experiences that improve neuromuscular coordination, joint strength, and ROM are also likely mechanisms that lead to improved balance.[9] Neuromuscular training program designed for soccer players, had demonstrated improvements in agility, speed, balance and abdominal endurance. [39] Some authors demonstrated that neuromuscular training seems to be highly efficient for enhancing explosive strength and neuromuscular activation at the onset of voluntary actions because neuromuscular training had a great impact on the neuromuscular system at the initiation of force production.[24] Soccer is a complex sport that involves many activities (tackles, jumps, direction and speed changes) that put a great strain on several neuromuscular parameters.[4] Functional ability in soccer can be exemplified by the performance of a soccer-related task. These tasks require appropriate control of the neuromuscular and musculoskeletal systems, including the proprioceptive system.[18] It is presumed that neuromuscular training has the most profound effect on the somatosensory and proprioceptive control systems.[19]

Studies have been conducted to determine the effect of neuromuscular training on selected coordination motor abilities in adolescent soccer players. But there is no research that has investigated the effect of neuromuscular training on selected coordination motor abilities among adolescent soccer players.For this purpose, this present study aims to find out the effect of six weeks neuromuscular training programs will improve the motor abilities for the various soccer techniques (sprinting, kicking, etc).

II. METHODS

A.Experimental Approach

A pre-post experiment design involving two groups (a training group and control group) was used in order to determine the effectiveness of a neuromuscular training program on selected coordination motor abilities in adolescent soccer players as part of a 6-weeks training program. A randomized controlled study was conducted.

B.Subjects

For this study, 84 subjects (42 males and 42 females, mean age 13 $\pm$ 1.5 years, range 11-16 years[14,17,32]) were randomly assigned in two i.e. in experimental (NMT) group, n = 42 and in control group, n =42. Experimental group underwent NMT program in addition to normal soccer training and the control group was involved in soccer training only. All subjects were school level soccer players. All the participants and their parents or coaches gave their consent for participation in the study. Subjects were fully informed about the protocol before the start of the study.

C. Procedures

Before the pretest, all the participants were familiarized with the different tests during a practice sessions. All subjects were allowed unlimited time for self-directed warm-up and stretching before the tests. Tests for selected coordination motor abilities were- kick the ball into the target test for kinaesthetic differentiation[33,34], standing on one leg while holding the ball test for balance[33,34], vertical ball throwing for orientation[34,42] and sprint at a given rhythm test for sense of rhythm[30,33,34]. After the pretest, participants were randomly divided into a training group and a control group. The training group conducted a neuromuscular training program consisting of 10 exercises per session (Table 1). Each participant repeated the training program 6 days per week for 6 weeks. The control group was involved in regular soccer training throughout the study period.

III. STATISTICAL ANALYSIS

The data was managed on excel spread sheet and conducted in SPSS (statistical package for the social sciences) software, version 21. Independent t-tests were used to assess for the differences in demographic data and comparison of absolute changes (post results-pre results) data between the groups. Paired t-tests were used to determine significant differences within the group. The level of significance was chosen to be $p < 0.05$, and all tests were two-tailed.

IV. RESULTS

Comparison of the demographic data between the neuromuscular and control groups showed no significant difference in age ($p > 0.05$). Pretest data indicated no statistical differences ($p > 0.05$) in selected CMA between the two groups. A statistically highly significant was found for kinesthetic differentiation and balance ($p < 0.001$) whereas statistically non-significant for orientation and sense of rhythm ($p > 0.05$).

Within Group Analysis: In this study four variables i.e. kinesthetic differentiation, balance, orientation and sense of rhythm were found to be significant in neuromuscular training group ($p<0.001$) whereas kinesthetic differentiation and orientation were found to be significant in control group. The mean difference of kinesthetic differentiation (mean difference=8.8333), balance (mean difference= 4.7724), orientation (mean difference= .8095) & sense of rhythm (mean difference=0.2164) in neuromuscular training group were more than the mean difference of control group i.e. kinesthetic differentiation (mean difference=1.62), balance (mean difference=0.0931), orientation (mean difference= 0.71429) and sense of rhythm (mean difference= 0.03762) (Figure 1).

