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Original

Effect of eight-week core muscles strength training on physical fitness and body composition variables in male players of team games

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ABSTRACT

Objective: To find out the effect of core muscles strength training for eight weeks (five days/week) on fitness and body composition variables in male players of team games.
Methods: Fifty five male players were selected for the study. Subjects were randomly divided into experimental (n: 30) and control group (n: 25). Lateral trunk endurance, endurance and explosive power of leg, abdominal muscles endurance, body weight, body fat percentage, essential fat mass, non-essential fat mass, absolute total body fat and body surface area were measured before and after intervention.
Results: The significant effect of core training program was observed ($p<0.05$) in lateral trunk endurance, explosive power of leg, abdominal muscles endurance(respectively; 38.29%, $p<0.001$; 10.57%, $p<0.001$; 71.23%, $p<0.002$). Also, significant changes were found in bodyweight, fat %, essential fat, non-essential fat, absolute total body fat, body surface area, lean body and fat free body mass(respectively; F: 28.88, $p<0.001$; F: 4.25, p: 0.41; F: 28.88, $p<0.001$; F: 5.37, $p<0.001$; F: 5.80, p: 0.20; F: 27.93, $p<0.001$; F: 2.40, p: 0.141; F: 2.03, p: 0.16).
Conclusion: The eight-week core muscles strength training program used in this study was very effective for producing significant benefits to fitness level performance and body composition, as well as lowering the weight of male players.
Keywords: Core training; Swiss ball exercises; Body composition; Muscles activation.

Efecto del entrenamiento de fuerza muscular del Core de ocho semanas en las variables de aptitud física y composición corporal en jugadores masculinos de juegos de equipo

RESUMEN

Objetivo: Averiguar el efecto del entrenamiento de fuerza de los músculos del Core durante ocho semanas (cinco días / semana) sobre las variables de estado físico y composición corporal en jugadores masculinos de juegos de equipo.
Métodos: Cincuenta y cinco jugadores masculinos fueron seleccionados para el estudio. Los sujetos se dividieron aleatoriamente en grupo experimental (n: 30) y grupo control (n: 25). La resistencia lateral del tronco, la resistencia y el poder explosivo de la pierna, la resistencia de los músculos abdominales, el peso corporal, el porcentaje de grasa corporal, la masa de grasa esencial, la masa de grasa no esencial, la grasa corporal total absoluta y el área de superficie corporal se midieron antes y después de la intervención.
Resultados: Se observó el efecto significativo del programa de entrenamiento del Core ($p<0.05$) en la resistencia lateral del tronco, la potencia explosiva de la pierna y la resistencia de los músculos abdominales (38.29 %, $p<0.001$; 10.57%, $p<0.001$; 71.23%, $p<0.002$ respectivamente). Además, se encontraron cambios significativos en el peso corporal, % de grasa, grasa esencial, grasa no esencial, grasa corporal total absoluta, área de superficie corporal, masa magra y masa corporal libre de grasa (F: 28.88, $p<0.001$; F: 4.25, p: 0.41; F: 28.88, $p<0.001$; F: 5.37, $p<0.001$; F: 5.80, p: 0.20; F: 27.93, $p<0.001$; F: 2.40, p: 0.141; F: 2.03, p: 0.16, respectivamente).
Conclusión: El programa de entrenamiento de fuerza muscular del Core de ocho semanas utilizado en este estudio fue muy efectivo para producir beneficios significativos para el rendimiento del nivel de condición física y la composición corporal, así como para reducir el peso de los jugadores masculinos.
Palabras clave: Entrenamiento Core; Ejercicios pelota suiza; Composición corporal; Activación muscular.

