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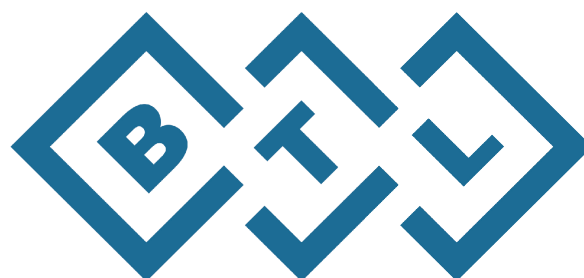


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# Comparative analysis of fitness attributes in female university athletes across team-based ball sports

*Analiza porównawcza cech sprawnościowych u zawodniczek uniwersyteckich w różnych zespołowych grach piłkarskich*

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## Abstract

**Introduction.** This study aimed to compare the fitness attributes among trained female university participants who regularly practised and engaged in four different team-based ball sports, including football, basketball, volleyball, and cricket, and an active control group.

**Materials and methods.** This observational cross-sectional study included 150 female players who participated in inter-university championships, aged 19 to 25 years. Thirty trained female university players were selected for each of the four team-based ball sports categories—football, basketball, volleyball, and cricket—to fulfil the study requirement. Additionally, thirty healthy female participants were selected to serve as the active control group. The active control group did not participate in any organized sports but could take part in recreational activities to maintain activity and health. Fitness attributes (FA) were measured using the linear sprint test (LST), curved sprint test (CST), and arrowhead agility test (AHAT). Data analysis used mean, standard deviation, one-way analysis of variance (ANOVA), Games-Howell (for unequal variances) post hoc test, and Tukey post hoc test (for equal variances).

**Results.** ANOVA revealed significant differences among groups' fitness attributes ( $p < 0.001$ ). The active control group exhibited significantly lower performance in agility and sprint tests compared to trained athletes ( $p < 0.001$ ), highlighting the impact of structured training. Tukey post hoc tests confirmed these differences in pairwise comparisons. Post hoc analyses (Games-Howell and Tukey tests) confirmed these differences through pairwise comparisons.

**Conclusions.** Findings suggest that football players exhibit superior sprinting and agility performance compared to other team-sport athletes, highlighting the need for sport-specific conditioning programs. These insights can inform training regimens to enhance speed and agility in female university athletes.

## Key words

athletic performance, female athlete physiology, sports-specific conditioning, motor fitness

## Streszczenie

**Wprowadzenie.** Celem niniejszego badania było porównanie cech sprawnościowych u wyszkolonych zawodniczek uniwersyteckich regularnie trenujących i uczestniczących w czterech różnych zespołowych grach piłkarskich: piłce nożnej, koszykówce, siatkówce i krykiecie, oraz w aktywnej grupie kontrolnej.

**Materiały i metody.** W przekrojowym badaniu obserwacyjnym uczestniczyło 150 zawodniczek biorących udział w międzyuczelnianych mistrzostwach w wieku 19–25 lat. Do każdej z czterech grup sportowych (piłka nożna, koszykówka, siatkówka, krykiety) wybrano po 30 wyszkolonych zawodniczek uniwersyteckich. Dodatkowo do aktywnej grupy kontrolnej zakwalifikowano 30 zdrowych kobiet, które nie brały udziału w zorganizowanych zajęciach sportowych, ale mogły uczestniczyć w aktywnościach rekreacyjnych w celu utrzymania aktywności i zdrowia. Do oceny cech sprawnościowych zastosowano liniowy test szybkościowy (LST), zakrzywiony test szybkościowy (CST) oraz test zwinności Arrowhead (AHAT). Analizę danych przeprowadzono za pomocą średnich, odchyłek standardowych, jednoczynnikowej analizy wariancji (ANOVA), testu post hoc Games-Howell (dla nierównych wariancji) oraz testu post hoc Tukeya (dla równych wariancji).

**Wyniki.** Analiza ANOVA wykazała istotne różnice w cechach sprawnościowych między grupami ( $p < 0,001$ ). Grupa kontrolna osiągnęła istotnie niższe wyniki w testach zwinności i szybkości w porównaniu do trenowanych zawodniczek ( $p < 0,001$ ), co podkreśla wpływ regularnych treningów. Testy post hoc Tukeya potwierdziły te różnice w porównaniach par grup. Dalsze analizy post hoc (Games-Howell i Tukeya) również potwierdziły te różnice.

**Wnioski.** Wyniki wskazują, że piłkarki nożne wykazują lepsze wyniki w zakresie szybkości i zwinności w porównaniu z innymi zawodniczkami sportów zespołowych, co podkreśla potrzebę programów przygotowania ukierunkowanego na specyfikę dyscypliny. Te wnioski mogą stanowić wskazówkę przy projektowaniu treningów poprawiających szybkość i zwinność u zawodniczek uniwersyteckich.