Figure 2. showed that a greater scores of kinesthetic differentiation (mean difference = 10.136), balance (mean difference = 5.396) and orientation (mean difference= 0.95455) in males as compared to the scores of kinesthetic differentiation (mean difference = 7.40), balance (mean difference = 4.09) and in orientation (mean difference = 0.65) in females. But sense of rhythm ((mean difference = 0.2355) was more in females as compared to males (mean difference = 0.1991) of neuromuscular training group. It was evident that males performed significantly more in kinesthetic differentiation, balance & orientation as compare to females. Therefore, neuromuscular training group showed better results in selected coordination motor abilities as compared to control group.

V. DISCUSSION

The present study investigated the effect of 6-weeks neuromuscular training on selected coordination motor abilities in adolescent soccer players. The main finding of present study was the comparison of neuromuscular training group and control group. A highly statistically significant difference was found for kinesthetic differentiation and balance ($p < 0.001$) in between the groups whereas orientation and sense of rhythm between the two groups was not significant ($p > 0.05$). The results for kinesthetic differentiation showed an improvement in kicking ability within the both neuromuscular training and the control groups. In the present study, greater value for kicking the ball into a goal (mean difference = 8.8333) was found in neuromuscular training group as compared to control group (mean difference = 1.21). The significant improvement in kinesthetic differentiation scores of neuromuscular training group can be attributed to the adaptations associated with increase in leg muscles power by the bounding, line jumps and lateral shuffling exercises considered as plyometric and agility components of neuromuscular training program that influences the neuromuscular system. This finding of present study is consistent with the previous study who considered that a combined plyometric and sprint program can be used for the enhancement of kicking performance in youth soccer players.[36] Our present study is also similar with the finding of previous studies who demonstrated that the effect of 6 weeks training programs was enough time to produce significant improvements in explosive strength, muscle power and kicking ability in soccer players.[10,14] These previous studies also suggested that improvement in kicking performance was due to the core stability and plyometric training.[10,14]Moreover, plyometric training improves coordination and induces a neuromuscular adaptation that augments power production.[11] Whereas the greater core stability may benefit sporting performance by providing a greater force production and force transfer to the extremities.[1] In this study, a significant improvement in kinesthetic differentiation ($p < 0.001$) was also found in the control group. This improvement observed may be due to the regular soccer skills training about 6 weeks which lead to the enhancement of kicking ability in adolescent soccer players which was similar to other previous studies.[13,46] Furthermore, participants in our study were adolescent players and as a result of soccer training they probably improved their soccer kicking performance.

Highly significant improvement in balance ($p < 0.001$) was seen in the present study, after neuromuscular training in adolescent soccer players while no significant change was found in the control group ($p > 0.05$). It was also found that the greater value for balance (mean difference = 4.7724) in neuromuscular training group as compared to control group (mean difference = 0.0931). It may be due to the balance component of neuromuscular training program such as single leg forward bend pass, single leg chest pass and figure of eight exercises which enhance the strength of the leg muscle and coordination activity by improving neuromuscular control. This finding of our study is concurrent with the results of previous studies which revealed that

neuromuscular training had positive effects on balance in soccer players.[15,20,40,49] In a few research studies, the balance training led to improvement in neuromuscular facilitation and enhanced the static balance by postural control including the muscular and proprioceptive systems.[15,27,28] In our study, it was also seen that there was no statistically significant effect of normal soccer activity on balance ($p > 0.05$) in control group which was similar to the result of the previous study who mentioned that it may be due to the role of fatigue induced by a soccer training session in soccer players.[22] This fatigue caused deterioration of postural control and may lead to imbalance.

