Original Article

Effects of short-term training on anthropometric, physical fitness and physiological variables of football players

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ABSTRACT

Football is popular sports worldwide and required high level of physical fitness and physiological demand. Training may improve the physical fitness and physiological variables when given according to the principle of periodization. The present study was designed to investigate the effects of training on anthropometric, physical fitness and physiological variables of football players. Ninety five male football players (age 14-16 yrs.) were included, and twenty five were excluded, the remaining seventy were divided into control group (CG, n = 35) and experimental group (EG, n = 35). The volunteers of EG followed a training (2 hrs/d, 5 d/wk., for 6 wks.), no training was followed for CG. Assessments of anthropometric, physical fitness and physiological variables were performed at 0 week and after 6 weeks. Paired sample t-test was performed to find out the differences in selected variables. An increase ($p < .05$) in grip and back strength, flexibility, anaerobic power, VO_{2max}, FEV_1, FVC and PEFR; and reduction ($p < .05$) in body mass, BMI, percent body fat, fat mass, reaction time of hands, resting heart rate, systolic blood pressure, pulse pressure were noted among the volunteers of experimental group after 6 weeks of training. Training may improve the anthropometric, physical fitness and physiological variables of the football players, and thus improve performance.

Keywords: Sport medicine, Body fat, Physical fitness, VO_{2max}, Lung functions, Training, Football.

Cite this article as:
Ghosh, K., Bera, S. J., Ghosh, S., Singha, P., Jana, A., Mahapatra, M., Khanna, G. L., & Manna, I. (2023). Effects of short-term training on anthropometric, physical fitness and physiological variables of football players. *Journal of Human Sport and Exercise, 18*(4), 786-798. https://doi.org/10.14198/jhse.2023.184.04

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Submitted for publication March 19, 2023.
Accepted for publication March 28, 2023.
Published October 01, 2023 *(in press* April 28, 2023).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2023.184.04

INTRODUCTION

The game of football is very popular worldwide. The game is played for 90 minutes which may continue up to 120 minutes (extra time). Playing football required high physical and physiological demand including endurance, strength, speed, power, flexibility etc (Manna, 2016; Siekmann, 2012). Anthropometric characteristics play a crucial role in football players. For example, a taller player is most suitable for central defensive positions, goalkeeping, and central attack (Lago-Peñaset et al., 2011). Playing football requires lower relative body fat, additional body fat adds to the weight of the body without contributing to its force production or energy producing capabilities (Hailu & Kibret, 2016). Studies showed that body mass and fat free mass (FFM) had a significant influential role in total distance covered among the international soccer players (Slimani & Nikolaidis, 2017). Playing football involves a lot of physical contacts while performing various skills, thus a high level of physical demand is required. Execution of various skills with the ball required high physical demand including strength, speed, power, flexibility and agility etc. (Karahan, 2020; Owen et al., 2014). The football players have to cover a big area in the ground during attacks and defences so the game demands for aerobic as well as anaerobic fitness. Football players are required to perform multi-directional sprints intercept the ball and maintain a fairly high intensity throughout the game but when the intensity is at sub maximal levels, majority of the energy production is provided by aerobic metabolism (Datson et al., 2014).

Training may improve all the performance of the sports persons when given scientifically (Rasmussen et al., 2022). A complete teamwork with personal skill is necessity for playing football (Bompa & Buzzichelli, 2021; McBurnie et al., 2021). Regular monitoring of anthropometric, physical fitness and physiological variables during training may provide valuable information for training and selection of players (Bompa & Buzzichelli, 2021). In view of the above, the present study was designed to investigate the effects of training on anthropometric, physical fitness and physiological variables of football players of 14-16 years age groups.

METERIALS AND METHODS

Subjects and group

For the present study, ninety five (n = 95) healthy male volunteers within the age group of 14–16 years were screened randomly from the Midnapore District, West Bengal, India. Subjects regularly playing football for last 2 years preceding the study were considered eligible for this study. All the volunteers were undergoing a medical check-up performed by physicians. Based on their decision volunteers without any history of disease, illness, injury and surgical conditions preceding the study were considered eligible for this study. Twenty five (not meeting the inclusion criteria = three; decline to participate = five; inability to perform training = eight; and unable to follow the schedule = nine) participants were excluded from the study. The remaining seventy volunteers were divided into two groups: (a) Control Group (CG, n = 35) and (b) Experimental Group (EG, n = 35).