## Słowa kluczowe

sprawność sportowa, fizjologia zawodniczek, przygotowanie specyficzne dla dyscypliny, sprawność motoryczna

## Introduction

Success in team-based ball sports requires high physical, technical, tactical, and psychosocial skills [1, 2]. Limited research exists on the fitness attributes that differentiate levels of performance in female team sports. Evaluating these attributes helps understand sport-specific physical demands and optimize training programs [3, 4]. Additionally, talent identification and athlete development depend on longitudinal evaluations of these performance qualities ([5-7]. A Longitudinal evaluation of performance attributes can improve training effectiveness and rehabilitation strategies across different sports seasons (preseason, competition, transition) [6,7]. Physical fitness is necessary to become a successful ball player, and it grows over time with proper training [6]. Physical fitness is defined as a set of qualities that an individual develops related to his or her ability to perform physical activity [8]. An individual's physical fitness depends on different attributes that have been shown to have a significant positive relationship with sports performance, even participation in different national and international sporting events [9]. These components could be measured by using different parameters, including body composition, cardiorespiratory fitness, muscular strength, muscular endurance, flexibility, agility, balance, coordination, power, reaction time, and speed [8, 10].

Along with the physical fitness component, motor fitness is also essential to carry out different physical skills related to speed, agility, power, balance, coordination and reaction time [11].

However, minimal research has investigated the comparative analysis of fitness attributes across various team-based sports in female populations. Sex-specific analysis may be integral when developing sports training regimes to ensure optimal player performance, especially due to the lack of research on female players. This study compares fitness attributes among trained female university athletes participating in four team-based sports — Football (FB), Basketball (BB), Volleyball (VB), and Cricket (CKT) — against a recreationally active control group (AC). By identifying sport-specific differences in agility, speed, and sprint performance, this research provides insights into optimizing training strategies for female athletes. Despite extensive research on male athletes, there are limited comparative studies on how different team sports impact female athletes' fitness attributes. Understanding these differences is crucial for optimizing training regimens, enhancing performance, and reducing injury risks. This study contributes to sports science by providing empirical evidence on the role of sport-specific training adaptations in agility and sprint performance among female university athletes.

## Materials and Methods

### Participants

A total of 150 female university athletes participated in the study, including Football ( $n = 30$ , age  $21.41 \pm 1.61$ ), Basketball ( $n = 30$ , age  $21.72 \pm 1.92$ ), Volleyball ( $n = 30$ , age  $21.82 \pm 1.94$ ), and Cricket ( $n = 30$ , age  $21.62 \pm 1.74$ ). An additional 30 recreationally active participants (age  $21.89 \pm 1.58$ ) formed the active control group. An a priori power analysis using GPower 3.1.9.7 ( $\alpha = 0.05$ , effect size = 0.40) indicated a minimum sample size of 125 for 80% power in a one-way ANOVA. Therefore, we recruited additional participants ( $n = 30$ , each group) to

consider potential dropouts. The subjects under different team-based sports were selected from the Visva-Bharati University team, a Central University institute of National importance, Visva-Bharati, Santiniketan, West Bengal, India.

### Procedure

An orientation programme for the athletes was organized in collaboration with the University Sports Board to orient and explain the need for the study. Participants trained year-round, averaging  $3.4 \pm 0.8$  years of experience. Their routine included five weekly 150-minute sessions, a practice match every two weeks, and a competition every three months. However, to select the subjects for the active control group, the researchers contacted the different departmental students at the parent institute, Visva-Bharati, to participate in this study. Willful students who fulfil the study's objective were invited to join the research study as an active control group. Ethical approval was granted by Visva-Bharati University (Reg. No. VB-29049 of 2023–24), and all procedures adhered to the Declaration of Helsinki. All subjects filled out a questionnaire in which they reported their injury history that needed medical treatment. Moreover, the questionnaire also asked for medication use, known disease, and daily diet patterns. The participants were informed of any risks and discomforts associated with the study. Written informed consent was obtained from the participants and, if necessary, from their parents/legal guardians prior to study participation. Finally, five distinctive groups were formed through purposive sampling to meet the research purpose.

### Study Location

The study was conducted at the Department of Physical Education and Sport Science sports ground, Visva-Bharati, Santiniketan, West Bengal, India.

