

DOI: 10.5281/zenodo.124261114

## CHARACTERISTICS OF PHYSICAL FITNESS OF MALE COLLEGE ATHLETES: A COMPARATIVE ANALYSIS

<sup>1</sup>Md. Shahariar Kabir, <sup>2</sup>Sharmin Akter Shanta, <sup>3</sup>Harshita Kapoor, <sup>4</sup>Krisnadas pal <sup>5</sup>Sunita Yadav, <sup>6</sup>Sangeeta Prdhan

<sup>1</sup>PhD Researcher, Department of Physical Education. Nims University Rajasthan, Jaipur, India.

<sup>2</sup>Lecturer, Department of Physical Education and Sports Science, Daffodil International University, Bangladesh

<sup>3</sup>PhD scholar, Mahatma Gandhi University of Medical Sciences and Technology, Jaipur

<sup>4</sup>Ph.D. Research Scholar, Department of Physiotherapy. Nims College of Physiotherapy and Occupational Therapy Nims University Rajasthan, Jaipur, India.

<sup>5</sup>Assistant Professor, Department of Physical Education. Nims University Rajasthan, Jaipur, India

<sup>6</sup>PhD Scholar, Department of Physical Education. Nims University Rajasthan, Jaipur, India.

Received: 03/12/2025

Accepted: 16/01/2026

Corresponding Author: Shahariar Kabir  
(email)

### ABSTRACT

**Background:** Physical fitness is a key component of athletic performance and overall health in collegiate athletes. Knowing the effects of different training orientations on the initial fitness profile is important to make a proper conditioning program. **Objective:** To compare selected physical fitness and physiological variables in male college athletes belonging to aerobic, anaerobic and control groups. **Methods:** 105 male students (18-22 years) were randomly selected out of 147 volunteers of NIMS University, Rajasthan. Participants were randomly assigned into aerobic ( $n = 35$ ), anaerobic ( $n = 35$ ) and control ( $n = 35$ ) groups based on the background of their predominant sport training during the previous 12 months. Fitness variables evaluated were balance (stork stand test), flexibility (sit-and reach test), vertical and horizontal explosive strength (vertical jump and standing long jump), agility (4 × 10 m shuttle run), upper body explosive strength (medicine ball throw), resting heart rate, and estimated VO<sub>2</sub>max (Queen's College Step Test). **Analysis** was performed using one-way ANOVA followed by Tukey's HSD post-hoc test and effect size ( $\eta^2$ ) ( $p \leq 0.05$ ). **Results:** There were no significant differences in balance, flexibility, horizontal explosive strength, agility, resting heart rate or VO<sub>2</sub>max ( $p > 0.05$ ). There were significant differences in vertical explosive strength ( $p = 0.046$ ) and upper-body explosive strength ( $p < 0.001$ ) with the anaerobic group being better. **Conclusion:** Despite the similar baseline fitness characteristics, the athletes who trained anaerobically had significantly higher explosive strength, suggesting the importance of training specificity on neuromuscular performance.

**KEYWORDS:** Aerobic Training, Anaerobic Training, Agility, Explosive Strength, Physical fitness, College Athletes.

## INTRODUCTION

Physical fitness is a multidimensional construct which includes cardiovascular endurance, muscular strength and power, flexibility, balance, agility, and the neuromuscular coordination and is important for athletic performance and general health (Caspersen, Powell, & Christenson, 1985). In college sport training environments, athletes are typically exposed to training regimens that target aerobic or anaerobic energy systems with specific physiological and neuromuscular adaptations. Aerobic training increases mainly cardiovascular efficiency, oxygen uptake capacity and tolerance to fatigue, whilst anaerobic training improves maximum muscle strength, power, speed and explosiveness by means of short-term high intensity activities (McArdle, Katch & Katch, 2015). The specificity of training hypothesis states that the type of physiological adaptation depends primarily on the training stimulus, especially the intensity and duration (Bompa & Buzzichelli, 2019). Thus, athletes involved in anaerobic-oriented activities are expected to have superior explosive strength and power, and athletes involved in aerobic training are expected to have improved endurance capabilities. Also, there is evidence that training history significantly contributes to developing some aspects of physical fitness. For example, anaerobic training is more effective for improving vertical jump performance and upper-body power than aerobic conditioning (Markovic & Mikulic, 2010; Suchomel *et al.*, 2016). However, balance and flexibility variables may not be different between training groups unless the program has specific proprioceptive or mobility exercises (Behm *et al.*, 2015).