Ethical considerations

The purpose and possible complication of the investigation was explained to all the participants and their guardians and a written informed consent was obtained. Institutional Ethical Committee (Human Studies) approved the present study.

Experimental design

All the volunteers were acclimatized for 15 days prior to the intervention, whereas the intervention was carried out for a period of six weeks. Football specific training (2 hrs/d, 5d/wk., for 6 wks.) was provided to the experimental group under the guidance of qualified football coach, whereas no such training was given to the control group and was allowed for recreational activities only. Volunteers were asked to maintain the traditional diet and stay away from fast food, carbonated cold drinks, alcohol and smoking throughout the study. Assessment of selected anthropometric, physical fitness and physiological variables were performed at beginning (0 week) and after 6 weeks (Figure 1).

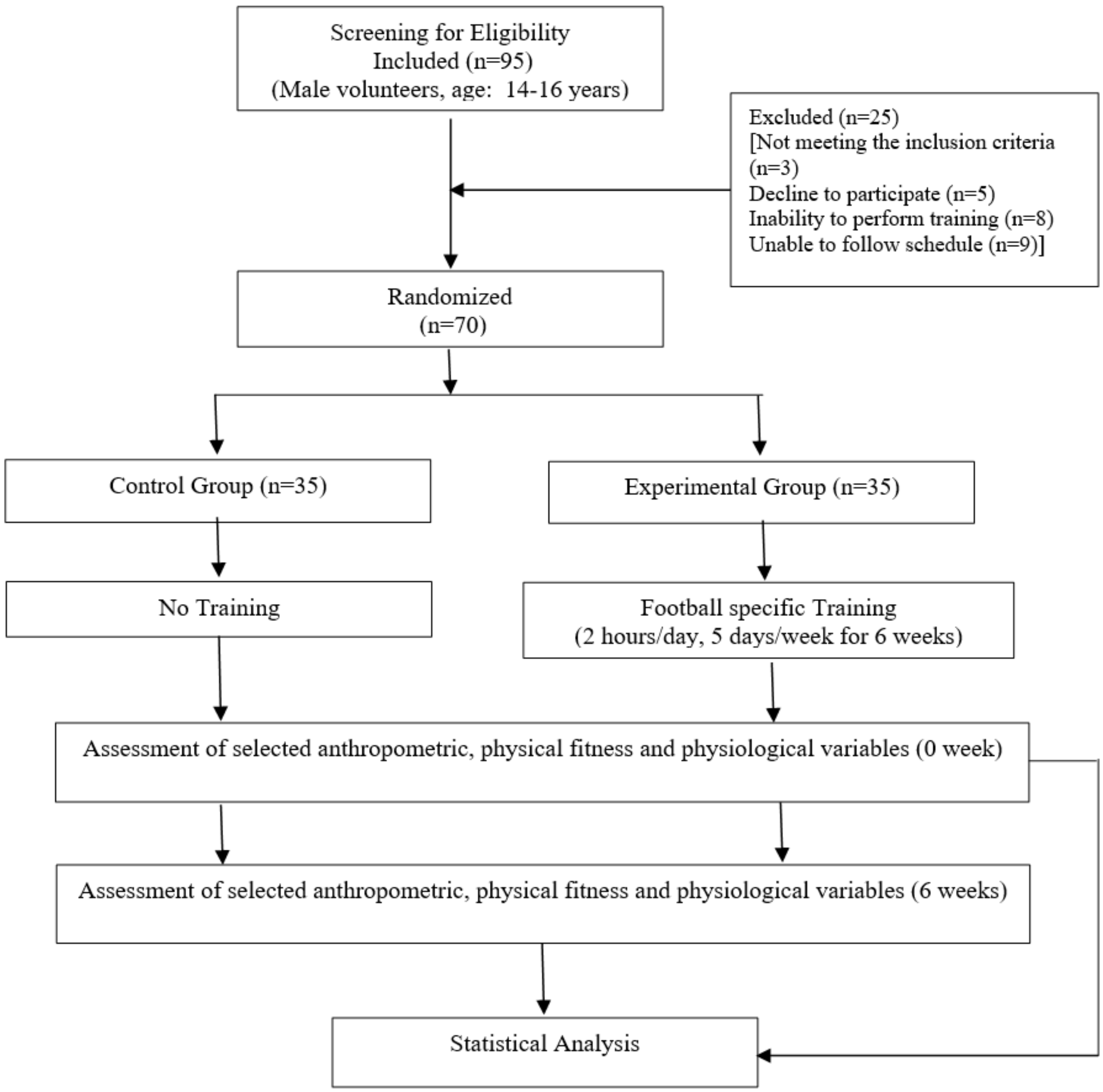

Figure 1. Experimental design.

Training

Football specific training was given 2 hours/day, 5 days/week for 6 weeks in the experimental group. The training includes speed training, strength and power training, flexibility training, interval training, endurance training. The training related techniques and tactics for football was also given during this period. The control group volunteers did not received training. The training schedule, the type of training, volume and intensity all are shown in Table 1.

Table 1. General training schedule used for female football players.

Training Type	0 week	6 weeks
Continuous Training	Low	High
Interval Training	Low	High
Strength Training	Low	Moderate
Power Training	Low	Moderate
Speed Training	Low	High
Skill Training	Low	Moderate
Flexibility Training	Low	High

Measurement of anthropometric variables

Measurement of body mass and stature (height)

The stature (height) was measured using a stadiometer (Seca 220, UK) and expressed in centimetres. The body mass was taken on a standard electronic weighing machine (Seca Alpha770, UK), and recorded in kilograms with accuracy nearest to the 50 grams (Jonson & Nelson, 1986). Body mass index (BMI) was derived from the standard equation using body mass and stature (Nuttall, 2015).

Determination of body fat