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Efeito do treinamento de força de oito semanas nos músculos do Core sobre variáveis de aptidão física e composição corporal em jogadores masculinos de jogos em equipe

RESUMO

Objetivo: Descobrir o efeito do treinamento de força dos músculos do Core por oito semanas (cinco dias/semana) nas variáveis de condicionamento e composição corporal em jogadores masculinos de jogosem equipe.
Métodos: Cinquenta e cinco jogadores do sexo masculino foram selecionados para o estudo. Os individuos foram divididos aleatoriamente em grupo experimental (n: 30) e grupo controle (n: 25). Resistência lateral do tronco, Resistência e potência explosiva da perna, Resistência dos músculos abdominais, Peso corporal, Percentual de gordura corporal, Massa gorda essencial, Massa gorda não essencial, Gordura corporal absoluta absoluta e Superfície corporal foram medidas antes e após a intervenção.
Resultados: O efeito significativo do programa de treinamento do Core foi observado (p<0.05) na resistência lateral do tronco, força explosiva da perna, resistência dos músculos abdominais (38.29%, p<0.001; 10.57%, p<0.001; 71.23%, p<0.002respectivamente). Além disso, foram encontradas alterações significativas no peso corporal,% de gordura, gordura essencial, gordura nãoessencial, gordura corporal total absoluta, área de superfície corporal, corpo magro e massa corporal livre de gordura (F: 28.88, p<0.001; F: 4.25, p: 0.41; F: 28.88, p< 0.001; F: 5.37, p<0.001; F: 5.80, p: 0.20; F: 27.93, p<0.001; F: 2.40, p: 0.141; F: 2.03, p: 0.16,respectivamente).
Conclusão: O programa de oito semanas de treinamento de força dos músculos do Core usado neste estudo foi muito eficaz para producir benefícios significativos ao desempenho do nível de condicionamento físico e composição corporal, além de diminuir o peso dos jogadores do sexo masculino.
Palavras chave: Treinamento Core; Exercícios bola suíça; Composição corporal; Ativação muscular.

Introduction

Core muscles are the group of muscles that include abdominals, paraspinals, gluteus, hip girdle musculature and pelvic floor that provide strength and stability to the body through the active contributions of the trunk musculature.[1] Also, there are 29 pairs1 of muscles designated as core muscles that help to stabilize the functional movement of the spine, pelvis and kinetic chain.[2]

The anatomical structure of the core is defined as all the soft tissue with a proximal attachment origin on the axial skeleton. The cornerstone of all the athletic movement is the abdominal or core muscle which controls the limb movement. Studies have shown that core muscles play an important role in stabilizing the body, generating forces[3], rehabilitation, improving strength and stability of core, hence core instability is directly associated with week core muscles.[4] It is theorized that core muscles control the core of the body that helps to maintain posture during movement, increases proprioception abilities including strength, endurance, power, speed and creates constant contraction of abdominal muscles especially in the region of transverseabdominis.[5]

Core endurance is the most crucial component in core training because it supports core muscles in maintaining an efficient trunk position. Barati et al indicate that core endurance is important to spinal stability during prolonged exercise.[6] When the current literature is examined, core muscles training is broadly used to improve strength, speed, dynamic balance, conditioning, health, fitness, and rehabilitation with claims of increasing performance and prevent from the risk of injuries,[6] very few studies have included combination of these core exercise (with and without swiss ball) for improving body composition components for the players of team games. Successful competition in sports has been related to specific anthropometric characteristics and body composition, for the better performance of player.[7]

Body composition (BC) is the percentage of muscular, fat and bone tissue in the overall body mass. In another word, it is the division of body weight in different compartments which constitute the human body.[8] Hence, BC analysis permits us to know the extents of the different constituents parts of the human body. The model generally used to assess BC having two compartments, or bicompartmental, which posits that the human body is composed of fat mass and lean body mass.[9]

Further studies have shown that the structure of the body and morphological characteristics are important determinants of performance in several sports, which include bound physical impressions like body composition (body fat, body mass, muscle mass) and physique (somatotype).[10]

Team games are characterized by the repetitive action of short duration with a high-intensity change in direction, jumps and arm actions in various postures. Therefore, players need to have the correct posture and good balance. Training effects are influenced by the characteristics of the participants, trained athletes require training of rather higher frequency.[11]

All fitness components depend on body composition to some extent. An increase in lean body mass contributes to developing strength and power. Strength and power are related to muscle size. The proper intervention program is needed to improve body composition and fitness level to achieve optimal performance of the players. The main objective of this research was to investigate the effect of eight-week core muscle strength training (CMST) on fitness and body composition variables in male players of team games. The study assumes that core muscle strengthening exercises can be effective tools for the players to increase the fitness level, improved body composition and reduce body weight in male players, through different core exercises with and without Swiss ball.

