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A comparative study of pen nation angle of fast and spin bowlers

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Abstract
This research paper deliberates the comparative analysis of the pennation angle of the vastus lateralis muscle in fast bowlers and spin bowlers in cricket. The study involved thirty state-level cricketers, with fifteen being orthodox spinners and fifteen medium pace bowlers. Measurements were taken on the dominant leg at specific sites, and the pennation angle was scored as the angle of insertion of muscle fiber fascicles. Comparative statistical analysis using SPSS software revealed that fast bowlers had a smaller pennation angle compared to spin bowlers. The discussion emphasized the importance of muscle architecture in cricket performance, with muscle characteristics influencing players' abilities based on their roles and techniques. The findings suggest that muscle architecture plays a crucial role in the specific demands of bowling techniques, with different pennation angles impacting speed, power, and performance in cricket.

Keywords: Muscle architecture, pennation angle, fast and spin bowlers

Introduction
Muscle architecture refers to the arrangement of muscle fibers within a muscle and how they contribute to its function. (Kumar, 2023) [8] There are three main components of muscle architecture: fiber length, pennation angle, and muscle thickness. Fiber length refers to the length of the muscle fibers themselves, which can vary greatly between different muscles. Pennation angle refers to the angle at which muscle fibers are oriented to the line of pull of the muscle, and muscle thickness refers to the depth of the muscle. Understanding muscle architecture is important in biomechanics and sports science as it directly influences the force production, range of motion, and contractile capabilities of the muscle.

Muscle architecture and sports performance are closely intertwined, as the arrangement of muscle fibers affects an athlete's ability to generate force and produce powerful movements. (Khare *et al*., 2023) [5] The fiber length, pennation angle, and muscle thickness not only affect the mechanical properties of the muscle but also play a significant role in its overall performance. (Kumar, 2023) [8] For example, muscles with longer fibers have been associated with a greater range of motion, whereas muscles with a higher pennation angle are better suited for generating force. (Kumar, 2022) [12] (Kumar & Jhajharia, 2020) [11] Furthermore, understanding these architectural elements can provide valuable insights into injury prevention, rehabilitation, and exercise programming tailored to an individual's specific needs.

Athletes with lesser pennation angle tend to have muscles that are more parallel to the line of pull, allowing for greater excursion and range of motion. On the other hand, those with a higher pennation angle have muscles that are more oblique, which is advantageous for producing larger amounts of force. This variation in muscle architecture impacts an athlete's performance in sports that require different types of movement, such as sprinting, jumping, and weightlifting. (Salimin, 2018) [15] (Kumar & Jhajharia, 2022) [12] (Woittiez *et al*., 1983) [17]. Cricket in this 20th century became very competitive and has evolved into a psychological (Jadaun *et al*., 2021) [4], physically demanding sport that requires a combination of strength, speed, endurance, accuracy (Gautam & Kumar, 2018) [1], coordination and agility. (Stuelcken *et al*., 2015) [16] The understanding of muscle architecture has become increasingly important in cricket as athletes strive to enhance their performance and prevent injuries.

In cricket, the demands on the muscles vary depending on the specific skills required for batting, bowling, and fielding.

For instance, fast bowlers need to generate explosive force during the delivery stride, while batsmen require quick reflexes and strength to execute powerful shots. The architecture of their muscles plays a crucial role in determining their efficiency in these movements. The researcher focused on the bowling department for this research, aiming to compare the pennation angle of the vastus lateralis muscle in spin bowlers versus fast bowlers.

Materials and Methods

Selection of Subject

Twenty (N=30) state level cricketer were selected from the different cricket academies of Bhopal Madhya Pradesh, India were selected as the subjects for this study. Out of all thirty selected cricketer 15 were orthodox spinner and 15 were fast bowlers and their age was in between 17 to 25 years.

