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# Association of Selected Fitness Variables with Perceived Performance Levels in Lawn Tennis Players

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## Abstract

**Objectives** Lawn tennis is an explosive sport that involves various fitness parameters such as explosive strength, endurance, power, and agility. Improved physical fitness leads to superior athletic performance. The coach's perception is contingent upon his perception of the player at the time the athlete is comparing himself to the coach. Thus, this study aimed to determine the association between chosen fitness factors and perceived performance by coach in lawn tennis players. Thus, the study aims to detect the relationship between different fitness variables and perceived level of performance in lawn tennis player.

**Materials and Methods** Fifty-two lawn tennis players from two sports academies were measured for various parameters of fitness and perceived performance level as rated by the coach.

**Statistical Analysis** The association between selected fitness metrics and perceived performance in lawn tennis players was investigated using Pearson's correlation test. Furthermore, the data were analyzed with paired *t*-test for male and female group, and ANOVA was used to analyze the difference between the levels of performance.

**Results** Fatigue index, closed kinetic chain upper extremity stability (CKCUEST) test, and peak power and energy expenditure taken by metabolic equivalent (MET) calculation was found to be statistically different between males and females. While comparing BMI with the peak power, there was a weak positive correlation for males, while for female there was no correlation. Metabolic equivalent, energy expenditure, and peak power were positively correlated with the level of performance; however, fatigue index and level of performance had a negative nonsignificant correlation.

**Conclusion** Peak power, fatigue index, energy expenditure, and BMI were found to be associated in males, but not in females. Peak power and energy expenditure were connected to performance in both genders.

**Keywords**
- energy expenditure
- fatigue index
- peak power
- upper limb stability
- perceived performance

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## Introduction

Tennis has developed from a highly technical sport that focused on a premium on sport-specific technical ability (e.g., stroke skills, service skills, and racquet and ball handling to a sport that is more dynamic and explosive, with faster stroke and serve velocities and dramatically increased physical demands.[1] It is widely believed that a better degree of fitness is necessary to compete effectively, gradually, and at the world level. According to some, players must possess a great level of agility, speed, coordination, and strength. Additionally, anaerobic and aerobic capacities are required for effective play.[2] As a result, great play cannot be described by a single dominant physical characteristic; rather, tennis requires a complex interaction of multiple physical components and metabolic pathways. Physical fitness has historically been used to predict an athlete's ability to succeed or fail in a tournament or match. Physical fitness enables constant training and, as a result, improved sports performance.[3,4] Thus, fitness testing is critical because it provides an excellent method for assessing and examining athletes' progress and development. Numerous research have been conducted to determine the relationship between fitness parameters and performance assessments in various sports.[3–5]

For instance, Lemos et al, 2017, reported a moderate correlation between shuttle run agility test (SR), repeated sprint ability with the ball (RSAB), and repeated sprint ability (RSA) in female professional hockey players.[6] Moreover, it has been suggested that repetitive badminton-specific field-test along with alternating vertical jump is associated with leg power performance and can thus be used to assess the sport's progression.[7] The superior performance in tennis is dependent on various anthropometric variables like height, weight, body structure, body surface area, and body mass index, which play a major role. For instance, body height is associated with serving speed while weight and body fat relate to the agility performance in tennis players.[8,9]

Lawn tennis is a very explosive sport that requires a unique movement technique, leaps, and strength on a small court. The most critical parameter in lawn tennis is the proper application of energy to strike the ball.[3] It has been proven that energy expenditure is influenced by the level of physical activity of an individual to avoid fatigue during and after the competition and thereby reducing the chances of injury. One such parameter, which is in discussion nowadays, is metabolic equivalent (MET).[10] MET of a task is defined as the utilization of energy in relation to the mass of an individual while performing a specific activity.[11] Scientists have inferred that one MET is the amount of consumption of oxygen while at rest and is equal to 3.5 mL of $O_2$ per kg body weight $\times$ min. It has been found that physical activity level can be estimated by calculating the MET score to express the intensity and energy expenditure of the individuals in a day, week, month, or year. Other factors that affect the coordination strategies in tennis are the upper body stability and jumping technique that act on the strokes played during the game.[12] For powerful strokes, the upper and lower body kinetic chains must work in coordination to produce highball velocity and racquet speed. This affects the pace, spin, direction, and placement of the shot.[13]