Though there has been considerable worldwide research on training-induced adaptations, few studies have comparatively investigated baseline physical fitness parameters among Indian collegiate athletes of aerobic, anaerobic and non-training background. Such baseline differences are important to consider when assessing intervention outcomes and designing evidence-based training strategies. The aim of the present study was to compare some physiological and physical fitness parameters between male college athletes in aerobic, anaerobic and control groups.

## LITERATURE REVIEW

Previous studies have shown that as a result of aerobic training, there are significant improvements in  $VO_2$ max and resting heart rate as well as improvements in cardiovascular efficiency (McArdle *et al.*, 2015; Powers & Howley, 2018). On the other hand, anaerobic and resistance training are highly associated with increases in muscular strength, power

and explosive performance as a result of increased motor unit recruitment and fast twitch muscle fiber activation. Field tests such as the vertical jump, standing broad jump and medicine ball throw have been well validated as measures of explosive strength (Kraemer & Ratamess, 2004; Suchomel *et al.*, 2016).

Components of physical fitness have been widely conceptualized as health-related and skill-related, including cardiovascular endurance, muscular strength and power, flexibility, balance and agility, which all affect athletic performance and health outcomes (Caspersen *et al.*, 1985; Wilmore *et al.*, 2012). The training orientation, intensity, and specificity of collegiate athletes influence the development level of these components.

Balance, agility and flexibility are seen as multifactorial traits affected more by neuromuscular coordination and specific skill practice than general training orientation (Sheppard & Young, 2006; Paillard, 2017). Recent research suggests that athletes with different training backgrounds may not show significant differences in these parameters if they are not specifically trained for balance or mobility. Unless systematic stretching routines are included, flexibility has been found to be relatively independent of aerobic or anaerobic conditioning as measured by sit-and-reach test (Alter, 2004).

Also, upper-body explosive power measured by medicine ball throw is known to be an effective indicator of functional power development (Chu & Myer, 2013). There is a wealth of international research in the area of training adaptations, but comparative studies on Indian collegiate population and assessment of both health and skill related fitness variables are limited. This gap in literature signifies the need for systematic comparative studies to evaluate the baseline physical fitness characteristics among aerobic, anaerobic and control groups in Indian college settings.

## METHODS AND MATERIALS

### Subjects

The study involved 147 male hostel residents as volunteers. 105 participants were randomly chosen after eligibility screening and informed consent. Participants were categorized according to their primary sports training background in the last 12 months. Students involved in endurance activities such as distance running and cycling were assigned to the Aerobic group. Those engaged in strength and power sports (e.g. sprinting, football, wrestling, resistance training) were included in the anaerobic group. The Control group consisted of students not participating in structured sports training.

**Criteria for Inclusion and Exclusion**

Healthy male undergraduate hostel residents with no medical conditions that restricted physical activity

were the participants. Excluded those with chronic illness, no consent or irregular participation.

**Table-1 Dependent variables**

Variables	Parameters	Test/Tools administered
Personal	Age (years)	Age proof certificate
Demographic	Height (cm)	Stadiometer
	Body mass (kg)	Weighing scale
Health/skill related	Balance(sec)	stork stand test
	Flexibility (cm)	Sit and reach test
	Vertical explosive strength (cm)	Vertical Jump test
	Horizontal explosive strength (cm)	Standing broad jump
	Agility (sec)	4x10m shuttle run
Physiological	Upper body explosive strength (m)	Medicine ball throw
	Resting heart rate (bpm)	PolarH7
	VO <sub>2</sub> max (ml/kg/min)	Queen's college step test

**Data Collection Procedure**

Before data collection, participants were given a standardized orientation and familiarization session. Participants were divided into Aerobic, Anaerobic, and Control groups to assess the physical fitness attributes of each group of college athletes in a structured training and testing framework. All assessments were performed by trained investigators under identical conditions. The study was approved by the Ethics Committee of the National Institute of Medical Science and Research (NIMS), Jaipur, India (approval number: NIMSUR/IEC/2023/699). All participants were required to sign an informed consent form prior to participating in the research.