Selection of Variable

The present study aimed to compare vastus lateralis pennation angle of dominating leg of selected state level spinners and fast bowlers. The vastus lateralis muscle plays a crucial role in sports performance, particularly in activities that require lower body strength and power, such as running, jumping, and cycling. As one of the quadriceps muscles located on the front of the thigh, the vastus lateralis is responsible for extending the knee and stabilizing the leg during dynamic movements. In running, the vastus lateralis muscle is activated during the push-off phase, helping propel the body forward with each stride. In jumping and explosive movements, this muscle is essential for generating the force needed to lift off the ground. (Kumar, 2023) [8] Similarly, in bowling, the vastus lateralis muscle contributes to the bowler's ability to generate power and momentum as they approach the delivery stride. Furthermore, the vastus lateralis muscle is also crucial for maintaining stability and balance during lower body movements. It provides support and control during dynamic activities, allowing athletes to execute precise and coordinated motions. Hence, the delimited variables for this study were Pennation angle and bowling type.

Measurement of Pennation angle

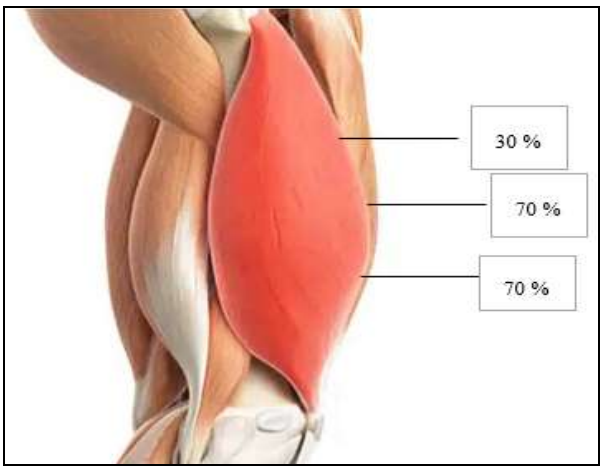

Fig 1: Illustration depicting the measurement sites for the skeletal muscle architectural characteristics. US images were acquired at lengths equivalent to the 30%, 50%, 70%, and 90% levels of the thigh length measured from the greater trochanter to the lateral epicondyle of the femur.

- **Purpose**-The objective of this test was to determine muscle architectural parameter i.e., Pennation Angle of Vastus lateralis muscles.
- **Equipment**- B-Mode ultra sonography (Wipro Ge Voluson E), Acoustic gel, 5–10 MHz linear-array transducer (EUP-L53L) and Assistant.
- **Procedure**- Before collecting ultrasound images, participants reported to the laboratory and laid supine for 15 minutes to allow fluid shifts to occur. Following that, non-invasive skeletal muscle ultrasound images of the quadriceps muscles were obtained. To improve spatial resolution, a 12 MHz linear probe scanning head was coated with water soluble transmission gel and positioned on the skin's surface to create acoustic contact without disturbing the dermal layer to gather the image. All measurements were collected on the dominant leg by the same technician. For each muscle in all individuals, the anatomical position for all ultrasound measurements was standardized. (Kumar, 2023) [8]

Table 1: Description of the skeletal muscle characteristics measurement site of VL, Vastus lateralis.

Muscle	Measurement Site
VL	30%, 50%, and 70% level between the greater trochanter and lateral epicondyle of femur on the line parallel to the RF line passing through the lateral border of patella

- **Scoring-** Briefy, pennation angle (^{0}) was measured as the angle of insertion of the muscle fiber fascicles into the deep aponeurosis.

Statistical Analysis

The data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software version 20.0. Descriptive statistics such as mean and standard deviation were computed, and statistical significance was determined with a p-value of less than 0.05. Independent t-test and corresponding p-values were utilized to explore the comparison between variables.