Lower leg power plays an important role and generates ∼50% force during a tennis shot or serve. In 2016, Dossena et al has associated the role of lower limbs with tennis serve. The study concluded that higher jump heights lead to faster tennis serve and have been found to be positively correlated. Hence, coaches and athletes should work on lower limb power to generate a powerful push while serving. Sports performance is determined by a complex array of fitness variables that all contribute significantly to the performance level.[14]

The coach, it has been suggested, must fulfil five roles: instructor, organizer, competitor, learner, and mentor. The coach's perception is contingent upon his perception of the player at the time the athlete is comparing himself to the coach. Thus, the current study continues in this direction by attempting to determine the association between chosen fitness factors and perceived performance in lawn tennis players. In 2018, Ekstrand et al studied the effect of coaching style and the rate of injuries in elite football team and concluded that there is a positive correlation between these two.[15] Another study by Angelina B. Cruz in 2017 laid emphasis on the gender and behvior of the coach on sports leadership preferences amongst Philippines players.[16]

Thus, the main aim of this study was to detect whether the fitness variables-lower leg peak power, fatigue index, energy expenditure, metabolic equivalent, and upper limb stability are related with the perceived level of performance in lawn tennis player. A secondary aim was to compare adolescent lawn tennis players based on gender and the ranking given by the perceived level of performance by coaches.

## Methods

After obtaining written informed consent from the players, all procedures were performed in accordance with the Helsinki Declaration. Additionally, they were requested to complete the assessment form with pertinent information such as their name, age, gender, address, contact number, dominant hand, and preferred type of match, level, and medical history. A stadiometer was used to determine the height in centimeters. The patients' weight was determined in kilograms using a weighing machine while they were dressed in minimum clothing and without shoes. Before the measurement for the next participant, the weighing machine was calibrated every time. To reduce the chances of injury during the tests, general whole body warm up exercises for 10 minutes were performed before taking the measurements for fitness variables.

### Sample size calculation

We conducted an a priori power analysis to find an appropriate sample size that would reach statistical significance with 80% power. With a substantial effect size (d) of 0.80, we estimated a clinically meaningful difference between male and female lawn tennis players. We then used a power analysis application (G*Power, version 3.1.9.7) to perform the analyses with $\alpha = 0.05$. The results of the power analysis indicated a sample