**Analysis of Individual and Demographic Factors**

Personal and demographic factors were age, height and weight. Age (in years) was verified from official government documents and recorded in full years relative to the individual's date of birth. Height (cm) was measured without shoes to the nearest 0.1 cm using a Seca 213 portable stadiometer. Participants were standing straight with their heads in the Frankfort horizontal plane. Body weight (kg) was measured using a calibrated Dr. Trust Model 513 digital scale (precision 0.1 kg) with participants in minimal clothing and barefoot.

**Variables of Health-Related Fitness**

Health-related fitness assessments consisted of several tests: static balance was tested with the Stork Stand Test (s); lower back and hamstrings flexibility was assessed through the Sit-and-Reach Test (cm); vertical and horizontal explosive strength was assessed with the Vertical Jump Test and Standing Broad Jump Test (cm), respectively; agility was measured with the 4 × 10 m Shuttle Run Test (s); upper-body explosive strength was assessed through the Medicine Ball Throw Test (m); resting heart rate was recorded with the Polar H7 chest strap and the Elite HRV app (bpm); predicted aerobic capacity (VO<sub>2</sub>max ml/kg/min) was estimated using the Queen's College Step Test (McArdle et al., 1972); and body fat percentage was calculated using the skinfold equation of Durnin and Womersley (1974).

**Statistics Analysis**

Normality was confirmed by the Anderson-Darling test. One-way analysis of variance (ANOVA) with post hoc Tukey's honestly significant difference (HSD) test was used. Effect size was determined by calculating eta squared ( $\eta^2$ ). Significance was set at  $p \leq 0.05$ .

**RESULTS****Table:2, Demographic characteristics of volunteers**

Parameters	Aerobic (n=35)	Anaerobic (n=35)	Controlled (n=35)	P value
Age (years)	19.69 ±1.85 (19.06-20.33)	19.10±2.01 (18.41-19.79)	19.91±2.19 (19.15-20.66)	0.226
Height (cm)	169.94±4.34 (168.45-171.43)	168.52±5.06 (166.78-170.25)	168.36±4.90 (166.68-170.05)	0.316
Body Mass (kg)	58.69±6.47	59.91±8.16	59.47±6.41	0.766

	(56.47-60.91)	(57.10-62.71)	(57.27-61.67)	
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Data are represented as Mean $\pm$ SD (95% confidence intervals); n=number of volunteers.

Table 4 presents the demographics of volunteers in the aerobic, anaerobic, and control conditions. Important characteristics considered are Age, Height and Body Mass. The mean for each characteristic, with its standard deviation and 95% confidence interval, is provided. For instance, the aerobic group mean age is 19.69 years with a standard deviation of 1.85 years and a confidence interval of 19.06 to 20.33 years. Likewise,

mean values for Height and Body Mass are reported with respective confidence intervals. Statistical significance was determined with P values, which show the differences among the groups. This large table gives a detailed summary of the volunteers' demographics for the different experimental conditions, which helps to understand and compare the results across the different conditions.