Methods

Subjects

Fifty-five male players who represented the University in National/Zonal competition in different games i.e. Volleyball-5, Baketball-5, Kabaddi-5, Handball-5, Kho-Kho-5,Football-5 were randomly selected. The subjects were randomly divided into two groups: experimental group (EG) (n: 30, age: 25.3 ± 1.52, height: 167.0 ±1.12 cm, body weight 60.0 kg, before training and 58.0 kg after training, Waist Circumference:78.0 ± 1.48 cm, before experiment and 76.0 ± 1.40 after experiment, Body Mass Index (BMI): 21.50 ± 0.60kg/m^2, before experiment and 20.90 ± 0.54 after experiment, and control group (CG) (n: 25, age: 26.4 ± 1.63 years, height: 168.8 ± 1.00 cm, weight: 62.8 kg, before experiment and 62.64 kg after experiment, Waist Circumference:79.08 ± 1.44 cm, before experiment and 79.6 ± 1.42 after experiment, Body Mass Index (BMI): 22.12 ± 0.58 kg/m^2, before experiment and 22.50 ± 0.47 after experiment),were the subjects of the present study. The core training program was scheduled daily from 6.30 to 7.30 am at the university multipurpose hall. The ethical committee of the university approved the study; consent was obtained from each participant.

Procedures

The participants were undergoing a post-graduation course in physical education and were aware of the core training program. All the subjects of the present study were tested for core muscle strength through the plank test. The scores of all subjects were

below ten which means the need for improvement[12] hence all the subjects were included. The duration of the experiment was 8th weeks. Body composition and fitness variables were measured at the pre and post end of the experiment. Core training was conducted at University multipurpose hall from January to March, with an average ambient temperature of 29°C, an average humidity level of 43%.

The control group participated in regular physical activity, ie 45 minutes conditioning program consisting of ten minutes warm-up followed by running, jumping, whole-body exercise and then cool down for five minutes and other than conditioning program mentioned above both the groups attended classes of physical education including game practice. All the subjects were tested to asses Lateral trunk endurance (LTE), Explosive power of leg (EPL), abdominal endurance and body composition variables before and after eight-week training period (Figure 1). The description of a test to measure LTE, EPL, Abdominal muscles endurance (AME), and body composition variables is given below.

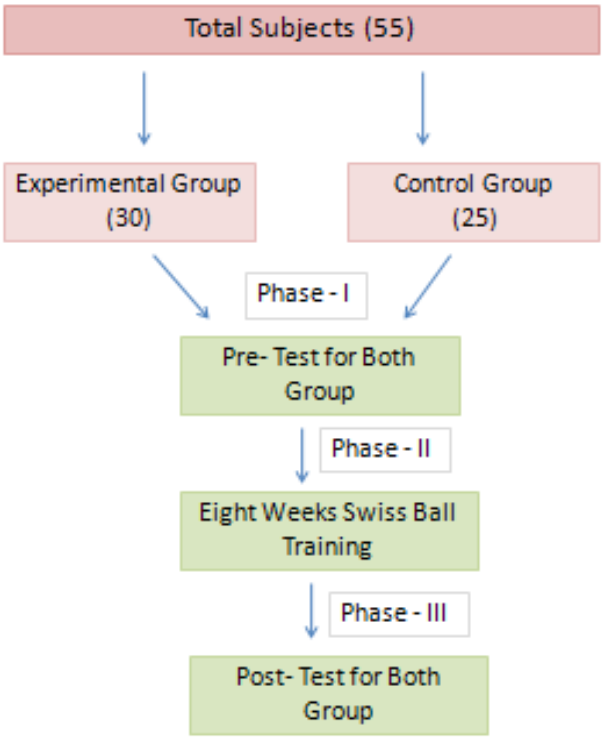

Figure 1. Flow chart for Eight week Core muscles strength training

Lateral trunk endurance

Subjects were asked to perform isometric contraction of the trunk on the right side of the lateral position. The participant assumes a full side- bridge position with the legs extended and the top foot placed in front of the lower foot. The participant supports the trunk on one elbow and their feet while lifting their hips off the floor to create a straight line over their entire body length. The uninvolved arm is held across the chest with the hand placed on the opposite shoulder. Endurance is measured in seconds and the test is terminated when the participant moves out of the original position. The ICC of the test was 0.82.[12]