### Inclusion and Exclusion Criteria

As Inclusion Criteria, female athletes with university sports achievements in their respective sports specialization and at least three years of regular active participation in inter-university level sports competitions were considered subjects in this study. The age sex-matched subjects, aged between 19-25 years, were assigned to the control group who did not participate in any organized sporting activities regularly. However, they were allowed to participate in recreational sports to keep them active and healthy. All the subjects stayed in the hostel, and the regular students at the university followed a similar lifestyle regarding the biological clock and diet pattern. As exclusion criteria, we defined the presence of chronic diseases (e.g., diabetes, obesity, metabolic syndrome) and medication usage that affects the female's fitness attributes.

### Administration of the test

The researcher collected data using the Linear Sprint Test (LST), Curved Sprint Test (CST), and Arrowhead Agility Test (AHAT) to measure the fitness attributes of the participants.

### The Linear Sprint Test

This test evaluates the peak and linear sprinting capacity of a player. The materials required to conduct this test were electronic timing equipment, e.g. photocells/stopwatch, a measuring tape, 8

markers (height preferably > 1.5 meters) and a pen. The course is shown in Figure 1. Gate 1 is the starting line, and gates 2, 3 and 4 mark the 10-, 20- and 30-meter line, respectively. Photocells are placed at the markers at a height of 1 meter. The width of the gates is 2 meters. A player starts at gate 1 with one foot on the starting line and the other foot behind the line. The researcher counted down three, two, one, "go", then the player started running and sprinted through the 30-meter gate (4). Since players tended to decelerate before reaching the 30-meter gate (4), the sprint course was extended by five meters, although photocells remained at gate 4, to ensure accurate 30-meter sprint performance measurement. The 10-, 20- and 30-meter sprint ti-

mes were assessed electronically. The 30-meter sprint was performed five times, with each sprint separated by a 25-second recovery period to assess repeated sprint ability. After the first sprint, the player has 22 seconds to return to the starting line (1). Then, the countdown was made. Sprint time for all five sprints was measured. The results were the time of the fastest sprint and the total time of all sprints, representing the player's ability to do repeated sprints. In addition, a fatigue index was also calculated as the difference, expressed in percentage, between the fastest time and the time of the fifth sprint, which provided information about the ability to maintain sprint performance. Fatigue Index = (last – fastest sprint)/ fastest sprint x 100% [12].

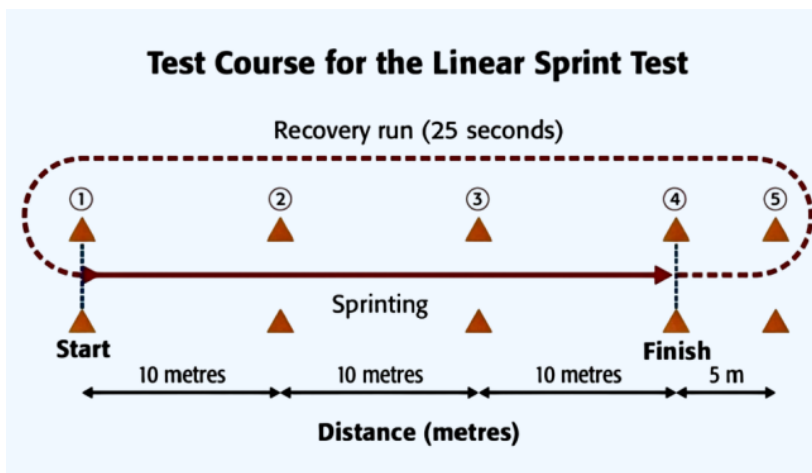


Figure 1. The test course for the Linear Sprint Test. The full course shows the player's movement during the sprint and the dotted line during the 25-second recovery period.

#### Curved Sprint Test

This test evaluates the peak and repeated sprinting ability when changing direction. The materials required to conduct this test were electronic timing equipment, e.g. photocells/stopwatch, a measuring tape, 10 markers (height preferably > 1.5 meters) and a pen. The course is shown in Figure 2. The sprinting course was about 35 meters with six gates, each two meters wide. The player started at Gate 1; gate 2 was placed 10 meters from Gate 1, gate 3 was positioned 5 meters in front and 5 meters to the right of Gate 2, gate 4 was 10 meters in front of Gate 2, and Gate 5 was 10 meters in front of gate 4. An extra gate (6) was placed 5 meters before gate 5. A player started at gate 1 with one foot on the starting line and the other foot behind the line. The researcher counted down three, two, one, "go", then the player star-

ted running and sprinted to gate 5. At gate 2, the player changed direction and sprinted through gate 3. Thereafter, the player changed direction again, sprinted through gate 4 and finally passed the finish line (5). The sprint time was measured with electronic sprinting devices, e.g. photocells, placed at gate 1 and gate 5. After the sprint, the player decelerated through gate 6 and jogged back to the starting line (gate 1) in 22 seconds to prepare for the next sprint. The player performed seven sprints separated by 25 seconds of active recovery. The test result was expressed as the fastest time, the average time for the seven sprints test, and the fatigue index, which was determined as the difference between the fastest and slowest sprints. If the player falls or stumbles, the time for this trial is omitted and replaced by the average of the previous and subsequent sprint [13].