**Table:3 Physical fitness characteristics of the assigned group volunteers**

Parameters	Aerobic (n=35)	Anaerobic (n=35)	Controlled (n=35)	P value
Balance (Sec)	29.62 $\pm$ 2.37 (28.80-30.43)	28.44 $\pm$ 3.65 (27.18-29.69)	29.52 $\pm$ 1.09 (29.15-29.90)	<b>0.232</b>
Flexibility (cm)	25.09 $\pm$ 4.08 (23.69-26.49)	25.23 $\pm$ 2.63 (24.33-26.14)	24.76 $\pm$ 1.79 (24.14-25.38)	<b>0.665</b>
Vertical Explosive Strength (cm)	35.74 $\pm$ 4.91 (34.05-37.43)	36.05 $\pm$ 5.36 (34.21-37.89)	33.58 $\pm$ 2.59 (32.69-34.47)	<b>0.046</b>
Horizontal Explosive Strength (cm)	226.51 $\pm$ 19.41 (219.84-233.17)	225.94 $\pm$ 10.76 (222.25-229.64)	220.25 $\pm$ 7.18 (217.78-222.71)	<b>0.104</b>
Agility (sec)	10.15 $\pm$ 0.70 (9.90-10.39)	10.26 $\pm$ 0.42 (10.11-10.40)	10.65 $\pm$ 0.99 (10.31-10.99)	<b>0.14</b>
Upper body Explosive Strength (m)	8.24 $\pm$ 1.37 (7.77-8.71)	9.53 $\pm$ 0.86 (9.23-9.82)	9.09 $\pm$ 1.06 (8.73-9.46)	<b>&lt;0.001</b>
Resting Heart Rate (bpm)	65.4 $\pm$ 4.4 (63.9–66.9)	66.5 $\pm$ 5.6 (64.6–68.4)	65.0 $\pm$ 7.9 (62.3–67.7)	<b>0.563</b>
VO <sub>2</sub> max (ml/kg/ min)	49.2 $\pm$ 2.6 (48.3–50.1)	49.4 $\pm$ 3.5 (48.2–50.6)	48.3 $\pm$ 2.6 (47.4–49.2)	<b>0.247</b>

Data are presented as Mean  $\pm$  SD with 95% confidence intervals. Post-hoc comparisons conducted using Tukey's HSD test.

Demographic characteristics were similar between groups (Table 1). No significant differences were observed for balance, flexibility, horizontal explosive strength, agility, resting heart rate or VO<sub>2</sub>max as shown in Table 2. Significant differences were found for vertical explosive strength and upper-body explosive strength, with the anaerobic group being

superior. Resting heart rate and VO<sub>2</sub>max values were statistically similar among all three groups at baseline ( $p > 0.05$ ), confirming comparable initial physiological status prior to any intervention. Effect size analysis of explosive strength variables showed moderate-to-large practical significance.