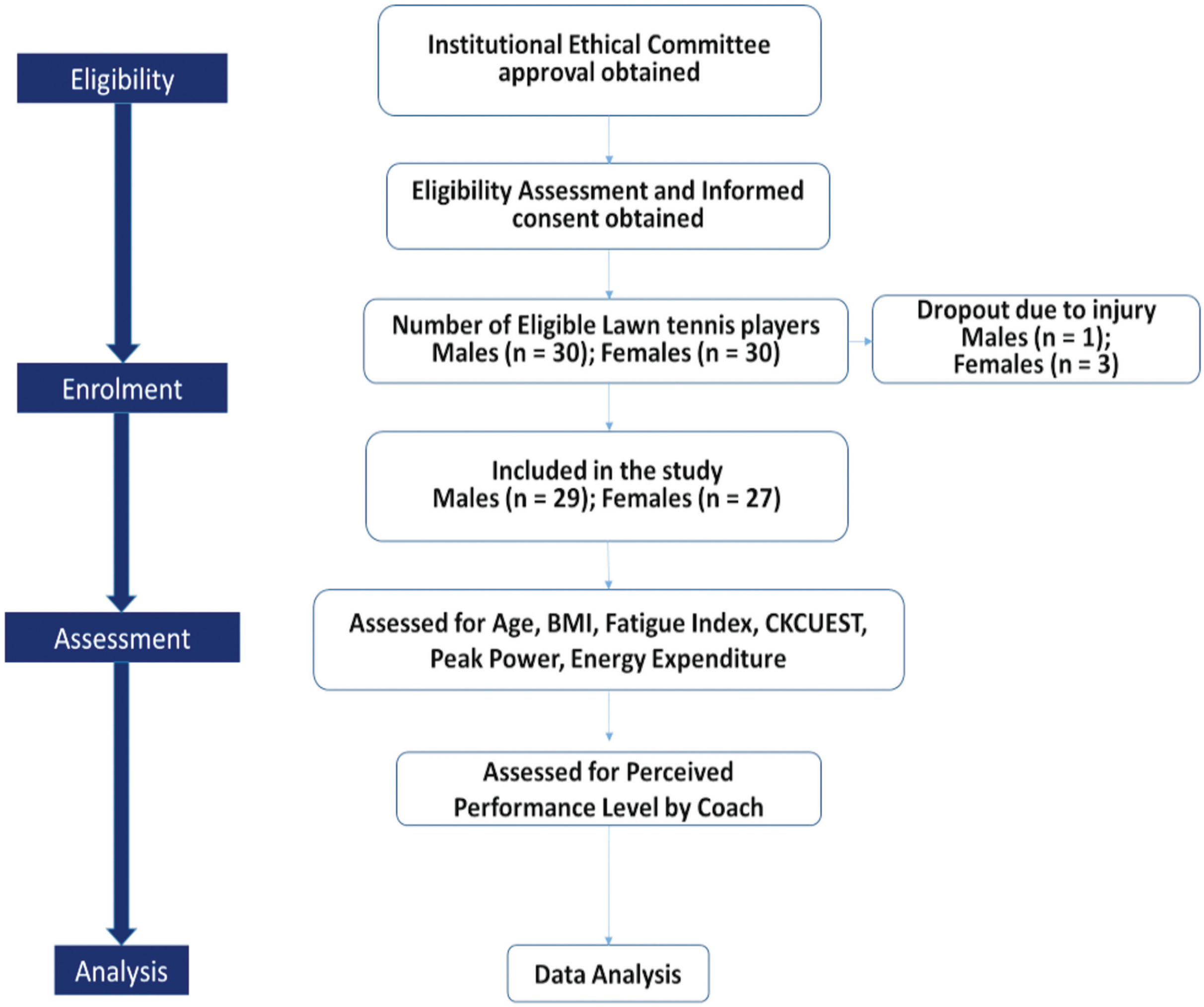


**Fig. 1** Flow chart of the study design.

size of 26 subjects was necessary for each group, which was further rounded off to 30 in each group of male and females (►**Fig. 1**).

Following tests were performed by the subjects to measure the parameters-

1. Peak power
   The subjects were asked to perform vertical jumps to measure their lower leg peak power. They were instructed to bend their knees to a freely comfortable angle and jump as high as possible to mark on the wall with their inked fingers. The measuring scale was mounted on the wall to measure the vertical displacement. Each participant was asked to jump three times and the best value among the three readings was used in the following equation to determine the peak power.[7] Peak power = [60.7 × jump height (cm)] + [45.3 × body mass (kg)] – 2055 (W).
2. Upper Body Stability
   Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) test was done to check the upper body stability of the subjects. The reliability of CKCUEST was 0.97. A clear explanation and demonstration about the test were given to the participants. Two strips of athletic tape (1.5 inches wide) were fixed parallel to each other at a distance of 36 inches. The starting position was push up position with each hand placed on the tape. Participants were instructed to use one hand and touch the tape under the opposite hand alternatively. The hand was returned to its original position after touching the tape. Each participant was asked to perform a trial before starting the actual test. Participants performed three trials of the test, and the total number of touches were counted in 15 seconds with a rest interval of 45 seconds between each trial. An average of all three trials was used for data analysis.[17]
3. Fatigue Index
   A repeated sprint test (RST) was done to determine the fatigue of the participants. A 12 × 20 m protocol was followed with 20 seconds recovery. All participants performed their warm-up before the RST. They were asked to sprint from one cone to another placed at a distance of 20 m. During the recovery period, participants walked back slowly toward the starting point. All subjects sprinted 12 times and the time taken for each sprint was measured using a stopwatch. Performance decrement (PD) score was calculated as a measure of fatigue index which is as follows: PD = [(TS/IS) × 100] – 100 where, TS:

Total time, calculated as the sum total of all 12 sprints; IS: Ideal time, calculated as the fastest time among all the sprints multiplied by 12.[18]