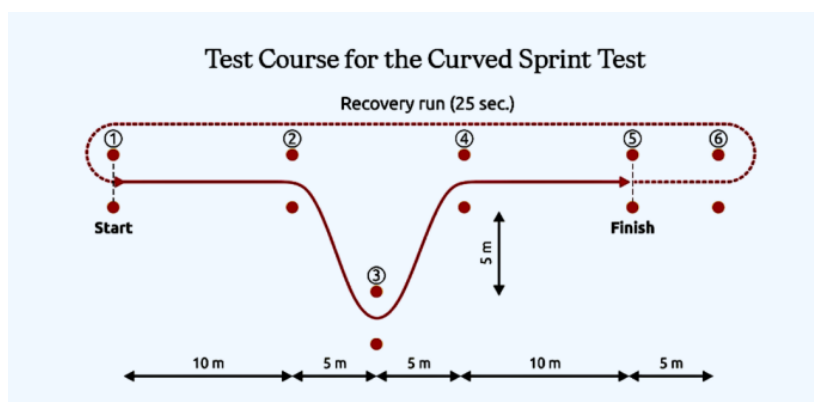


Figure 2. The test course for the Curved Sprint Test. The full course shows the player's movement during the sprint and the dotted line during the 25-second recovery period.

**Arrowhead Agility Test**

This test evaluates the speed, explosion, body control and ability to change direction over various angles and directions. The materials required to conduct this test were electronic timing equipment, e.g. photocells/stopwatch, a measuring tape, 6 markers (height preferably > 1.5 meters) and a pen. The course is shown in Figure 3. The markers are placed with three sets in an arrowhead shape and one set to indicate the start and finish line. A player started with one foot on the starting line and the other behind the line in a sprint start position. The researcher counted down three, two, one, “go”, then the player started running as

fast as possible from the starting line to the middle markers (A), turn to run through the side markers (C), through the far markers (B) and back through the start/finish line. The player completes two trials, one to the left and one to the right, separated by at least 5 minutes of recovery. The test was invalid if any player stepped over a cone instead of going around it. The test result was the total time to complete the test for the left and right turning trials. The time was recorded in seconds to the nearest two decimal places for each direction. In addition, the test course was completed once at a low and once at a moderate pace before the real test was initiated [14].

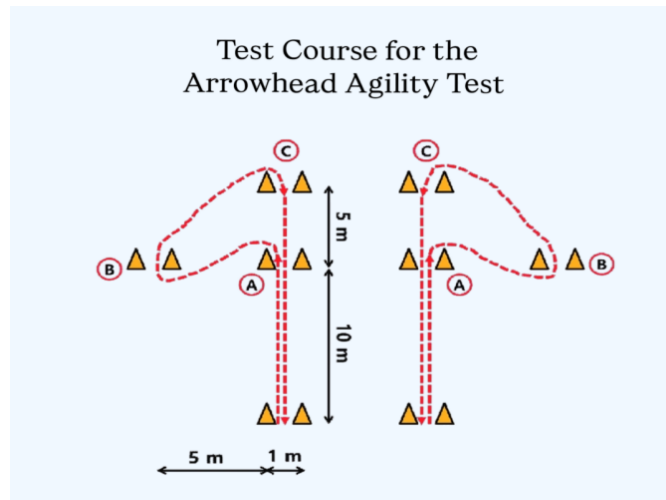


Figure 3. The test course for the Arrowhead Agility Test. The red dotted line shows the running path.

