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Original Research Article

A Study to Determine the Effect of 12 Weeks Sports Specific Training Program on Physical and Physiological Variables in Amateur Basketball Players - A Randomized Controlled Trail

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ABSTRACT

AIM: A Study to determine the effect of 12 weeks sports specific training program on physical and Physiological variables in amateur basketball players- A Randomized Controlled Trial
Objectives: To evaluate effectiveness of basketball-specific training program on selective physical, physiological variables in amateur basketball players.
Methods: Randomized controlled trial with concealed allocation, blinding of the accessor, and intention to treat analysis. Participants: 56 amateur basketball players participated regularly in basketball practice. Intervention: The experimental group undertook sports specific training program with a session of 60 min thrice a week for 12 weeks. The control group performed the usual conditioning program Outcome measures: Agility, Speed, and flexibility, vertical Jump, Anaerobic Power, Fatigue Index, VO2 max, were assessed at week 0 and week 12.
Results: Randomization allocated 29 participants in each group. Three participants from the experimental group and two from the control group did not complete the study. After 12 weeks the mean between-group difference in speed was -1.51 Sec in favor of the experimental group was a very precise estimate (95% CI -1.80 to -1.21), for Agility was (4.47 to 6.02 sec), for flexibility was (-13 to 10.3 cm), for Vo2 max it was (6.48 to 11.22). The anaerobic power was (-163.16 to 32.48) and the fatigue index was between 2.56 to 3.
Conclusion: Basketball sports-specific training program that incorporates basketball-specific exercises have shown improvement in the level of physical, physiological related variables in amateur basketball players. The effect appears to be more significant when the program is implemented for 12 weeks.
Trial registration Number: CTRI/2020/02/023553.

Keywords: *Strength Training, Team Sports, Aerobic fitness, Amateur Basketball players.*

INTRODUCTION

Basketball is a team sport played by five players in two opposing teams following a set of rules to score in the opponents' basket and prevent them from scoring.

In the present study sport specific training program was incorporated for skills and movements specific to the sport, at intensities sufficient to promote physical, aerobic and anaerobic adaptations. Programs Supplemented with sports-specific exercises like strength, plyometric, agility training and a combination of pieces of training with sports specific skill movements are important for Sportsmen to realize a greater proportion of their potential and further improve their performance. We have found previous studies with similar characteristics but are focused on short-term effects: 4 weeks or 6 weeks. Therefore it is still to be established whether chronic improvements can be accomplished with sports-specific training programs over a longer training period.

Our starting point was the fact that the combined training provides broader neuromuscular adaptations which result in greater transfer to a wide variety of performance variables. We hypothesized that the sports-specific training program based on combining sprinting, strength, endurance, jumping, flexibility and agility performance in amateur basketball players. Therefore, the purpose of the study was to examine the effect of 12 weeks of sports specific training programs on physical, physiological and performance-related abilities in amateur basketball players.