Results

Table 2: Descriptive statistics of selected variable

Pennation Angle	Bowlers	Mean	Std. Dev.
Vastus Lateralis	Fast Bowlers	15.9933	1.12470
	Spin Bowlers	18.2200	1.07251

Table No. 2 illustrate descriptive data i.e., mean and std. dev. of pennation angle for fast bowlers Vastus Lateralis was 15.99±1.12˚and for spin bowlers it was 18.22±1.7˚.

Table 3: Comparative statistics of selected variable

Pennation Angle		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
VL_PA	Equal variances assumed	0.056	0.815	-7.363	28	0.000	-2.79333

The value of the Levens test and T-statistics is shown in Table no. 3 The Levens assumption is used in the two-

sample T-test to determine group homogeneity. The resulting value for the Levens test was 0.815 which is more than 0.05, indicating that the equality of variance assumption is not violated. Thus, the null hypothesis of equality of population means of the two groups is rejected, and it may be concluded that the muscle Pennation Angle of VL of Fast bowlers and selected spin bowlers are different.

Discussions on Findings

This research highlighted; fast bowlers had smaller vastus lateralis pennation angle when compared to spin bowler vastus lateralis pennation angle because it is related to their specific role and the demands of their bowling technique. Muscle architecture plays a crucial role in the performance of cricket players, especially fast bowlers and spin bowlers. The specific demands of their bowling techniques are closely related to the muscle architecture, particularly the vastus lateralis pennation angle. For fast bowlers, having a smaller vastus lateralis pennation angle is advantageous as it allows for greater excursion and range of motion, which is essential for generating the speed and power needed to bowl fast effectively. Similar researches which also concluded smaller pennation angle association with sprint and jumping abilities are (Nadzalan *et al*., 2018) [14] (Hyung-Jin *et al*., 2021) [3].

Sprinting and jumping abilities are associated with lesser pennation angles because a lower angle of pennation in the muscles allows for more sarcomeres to be arranged in series. When muscles have more sarcomeres in series, they can contract faster and lengths can change more during each contraction, which is beneficial for activities requiring rapid movements, such as sprinting and jumping. This configuration enhances the muscle's ability to generate high velocities, which is crucial in power-based activities (Goodin, 2018) [2]. Additionally, for sprinters, a lesser pennation angle might be offset by greater muscle thickness or cross-sectional area, providing the necessary force for rapid acceleration (Goodin, 2018) [2].

In contrast, spin bowlers execute slower bowling action focusing on number of revolutions imparted and flight on the ball may benefit from a different muscle architecture to suit their specific technique and skill requirements.

Conclusions

The study focused on comparing the pennation angle of the vastus lateralis muscle in fast bowlers and spin bowlers. The measurements were taken on the dominant leg of individuals at specific sites between the greater trochanter and lateral epicondyle of the femur. The pennation angle was scored as the angle of insertion of muscle fiber fascicles into the deep aponeurosis. Statistical analysis using SPSS software included descriptive statistics, Levene's test for equality of variances, and an independent t-test. The results showed that the mean pennation angle for fast bowlers was 15.99±1.12˚, while for spin bowlers, it was 18.22±1.7˚. The Levene's test indicated that the equality of variance assumption was not violated, leading to the rejection of the null hypothesis and concluding that the muscle pennation angle of fast bowlers and spin bowlers was different.

The discussion highlighted that fast bowler had a smaller pennation angle compared to spin bowlers, which is related to their specific role and bowling technique demands. Muscle architecture plays a crucial role in the performance of cricket players, with the pennation angle influencing their ability to generate speed and power effectively. Research also suggested that a smaller pennation angle is associated with sprinting and jumping abilities due to the arrangement of sarcomeres in series, allowing for faster contractions and greater velocity generation. In contrast, spin bowlers with slower bowling actions may benefit from a different muscle architecture to suit their specific technique and skill requirements. Overall, the study emphasized the importance of muscle architecture in sports performance, particularly in cricket, where different muscle characteristics can impact players' abilities based on their roles and techniques.

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