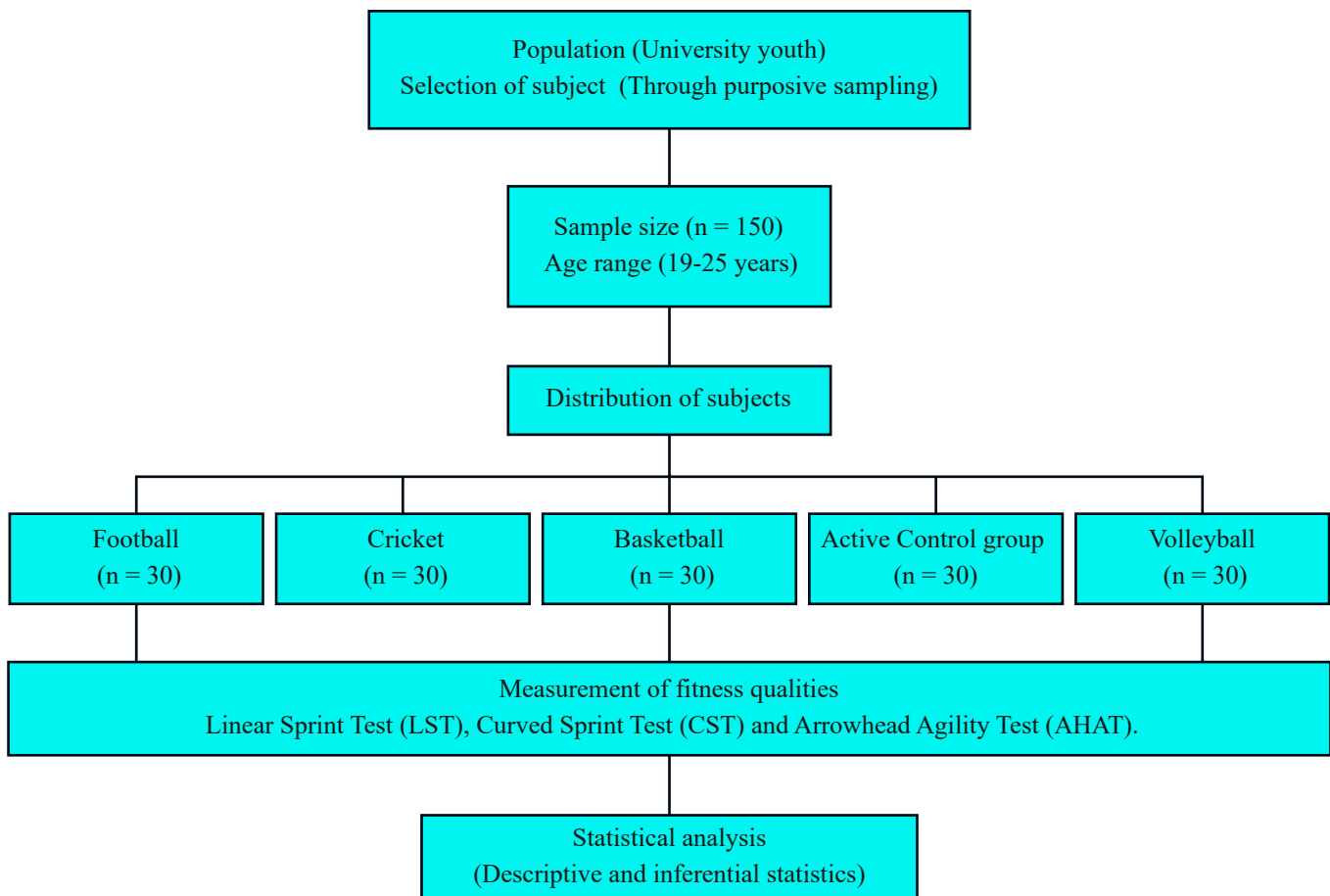


Figure 4. Flow diagram outlining the Study Design

**Statistical Analysis**

Means and Standard Deviations (SD) were used to describe all variables and baseline characteristics of the athletes and active control group subjects. To ensure the validity of our statistical analyses, the researchers assessed the assumptions of normality and homogeneity of variances. The Shapiro-Wilk test was performed to evaluate the normality of data distribution, and Levene’s test was used to assess the homogeneity of variances across the groups. The Shapiro-Wilk test showed non-normal distributions for the Linear Sprint Test ( $W = 0.981, p = 0.036$ ) and Curved Sprint Test ( $W = 0.851, p < 0.001$ ), but normal distribution for the Arrowhead Agility Test ( $W = 0.995, p = 0.862$ ). Levene’s test for homogeneity of variances indicated that there were unequal variances across groups for Linear Sprint Test ( $F = 8.89, p \leq 0.001$ ), Curved Sprint Test ( $42.4, p \leq 0.001$ ), and Arrowhead Agility Test ( $F = 4.33, p = 0.002$ ). Hence, the assumption of variance homogeneity was not satisfied. The intraclass correlations (ICCs) test and retest accuracies for all tests were also analyzed. A one-way analysis of variance (ANOVA) was computed as inferential statistics for the Linear Sprint Test, Curved Sprint Test and Arrowhead Agility Test to compare the difference among four team-based sports and active control groups. It was hypothesized that female university athletes participating in Football would exhibit significantly superior agility and sprint performance compared to those engaged in Basketball, Volleyball, and Cricket, as well as the active control group. In cases where significant differences were observed, the Games-Howell test (for unequal variances) and the Tukey post hoc test (for equal variances) were applied. The level of significance was set at  $p \leq 0.05$ . All analyses were carried out using JAMOVI Version 2.4 software