**Figure:1, Graphical analysis of balance using the stork stand test**

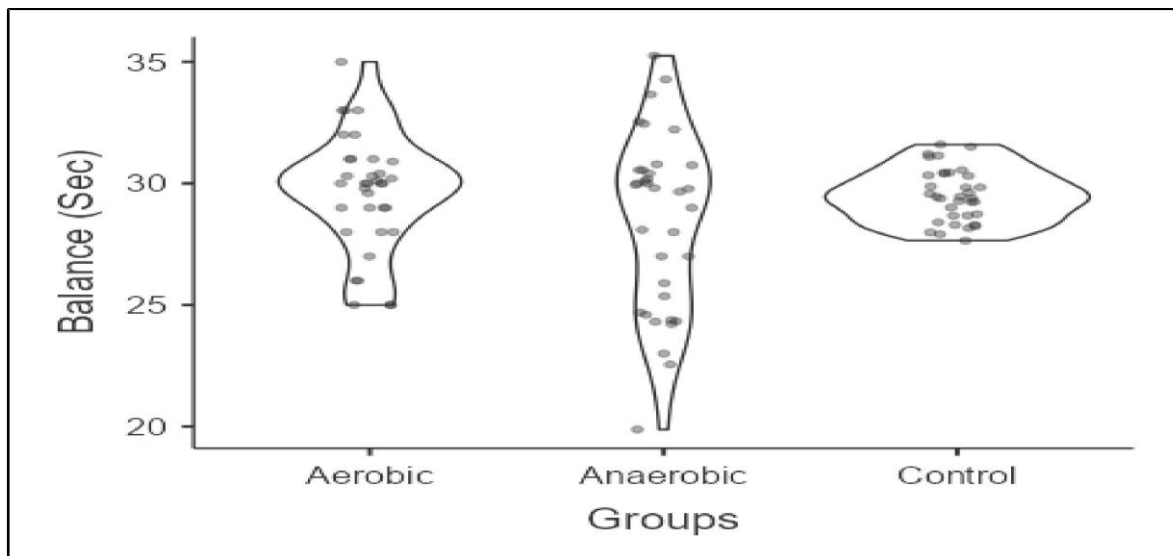
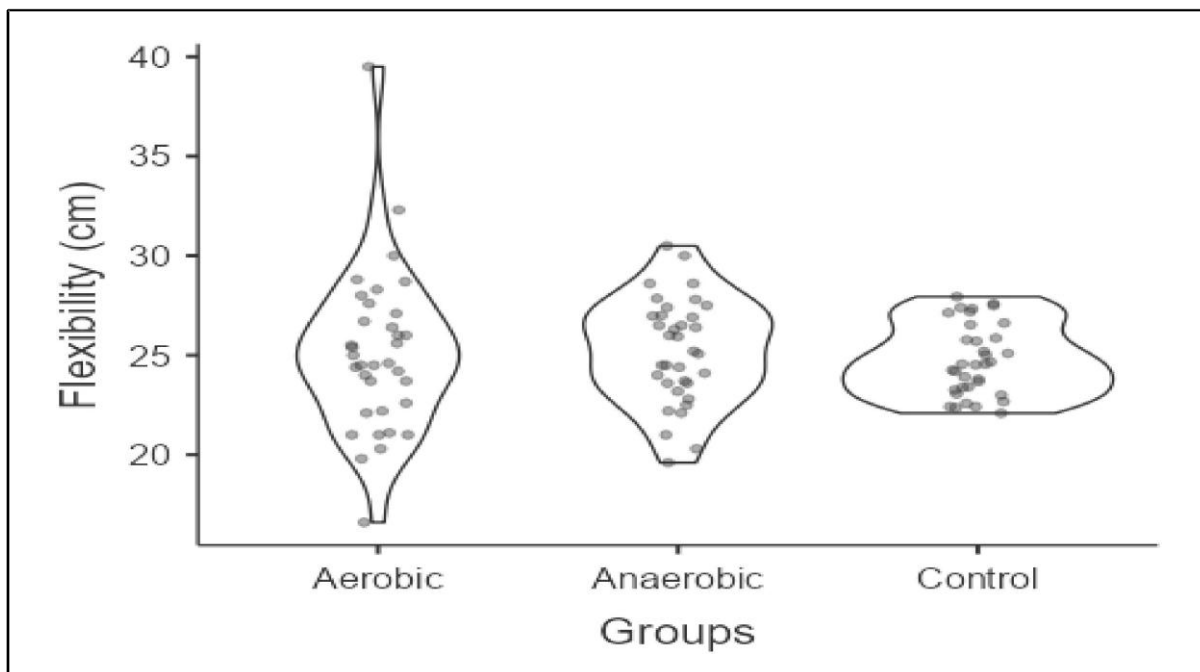


Figure 1 shows violin plots depicting the baseline balance performance across the Aerobic, Anaerobic and Control groups before intervention. The Aerobic group has a moderate variation of balance times (25.0 to 35.0 seconds). On the other hand, the Anaerobic group is the one with the highest variability, with times ranging from 19.9 to 35.3 seconds, which means

there is a wide range of capabilities within this group. The range of the Control group is smaller (27.6 to 31.6 seconds), indicating the balance performance of the group is more consistent. Overall, the violin plots depict the differences in balance variability between the groups at baseline (prior to intervention).