MATERIALS & METHODS

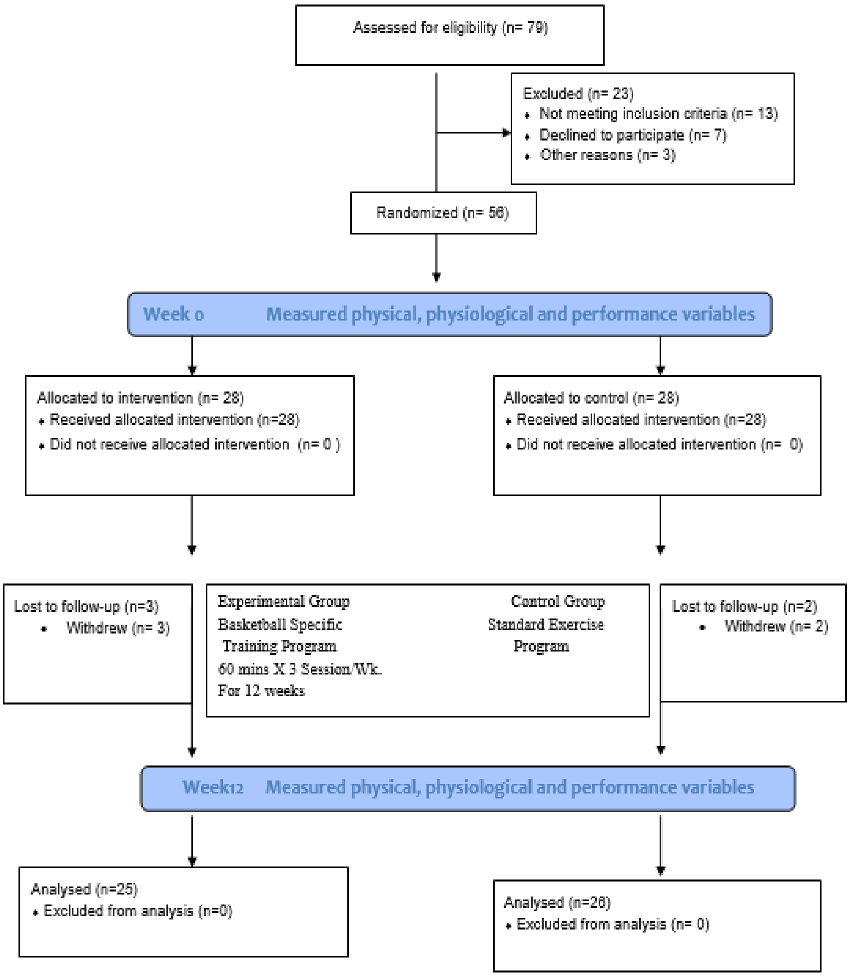
A randomized controlled trial was conducted from January 2021 to October 2022 at the Basketball Court of Pravara Institute of Medical Sciences. Potential participants were assessed according to eligibility criteria. Eligible participants who are willing to participate in the study were provided with verbal information about the study and a written information sheet and were required to give informed consent before undergoing baseline assessment and being allocated to a group. Randomization was performed using simple random sampling into two groups: The experimental group and the controlled to conceal the upcoming random allocation, the randomized allocations were concealed in envelopes. The new participant was required to contact the researcher who had no other involvement in the study with the new participant’s enrollment details before receiving random allocations whenever they enroll. Before the intervention period, the demographic data and baseline assessment of the study outcome measures were recorded. Participants in the experimental group had undergone 12 weeks of sports specific training exercise program (Fig.1) and those in the control group had undergone 12 weeks of conventional routine exercises (Fig.2). To limit the impact of knowing whether they were in the experimental group or controlled group, participants were advised that the study were compared two exercise regimens and they received no information about the exercise intervention to which they were not allocated. The same researchers reassessed the outcome measures after the completion of 12 weeks of the intervention period. Outcome assessors were blinded to the group to which each participant was allocated. The data were analyzed with an intention to treat approach.

Participants

56 basketball players fulfilling the eligibility criteria from different areas of Maharashtra state took part in the present study. Participants attended practice sessions regularly. They were aged between 18-24 years, of all genders and qualified PAR-Q. Exclusion criteria were players having any recent injury, any systemic illness and players involved in any other type of personal training methods. No Exclusion was made due to gender or Weight.

Intervention

Experimental group:



Basketball sports-specific training programs were administered which include speed, strength, and endurance training along with core exercises; proprioception and agility drills for 12 weeks (Fig. 1). Exercises were progressed after every 4 weeks with alteration in frequency and intensity. The intervention was performed for 60 min/per session and 3 sessions per week for 12 weeks. (Table 1)

***Control group*:**

Control group intervention continued with the usual conditioning program (Table 2) which include warm-up, running, stretching and cool-down for 12 weeks.

Outcome measures

The physical parameters speed and flexibility were assessed with the 30m DASH test and sit and reach test respectively. The physiological parameters of aerobic capacity were assessed by measuring VO2 max on Queens's college step test. Each parameter was measured using the stopwatch and tape measure and scored and summed for the total score. The best of three trials was considered for better performance.

STATISTICAL ANALYSIS

Sample size calculation was based on the data obtained from the previous two studies and was calculated with mean differences on open Epi software. Analysis was conducted using commercial software. The Normality of data was assessed using the Shapiro-Wilk test Post hoc test was used for multiple comparisons and the Analysis of Variance (ANOVA) was used for the comparison of mean values at different time intervals within the control and experimental group. Quantitative variables were reported as mean (SD). The mean group difference between the experimental and controlled groups was calculated with unpaired data and reported with a 95% confidence interval.

