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Electromyographic Representation Of Vastus Lateralis In Volleyball Players And Its Relationship With Lower Limb Anthropometric Measurements

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Resumen

Introducción: Los jugadores de voleibol dependen en gran medida de los músculos de las extremidades inferiores para mejorar su rendimiento. El propósito de este estudio es relacionar algunas características antropométricas y físicas con el vasto lateral, un músculo importante de la extremidad inferior en jugadores de voleibol entrenados. **Métodos:** este estudio incluyó a cuarenta jugadores de voleibol masculino entrenados entre las edades de 14 y 19 años, divididos en tres grupos (14-15, 16-17 y 18-19). Se midieron la antropometría de las extremidades inferiores, varios rendimientos físicos y registros electromiográficos del músculo vasto lateral usando EMG de superficie (sEMG). IBM SPSS v25 realizó Anova unidireccional seguido de post hoc (Scheffe) y correlación de Pearson. **Resultados:** hubo diferencias significativas en la masa corporal magra, la longitud de la parte superior de la pierna, la circunferencia de la pantorrilla, la fuerza elástica de la pierna, la contracción voluntaria máxima (MVC) y la actividad muscular (RMS) (P<0,05) entre los tres grupos. MVC y RMS del vastus lateralis se correlacionaron significativamente con la circunferencia de la pantorrilla y la fuerza elástica de la pierna (P <0.05). Además, la longitud de la parte superior de la pierna se correlacionó significativamente tanto con MVC como con RMS (P<0.05). **Conclusiones:** el voleibol está influenciado por la edad y el crecimiento, como se ve en la mayor estatura, masa corporal, masa corporal magra, longitud de la parte superior de la pierna y fuerza elástica de la pierna. en jugadores. La capacidad de salto es un aspecto crítico en el rendimiento del voleibol y puede medirse utilizando la fuerza elástica de las piernas. La fuerza elástica de las piernas de los jugadores de voleibol mejora junto con la actividad del músculo vastus lateralis.

Palabras Clave: Fuerza elástica de piernas, Máxima Contracción Voluntaria, Actividad Muscular, EMG de Superficie, Vastus lateralis, Voleibol

Abstract

Introduction: Volleyball players rely heavily on their lower limb muscles to improve their performance. The purpose of this study is to link some anthropometric and physical characteristics to the vastus lateralis, a significant lower-limb muscle in trained volleyball players. **Methods:** This study included forty trained male volleyball players between the ages of 14 and 19, divided into three groups (14-15, 16-17, and 18-19). Anthropometry of the lower limbs, several physical performances, and electromyographic recordings of the vastus lateralis muscle using surface EMG (sEMG) were all measured. One-way Anova followed by post hoc (Scheffe) and Pearson's correlation were performed by IBM SPSS v25. **Results:** There were significant differences in Lean Body Mass, Upper Leg length, Calf girth, Elastic Leg strength, Maximum Voluntary Contraction (MVC), and Muscle activity (RMS) (P<0.05) among the three groups. MVC and RMS of the vastus lateralis were significantly correlated with Calf girth and elastic leg strength (P<0.05). Furthermore, upper leg length was significantly correlated with both MVC and RMS (P<0.05). **Conclusion:** Volleyball is influenced by age and growth, as seen by larger stature, body mass, lean body mass, upper leg length, and elastic leg strength in players. Jumping ability is a critical aspect in volleyball performance, and it may be measured using elastic leg strength. Volleyball players' elastic leg strength improves in tandem with their vastus lateralis muscle activity.

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Keywords: Elastic leg strength, Maximum Voluntary Contraction, Muscle Activity, Surface EMG, Vastus lateralis, Volleyball

Introduction

Volleyball has been a prominent event in several sport competitions both nationally and globally for many years. According to the Federation Internationale de Volleyball's 2016 report, approximately 800 million people played volleyball at least once a week. This game is unquestionably good to an individual's physical and mental fitness because it involves a variety of somatic and motor tasks. Individuals' health-related fitness improved as a result of the volleyball course (Hamdan Hashem Mohammed 2018). Individuals' lower limb alignment, abdominal strength, estimated maximal aerobic power, and vertical jump height all increased significantly after participating in a volleyball training programme (Barber-Westin and Noyes 2011). It is thought to be a difficult game with easy skills. An underarm pass with the forearms, an overhead pass with the hands, and an overhead offensive shot are the standard patterns in this game. Power, mobility, and brain synchronization are required for all activities related with this game. This game's three key components are power, height, and movement. Aside from them, agility, flexibility, and reaction speed are all important factors in player performance.