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**Results**

Descriptive and inferential statistics were performed based on the data acquired through LST, CST and AHAT of all trained female university Football, Basketball, Volleyball, and cricket players and active control groups. One-way ANOVA revealed significant group differences in the Linear Sprint Test, Curved Sprint Test, and Arrowhead Agility Test. Further, the Games-Howell (unequal variances) post hoc test for LST, CST and AHAT Tukey post hoc test (equal variances) was conducted, which gave pairwise comparisons.

Post-hoc analysis (Games-Howell and Tukey tests) revealed significant differences in fitness attributes among team athletes and the active control group. Football players outperformed all other groups in sprinting and agility tests, followed by basketball volleyball and cricket players.

The AC group, which did not participate in structured sports but engaged in recreational activities, had the weakest performance across all fitness tests. These results underscore the crucial role of regular training in enhancing speed and agility, with team-based sports significantly contributing to better fitness attributes than non-trained individuals.

**Table 1. One-way ANOVA**

| TEST                  | F    | df1 | df2  | p       |
|-----------------------|------|-----|------|---------|
| LST score (Welch's)   | 1038 | 4   | 65.5 | < 0.001 |
| CST score (Welch's)   | 6528 | 4   | 63.7 | < 0.001 |
| AHAT score (Fisher's) | 94.7 | 4   | 145  | < 0.001 |

**Table 2. Descriptive statistics of LST**

| TEST | Sport Grp | N  | Mean  | SE      | Median | SD     | Min  | Max   | Skewness | SE    | Kurtosis | SE    |
|------|-----------|----|-------|---------|--------|--------|------|-------|----------|-------|----------|-------|
| LST  | FB        | 30 | 5.38  | 0.00508 | 5.37   | 0.0278 | 5.35 | 5.43  | 0.866    | 0.427 | -0.490   | 0.833 |
|      | BB        | 30 | 5.71  | 0.01367 | 5.70   | 0.0749 | 5.58 | 5.85  | 0.220    | 0.427 | -1.112   | 0.833 |
|      | VB        | 30 | 5.88  | 0.01793 | 5.87   | 0.0982 | 5.69 | 6.08  | 0.398    | 0.427 | -0.352   | 0.833 |
|      | CRT       | 30 | 6.08  | 0.01868 | 6.05   | 0.1023 | 5.92 | 6.28  | 0.534    | 0.427 | -0.726   | 0.833 |
|      | AC        | 30 | 6.26  | 0.01644 | 6.25   | 0.0901 | 6.09 | 6.40  | -0.216   | 0.427 | -0.867   | 0.833 |
| CST  | FB        | 30 | 8.78  | 0.01617 | 8.79   | 0.0886 | 8.55 | 8.91  | -0.913   | 0.427 | 0.650    | 0.833 |
|      | BB        | 30 | 8.98  | 0.00197 | 8.98   | 0.0108 | 8.96 | 9.00  | -0.315   | 0.427 | -0.925   | 0.833 |
|      | VB        | 30 | 9.20  | 0.01268 | 9.21   | 0.0695 | 9.06 | 9.30  | -0.631   | 0.427 | -0.251   | 0.833 |
|      | CRT       | 30 | 9.70  | 0.00400 | 9.71   | 0.0219 | 9.66 | 9.74  | -0.323   | 0.427 | -1.069   | 0.833 |
|      | AC        | 30 | 10.00 | 0.04353 | 9.94   | 0.2384 | 9.72 | 10.60 | 0.868    | 0.427 | -0.171   | 0.833 |
| AHAT | FB        | 30 | 8.78  | 0.01617 | 8.79   | 0.0886 | 8.55 | 8.91  | -0.913   | 0.427 | 0.650    | 0.833 |
|      | FB        | 30 | 20.1  | 0.1155  | 20.0   | 0.633  | 18.8 | 21.6  | 0.518    | 0.427 | -0.0950  | 0.833 |
|      | BB        | 30 | 20.9  | 0.1320  | 20.9   | 0.723  | 19.2 | 22.1  | -0.425   | 0.427 | -0.3046  | 0.833 |
|      | VB        | 30 | 21.4  | 0.0779  | 21.5   | 0.426  | 20.6 | 22.4  | 0.216    | 0.427 | -0.2631  | 0.833 |
|      | CRT       | 30 | 22.0  | 0.0632  | 22.0   | 0.346  | 21.2 | 22.6  | -0.186   | 0.427 | -0.2043  | 0.833 |
| AC   | AC        | 30 | 22.8  | 0.1231  | 22.9   | 0.674  | 21.7 | 24.3  | 0.185    | 0.427 | -0.4438  | 0.833 |
|      | FB        | 30 | 20.1  | 0.1155  | 20.0   | 0.633  | 18.8 | 21.6  | 0.518    | 0.427 | -0.0950  | 0.833 |