RESULT

Deviations from the study protocol:

Apart from five participants who could not complete the study due to losing their interest in participation. There was no deviation from the study protocol. The registered study questions were assessed, all participants were prescribed their randomly allocated interventions and both registered outcomes were measured at the scheduled time points.

Flow of participants throughout the study:

Among the 79 participants who were screened for the study, 56 met the eligibility criteria and were randomized into two groups -28 in the experimental group and 28 in the controlled group (Fig.1)

The groups were comparable at baseline as presented in table-3. Five participants were lost follow-up, three from the experimental group and two from the control group (Fig.1). After 12 weeks of assessment 25 participants in the experimental group and 26 participants in the control group were available for assessment and all were measured. Compliance with the prescribed resume was not assessed.

Effect of intervention:

Physical fitness variables: Both groups showed improvement in running performance and flexibility at end of the training period. Sports-specific training programs are estimated to be more effective than conventional training methods for several major physical and physiological fitness levels. The mean between-group difference in speed is -1.51 Sec in favor of the experimental group was a very precise estimate (95% CI -1.80 to -1.21).
(Table 4).

Exercise training in both groups was well tolerated and there were no adverse events. Individual participant data for all outcomes is presented in (Table-4)

Table- 1: Content and progression of the experimental group intervention

Exercise Category	Exercises	Level I Week 1-4		Level II Week 5-8		Level III Week 9-12		Frequency *(Sessions/week)*
Warm up (7 min)	ROM for all joints, Spot marching, small distance jogging (1- 12 weeks)							
		Reps.	Sets	Reps.	Sets	Reps.	Sets	
Speed	200m Run	2	1	2	1	3	1	3
Strength	Push Up	8-10	2	10-12	2	10-12	3	3
	Arm Swing Squat	8-10	2	10-12	2	10-12	3	
Endurance	Medicine Ball Throw	8-10	2	10-12	2	12-15	2	3
	Kettle Bell Swing	8-10	2	10-12	2	12-15	2	
Core Strengthening	Planks							3
Agility Drill	Cone Drills	8-10	2	8-10	2	8-10	3	3
Proprioception Drills	Depth Jump	8	2	10	2	12	2	3
	Split Jump	8	2	10	2	12	2	
	Squat Jump	8	2	10	2	12	2	
	Reactive Double Leg Bounding	8	2	10	2	12	2	
Flexibility	Lunge with a twist	8-10	3	10-12	3	10-12	3	3
	Knee to chest	8-10	3	10-12	3	10-12	3	
	High Kicks	8-10	3	10-12	3	10-12	3	
Cool down (5 min)	Stretching of Major group of muscles, gentle walk for 3 min. (1- 12 weeks)							

*Three sessions per week were prescribed to occur on Tuesday, Thursday, and Saturday
Min=Minutes, Reps=Repetitions

Table- 2: Content and progression of the control group intervention

Exercise Category	Exercise	Volume		Frequency *(Sessions/week)*
Warm Up	ROM, Spot marching, small distance jogging (1- 12 weeks)			
		Reps	Sets	3
Strength Training	Pull Ups	15	2	
	Squats	15	2	
Aerobic group exercise Session	Running 100m	2	1	3
	Curl Ups	15	2	
	Medicine ball Throw	15	2	
Cool Down	Stretching of Major group of muscles, gentle walk for 3 minutes. (1- 12 weeks)			

*Three sessions per week were prescribed to occur on Tuesday, Thursday, and Saturday
Min=Minutes, Reps=Repetitions

Table 3: Characteristics of participants at baseline (n=56)

Characteristics of participants	Experimental Group (n=28)	Controlled Group (n=28)
Age (yr.), mean (SD)	20.07(1.24)	19.71(1.24)
Gender male, n (%) Female, n (%)	17(61%) 11(39%)	18(64%) 10(36%)
Height (cm), mean (SD)	166.9(7.04)	167.6(11.83)
Weight (Kg), mean (SD)	63.3(13.6)	60.5(12.7)
BMI (kg/m^2), mean (SD)	22.58(3.9)	21.48(3.85)

*Con= control group, Exp = experimental group,

Table 4 Mean (SD) of Groups, Mean (SD) Difference within groups and mean (95% CI) difference between groups