Anthropometrical traits have a significant impact on competitive sports performance. A combination of technical, tactical, physical, psychological, and anthropometric elements influences athletic performance (Bompa 1999; Grosser and Neumaier 1986). Due to the existence of a hurdle that players must overcome in volleyball: a net that is 2.43 m high for males and 2.24 m high for females, the anthropometric characteristics of the players are an important aspect in peak performance. Physical capacities account for 17% of a player's jump reach, while anthropometric features and technical ability account for 83% (Vint 1994). When doing the spike and block, the jump reach is crucial. Because the spike, in both men's and women's volleyball, and the block, in men's volleyball, are the activities most connected with winning, the relevance of anthropometric, physical, and technical factors grows (Eom and Schutz 2013; Palao et al. 2014). Players with a lower body fat percentage perform better in several competitive sports, such as volleyball. This occurs because reduced body fat is a direct reflection of exercise intensity. Coaches should be interested in these findings since they will assist athletes enhance their performance, but they must be at a reasonable high level in all areas. This explains why great players have such a wide range of anthropometric and physiological traits. In a study of physical and anthropometric characteristics, it was discovered that the prevalence of overweight in adolescent volleyball players was higher than in the general population, which was a novel finding, implying that proper exercise interventions to target excess body mass in youth volleyball clubs should be developed (Nikolaidis and Ingebrigtsen 2013). In volleyball, the Sargent jump is vital because the ball must be hit around the opponent on the opposite side of the net (Schaal 2011). Leg muscular power is a key component of good athletic performance (Bobbert et al. 1996; Ravn et al. 1999), and it's especially important in volleyball (Menzel et al. 2010; Sheppard et al. 2008).

Regularly executed training regimens have a positive impact on anthropometrical and physical attributes. It should also be emphasized that genetic variables, as well as disorders that influence physical and electromyographic characteristics in early development, have an impact on the body physique of athletes. Athletes' performance is influenced by a number of elements in health. Height, age, sex, and, to a lesser extent, weight and ethnic origin are among them (Cotes 1979).

Surface electromyography (sEMG) has long been used to assess muscle health. The effect of progressive endurance-strength training in volleyball players can be measured using sEMG (Shavandi et al., 2006). In volleyball players, there was a significant relationship between the height of the jump- concentric force development rate and power- concentric force development rate, with the medial vasti muscle contributing the most during the countermovement jump (Bello et al. 2017). Despite the game's worldwide popularity, there is a scarcity of scientific data on the neuromuscular activities and anthropometric characteristics of professional volleyball players while they are growing.

This study only takes into account minimum two years trained male volleyball players without any physical disabilities and medical problems within age ranges 14 and 19 years. This study looked at the anthropometric, physical, and neuromuscular activities of one most important muscle, Vastus lateralis of lower limbs. Lower limb muscles are active and vital in volleyball games for volleyball players to have greater performance. The vastus lateralis is a significant muscle in the lower limb that is important for jumping and other actions when playing. The main goal of this study is to link some anthropometric and physical characteristics to the vastus lateralis, a significant lower-limb muscle in trained volleyball players.

Material and Methods

Selection of participants

Forty male volleyball players, ranging in age from 14 to 19, were used as participants and were split into three groups: Group 1: 14-15 years old, Group 2: 16-17 years old, and Group 3: 18-19 years old. None of them had any additional physical or physiological issues, and the players' consent was obtained beforehand.

Study Design

This observational study was carried out at the Department of Physiology, Serampore College, University of Calcutta. The study protocol was approved by Human Ethical Committee, Serampore College, Hooghly, West-Bengal, India. According to the report of club authorities, all players were under the proper supervision of coaches.

Measurements

- **Physique and body fat measurement:**

Stature (cm) and **body mass (kg)** were measured by SECA height measurement scale and SECA weighing scale. **BMI (kg/ m^2)** was calculated according to Hashim et al. 2006 and the equation was given below-

BMI=body weight (kg) / body height (m^2)

The skinfold thickness of several body regions (Biceps, Triceps, Subscapular, Supraspinale) was measured with the help of an Innovare skinfold caliper (Cescorf), which required a steady closing compression of 10 g.mm^{-2} throughout the measuring range. During the measurement, participants were told to keep their body regions relaxed because skinfold thickness varies from one location to the next. The generalized equation of Durnin and Womersley (1974) was used to get the Body Density (kg/mm^3). Brožek et al. (1963) developed an equation that was used to compute Total Body Fat Percentage (percent). Using the values of Total Body Fat Percentage (percent) and Body Mass, the Total Fat Mass (kg) was calculated. The Lean Body Mass (kg) was computed by subtracting the Total Fat Mass (kg) from each subject's Total Body Mass (kg).