4. Metabolic equivalent (MET)
   MET-minutes/week were calculated for household chores, training, leisure, and recreational activities. A list of activities was given to all subjects and were asked to write the total number of minutes or hours in a day and the number of days in a week of any of the activity they performed during their daily life. MET-minutes/week were calculated by multiplying the MET value of each activity with the number of days and minutes or hours. The MET value was taken according to the guidelines for exercise testing given by ACSM. The sum of all the three categories was taken as the final MET minutes/week.[11,19]
5. Energy expenditure
   The energy expenditure of each activity was calculated using the following formula: EE (kcal) = [MET value of the activity × body weight (kg)/60] × time of the activity (min). A sum of all kcal was taken for the data analysis.[19]
6. Performance evaluation

The coach of Subjects was asked to rank the subject's competitive level in the sport on a scale from 1 to 10, with 1 representing no participation in sports and 10 representing international level participation.[13]

### Statistical Analysis

Data analysis was done with the help of SPSS for windows version 22.0 to verify the investigations of the study. Mean and standard deviation of all variables were analyzed. Pearson's correlation test, analysis of variance (ANOVA) followed with post hoc test was performed to find the relationship between selected fitness parameters and perceived performance by coach in lawn tennis players.

## Results

Demographic characteristics and outcome variables were present in mean ± SD. Age and BMI were not found to be statistically different between males and females whereas fatigue index ($p = 0.03$), CKCUEST ($p = 0.02$), peak power ($p = 0.01$) and energy expenditure ($p = 0.04$) were found to be statistically different between the males and females (►**Table 1**).

The BMI and peak power showed weak and positive correlation in males (►**Fig. 2**). Fatigue index was found to be negatively and moderately correlated with peak power ($r = 0.531$, $p = 0.003$) and energy expenditure ($r = 0.656$, $p < 0.001$) in males (►**Fig. 1**). In addition, peak power and energy expenditure ($r = 0.428$, $p = 0.021$) showed weak and positive association in males, whereas in females none of the outcome variables were found to be correlated with each other (►**Fig. 2**).

Results of ANOVA indicate that fatigue index ($F(3,25) = 5.06$, $p = 0.01$), peak power ($F(3,25) = 5.32$, $p = 0.01$), and energy expenditure ($F(3,25) = 13.15$, $p < 0.001$) were found to be significant difference between the ranking of perceived performance by coaches for male tennis players whereas CKCUEST endurance was found to be nonsignificant (►**Table 2**). For female tennis players, peak power ($F(3,23) = 5.06$, $p = 0.01$) and energy expenditure ($F(3,23) = 5.06$, $p = 0.01$) were found to be significant whereas fatigue index ($F(3,) = 5.06$, $p = 0.01$), and CKCUEST endurance ($F(3,23) = 5.06$, $p = 0.01$) was found to be nonsignificant between the perceived performance ranking given by the coaches (►**Table 2**).

Post hoc test was done to find the relation between the selected fitness variables and ranking of perceived performance by coaches (►**Fig. 3**). In males, there was a significant difference in fatigue index between rank 7 and rank 10 players. There was a significant difference in CKCUEST endurance between ranks 7 and 8 ($p = 0.021$) and between ranks 7 and 10 ($p = 0.013$). There was significant difference in energy expenditure between rank 7 and 9 ($p = 0.031$) and between ranks 7 and 10 ($p < 0.001$), between ranks 8 and 10 ($p < 0.001$). In females, only peak power showed a significant difference between ranks 7 and 10 ($p = 0.039$).

## Discussion

Physical fitness levels and anthropometric measures are the most important factors in determining sports talent. The innovative approach of evaluating sports ability by associating

**Table 1** Comparison of outcome variable between male and female players through Independent *t*-test

| | Male | Female | *t*-test for equality of means | | 95% Confidence interval | |
|---|---|---|---|---|---|---|
| | ($n = 29$) | ($n = 27$) | T | *p*-Value | Lower | Upper |
| Age | 20.38 ± 2.06 | 20.81 ± 2.06 | −0.791 | 0.43 | −1.54 | 0.67 |
| BMI | 21.06 ± 2.32 | 20.46 ± 2.32 | 0.98 | 0.33 | −0.64 | 1.86 |
| Fatigue Index | 14.37 ± 3.36 | 16.61 ± 4.32 | −2.18 | 0.03* | −4.31 | −0.18 |
| CKCUEST Endurance | 26.47 ± 3.93 | 23.63 ± 4.72 | 2.46 | 0.02* | 0.53 | 5.16 |
| Peak power | 16145.12 ± 1715.01 | 14944.37 ± 1514.20 | 2.77 | 0.01** | 331.38 | 2070.10 |
| Energy expenditure | 16616.42 ± 5075.88 | 14150.76 ± 3501.43 | 2.10 | 0.04* | 112.48 | 4818.85 |

Note: BMI, body mass index; closed kinetic chain upper extremity stability (CKCUEST) test.
*$p < 0.05$.
**$p < 0.001$.