Outcome Measures		Groups				Within group difference		
		Week 0		Week 12		Week12 minus Week0		P Value
		Exp(n=25)	Con(n=26)	Exp(n=25)	Con(n=26)	Exp(n=25)	Con(n=26)	
Physical Variables	Speed (Sec)	5.23(0.71)	5.52(0.70)	4.01(0.34)	4.58(0.49)	-1.22(0.5)	-0.94(0.43)	0.000
	Flexibility (Cm)	26.04(0.34)	25.50(5.81)	38.50(4.11)	32.00(5.43)	12.46(3.57)	6.5(2.25)	0.000
	Agility(sec)	15.14(1.91)	15.35(1.90)	10.10(0.75)	13.11(1.70)	-5.04(1.48)	-2.23(0.6)	0.000
	Vertical jump height(cm)	38.43(8.13)	39.75(6.28)	44.57(6.41)	43.75(6.26)	6.14(2.2)	4.0(0.9)	0.630
Physiological Variable	HR REST (BPM)	90.86(9.51)	81.25(11.7)	81.04(8.5)	75.11(11.5)	-9.8(2.95)	-6.14(3.5)	0.001
	VO2 MAX (ML/kg/min)	40.17(5.30)	40.18(4.06)	49.03(4.76)	45.72(4.39)	8.86(2.64)	5.54(2.03)	0.005
	Anaerobic power (watta)	386.60(127.46)	405.85(140.24)	503.67(100.36)	498.93(143.27)	117.0(39.8)	93.0(30.3)	0.887
	Fatigue Index (watta/Sec)	8.29(9.94)	8.32(10.99)	6.86(9.16)	7.09(8.96)	-1.43(1.6)	-1.23(2.0)	0.924

*Con= control group, Exp = experimental group

DISCUSSION

This study estimated that a sports-specific training program that combines various training methods like strength, speed, agility, balance, etc was more beneficial than conventional training for several outcomes including speed, flexibility, oxygen consumption and performance in amateur basketball players.

Linear sprinting:

Sprinting bouts are regularly performed during decisive defensive and offensive game situations in basketball. Our findings showed significant improvements in shorter (≤30m) and longer (≥30m) sprint times in basketball players after SSTP, in comparison to the control group. Increases in sprint performance after SSTP is due to increased neuromuscular activation of the trained muscles. More specifically, increases in the number and /or firing frequencies of activated motor units, as well as changes in the recruitment pattern of the motor units (primarily in fast-twitch muscle fibers), might account for the observed improvements in linear sprint performance following the SSTP. [3] In turn, these adaptations will likely increase maximal muscle force and power capabilities, permitting players to explode more rapidly at the start of sprints and to execute longer stride lengths as sprints progress.[4, 5] Moreover, neuro-mechanical adaptations induced by lower power SSTP, such as enhanced neural drive to agonists muscles and optimization of muscle-tendon stiffness[6] may improve Stretch shortening cycle efficacy. As a result of improvements in the Stretch shortening cycle in lower body musculature, greater force production likely occurs in the concentric movement phase after rapid eccentric muscle action[6, 7, 8] which is a key requirement for enhanced sprint performance[5], Of note, 27 of the 32 studies included in our meta-analysis employed a mixture of horizontal and vertical jumps in SSTP. While horizontal force-related capabilities are of particular relevance in the acceleration phase of linear sprints (i.e. ≤ 30m), vertical force applied to the ground becomes more prominent as sprints progress and speed increases (i.e. >30m). In this sense, the combination of horizontal and vertical jumps included in SSTP may be an adequate strategy for basketball players aiming to improve sprinting performance. Following sprint training programs involving high-intensity Stretch shortening cycle muscle actions similar to SSTP. Complex changes in physical performance take place during an athlete's growth and maturation, which can affect their sprinting capabilities[9,10] and changes integral to sprint performance occurs during growth and maturation due to greater muscular size, increased limb length, changes to musculotendinous tissue, enhanced neural and motor development, and better movement quality and coordination.[8,9] As the time and tempo of the mentioned factors are highly variable between individuals, basketball coaches working with youth populations should consider not only the characteristics of the applied SSTP but also the dynamic physiological changes that transpire throughout adolescence.[3]

Flexibility:

In this study, both groups showed better improvement in flexibility but when compared between the group, the experimental group showed a significant difference in a mean difference of 12.46cm in the experimental group and a mean difference of 6.5 cm in the control group when assessed on the Sit and reach test.