Equations for calculating Body Density (kg/mm^3), Total Fat percentage (%), Total Fat Mass (kg) and Lean Body Mass (kg) are given below-

Body Density =1.1620-0.0630log (Biceps + Triceps + Subscapular + Supraspinale) for 14-19 years Male.
Total Body Fat Percentage (%) = {(4.45/Body density)-4.142} x 100
Total Body Fat Mass (kg) = (% of Body Fat/100) x Body Weight in kg.
Lean Body Mass (kg) = Total Body Mass or Weight (kg) – Total Fat Mass (kg)

Anthropometric measurements: They were measured by the help of anthropometric tape (Cescorf). The measured variables are- **Upper Leg Length (cm), Lower Leg Length (cm), Calf Girth (cm)**.

- **Physical variable measurement: Elastic Leg Strength** was measured through vertical jump test protocols (Sargent, 2013).
- **Electromyographic measurement by sEMG:** The Vastus lateralis, a prominent lower-limb muscle involved in volleyball, was selected as the subject muscle for the myoelectric investigation. Players were brought to the lab, rested, and recordings were made in the following order: EMG recording kit (iWorx IX-214) was set up and prepped for recording using EMG lead cable and electrode wire. The Vastus lateralis muscle was then identified, and surface button electrodes (Positive, Negative, and Neutral) were attached after applying gel to the skin (hair removal was done as per need). Subjects were instructed to stand and the recorder was started, and muscle activity was recorded on the computer while in resting condition using the software 'Labscribe,' and then each subject was given a 5 kg dumbbell and requested to do 10 repetitions with that load in the dominant leg. The measurements were obtained in real time.
- **EMG data recording:** The main variables are amplitude related (MVC and RMS), we got after the analysis are as follows (Ruchika 2013):
  - **MVC:** This defines the Maximum Voluntary Contraction i.e., maximum force generated by the concerned muscle.
  - **RMS:** It stands for Root Mean Square and represents the signal's mean power. It can be used to determine when a muscle is activated and represents involvement of motor units. It can also be used to check signal quality and look for artefacts. RMS can be used for biofeedback and to determine a muscle's resting level.

Statistical analysis

Each of the variables' mean and standard deviations were determined. The Shapiro-Wilk normality test revealed that the data were normally distributed, thus one way analysis of variance (ANOVA) was used to compare each of the groups' variables (P<0.05). The statistically significant variables were further subjected to post hoc analysis (Scheffe). The Pearson correlation (r) values of Upper leg length (cm), Lower leg length (cm), Calf girth (cm), Elastic leg strength, MVC (mV), and RMS (mV) were also assessed. IBM SPSS, Version 25 software was used for all statistical calculations and analysis. P<0.05 was defined as statistically significant outcome.

Results

The Mean, standard deviation (SD) and the one-way Anova result of each variable of the three age groups Group 1 (14 to 15 years), Group 2 (16 to 17 years), and Group 3 (18 to 19 years) was calculated and shown in Table 1 (body physique related variables), Table 2 (anthropometric and physical variables), and Table 3 (electromyographic variables) respectively.

Significant differences (P<0.05) were observed in age (years), stature (cm), body mass (kg), and lean body mass (kg) [Table 1] among the three groups. Table 2 and Table 3 reflected significant differences among the three groups in upper leg length (cm), calf girth (cm), elastic leg strength and electromyographic variables, MVC (mV) and RMS (mV) respectively (P<0.05).

Scheffe Post-hoc analysis was performed for the statistically significant variables to find out the groupwise mean differences among them [Table 4]. Most of the measured variables were found highest in Group 3. Insignificant differences were found among the groups when lower leg length was considered.