A skin fold calliper (Cescorf, Brazil) was used to assess the body fat percentage following standard methodology (Jonson & Nelson, 1986). The skin fold was taken from biceps, triceps, sub-scapular and suprailiac sites using the skin fold calliper on the right side of the body. Body density (BD) of subjects was calculated by formula provided by Durnin & Womersley (1974). Percent Body fat was derived using the standard equation (Siri, 1961). Lean body mass (LBM) was derived by subtracting fat mass from total body mass (Jonson & Nelson, 1986).

Measurement of mid upper arm circumference

By using a flexible non stretch tape (Cescorf, Brazil) laid at the midpoint between the acromion and olecranon processes on the shoulder blade and the ulna of the arm mid upper arm circumference was measured to the nearest of 0.1 cm (Jonson & Nelson, 1986).

Determination of waist-hip ratio (WHR)

Measurements of hip and waist circumference of the subject was taken by a steel tape using standard procedure and the waist-hip ratio (WHR) was determined by standard equation (Jonson & Nelson, 1986).

Assessment of physical fitness variables

Measurement of grip and back strength

The measurement of hand grip strength of the subject was performed following standard procedure (Lee & Gong, 2020). The subject stands erect and holds the grip dynamometers (Baseline, USA) in right hand at 90° with the body. Then the subject was instructed to continuously squeeze for 3-5 seconds. The maximum value was recorded from the grip dynamometers in kg with accuracy nearest to the 0.01 kg. The back dynamometers (Baseline, USA) were used to record the strength of back muscles following a standard method (Bhandari & Koley, 2019). For the measurement of back strength, the subject stand on the base of dynamometer keeping both feet apart and hold the centre of the bar mounted at the end of the chain with the palm facing upwards to the head and then the length of the chain was adjusted to the participants' height to the elongated knees. Eventually, the handle was set at the height of the intra-articular space of the knee joint. Then without bending and jerking the subject pull the bar with maximum force for 5 seconds. The strength of the back muscle was recorded in kg from back dynamometer with accuracy nearest to the 0.01 kg.