Explosive power of leg

EPL was measured by Standing Broad Jump Test (SBJT). The subject stands behind a line marked on the ground with feet slightly apart. A two feet take-off and landing area are used, subjects were instructed to perform with the swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backward. The longest distance jumped, out of three attempts was recorded. The measurement is taken from the take-off line to the nearest point of contact on the landing (back of the heels). The best distance jumped was recorded out of three trials in centimeter. The ICC of the test was 0.97.[13]

Abdominal muscles endurance

Abdominal muscular endurance was assessed by the curl-up test. Abdominal muscular endurance was assessed as the maximum curl-ups performed without rest in 1 min. Abdominal curl-ups were performed in the supine position with the knees flexed at 45° with legs slightly apart and feet on the ground. The arms were extended along the sides of the body with hands in prone position and fingers outstretched. Participants were instructed to curl-up to lift the shoulder blades off the mat and slide their fingers from one end of a 12 cm ruler. After each curl-up, the subject was instructed to return to the starting position. The maximum number of curl-ups was recorded. The ICC of the test was 0.97.[14]

Core Muscles Strength Training

A training program of eight-weeks, five days/week, once/day was developed for core training, the program was started with ten repetitions, 2-3 second holds on the first day of the exercise week (Table 1). For timed exercises, it was 20 seconds. On the days 2-5 repetition was added, for repetition exercises or ten seconds for timed exercises. It was continued with adding repetition or time each day until 20 repetitions are met or 60 seconds are performed for each exercise. A pain-free motion was maintained. The CMST followed the training principles and the load was increased gradually. The CMST included exercises with swiss ball and without swiss ball followed by cool-down exercises for 10-15 minutes. Before the commencement of CMST, the orientation session was organized by the trainer to get familiar with the core and swiss ball. The swiss ball trainer introduced the subjects that how to perform the exercise on the swiss ball. It included different special exercise and the increase of load was progressive, from simple to complex exercises. The subjects were instructed to stop the training whenever there is pain or discomfort while doing core exercises. Total 30 swiss balls, were used for the core training program, size between 60 to 85 cm in diameter, according to the height of the subjects. CMST was started with a proper warm-up for 10-15 minutes which included exercise like stretching with hand, wrist, and ankle rotation with slow jogging. Some of the exercises are illustrated (Figure 2).

Body composition measurements

All subjects were measured for selected body composition variables before and after the completion of the eight weeks. Measurements were performed in the morning session, more than two hours after waking up. Anthropometric parameters Height (m), triceps (mm), biceps (cm), body mass (kg), waist circumference (cm), calf circumference (cm), supraspinal (mm), subscapular (mm), and calf skinfold (mm) were taken by trained researchers, as prescribed by the International Society for the Advancement of Kinanthropometry (ISAK). Measures Date of birth was obtained by self-report and age calculated. Height was measured to the nearest 0.1 cm on a stadiometer. Body Weight was measured to the nearest 0.1 kg using a pre-calibrated electronic scale (SECA Alpha 882, Vogel and Halke, Hamburg). The variables measured were: body weight (kg), Body fat percentage (BF %), Essential fat mass (EFM, kg,), %), Non Essential fat mass (NEFM, kg,), Absolute total body fat (ATBF, kg), Body surface area (BSA, sq.m), Lean body mass (LBM, kg) and fat-free body mass (FFBM, kg).