Table 5 represented the correlation between hind limb characteristics such as upper leg length (cm), lower leg length (cm), calf girth (cm), elastic leg strength (cm), and myoelectric variables such as MVC (mV) and RMS (mV). Upper leg length, calf girth, and elastic leg strength were all found to be substantially correlated with myoelectric variables. (P<0.05). The positive correlations were found in upper leg length and elastic leg strength with MVC and RMS of electromyographic recordings (P<0.05). The MVC and RMS of the Vastus Lateralis muscle have the most negative correlation with calf girth among the myoelectric variables. Elastic Leg Strength has the strongest positive connection with MVC, followed by Upper Leg Length. The highest positive correlation was found with the Elastic Leg Strength followed by Upper Leg Length when RMS was considered. The MVC and RMS themselves were also positively correlated with each other. The lower limb length was found to have no significant correlation with the myoelectric variables.

Table 1. Mean ± SD & One Way Anova of Body Physique of Volleyball Players

Variables	**Group 1** (Age 14-15 years), **n=15**	**Group 2** (Age 16-17 years), **n=13**	**Group 3** (Age 18-19 years), **n=12**	**F - value**	**P value**
Age (years)	***14.72±0.39***	***16.14±0.45***	***18.77±0.62***	***232.427***	***0.000****
Stature (cm)	***160.11±7.75***	***164.45±7.09***	***174.34±8.60***	***11.341***	***0.000****
Body Weight (kg)	***54.45±11.76***	***58.05±13.00***	***66.65±11.36***	***3.512***	***0.040****
BMI (kg/m²)	21.15±3.97	21.42±4.24	22.02±3.61	0.162	0.851
Body fat percentage (%)	18.25±5.55	16.63±5.85	14.73±5.14	1.349	0.272
Total fat content (kg)	10.47±4.55	10.17±5.46	10.45±4.52	0.016	0.984
Lean body mass (kg)	***43.98±7.50***	***47.87±8.17***	***56.19±7.74***	***8.347***	***0.001****
n=number of participants, ***P<0.05 (statistically significant)**, df=2					

Table 2. Mean ± SD & One Way Anova of anthropometric and physical variables of Volleyball Players

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Variables	**Group 1** (Age 14-15 years), **n=15**	**Group 2** (Age 16-17 years), **n=13**	**Group 3** (Age 18-19 years), **n=12**	F - value	P-Value
Upper leg length (cm)	***44.32±5.06***	***47.06±2.21***	***50.52±5.08***	***6.750***	***0.003****
Lower leg length (cm)	47.10±3.86	46.73±4.37	48.57±5.71	0.551	0.581
Calf girth (cm)	***31.79±3.14***	***33.33±3.75***	***22.47±4.93***	***27.737***	***0.000****
Elastic leg strength (cm)	***34.90±6.12***	***44.49±6.15***	***49.11±12.69***	***9.688***	***0.000****
n=number of participants, ****P<0.05 (statistically significant)***, df=2					

Table 3. Mean ± SD & One-way Anova of Electromyographic variables of Volleyball Players

Variables	**Group 1** (Age 14-15 years), **n=15**	**Group 2** (Age 16-17 years), **n=13**	**Group 3** (Age 18-19 years), **n=12**	F - value	P-Value
Maximum voluntary contraction (mV)	***0.33±0.13***	***0.61±0.15***	***0.98±0.26***	***41.524***	***0.000****
Root Mean Square (mV)	***0.06±0.02***	***0.16±0.03***	***0.96±0.64***	***25.696***	***0.000****
n=number of participants, ****P<0.05 (statistically significant)***, df=2					

Table 4. Results of Post-hoc Multiple comparisons (Scheffe)

Dependent Variables			Mean Difference	P Value
Age	**Group 1**	**Group 2**	***-1.42374****	***0.000***
		Group 3	***-4.05650****	***0.000***
	Group 2	**Group 1**	***1.42374****	***0.000***
		Group 3	***-2.63276****	***0.000***
	Group 3	**Group 1**	***4.05650****	***0.000***
		Group 2	***2.63276****	***0.000***
Stature	**Group 1**	**Group 2**	-4.34051	0.352
		Group 3	***-14.22833****	***0.000***
	Group 2	**Group 1**	4.34051	0.352
		Group 3	***-9.88782****	*0.012*
	Group 3	**Group 1**	***14.22833****	***0.000***
		Group 2	***9.88782****	***0.012***
Bodymass	**Group 1**	**Group 2**	-3.59949	0.735
		Group 3	***-12.20333****	***0.044***
	Group 2	**Group 1**	3.59949	0.735
		Group 3	-8.60385	0.218
	Group 3	**Group 1**	***12.20333****	***0.044***
		Group 2	8.60385	0.218
Lean Body Mass	**Group 1**	**Group 2**	-3.89005	0.429
		Group 3	***-12.20967****	***0.001***
	Group 2	**Group 1**	3.89005	0.429
		Group 3	***-8.31962****	***0.039***
	Group 3	**Group 1**	***12.20967****	***0.001***
		Group 2	***8.31962****	***0.039***
Upper Leg Length	**Group 1**	**Group 2**	-2.74154	0.264
		Group 3	***-6.19667****	***0.003***