Measurement of flexibility

Modified sit and reach test was used to assess subject's heap and trunk flexibility by using the modified sit and reach box (Baseline, USA). The subject had to remove shoes and sit on the floor placing head and back against a wall. The subject had to sit by stretching the leg ahead and keeping the knees flat against the floor. The box was placed touching subject's feet. The fingertips of both hands of the subject were placed on the ruler of the box after adjusting the zero mark on the ruler. Placing the hands side by side, the subject had to lean forward slowly as far as possible maintaining fingertips at the same level and keeping the legs flat (Dhayal et al., 2019). After keeping the stretching position for 2 seconds the measure on the ruler of the box was recorded in centimetre.

Measurement of anaerobic power

Running based anaerobic sprint test (RAST) was performed to assess anaerobic power of the subjects. The subject had undertaken six 35 metre sprints with 10 seconds recovery between each sprint. The 35 meters ground surface was marked with cones. The subject warmed up for 10 minutes, then the subject stand at the starting position and start running to the second cone when whistle is heard by him. The time taken by subject to cover 35 meter was recorded. Then the subject took rest for 10 seconds and came back to the first cone to cover 35 meters. This test was repeated for 3 times and time taken for six sprints was recorded. The anaerobic power of the subject was measured by the following formulae (Burgess et al., 2016).

Anaerobic Power (watt) = Body mass × Distance^2 ÷ Time^3

The power of each six runs was calculated separately.

Maximum power (watt) = the highest value.
Minimum power (watt) = the lowest value.
Average power (watt) = the sum of all six values / 6.
Fatigue Index (watt / sec) = (Maximum power output - Minimum power output) / Time taken for the 6 sprints.
Anaerobic Capacity (watt) = Sum of all six sprint power out puts.

Measurement of reaction time

To measure the alertness and hand - eye coordination, ruler drop test was used (Rossi et al., 2014). Reaction time was calculated using following formulae: T (sec) = $(2D/A)^{1/2}$
D = the distance (in meters) where ruler is caught by the athlete; A = gravitational acceleration = 9.81 m/s^2

Assessment of physiological variables

Measurement of heart rate and blood pressure

Resting pulse rate was measured using standard methods after 15 minutes in rest. Systolic and diastolic blood pressure was measured with a sphygmomanometer (Hall & Hall, 2020). Pulse pressure and mean pressure was calculated.

Measurement of maximal aerobic capacity (VO_{2max})

The VO_{2max} was assessed using *Yo-Yo Intermittent Recovery Test 1 (YYIR1)*. The subject was asked to performed specific running test for 20 m distance. A track was created for 20 m and 5 m for recovery. The athlete ran in a specific rhythm and with the advancement of duration the speed of the athlete was increased. The test was terminated when the subject was exhausted, the specific lap and shuttle was noted and from that specific lap and shuttle the VO_{2max} was calculated and expressed in ml/min/kg (Grgic et al., 2019).

Assessment of lung functions

Pulmonary function of the subject was assessed by using a digital spirometer (Micro I Spiromete, CareFusion, Japan). The force vital capacity (FVC), force expiratory volume in 1st second (FEV_1), peak expiratory flow rate (PEFR) was evaluated using standard procedure (Gallucci et al., 2019).

Statistical analysis

All the collected data were analysed by using a standard statistical software package IBM SSPSS Statistics for Windows, Version 28.0.1 (IBM Corp., Armonk, NY: USA). To check whether the data were normally distributed the Shapiro–Wilk normality test was conducted. Mean and standard deviation were competed. The paired sample 't'-test was used to find out the differences in within group and between group variables (Banerjee, 2018). The significant level was chosen at $p \leq .05$.

RESULTS

Effects of short-term training on body composition of football players

In the present study, a significant reduction ($p < .05$) in body mass, BMI, percent body fat, fat mass was noted among the volunteers of experimental group after 6 weeks of training. Moreover, significantly lower ($p < .05$) body mass, BMI, percent body fat and fat mass was reported among the volunteers of experimental group when compared with control group after 6 weeks of study (Table 2).

Table 2. Effects of training on body composition of football players.