Figure 2. Core muscles strength training exercises. Core training Exercises (A) Supine Position with One Arm and Leg Lift, (B) Quadruped Position, (C) Quadruped Position with One Arm and Leg Lift, (D) Plank ,(E) Bridge with arm left, (F) Bridge with Swiss Ball, (G) Abdominal Crunches with Swiss Ball, (H) Opposite Arm and Leg Lowering with Knee Straight, (I) Both Leg Lift with Swiss ball, (J) Plank with arm left, (K) Plank with One Arm and Leg Lift (L) Plank with leg left

Table 1. Eight Week Core muscles strength training program

Exercise with and without swiss ball	Week 1-2		Week 3-4		Week 5-6		Week 7-8	
Warming up of 15 minute before started training	Repetition	Set	Repetition	Set	Repetition	Set	Repetition	Set
Quadruped alternate arm and leg lift	10	2	13	3	15	4	17	4
Swiss-ball alternate arm and leg extension	10	2	13	3	15	4	17	4
Swiss-ball supine Bridge	10	2	13	3	15	4	17	4
Prone Bridge	10	2	13	3	15	4	17	4
Side bridge with shoulder abduction	10	2	13	3	15	4	17	4
Supine position alternate arm and leg Lift	10	2	13	3	15	4	17	4
Bridge with arm lift	10	2	13	3	15	4	17	4
Abdominal crunches with swiss ball	10	2	13	3	15	4	17	4
Swiss-ball back	10	2	13	3	15	4	17	4
Extension Plank with one arm and one leg lift	10	2	13	3	15	4	17	4
Swiss-ball hamstring Curl	10	2	13	3	15	4	17	4

Anthropometric Measurement techniques

Anthropometric dimensions are needed to calculate the anthropometric somatotype: stretch stature, body mass, four skinfolds (triceps, subscapular, supraspinale, medial calf). The following descriptions are adapted from Carter and Heath.[15]

Stature (height).The height measured with the help of stadiometer. Body mass (weight). with help of weighing scale. Skinfolds: A fold of skin and subcutaneous tissue were raised firmly between thumb and forefinger of the left hand and away from the underlying muscle at the marked site. The edge of the plates was applied on the caliper branches 1 cm below the fingers of the left hand and full pressure exerted before reading at 2 sec the thickness of the fold. All skinfolds were taken on the right side of the body. The subject stood relaxed, except for the calf skinfold, which is was taken with the subject seated. Triceps skinfold: With the subject's arm hanging loosely in the anatomical position, a fold was raised at the back of the arm at a level halfway on a line connecting the acromion and the olecranon processes. Subscapular skinfold: The subscapular skinfold was raised on a line from the inferior angle of the scapula in a direction that is obliquely downwards and laterally at 45 degrees. Supraspinale skinfold: The fold 5-7 cm was raised above the anterior superior iliac spine on a line to the anterior auxiliary border and on a diagonal line going downwards and medially at 45 degrees. Medial calf skinfold: A vertical skinfold was raised on the medial side of the leg, at the level of the maximum girth of the calf.

Statistical Analysis

Data analysis was performed using the Statistical Package for social sciences 22 (SPSS-22). Descriptive statistics (Mean ± SD) were calculated for all the variables. Shapiro-Wilk test was used to test the normality of the values of all dependent variables. A comparative statistical analysis of covariance (ANCOVA) was applied to analyse the between-group (CG and EG) and within-group (pre- and post-) effects. The level of significance was set atp<0.05.Effect size is also reported through partial eta squared (η2). The ES was used to estimate the (standardized) magnitude of the difference, and the values were classified according to Cohen[16] in: ≤0.20 (trivial), 0.21–0.50 (small), 0.51–0.80 (moderate) and >0.80 (large). For all analyses, a significance level of p< 0.05 was adopted. Percent change in test variables was calculated as follows: pre-test value was subtracted from the post value, then divided by the pre-test value and multiplied by 100. Each time, p<0.05 was considered a significant difference.

Results

The core-training intervention had a possibly large beneficial effect on fitness and body composition variables. Description of participants of EG and CG are given in the methodology section. Results of fitness tests can be seen in Table 2. Significant effect of core training was observed in LTE (p:0.35,F: 16.812, η2:0.53), EPL at p<0.001,F: 12.310, p<0.001 η2:0.76) and AME p:0.002,F: 11.069, η2:0.42). The percentage increased in LTE,EPL and AME were 38.29%, 10.57% and 71.23%, respectively.