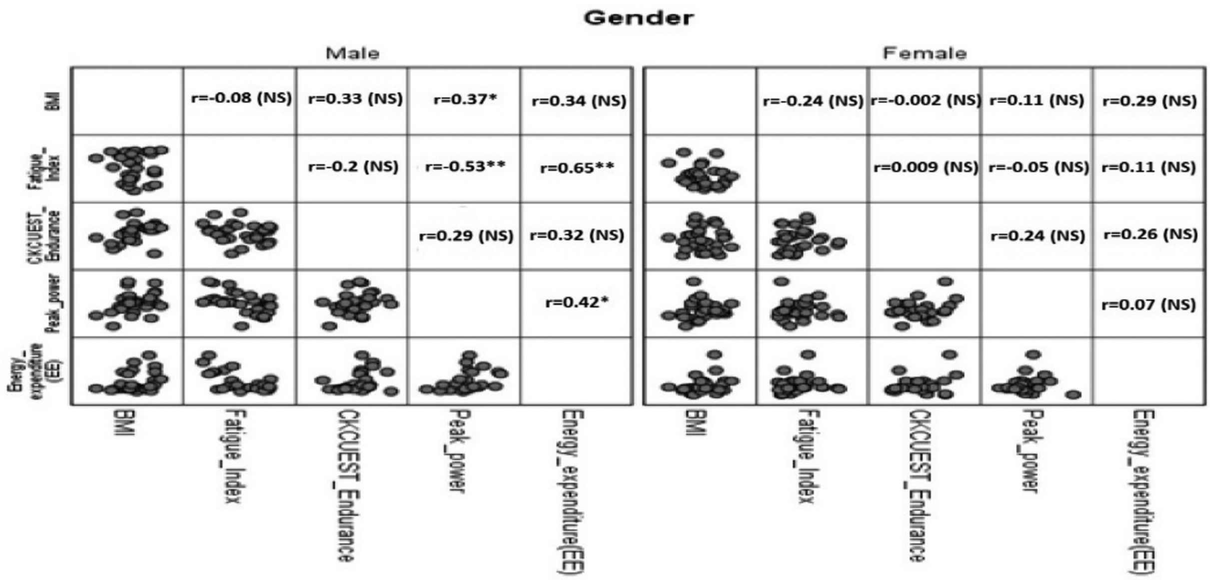


**Fig. 2** Correlation matrix comparing the gender and different outcome variables (Note: BMI, body mass index; closed kinetic chain upper extremity stability (CKCUEST), $^{*}p < 0.05$, $^{**}p < 0.001$).