**Figure:2, Graphical analysis of flexibility using the sit and reach test**



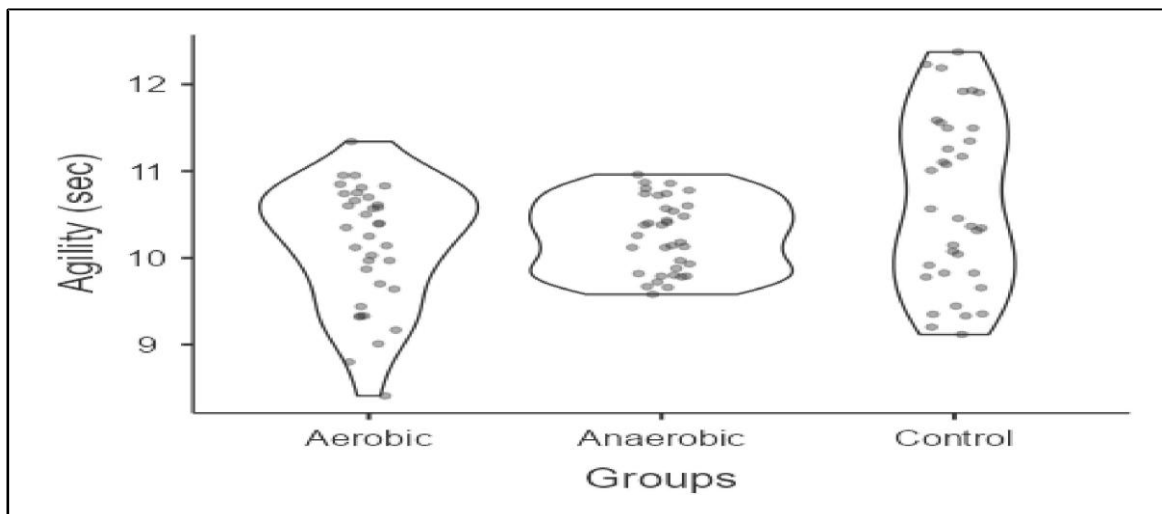
The pre-intervention flexibility performance for the Aerobic, Anaerobic and Control groups are presented using violin plots in Figure 2. The Aerobic group has a wider range of values (16.6-39.5 cm) and a slightly

right-skewed distribution. The Anaerobic group, on the other hand, has a smaller range of 19.6-30.5 cm, which indicates a variety of levels of flexibility. In contrast, the Control group has a narrow range (22.1-

27.9 cm), indicating low variance and high consistency. Overall, these plots clearly show the

baseline flexibility distribution over the three groups prior to intervention.

**Figure:3, Graphical analysis of agility using 4\*10m shuttle run**



Pre-intervention agility performance (Aerobic, Anaerobic, Control) is presented in violin plots (see Figure 3). The agility of the Aerobic group varies from 8.41 to 11.30 seconds, and it is characterized by a significant dispersion toward the fastest times. The Anaerobic group, however, is more evenly spread out

and has a moderate range of 9.58 - 11.00 seconds. On the other hand, the Control group has the largest range of 9.12 to 12.40 seconds, showing more variability in agility performance. Figure 2 shows the baseline differences in the distribution of agility between the groups before intervention.