Table 3 shows that during the period of eight weeks male players of EG achieved significant improvements in their body composition. Significant effect of core training was observed in body weight (p:0.35,F: 16.812, η2:0.53), BF % (p:0.35,F: 16.812, η2:0.53), EFM (p:0.35,F: 16.812, η2:0.53), NEFM (p:0.35,F: 16.812, η2:0.53), ATBF(p:0.35,F: 16.812, η2:0.53), BSA (p:0.35,F: 16.812, η2:0.53), LBM (p:0.35,F: 16.812, η2:0.53), and FFBM (p:0.35,F: 16.812, η2:0.53).

Discussion

The purpose of this study was to determine the effects of CMST on fitness and body composition variables in male players. The results indicated that an eight week of CMST led to a significant increase in fitness variables. Result provide evidence that the performance of LTE, EPL, and AME increased after eight weeks CMST, which indicate increased in muscle endurance, strength, and power. Increased muscle strength, can be attributed to physiological and neural adaptation of muscles. Neural adaptation includes more efficient neural recruitment and increased conduction velocity, enhanced motor unit synchronization. Apart from this neural inhibitor reflexes are lowered.[17]

Performance of the trunk endurance test improved by 38.29 % after CMST. The major function of the trunk muscles is balancing, transfer of force and the gait. The core training emphasizes the strength and conditioning of muscles of the trunk. It is also known as trunk dynamic control that allows transfer, control of force and motion to distal segments of the kinetic chain for the treatment of trunk related injuries.[1,3]Another study Schilling et al.[18] attempted to find out the effect of core strength and endurance training on performance in college students and found that strength-trained group showed significant improvement in flexor and extensor endurance and the endurance-trained group improved in the right lateral and flexor endurance tests.

AME showed 71.23% improvement due to training with large effect size which definitely can help achieve better performance in games. Other studies have also reported an increase in abdominal endurance through core training. On or off swiss ball exercises have shown a significant increase in abdominal muscle endurance.[19] Studies have shown improvement in strength and proprioceptor activities through swiss ball exercise on an unstable surface (abdominal and back exercises), due to adaptive changes in the neuromuscular system[20] In an, another study on 20 badminton players who participated in six weeks of core strength training significant increase in abdominal fatigue Test (154%), Back Extensor Test (106%), and Side Bridge Test (113%) was recorded.[21]

The result of the present study shows an increase in EPL performance by 10.57%. Improved performance in EPL may be due to an increase in power relay to lower extremities through increased strength of muscles of the core region after training. Lacono et al,[22] also suggested that a 6-week CMST program is an effective method for improving the lower limb strength balance of young footballers. The significant effect of CMST on the ability to create and transfer the forces on athlete's extremities for vertical jump, standing broad jump, and push press was reported.[23] Increased speed, agility, leg explosive power, and upper body strength were observed after eight weeks of CMST in Handball player.[24] Sato & Mokha,[25] reported improved performance in 5000-m performance, running kinetics, lower-extremity stability, and in runners, 6 weeks CMST in the experimental group. Mendes,[26] increased sprinting performance after CMST due to increasing explosive power of lower extremity.

Table 2. Mean and Standard deviation data of fitness variables of male players (n=55)

Variables	EG(M ± SD)		Δ (%)	CG(M ± SD)		F	p	Effect size
	Pre Test	Post Test		Pre Test	Post Test			
LTE (s)	63.80±3.59	88.23 ±4.67[a]	38.29 %	56.60± 5.34	65.00 ± 5.26	16.90*	0.001	0.053(Moderate)
EPL (cm)	190.80±3.72	210.97±4.66[a]	10.57 %	201.16±3.99	206.44±4.12	12.31*	0.001	0.76(Moderate)
AME(n)	21.26±3.84	36.40±4.73[a]	71.23 %	30.32±2.21	34.12±2.72	11.06*	0.002	0.42(Small)

EG: Experimental Group; CG: Control Group; SD: Standard Deviation;a: significance differences from pre-test (p < 0.05); Δ (%): improvement in experimental group; p value: Statistically significant values are in bold characters;LTE:Lateral trunk endurance; EPL:Explosive power of leg;AME:Abdominal muscles endurance.