**Table 2** ANOVA test between the outcome variables and different perceived performance level in males and females

| | Perceived Performance | Level 7 | Level 8 | Level 9 | Level 10 | F | *p*-Value |
|---|---|---|---|---|---|---|---|
| Male | Age | 20 ± 1.76 | 21.5 ± 2.35 | 20.8 ± 2.17 | 19.75 ± 2.12 | 1.03 | 0.40 |
| | BMI | 19.89 ± 2.61 | 20.917 ± 1.30 | 21.46 ± 2.05 | 22.4 ± 2.27 | 1.97 | 0.14 |
| | Fatigue Index | 16.86 ± 1.73 | 14.117 ± 3.11 | 13.92 ± 4.08 | 11.725 ± 2.80 | 5.06 | 0.01* |
| | Upper limb stability | 25.14 ± 4.54 | 25.85 ± 2.79 | 27.68 ± 0.59 | 27.825 ± 4.83 | 0.90 | 0.46 |
| | Peak power | 14735.97 ± 1221.13 | 17100.78 ± 1113.12 | 16377.24 ± 2133.31 | 17044.73 ± 1333.91 | 5.32 | 0.01* |
| | Energy expenditure | 12903.3 ± 589.85 | 13899.27 ± 705.42 | 18515.74 ± 3702.53 | 22108.6 ± 5598.89 | 13.15 | <0.001* |
| **Female** | Perceived Performance | **Level 7** | **Level 8** | **Level 9** | **Level 10** | **F** | ***p*-Value** |
| | Age | 20.7 ± 1.8 | 19.33 ± 1.4 | 22 ± 1.9 | 21.5 ± 2.6 | 2.04 | 0.14 |
| | BMI | 19.11 ± 2.5 | 20.9 ± 2.0 | 21.92 ± 2.2 | 21.03 ± 1.6 | 2.27 | 0.11 |
| | Fatigue Index | 17.95 ± 5.3 | 16.72 ± 4.1 | 16.02 ± 3.7 | 14.77 ± 3.1 | 0.69 | 0.57 |
| | Upper limb stability | 21.86 ± 3.3 | 22.9 ± 4.3 | 24.16 ± 3.6 | 26.85 ± 6.9 | 1.57 | 0.22 |
| | Peak power | 14290.32 ± 1161.1 | 14388.75 ± 884.7 | 15222.48 ± 1454.8 | 16358.33 ± 1821.4 | 3.45 | 0.03* |
| | Energy expenditure | 12302.16 ± 908.7 | 13443.63 ± 1021.7 | 15810.06 ± 248.2 | 16556.12 ± 6636.4 | 2.82 | 0.06* |

Abbreviation: BMI, body mass index.
$^{*}p < 0.05$.
$^{**}p < 0.001$.

multiple fitness variables to performance is drawing researchers' interest. Many researches have attempted to determine the association between various fitness variables and sports performance, but none have shown a link between Peak Power, Fatigue Index, MET, EE, and Level of performance as given by the coach in lawn tennis players.[4] As the coach's perception and the training given by the coach has a lot of importance in the athlete's life and the same can produce some impact on the athlete's fitness parameters.[9]

In this study, the fatigue index, CKCUEST test for upper limb stability, peak power and energy expenditure taken by MET calculation were found to be statistically different between the males and females. Males and females have different physical characteristics, have differences in different fitness parameters too. While comparing BMI with the peak power, there was a weak positive correlation for males while for female there was no correlation. Percent decrement (PD) was estimated using a $12 \times 20$ m RST protocol. The