Our results for orientation indicated an improvement in vertical ball throwing test within the neuromuscular training and control groups. Both the groups showed highly significant differences ($p<0.001$) after six weeks of training. The mean value suggested that orientation (vertical ball throwing test) improved more for neuromuscular training group (mean difference = 0.80952) as compared to control group (mean difference = 0.71429). The improvement in orientation for neuromuscular training group can be attributed due to enhanced neuromuscular control. This result was supported by the previous study who concluded that after skills-specific training enhanced orientation in adolescent soccer players.[31] In present study, an improvement in orientation was also seen ($p< 0.001$) in control group which was similar to the results observed by previous studies who determined that the soccer specific technical performance can be learned faster and more effectively in the adolescent soccer player because they regularly participated in soccer training.[13,46] However, previous research had demonstrated that long term soccer training and skill training both have positive impact on the level of development of orientation.[6]

Sprint at a given rhythm test (sense of rhythm) scores was decreased significantly in the neuromuscular training group (mean difference = 0. 21643) but not in the control group (mean difference = 0.03762). This result of the present study showed highly significant improvement in sense of rhythm ($p< 0.001$) after neuromuscular training in adolescent soccer players while no significant change was found in the control group ($p> 0.05$). This result seemed to suggest that the neuromuscular training may be more beneficial in improving sense of rhythm component of coordination motor abilities in adolescent soccer players. Similar studies also suggested that an improvement may be found in sense of rhythm after neuromuscular training because core stability, balance and plyometric components of neuromuscular training enhances proprioceptive control and changes in temporal sequencing of muscle activation for more efficient movement.[11,23,36] In our study, there was no significant difference in sense of rhythm ($p> 0.05$) in control group which was similar to the previous study who suggests that soccer players required less sense of rhythm ability during playing.[48]

In the current study, a highly significant improvement of selected coordination motor abilities in males as compared to females of neuromuscular training group. This can be supported by previous study who explained that most ball games characterized by the necessity to adapt to changing environmental conditions are gender biased, with males usually practicing them more than females.[21] In present study, these differences may be found due to the puberty onset early in females which delayed the onset of motor abilities and slow the development of neuromuscular control after training. The results of our study showed greater scores of kinesthetic differentiation (mean difference = 10.136), balance (mean difference = 5.396) and orientation (mean difference = 0.95455) in males as compared to the scores of kinesthetic differentiation (mean difference = 7.40), balance (mean difference = 4.09) and orientation (mean difference = 0.65) in females. But score for sense of rhythm (mean difference = 0.1991) in males was less effective than the score for sense of rhythm (mean difference = 0.2355) in females of neuromuscular training group. Therefore, males performed significantly more in kinesthetic differentiation, balance & orientation as compared to females. But females performed significantly better in sense of rhythm, it may be due to the fact that females control some movement skills with exact rhythm which regulate the speed and mechanism of force during performance which was stated by previous study.[16] This finding of present study is also consistent with the results of previous studies which also observed that the improvement of coordinative motor abilities were found to be more in males as compared to females.[31,44] These coordination motor abilities are dynamically changing which depends on age and growth of sport performance.[45]

Therefore, the primary outcome of the present study showed that 6 weeks neuromuscular training resulted in an improvement in selected coordination motor abilities in adolescent soccer players. Statistically highly significant differences were seen in the results of kinesthetic differentiation ($p<0.001$), balance ($p<0.001$), orientation ($p<0.001$) and sense of rhythm ($p<0.001$) after completing neuromuscular training in adolescent soccer players. The results of the present study was in accordance with the result of previous study which examined that coordination skills training caused improvement in selected coordination motor abilities in 11-19 year old soccer players and also suggested that coordination motor abilities were significantly higher in adolescent male soccer players than in female soccer players of the same ages.[31] So, the results of the present study can be attributed due to the physiologic effects of neuromuscular training for enhancing explosive strength, muscle power and neuromuscular activation and the neuromuscular training had a great impact on the neuromuscular system at the initiation of force production and led to the improvement of the coordination motor abilities. Thus from the above discussion it can be concluded that 6 weeks of neuromuscular training is beneficial for improving kinesthetic differentiation, balance, orientation and sense of rhythm in adolescent soccer players.

Clinical Relevance

The six week neuromuscular training program used in our study is a unique program that included core strengthening, balance training and plyometric training especially designed for soccer players. It incorporates jump training, strength training, balance training and dynamic warm-up program reported to improve neuromuscular control i.e. movement patterns of athletes can be altered with training which reduce the risk of injuries and a potential for improving sports performance in adolescent athletes. Most of the training programs focus only on improvement in physical variables whereas motor abilities variables important for enhanced performance are ignored, so this training protocol can be used to enhance abilities of soccer players. Neuromuscular training is vitally important for youth whose motor abilities are highly plastic and amenable to age appropriate intervention and may be even more beneficial to youth with a decreased genetic potential for motor development and competence.