**Figure:4, Graphical analysis of vertical, horizontal and upper body explosive strength**

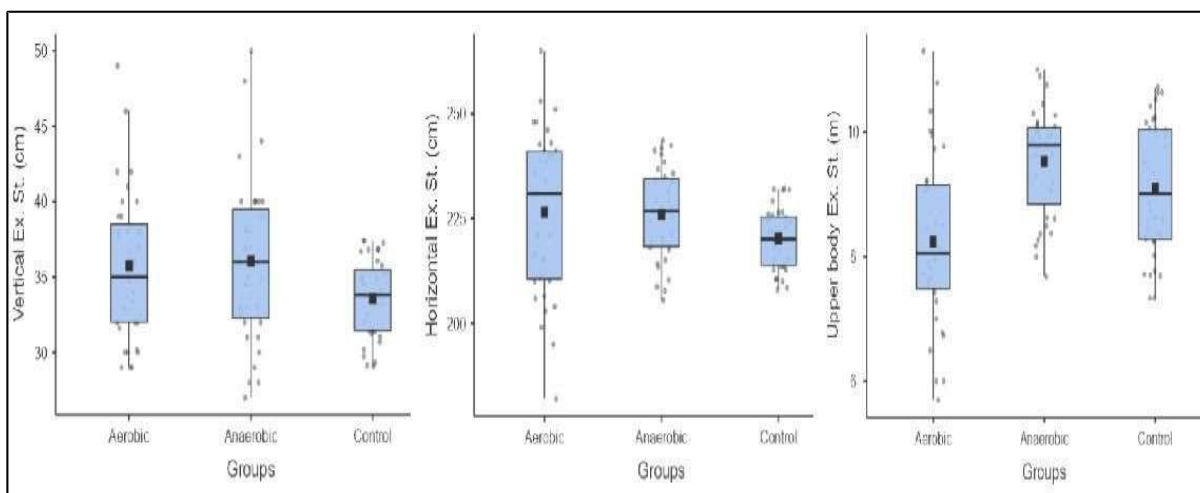


Figure 4 displays box plots of vertical, horizontal, and upper-body explosive strength for Aerobic, Anaerobic and Control groups. These plots display median values, interquartile ranges and minimum-maximum non-outlier values. The Anaerobic group has the highest median performance in all the explosive strength metrics among all groups, followed closely by the Aerobic group, with the Control group lagging behind. The boxes and whiskers represent the

variability within each group and make it easy to compare the strength distributions and identify any potential outliers.

**DISCUSSION**

Present findings indicated most baseline characteristics were similar between aerobic, anaerobic and control groups suggesting a generally homogenous sample in terms of age, height, body

mass and general fitness status. The similarity provides a useful basis for interpreting the few variables that did differ, mainly within explosive strength measures, in light of training specificity (Bompa & Buzzichelli, 2019). Balance, flexibility and agility did not differ significantly. These results are in line with evidence that such attributes are more contingent on specific proprioceptive, mobility, and coordination training than on general aerobic or anaerobic conditioning (Behm et al., 2015; Paillard, 2017; Alter, 2004; Sheppard & Young, 2006). Without specific drills for these qualities, one would expect performance to be similar across groups. The most striking differences were observed in explosive strength variables. Vertical jump performance was significantly better in the anaerobic group compared to the control group, and upper-body explosive strength was highest in the anaerobic group but lowest in the aerobic group. These results are consistent with the neuromuscular adaptations to high-intensity, short-duration training that increase motor unit recruitment and fast-twitch fiber activation (Kraemer & Ratamess, 2004; Suchomel et al., 2016; Markovic & Mikulic, 2010). Horizontal jump differences were not statistically significant, but mean values tended to follow a similar trend. Notably, resting heart rate and  $VO_2\text{max}$  did not differ significantly between aerobic and anaerobic groups, contrary to theoretical expectations that aerobic training improves cardiovascular efficiency (McArdle et al., 2015; Powers & Howley, 2018). This may be attributed to the overlapping conditioning practices occurring in collegiate sport settings, with athletes often participating in mixed training routines irrespective of primary sport.

Finally, because group allocation was based on existing sport participation rather than an experimental intervention, the superior explosive strength in the anaerobic group may reflect both pre-existing athlete selection and training effects. In general, the findings indicate that anaerobic training is specifically suited for developing power, whereas

the other fitness components do not appear to be affected unless specifically trained.

#### Limitations

This study is not without limitations, such as cross-sectional design, male-only sample, single institution, and self-reported training background. Quantification of training history and control over diet may also have influenced the findings.

#### CONCLUSION

Collegiate male athletes' baseline physical fitness characteristics were similar between aerobic, anaerobic, and control groups. Only significant differences were found in the explosive strength measures, where the anaerobic group had a better performance, which supports the principle of specificity. No significant differences were observed between groups in balance, flexibility, agility, resting heart rate and  $VO_2\text{max}$  suggesting that these attributes may require specific training to differentiate groups. The results indicate that the anaerobic-oriented training is especially effective for power development, while other fitness components are similar in the absence of specific interventions. Most of the fitness parameters were similar, however athletes with anaerobic training background showed superior explosive strength. These findings emphasize the need for power-oriented training to be included in collegiate conditioning programs.

#### Acknowledgments

We would like to thank all participants for their sincere cooperation in this study. Especially all author co-authors efforts and contribution with data analysis, critical analysis, designing, drafting, planning and data collection, I really acknowledge and obliged to Dr Subhashis Biswas For share his knowledge and guide us for complete this work Smoothly.

**Conflict of Interest** The author declares no conflict of interest

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