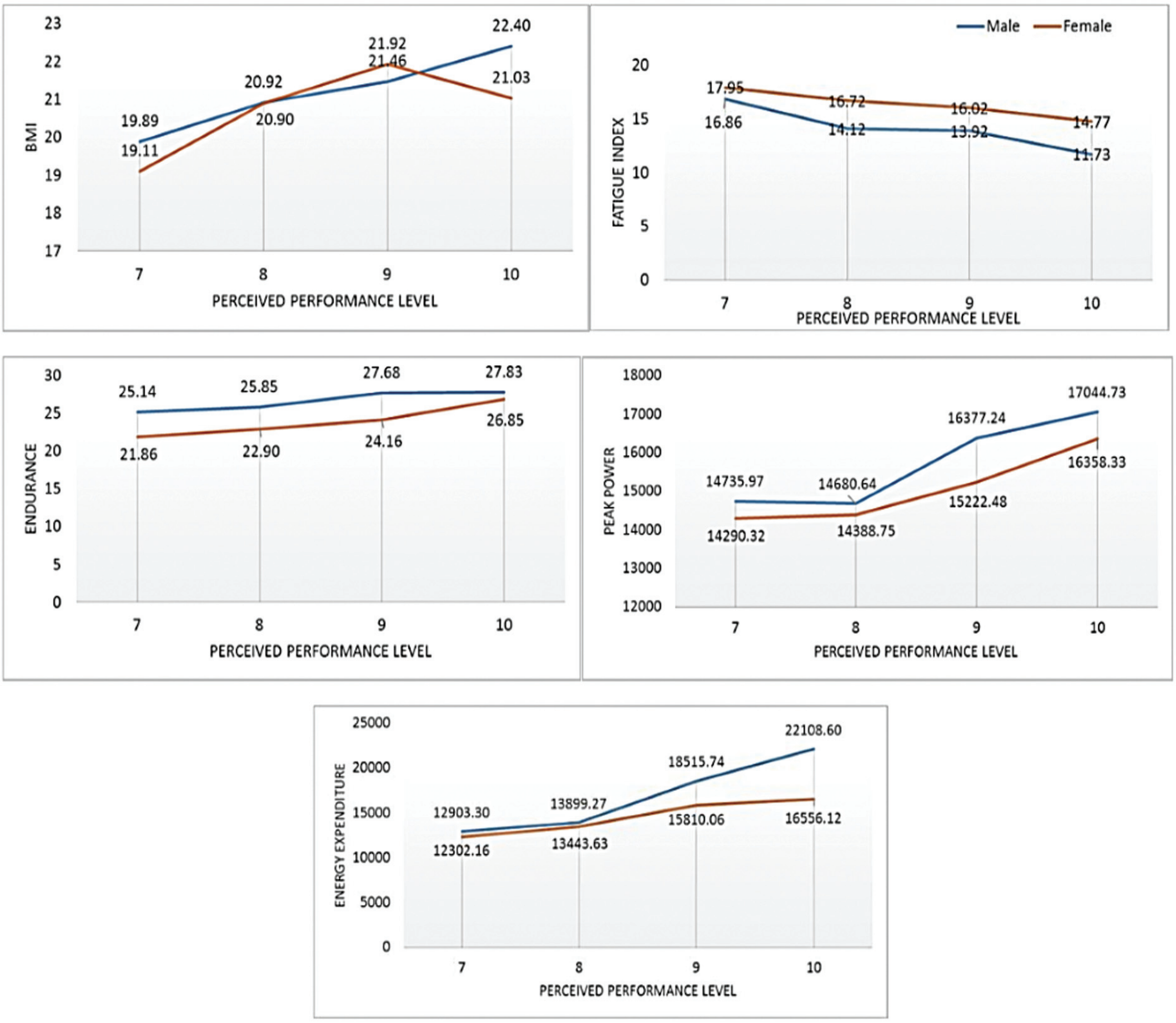


**Fig. 3** Relation between perceived performance level and BMI, Fatigue Index, endurance, peak power, energy expenditure.

explanation for this could be established from the previous theory given by Gaitanos et al, 1993 that the energy derived for the first sprint was mainly from the ATP-PCr (phosphate-creatinine) system and anaerobic glycogenolysis. By the end of the test, the lactic acid system comes into function in which ATP production occurs due to oxidative metabolism. With better ATP resynthesis, participants completed the test in minimal time which links directly with less percent decrement and better aerobic performance of the athletes.[20]

Lean body mass is the indicator that most positively correlates with absolute peak power. An increase in body mass resulting from an increase in body fat does not increase absolute peak power, and it leads to a decrease in peak and muscle power relative to body mass. As the exercises/training given to the athletes improves the lean mass that in turn can improve the peak power. Our finding goes in line with the findings of Marcin et al, who found out that the peak power increase and decrease are impacted by the composition of the body mass.[21]

The study found a positive but statistically nonsignificant correlation between upper limb stability and level of performance of the players. This could be due to the interdependence of core stability and upper body function. As the kinetic theory reports, the kinetic chain is responsible for transmitting energy from core muscles to the upper body. It is probable that routine core stability exercises, which can be incorporated into an athlete's training plan, are the cause of improved upper extremity function.[22]

Another finding of the study was the moderate positive correlation between fatigue index and energy expenditure, weak positive correlation between peak power and energy expenditure in males. None of these were found to be correlated in females. The result of our study are in association with previous findings.[23,24] It might be because of the lower limb musculature and its strength which may lead to better utilization of phosphagens and therefore quick resynthesize of ATP that could be responsible for higher power development. So an increase in power during the vertical jumps are responsible for better sprint performance as proven by previous studies that could eventually be responsible for higher sports performance.