Limitation of Study

Sample size is small. Only adolescent players were taken into consideration so results cannot be generalized to athletic population of other age groups. Soccer players having specific position in game (i.e. midfielders, defenders, attackers and goalkeeper) were not studied.

Future Research

The present study can be incorporated into other sports specific training program which can be effective in respective sports for improving coordination motor abilities. The same neuromuscular training protocol can be applied to adult population.

VI. CONCLUSION

There was a highly statistically significant difference ($p < 0.001$) found in selected coordination motor abilities in neuromuscular training group. Therefore, it can be concluded that adolescent soccer players from experimental group (six weeks neuromuscular training) improved their coordination motor abilities more than the control group. Improvements of coordination motor abilities were found to be more in males of neuromuscular training group as compared to females of neuromuscular training group.

Table & Figures

Table1: Neuromuscular training[12] protocol

Exercises	Amount
Abdominal Crunches	20 rep.
Cross Crunches	20 rep.
Lunges	20 rep. for each
Plank	Hold for 60 sec.
Single leg Forward chest pass	20 rep. for each leg
Forward bend pass	20 rep. for each leg
Single leg figure of 8	20 rep. for each side
Lateral shuffle	20 rep. for each side
Line jump	20 rep.
Bounding	20 jumps

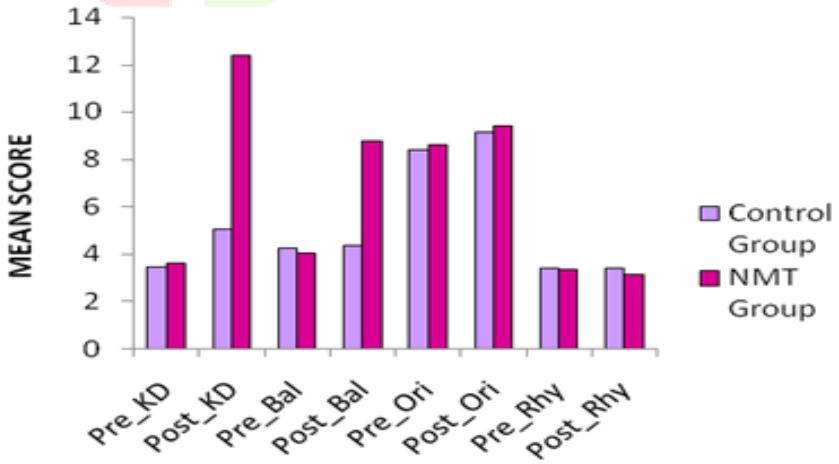

Figure1: Comparison of mean scores of pre and post- reading of selected coordination motor abilities in NMT group and Control group.

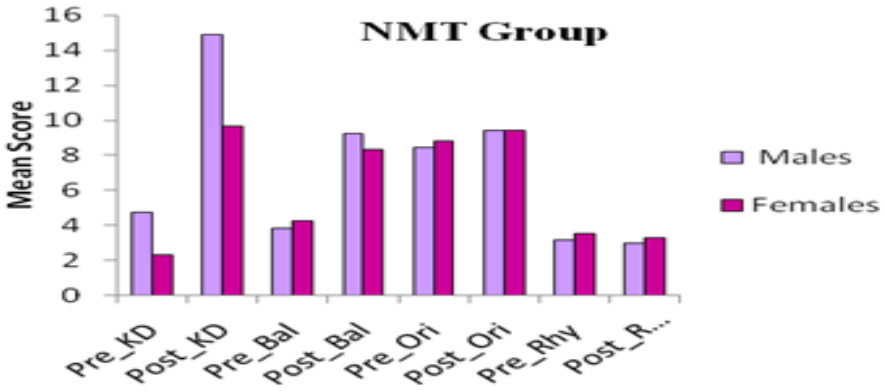

Figure 2: Comparison of the mean score of pre and post readings of the selected coordination motor abilities in both females and males of neuromuscular training group

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