Parameters	Control Group (CG, n = 35)		Experimental Group (EG, n = 35)	
	0 Week	6 Weeks	0 Week	6 Weeks
Height (cm)	$164.3^{NS} \pm 5.5$	$164.4^{NS} \pm 5.4$	$164.5^{NS} \pm 5.4$	$164.6^{NS} \pm 5.6$
Body mass (kg)	$48.2^{NS} \pm 3.1$	$49.3^{NS} \pm 3.4$	$47.2^{NS} \pm 3.3$	$45.3^{*\#} \pm 3.2$
BMI (kg/m²)	$17.8^{NS} \pm 1.9$	$18.4^{NS} \pm 1.9$	$17.9^{NS} \pm 1.9$	$16.8^{*\#} \pm 1.9$
Body fat (%)	$11.1^{NS} \pm 1.5$	$11.3^{NS} \pm 1.6$	$11.2^{NS} \pm 1.6$	$8.7^{*\#} \pm 1.8$
Fat mass (kg)	$5.4^{NS} \pm 0.8$	$5.6^{NS} \pm 1.1$	$5.0^{NS} \pm 1.1$	$4.0^{*\#} \pm 1.0$
LBM (kg)	$42.8^{NS} \pm 3.3$	$43.7^{NS} \pm 3.5$	$42.2^{NS} \pm 3.2$	$41.4^{\#} \pm 3.4$
WC (cm)	$66.7^{NS} \pm 4.2$	$66.6^{NS} \pm 4.4$	$65.9^{NS} \pm 4.1$	$65.5^{NS} \pm 4.3$
HC (cm)	$80.7^{NS} \pm 5.4$	$80.6^{NS} \pm 5.3$	$80.3^{NS} \pm 5.5$	$78.5^{NS} \pm 5.6$
WHR	$0.83^{NS} \pm 0.05$	$0.83^{NS} \pm 0.04$	$0.83^{NS} \pm 0.03$	$0.82^{NS} \pm 0.03$

*Note. Data presented as mean ± SD, n = 35, paired sample t-test was performed; *p < .05, when compared to '0 week' and '6 week', #p < .05, when compared to CG and EG. SD = standard deviation, NS = non-significant, BMI - Body mass index, LBM = Lean body mass, WC = Waist Circumference, HC = Hip Circumference, WHR - Waist Hip ratio.*

Effects of short-term training on physical fitness variables of football players

The present study showed a significant increase ($p < .05$) in grip and back strength, flexibility, anaerobic power (highest power output, lowest power output, average power output, fatigue index, anaerobic capacity); and reduction ($p < .05$) in reaction time among the volunteers of experimental group after 6 weeks of training. Further, significantly higher ($p < .05$) in grip and back strength, flexibility, anaerobic power; and lower ($p < .05$) hand reaction time was observed among the volunteers of experimental group when compared with control group after 6 weeks of study (Table 3).

Table 3. Effects training on physical fitness variables of football players.

Parameters	**Control Group (CG, n = 35)**		**Experimental Group (EG, n = 35)**	
	0 Week	6 Weeks	0 Week	6 Weeks
GSTRH (kg)	$24.8^{NS} \pm 3.4$	$25.6^{NS} \pm 3.3$	$25.8^{NS} \pm 3.3$	$28.8^{*\#} \pm 3.0$
GSTLH (kg)	$23.6^{NS} \pm 3.1$	$25.2^{NS} \pm 3.3$	$24.8^{NS} \pm 3.1$	$28.0^{*\#} \pm 3.2$
BST (kg)	$90.3^{NS} \pm 10.8$	$93.8^{NS} \pm 12.5$	$88.4^{NS} \pm 11.8$	$97.0^{*\#} \pm 11.5$
Flexibility (cm)	$33.5^{NS} \pm 3.3$	$33.0^{NS} \pm 3.5$	$32.7^{NS} \pm 3.7$	$35.4^{*\#} \pm 3.4$
HPO (watt)	$317.5^{NS} \pm 21.7$	$321.6^{NS} \pm 21.5$	$316.5^{NS} \pm 20.3$	$430.1^{*\#} \pm 22.3$
LPO (watt)	$159.3^{NS} \pm 12.1$	$155.5^{NS} \pm 15.8$	$165.0^{NS} \pm 16.8$	$260.0^{*\#} \pm 17.7$
APO (watt)	$227.6^{NS} \pm 68.2$	$237.5^{NS} \pm 70.3$	$226.4^{NS} \pm 66.0$	$337.0^{*\#} \pm 58.2$
FI (watt/sec)	$4.3^{NS} \pm 1.1$	$5.1^{NS} \pm 1.2$	$4.0^{NS} \pm 1.0$	$5.4^{*\#} \pm 1.1$
AC (watt)	$1365.8^{NS} \pm 43.7$	$1389.2^{NS} \pm 46.5$	$1364.4^{NS} \pm 39.1$	$2021.9^{*\#} \pm 41.3$
RTLH (sec)	$0.17^{NS} \pm 0.03$	$0.18^{NS} \pm 0.04$	$0.16^{NS} \pm 0.02$	$0.15^{*\#} \pm 0.01$
RTRH (sec)	$0.15^{NS} \pm 0.04$	$0.14^{NS} \pm 0.06$	$0.16^{NS} \pm 0.01$	$0.15^{*} \pm 0.01$