In the present study, results of ANOVA indicate that fatigue index, peak power and energy expenditure was found to be significantly different between the ranking of perceived performance by coaches for male tennis players, whereas CKCUEST endurance was found to be nonsignificant. Post hoc shows that the tennis players with ranking 7 is significant different with ranking 10 for fatigue index, peak power, and energy expenditure. Also, ranking 7 is significantly different with ranking 8 for fatigue index. Similarly, ranking 7 is significantly different with ranking 9 and ranking 8 is significantly different with ranking 10 for energy expenditure. Moreover, decrease in athletic performance could be due to lactic acid accumulation which has been found to be one of the major contributing factors of fatigue. This could be attributed due to less oxygen uptake by the individuals that may lead to poor performance. This theory seems to be consistent with the study done in elite adolescent soccer players that found a significant negative correlation between PD and peak $O_2$.[25] Hence, it was suggested that higher number of trials and recovery time, longer total sprint time and short interval protocol ($12 \times 20$ m) are responsible for power maintenance during long duration sprints. The same reason goes in line with the findings that rankings 9 and 10 are given to the athletes who are playing ready/ already playing at international levels, being them, more professional and higher competitions faced and played. The same training given to the athletic groups but the finding suggested of significant difference in between the perceived level of performance and the parameters of physical fitness.

For female tennis players peak power and energy expenditure as found to be significant, whereas fatigue index and CKCUEST endurance were found to be nonsignificant between the perceived performance ranking given by the coaches. Any changes in weight affects energy expenditure which are the major determinants in higher sports performance. Dietary food intake changes the physical and morphological features of human body that affects the tissue metabolism and bodily movements required during a match play. Therefore, individuals with less body weight are more active as activity energy expenditure is higher, whereas an increase in activity expenditure that is produced by exercise and other physical activities is a function of the training status.[26]

Post hoc revealed that only females with ranking 7 and ranking 10 were found to be significant different for peak power. The same reason as that of males, level of playing, and the more number of competition faced also applies here. We found a significant positive correlation between MET and level of performance. Previous studies have found MET score calculation as an appropriate method to express the exercise tolerance of an individual. Also, MET is a significant predictor to describe the intensity of diverse physical activities in adolescents and is directly associated with it.[27,28] It has been found that physical activity is significantly associated with aerobic fitness and better endurance performance which supports our study findings.[29] Other studies have found a positive association of physical activity with health related quality of life and the functional capacity in Brazilian Basketball athletes that results in positive impact on performance.[30] It has been reported that physical activity measurements in terms of MET can be used to estimate the energy expenditure in individuals. We determined energy expenditures (EE) using MET values for each physical activity and intensity up to a time frame of 7 days and found a statistically significant positive correlation with level of performance.

## Conclusion

The purpose of this study was to determine whether fitness factors such as lower leg peak power, fatigue index, energy expenditure, metabolic equivalent, and upper limb stability are associated with a player's perceived level of performance. Males' peak power, fatigue index, energy expenditure, and BMI were found to be connected, whereas these parameters seemed to have no influence on females. Another objective was to compare adolescent lawn tennis players by gender and by the coaches' estimated level of performance. The peak power and fatigue indexes were shown to be positively linked with performance in both genders.

## Clinical Application

The outcomes of this study can assist coaches in the future in training different genders appropriately to enhance fitness metrics. The sample was drawn from two different academies, but because the coaching provided to athletes of various levels is consistent, the findings can also assist coaches in learning/applying the various training protocols for various levels of players.

## Limitations of the Study

The study's primary weakness was the use of a subjective tool to determine level of performance. Due to the nature of the technique used, the researcher was unable to eliminate the coach's prejudice. The physiological parameters that would have been used to accentuate the findings were omitted from this investigation.

## Future scope of Study

The outcome of this research give us an opportunity to check the selection of players as perceived by different coaches and their actual performance in various competitions retrospectively that might further raise the standard of both players and coaches.

### Authors' Contributions

**S.M.** contributed to the article's conception, design, research, and writing. **S.S.** also helped in the data collection phase of the project, data interpretation, data gathering, and writing. **A.S.** was involved in the article's conceptualization, design, and data interpretation. **M.R.R.** assisted in the statistical analysis of study data, the interpretation of data, the authoring, and dissemination of the scientific work. **I.A.** contributed to the creation of the literature review, writing results and research publications. **S.J.K.** contributed in conceptualization, data interpretation and critical review of the article.

All authors read and approved the final version of the manuscript.

Ethical Considerations and Ethical Approvals
Ethical approval was obtained from the ethics committee at Faculty of Allied Health Sciences in accordance to Ethical Principles for Medical Research Involving Human (WMA Declaration of Helsinki) having reference No: MRIIRS/FAHS/DEC/2021-S26 dated April 10, 2021.

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Conflict of Interest
None declared.

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