The assessment of flexibility is an important consideration to improve muscle work efficiency. The factors that affect flexibility are age, gender, environmental conditions and physiological limitations, etc.

The portable reason for an increase in flexibility is an increase in stretch force on muscle has increased tension on the series elastic component and parallel elastic component of the muscle. The muscle cells which store the energy in eccentric contraction are released once the stretch is released.[11] dynamic stretching and ballistic stretching are the common stretching methods used in a sports-specific training program which are characterized by quick bouncing movements that create momentum to carry the body segment to the range of motion to stretch the shorten structures. Repetitive loading on the tissues at a sub-maximal level for successive days increases the deformation of collagen tissues. The collagen tissue deformation occurs to different degrees at different intensities of force and different forces of application and it further requires the breaking of collagen bonds and realignment of fibers for permanent elongation or increase flexibility.[11] It is imperative that the individual use the newly gained range to allow the remodeling of tissues and to train the muscle to control the new range or else the tissue will eventually return to its shorter length.

Agility

The SST program is inclusive of short stretching cycle movements (like jumping, hopping, and bounding) which is a combination of concentric and eccentric forms of muscle function which has proved to improve the production of muscle force and power. Agility is a skill relatively more complex than jumping or sprinting as the agility task requires rapid change from eccentric to concentric muscle contractions.[18]

In this study, both the groups show improvement in agility but when compared between the groups, it showed significant improvement with a significant group difference of 5.24 seconds after 12 weeks. However, programs associated with proper recovery intervals help the player for better performance and response to the stimulus during training sessions. [20]

The SSTP inclusive of change of direction exercises with varying speeds will facilitate and contribute to the development of neuromuscular and metabolic adaptations. Three trials were completed for the agility-'t-test, and the best performance trial was used for the subsequent statistical analysis.

The improvement in the power performance is one of the important variables along with neural adaptations and enhancement of motor unit recruitment for an increase in agility. [19]

However, we could not exactly determine whether neural adaptations occurred or better facilitation of neural impulse to the spinal cord; therefore future studies are necessary to determine the mechanisms of agility improvement by SSTP.

Vertical Jump task constitutes an integral component of explosive performance in several athletic activities.[17] our findings show a significant improvement in the vertical jump with a significant difference in a mean difference of 6.14 cm in the experimental group and 4.0cm in the control group when assessed on the Vertical jump test. For an increase in the improvement of vertical jump performance, it is necessary to systematically increase the stress-related overload placed on the body during training sessions. The sports-specific training design has increased the training volume with the help of a total number of repetitions, jumps and their type during the training sessions.[18]

The other factors that may have contributed to the improvement of the vertical jump are better synchronization of a body segment, increased coordination levels, muscular strength and adaptive changes in neuro-muscular function causing an improvement in inter-muscular coordination.

Heart Rate:

The heart rate values reflect the considerable demands imposed on the cardiovascular system of basketball players. In addition to the physical parameters monitoring the heart rate of the player also provides objective information about the physiological stress encountered during basketball match-play.[12] In this study the average resting heart rate ranged between 86.06 ±4.80 beats/ min for the selected samples before the start of the training session and ranged between 81.14 ± 3.28 beats/min after completion of the entire training period of 12 weeks.

Both the group showed a reduction in resting HR but the reduction was estimated to be greater in the experimental group than the controlled group with mean differences of 4.92 beats /min.

We observed that the majority of sports-specific training time spent on performing low to moderate-intensity activities for longer periods and additional activities (shooting, maintaining position, acceleration, deceleration, change in direction with modified rest interval for recovery) could have been effective to amplify the adaptations into the cardiovascular system, which could further reduce the load and improve the cardiovascular performance.