*Note. Data presented as mean ± SD, n = 35, paired sample t-test was performed; *p < .05, when compared to '0 week' and '6 week', #p < .05, when compared to CG and EG. SD = standard deviation, NS = non-significant, GSTRH = grip strength of right hand, GSTLH = grip strength of left hand, BST = Back strength, HPO = Highest power output, LPO = Lowest power output, APO =Average power output, FI = Fatigue index, AC = Anaerobic capacity, RTLH = Reaction time left hand, RTRH = Reaction time right hand.*

Effects of short-term training on physiological variables of football players

In this study, significant reduction ($p < .05$) in resting heart rate, systolic blood pressure, pulse pressure; and increase ($p < .05$) in maximal aerobic capacity (VO_{2max}), force expiratory volume in 1st sec (EFV1), force vital capacity (FVC) and peak expiratory flow rate (PEFR) was noted among the volunteers of experimental group after 6 weeks of training. In addition, significantly higher ($p < .05$) VO_{2max} and PEFR; and lower ($p < .05$) resting heart rate, systolic blood pressure, pulse pressure was observed among the volunteers of experimental group when compared with control group after 6 weeks of study (Table 4). Further, VO_{2max} showed significant negative correlations ($p < .05$, r = -0.37) with BMI.

Table 4. Effects training on physiological variables of football players.

Parameters	**Control Group (CG)**		**Experimental Group (EG)**	
	0 Week	6 Weeks	0 Week	6 Weeks
RHR(beats/min)	$72.6^{NS} \pm 6.2$	$71.2^{NS} \pm 5.9$	$71.5^{NS} \pm 6.4$	$67.2^{*\#} \pm 5.4$
SBP (mm Hg)	$115.0^{NS} \pm 9.0$	$112.7^{NS} \pm 8.4$	$113.0^{NS} \pm 8.0$	$106.8^{*\#} \pm 8.7$
DBP (mm Hg)	$62.7^{NS} \pm 6.5$	$62.5^{NS} \pm 6.4$	$63.0^{NS} \pm 6.5$	$64.2^{NS} \pm 6.6$
PP (mm Hg)	$52.2^{NS} \pm 5.8$	$50.3^{NS} \pm 5.2$	$50.0^{NS} \pm 5.7$	$42.6^{*\#} \pm 5.0$
MP (mm Hg)	$80.2^{NS} \pm 7.2$	$79.2^{NS} \pm 6.8$	$79.7^{NS} \pm 6.7$	$78.4^{NS} \pm 6.6$
VO_{2max} (ml/kg/min)	$39.8^{NS} \pm 3.5$	$40.0^{NS} \pm 3.3$	$42.4^{\#} \pm 3.4$	$46.3^{*\#} \pm 3.4$
FEV_1 (l)	$2.8^{NS} \pm 0.7$	$2.8^{NS} \pm 0.9$	$2.9^{NS} \pm 0.5$	$3.1^{*} \pm 0.6$
FVC (l)	$2.8^{NS} \pm 0.8$	$2.9^{NS} \pm 0.8$	$2.8^{NS} \pm 0.5$	$3.2^{*} \pm 0.6$
FEV_1/FVC (%)	$98.2^{NS} \pm 2.3$	$97.6^{NS} \pm 2.5$	$98.6^{NS} \pm 2.7$	$98.1^{NS} \pm 2.8$
PEFR (l/min)	$337.5^{NS} \pm 28.7$	$345.7^{NS} \pm 25.5$	$354.8^{\#} \pm 27.3$	$404.0^{*\#} \pm 29.7$