Table 3. Mean and Standard deviation data of body composition variables of male players (n=55)

Variables	EG (M ± SD)		CG (M ± SD)		F	p	Effect size (f2)
	Pre Test	Post Test	Pre Test	Post Test			
Body Weight(kg)	59.59 ± 10.01	58.22 ± 9.46	62.78 ± 9.33	62.64 ± 9.44	28.88*	0.000	0.35(Small)
Body Fat (%)	13.31 ± 3.48	12.50 ± 3.69	14.39 ± 5.73	14.39 ± 4.91	4.25*	0.041	0.07(Trivial)
EFM (kg)	1.78 ± 0.30	1.74 ± 0.28	1.88 ± 0.28	1.87 ± 0.28	28.88*	0.001	0.35(Small)
NEFM (kg)	6.50 ± 3.62	5.81 ± 3.28	7.59 ± 4.81	7.56 ± 4.44	5.37*	0.001	0.35(Small)
ATBF (kg)	8.29 ± 3.89	7.55 ± 3.53	9.47 ± 5.05	9.44 ± 4.70	5.80*	0.020	0.10(Trivial)
BSA (sq.m.)	1.66 ± 0.14	1.64 ± 0.13	1.71 ± 0.12	1.71 ± 0.12	27.93*	0.001	0.34(Small)
LBM	53.08 ± 1.26	53.08 ± 1.22	55.19 ± 1.16	55.07 ± 0.15	2.40	0.141	0.04(Trivial)
FFBM	51.29 ± 1.20	50.66 ± 1.17	53.31 ± 1.11	53.19 ± 1.10	2.03	0.16	0.03(Trivial)

EG: Experimental Group; CG: Control Group; SD: Standard Deviation; p value: Statistically significant values are in bold characters; EFM:Essential fat mass; NEFM: Non Essential fat mass; ATBF:Absolute total body fat; BSA:Body surface area; LBM:Lean body mass; FFBM: fat-free body mass.

The results of our research also indicated that in the male players of EG found to be significant in pre- to post-test changes at p<0.05 in 6 body composition variables, while in CG, no significant changes were observed. Statistically significant effect of Core Muscles Strength Training was observed on Body weight, BF%, BSA, ATBF, EFM and NFM of Males Players of team games in EG. Similarly, Aguilar et al.[27], in their systematic review on physical activity programs to reduce excess weight and obesity in adolescents, indicated that several studies found links between physical activity and improvements in fat-free mass and BMI.

The difference in the means of the pre- and post-tests of supraspinal, biceps, triceps, subscapular, body fat percentage, waist-hip ratio and calf girth of the EG proved to be significant, compared to the control group after CMST. Similarly, Dedecan,[28]stated that CMST affects the[29] percentage of body fat positively. These findings are consistent with previous studies showing that strength training can improve body composition and decrease abdominal obesity in the absence of changes in body weight.[29] There are some limitations in this study. We have selected adult trained male players as sample. Novice participants could have yielded more significant difference. Dietary intake, amount of sleep, and daily routine of the participants were the limitation of the study.

The current study suggests that eight weeks five days/week of CMST improves LTE, EPL, AME and BC variables in male players. The strengthening of core muscles might be contributed to athletic performance. Results of the study indicate improvement in core muscle strength, endurance, and explosive strength, further studies can be conducted to observe improvement in game-specific performance with an increase in above components of fitness and body composition. Coaches should incorporate core strengthening exercises into fitness training. Applying the methods utilized in this study to other populations would also likely present very interesting data, as this study analyzed several more variables (flexibility, posture deformities, injury rehabilitation) than other studies. So, more research is being conducted to compare and correlate the factors affecting the core muscles strength. Another future studies should investigate the effects of CMST programs on the performance of team game players during the rehabilitation period after injury and prevent injuries in athletes.

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