Note. LST = Linear Sprint Test, CST = Curved Sprint Test, AHAT = Arrowhead Agility Test, FB = Football, BB = Basketball, VB = Volleyball, CKT = Cricket, AC = Active control group

Table 3. Post Hoc Tests

|                     |                            | Games-Howell post-hoc test |                 |           |           |           |           |
|---------------------|----------------------------|----------------------------|-----------------|-----------|-----------|-----------|-----------|
| Sport Grp           | Criteria                   | FB                         | BB              | VB        | CKT       | AC        |           |
| L<br>S<br>T         | FB                         | Mean difference            | —               | -0.329*** | -0.503*** | -0.702*** | -0.881*** |
|                     |                            | p-value                    | —               | < 0.001   | < 0.001   | < 0.001   | < 0.001   |
|                     | BB                         | Mean difference            | —               | —         | -0.174*** | -0.373*** | -0.552*** |
|                     |                            | p-value                    | —               | —         | < 0.001   | < 0.001   | < 0.001   |
|                     | VB                         | Mean difference            | —               | —         | —         | -0.198*** | -0.378*** |
|                     |                            | p-value                    | —               | —         | —         | < 0.001   | < 0.001   |
|                     | CKT                        | Mean difference            | —               | —         | —         | —         | -0.180*** |
|                     |                            | p-value                    | —               | —         | —         | —         | < 0.001   |
|                     | AC                         | Mean difference            | —               | —         | —         | —         | —         |
|                     |                            | p-value                    | —               | —         | —         | —         | —         |
|                     | Games-Howell post-hoc test |                            |                 |           |           |           |           |
|                     | C<br>S<br>T                | FB                         | Mean difference | —         | -0.198*** | -0.420*** | -0.917*** |
| p-value             |                            |                            | —               | < 0.001   | < 0.001   | < 0.001   | < 0.001   |
| BB                  |                            | Mean difference            | —               | —         | -0.221*** | -0.719*** | -1.021*** |
|                     |                            | p-value                    | —               | —         | < 0.001   | < 0.001   | < 0.001   |
| VB                  |                            | Mean difference            | —               | —         | —         | -0.498*** | -0.799*** |
|                     |                            | p-value                    | —               | —         | —         | < 0.001   | < 0.001   |
| CKT                 |                            | Mean difference            | —               | —         | —         | —         | -0.301*** |
|                     |                            | p-value                    | —               | —         | —         | —         | < 0.001   |
| AC                  |                            | Mean difference            | —               | —         | —         | —         | —         |
|                     |                            | p-value                    | —               | —         | —         | —         | —         |
| Tukey post-hoc test |                            |                            |                 |           |           |           |           |
| A<br>H<br>A<br>T    |                            | FB                         | Mean difference | —         | -0.735*** | -1.313*** | -1.840*** |
|                     | p-value                    |                            | —               | < .001    | < 0.001   | < 0.001   | < 0.001   |
|                     | BB                         | Mean difference            | —               | —         | -0.578**  | -1.105*** | -1.959*** |
|                     |                            | p-value                    | —               | —         | 0.002     | < 0.001   | < 0.001   |
|                     | VB                         | Mean difference            | —               | —         | —         | -0.527**  | -1.380*** |
|                     |                            | p-value                    | —               | —         | —         | 0.005     | < 0.001   |
|                     | CKT                        | Mean difference            | —               | —         | —         | —         | -0.853*** |
|                     |                            | p-value                    | —               | —         | —         | —         | < 0.001   |
|                     | AC                         | Mean difference            | —               | —         | —         | —         | —         |
|                     |                            | p-value                    | —               | —         | —         | —         | —         |

Note. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ , FB = Football, BB = Basketball, VB = Volleyball, CKT = Cricket, AC = Active control group

**Discussion**

To support adolescent athletes in their long-term growth, knowledge of typical trends in physical characteristics during adolescence is crucial. This knowledge would contribute to monitoring and evaluating adolescent athletes' progress, identifying their strengths and weaknesses, optimizing the design of effective training programs, and evaluating training interventions[15]. Understanding the various factors influencing the development process can enhance the customization of training programs to optimize the development of adolescent athletes.