*Note. Data presented as mean ± SD, n = 35, paired sample t-test was performed; *p < .05, when compared to '0 week' and '6 week', #p < .05, when compared to CG and EG. SD = standard deviation, NS = non-significant, RHR = resting heart rate, SBP = systolic blood pressure, DBP = diastolic blood pressure, PP = Pulse Pressure, MP = Mean pressure, VO_{2max} = maximal aerobic capacity, FEV_1 = force expiratory volume in 1st sec, FVC = force vital capacity. PEFR = Peak expiratory flow rate.*

DISCUSSION

The anthropometric characteristics are also used as an indicator for growth and development of the players in longitudinal studies (Hailu & Kibret, 2016; Slimani & Nikolaidis, 2017). Anthropometrical indicators such as height, body mass, body fat play a significant role in playing football (Lago-Peñas et al., 2011; Vega et al., 2020). In football the anthropometric characteristics such as height and body mass varies with specific playing positions (Hailu & Kibret, 2016; Portes et al., 2015). Height is particularly important for goalkeepers, defenders and forward players; however midfield players required an optimum height. The body mass also play a significant role as football is a body contact game. The players need an optimum body mass for performing the strenuous activities such as short sprint, kecking, dribbling, though, heading during the game. The optimum body weight reduces and risk of injury (Vega et al., 2020). Excess body fat may hinder the performance of the football players. The excess body fat may reduce the ability of the football player to move freely in the field and the extra weight in terms of body fat may cause early fatigue (Joksimović et al., 2019; Kovač et al., 2012; Zerf, 2017). The present study showed a significant reduction in body mass, BMI, percent body fat, fat mass among the volunteers of experimental group after 6 weeks of training. Further, the volunteers of the experimental group had significantly lower body mass, BMI, percent body fat and fat mass when compared to control group after 06 weeks of study. It can be said that the reduction in body mass, percent body fat, fat mass among the volunteers of experimental group might be due to the training. The reduction in body fat might be because of increase aerobic endurance exercise which is responsible for grater utilization of fat for energetic process (Damayanti & Adriani, 2021; Manna et al., 2010). The reduction in body mass and BMI may be due to reduction in of body fat after training (Manna et al., 2010). As the control group athletes were not exposed to training, therefore higher body mass, BMI, percent body fat and fat mass was observed among theme. These changes also depend on the pre-existing fitness levels and training load adopted by the volunteers (Lesinski et al., 2017). Similar observation also showed that training may be effective in reducing body fat (Lesinski et al., 2017; Manna et al., 2010; Suarez-Arrones et al., 2019).

The physical fitness characteristics such as muscle strength, power and flexibility are essential for football players (Behm et al., 2017). Playing football involves activities such as kicking, tackling, dibbling, heading, through and passing which provide an additional stress to the player (Behm et al., 2017; Li et al., 2022; Reilly, 2005). The physical fitness variables thus play a significant role in determination of success during competition (Behm et al., 2017; Li et al., 2022; Reilly, 2005). A football player requires high anaerobic power as quick acceleration and deceleration is associated with the game (Karahan, 2020; Owen et al., 2014). In addition, strength is the central component of a football training program (Manna, 2016). The strength is the key component of fitness among football players, as kicking, passing, changing pace etc are part of the game, so the football players need greater back strength (Reilly, 2005). Furthermore, strength of grip muscle also has a significant impact on the performance of soccer players, which is needed for throw-in, catching or fisting the ball (goal keeping) (Karahan, 2020; Owen et al., 2014). The flexibility is also an important component of the game (Reilly, 2005). The present study showed a significant elevation in grip and back strength, flexibility, anaerobic power; and significant reduction in hand reaction time among the volunteers of experimental group after 6 weeks of training. Further, the volunteers of the experimental group had significantly greater grip and back strength, flexibility, anaerobic power; and lower right hand reaction time when compared to control group after 06 weeks of study. It can be stated that these changes might be due to the effect of training. The football specific training might be responsible for the development of these variables among the players (Atli, 2021; Karahan, 2020; Manna et al., 2010). Further, as the control group volunteers did not receive training therefore lower grip and back strength, flexibility, anaerobic power; and lower right hand reaction time was note among them. Similar observations were reported by other research groups (Atli, 2021; Behm et al., 2017; Karahan, 2020; Silva et al., 2022).