VO2max:

Aerobic capacity is an integral indicator of the functional capacities of all systems involved in the supply, transportation and energic oxygen transformation.15 The maximal expiratory ventilation increases (increase tidal volume and breathing rate) as maximum oxygen consumption increases any increase in VO2 max raises both the oxygen requirement and the corresponding need to eliminate additional carbon dioxide via alveolar ventilation.14

Aerobic fitness is paramount in basketball because players will experience early fatigue which will have a negative effect on performance. [16]

In this study, VO2 max was measured with Queen's College step test and the findings of the study showed a difference in the post-intervention values of VO2 max among both groups. The experimental group showed significant improvement with a mean of 49.03 ml/kg/min. when compared with the control group's mean of 45.72 ml/kg/min

The probable reason for the increased aerobic capacity in basketball players are:

Increase in cardiovascular adaptations like increased cardiac output, stroke volume and increased arteriovenous oxygen difference. Regular physical training increases the VO2 max by 50% and rests by 50% is increased because of the extraction of oxygen by working muscles which is reflected as an increase in arteriovenous oxygen difference.[14]

Several weeks of Sports Specific Training Program which includes speed and aerobic training methods reduces the ventilatory equivalent for oxygen (VE/VO2) during sub-maximal exercise and lowers the percentage of the total exercise oxygen cost attributable to breathing. Reduce ventilatory oxygen musculature may enhance endurance for two reasons-

1. It reduces the fatiguing effect of exercise on ventilatory musculature

Oxygen freed from the use by the respiratory musculature now becomes available to the active locomotor muscles.[14]

Also the sport-specific training program has included speed, agility and aerobic conditioning exercises to gear up the cardiorespiratory performance of the basketball players.

Anaerobic capacity: Basketball is considered an intermittent high-intensity bout that requires a significant contribution from anaerobic metabolism for tactile moves (like defensive, offensive transition, shooting, jumping, blocking, and passing)[21]

It also requires a higher level of aerobic metabolism to enhance the resynthesis of creatinine phosphate, lactate clearance and removal of accumulated intracellular inorganic phosphate from active muscles. Thus this interaction between aerobic and anaerobic metabolism should be considered in the evaluation and training prescription.

In this study, the running anaerobic sprint test (RAST) was used to evaluate the anaerobic power and the fatigue index.

The statistical analysis showed that the sports-specific training group has significant improvement when compared with the control group with a mean group difference of 117.0 W/kg/s in the experimental group and 93.0 W/kg/s in the control group.

Anaerobic Power

The explanation underlying three possibilities related to the central and peripheral adaptations to training- 1. Decrease the rate of lactate formation during exercise 2. Increase rate of lactate clearance during exercise 3. The combined effect of both. Players who engaged in various anaerobic activities tolerate higher blood lactate levels and lower pH values than their untrained counterparts. This raises speculation that anaerobic training proves the body's capacity for acid-base regulation perhaps, enhancing chemical buffers or alkaline reserve. [14]

Fatigue Index

The study shows a significant decrease in fatigue index with a significant between-group difference of 1.46 W/kg/s after 12 weeks. The percentage decline in the power output during exercise and an increase in the rate of fatigue occur due to the depletion of energy sources. In this study, the level of fatigue index has been reduced; this could be because of improvement in the aerobic and anaerobic capacities and body adaptations to regular training. The metabolic adaptations such as the capacity to mobilize, deliver and oxidize fatty acids, and carbohydrates would have occurred because of greater blood flow to train muscles, more fat mobilizing and fat metabolizing enzymes, enhanced muscle mitochondrial capacity, decrease muscle glycogen use and reduce plasma-borne lipid. Furthermore, enhanced fat catabolism benefits the player to conserve the glycogen stores which are further important during high-intensity prolonged exercise. Fatty acid continuation combined with reduced carbohydrate metabolism contributes to blood glucose homeostasis and improved endurance capacity. Training also enhances the hepatic gluconeogenic capacity which further provides resistance to hyperglycemia during prolonged exercise. The trained muscles increase the capacity of subsarcolemmal and Intermyofibrilar muscle mitochondria to generate ATP aerobically. [14]

CONCLUSION

Basketball sports-specific training program that incorporates basketball-specific exercises have shown improvement in the level of physical, physiological related variables in amateur basketball players. The effect appears to be more significant when the program is implemented for 12 weeks.

Declaration by Authors

Ethical Approval: The Institutional Ethics Committee(s) approved this study. (PIMS/DR/PhD/2020/COPT/108)

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