Growth and maturation drive physical changes during this period [16], including increases in body mass and height, fibre-type differentiation, resting adenosine triphosphate and creatine phosphate levels, androgen concentrations, and musculo-tendon unit architecture [17]. Related literature has demonstrated sex-based differences in team-based ball sports performance [18-20]. This study highlights how sport-specific demands shape physical attributes in female athletes, with football players excelling in sprinting and agility. These findings align with previous research showing that sport-specific physical demands influence speed

and agility levels in female athletes [21,22]. Similar results have been reported in elite-level volleyball and basketball players, where agility and sprinting capabilities were higher than in athletes from other sports [23, 24]. Training female university Football participants were significantly better in the Linear Sprint Test, Curve Sprint Test and Arrowhead Agility Test than Basketball, Volleyball, Cricket, and Active control group participants. Football training, which emphasizes high-intensity drills and rapid directional changes, offers valuable strategies that basketball and volleyball coaches can adopt to improve agility and sprint performance in their female athletes [25, 26]. This combination of anaerobic and aerobic demands likely explains the superior sprint and agility performance observed in the football players of this study. Small-sided games in football enhance key physiological variables, supporting both athletic performance and general health [27]. Additionally, there is a large quantity of work profiling the physical fitness qualities of different playing positions in various land-oriented, team-based ball sports, such as soccer [25, 26, 28], rugby league [29, 30], Volleyball [31, 32], Australian Football [33], and team handball [34, 35]. Additionally, basketball, volleyball, and cricket players performed better in all fitness attributes compared to their counterparts from other team-based ball sports, respectively. There is a substantial amount of published research delineating the various physical fitness components required to successfully compete across team-based ball sports [22–24, 34, 36, 37]. It has been reported [38] that the level of strength and endurance training influences different team-based ball sports, including football, basketball, volleyball, cricket, and the active control group, contributing to differences in physical fitness parameters observed among the athletes.

Thus Engagement in team sports appears to enhance mental well-being and overall life satisfaction, even when controlling for general physical activity levels [39, 40]. Lorenz and colleagues describe specific performance characteristics seen in elite players of team-based ball sports, such as rugby and Volleyball, and endurance-based sports, including swimming and running. Elite players often demonstrate superior power qualities relative to their sub-elite counterparts in field and court sports, which is likely to implicate speed and agility components [41]. It was found that national-level football players had better VO<sub>2</sub>max, upper body strength, flexibility, reaction time, agility, and lower fat percentage [42]. Atan and Akyol [43] also showed that reaction time is better in footballers than in basketball players.

In addition, small-sided floorball training has efficiently improved muscle strength and physical function in recreationally active men aged 65-75 years [44]. Favourable social and psychological effects have also been demonstrated with team sports training organized as small-sided games [45]. Thus, participation in team sports may positively benefit psychological health and quality of life beyond the effects of participation in physical activity [39,40]. Furthermore, team sports seem more

motivating than individual physical activities due to a feeling of belongingness and competence in team sports [45]. This study observed a significant difference between team-based ball sports participants and the fitness attributes of trained female university participants. All the sports require high speed and agility. However, the type of movement differs, with Basketball and Volleyball involving more vertical movements (jumping), whereas Football and Cricket involve more horizontal movements (running and changing direction). Similarly, Basketball, Volleyball and Cricket require superior hand-eye coordination. In contrast, Football needs exceptional foot-eye coordination, which makes it superior in all fitness attributes undertaken compared to other team-based ball sports. Furthermore, football emphasizes sustained aerobic endurance over long periods, contributing to superior fitness attributes compared to other team-based ball sports. However, the findings are limited to university athletes, and variations in training programs across sports may have influenced the results. Further studies should address these factors. Another implication of this study is that football players are fitter than athletes in other specified team-based ball sports.

### Conclusions

University-level female football players outperformed other team sports and the control group in sprinting and agility tests, emphasizing the need for sport-specific training programs. This study confirmed that sportspersons engaged in regular physical fitness and team sports activities have higher fitness attributes than the recreationally active and healthy participants considered under Active control. Vice versa, this study also said that the fitness quality of trained female university Football players is better than that of trained female university Basketball, Volleyball and Cricket players, respectively.

Future research should consider longitudinal approaches to examine how participation in different sports influences fitness development over time. Intervention-based training studies could provide valuable insights into the effectiveness of specific agility, speed, and endurance programs tailored for female athletes. Examining injury prevention strategies that align with sport-specific physical demands may help reduce injury risks and improve athlete longevity. Psychological and cognitive factors influencing performance in team-based sports should also be analyzed to understand how mental conditioning impacts athletic development. Collectively, these research directions would contribute to a more nuanced understanding of training adaptations and performance in female university athletes.

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