The cardiovascular fitness is one of the important fitness indicators in sports (Mc Ardle et al., 2015). The measurement of maximum aerobic capacity (VO_{2max}) is considered as the indicator of cardiovascular fitness and aerobic endurance and is considered as the gold standard for determination of cardio-respiratory fitness, because the muscles need oxygen for aerobic exercise, and the heart must pump adequate amounts of blood through the circulation to meet the demands of aerobic exercise (Mc Ardle et al., 2015; Relly, 2005). Maximum aerobic capacity (VO_{2max}) plays an important role in football and it influence the technical and overall performance of the players. It has been reported that the energy used by football players is mainly produced by aerobic metabolism therefore, it is important for players to have high level of aerobic fitness (Mc Ardle et al., 2015; Relly, 2005). A well-developed aerobic fitness helps the player to maintain repetitive high-intensity actions during the football match. It also helps to accelerate the recovery process, and to maintain their physical condition at an optimum level during the entire game (Modric et al., 2020). The VO_{2max} of the top level professional football players vary from 55 to 65 ml kg^{-1} min^{-1} (Relly, 2005). The cardiovascular status is also reflected by heart rate and blood pressure. Lung functions measurements particularly FEV_1, FVC, PEFR are used as an indicator of general health. The improvement in lung functions have significant role in performing aerobic activities (Singh et al., 2015).

In the present study, a significant elevation in VO_{2max} was noted among the volunteers of experimental group after 6 weeks of training. Further, the volunteers of the experimental group had significantly greater VO_{2max} when compared to control group after 06 weeks of study. It has been reported that exercise training increased the maximal oxygen consumption, which improve the cardio-respiratory function and ability to deliver oxygen, increase blood supply to muscles and ability to utilize oxygen and an increase in maximal cardiac output (Manna et al., 2010; Modric et al., 2020; Michaelides et al., 2021). This is accepted as the main reason for elevation of VO_{2max} after a training program. The present study also showed a significant elevation in FEV_1, FVC and PEFR; and significant reduction in resting heart rate, systolic blood pressure and pulse pressure among the volunteers of experimental group after 6 weeks of training. Further, the volunteers of the experimental group had significantly greater PEFR; and lower resting heart rate, systolic blood pressure and pulse pressure when compared to control group after 06 weeks of study. It can be stated that aerobic endurance training in responsible for the changes in heart rate, blood pressure and lung function variable of the football players. Former studies showed that intense physical training made an impact on the respiratory parameters (Shivesh et al., 2007; Tulin et al., 2012). It can also be stated that as the football players had higher lung function; and lower heart rate and blood pressure than control group volunteers as the control subjects did not expose to training. Earlier studies reported that athletes had higher lung functions than the control volunteers who are not engaged in regular exercise (Singh et al., 2012). It has been reported that the physical training lowering the resting heart rate, thus the heart pumps more blood in each beat (Manna et al., 2010; Mc Ardle et al., 2015; Michaelides et al., 2021). A lower heart rate after training indicates that more blood is delivered in each heartbeat (Mc Ardle et al., 2015).

CONCLUSION

Training effects were reflected on various parameters like body fat, aerobic capacity, anaerobic power, grip strength, back strength, flexibility and lung functions of the football players. Regular monitoring of anthropometric, physical fitness and physiological variables of the players provide valuable information to the coaches which may help them to modify the training schedule to achieve the desired performance.

AUTHOR CONTRIBUTIONS

Study design, Manna, I., Khanna, G. L.; Data collection, Ghosh, K., Mahapatra, M.; Statistical analysis, Ghosh, K., Bera, S. J.; Data interpretation, Manna, I., Khanna, G. L.; Manuscript preparation, Ghosh, K., Bera, S. J.; Literature search, Singha, P., Ghosh, S., Jana, A.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

ACKNOWLEDGMENTS

The authors sincerely acknowledge the contribution of the volunteers of this study. The authors are also thankful to the UG and PG students, coaches, and laboratory staffs for their support for conducting the present study.

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