	Group 2	**Group 1**	2.74154	0.264
		Group 3	-3.45513	0.155
	Group 3	**Group 1**	***6.19667****	***0.003***
		Group 2	3.45513	0.155
Calf Girth	**Group 1**	**Group 2**	-1.54410	0.590
		Group 3	***9.31167****	***0.000***
	Group 2	**Group 1**	1.54410	0.590
		Group 3	***10.85577****	***0.000***
	Group 3	**Group 1**	***-9.31167****	***0.000***
		Group 2	***-10.85577****	***0.000***
Elastic Leg Strength	**Group 1**	**Group 2**	***-9.59231****	***0.021***
		Group 3	***-14.20833****	***0.001***
	Group 2	**Group 1**	***9.59231****	***0.021***
		Group 3	-4.61603	0.417
	Group 3	**Group 1**	***14.20833****	***0.001***
		Group 2	4.61603	0.417
Vastus Lateralis MVC	**Group 1**	**Group 2**	***-.28074****	***0.001***
		Group 3	***-.65003****	***0.000***
	Group 2	**Group 1**	***.28074****	***0.001***
		Group 3	***-.36929****	***0.000***
	Group 3	**Group 1**	***.65003****	***0.000***
		Group 2	***.36929****	***0.000***
Vastus Lateralis RMS	**Group 1**	**Group 2**	-0.10685	0.724
		Group 3	***-.90772****	***0.000***
	Group 2	**Group 1**	0.10685	0.724
		Group 3	***-.80087****	***0.000***
	Group 3	**Group 1**	***.90772****	***0.000***
		Group 2	***.80087****	***0.000***
**** The mean difference is significant at the 0.05 level.***				

Table 5. Pearson Correlation (r values) among the variables in 14 to 19 years Trained Male Volleyball Players

Variables	Upper leg length (cm)	Lower leg length (cm)	Calf girth (cm)	Elastic leg strength (cm)	MVC (mV)	RMS (mV)
Upper leg length (mm)		0.253	***-.421****	0.300	***.465****	***.507****
Lower leg length (mm)			-0.050	0.093	0.250	0.028
Calf girth (cm)				***-.365****	***-.568****	***-.693****
Elastic leg strength (cm)					***.491****	***.636****
MVC (mV)						***.513****

****Correlation is statistically significant at 0.05 level (2 tailed)***

***** Correlation is statistically significant at 0.01 level (2 tailed)***

Discussion

Volleyball players are distinguished by their height, strength, speed, motor coordination, and jumping ability. Volleyball players were advised to have a low body fat percentage to improve their performance (Morrow et al. 2013; Schutz 1999). In this study, Volleyball players in Groups 1 (14 to 15 years), 2 (16 to 17 years), and 3 (18 to 19 years) have significantly higher body weight and lean body mass. But, BMI (kg/m^2), body fat percentage (%), and total fat content (kg) are not significantly different among the three groups. The volleyball players in Group 3 have more body mass (Kg) and lean body mass (Kg) than the players in Groups 1 and 2. This indicates that the players' muscle content has increased as they have grown older, replacing the higher body fat. A balanced diet and increased physical activity might be helpful for improving their performance by lowering their body fat percentage and increasing their lean mass (Abreu de Almeida and Abreu Soares, 2003). The group 1 players have a shorter upper leg length (cm), and lower leg length (cm) than Group 2 and Group 3 players indicating anthropometric measurements are influenced by the developmental stage.

The force generated by the muscle (MVC) and the involvement of motor units (RMS) are significantly higher in Group 3 than in Group 2 and Group 1 participants, according to an EMG investigation of the Vastus lateralis. Volleyball players must work their lower-limb muscles a lot. Leg muscle strength is recognized as an important component of successful volleyball athletic performance. Any weakening or disease in the lower leg muscles may have a major impact on their ability to execute. According to EMG findings, the neuromuscular elements of one of the most essential muscles, the Vastus lateralis, become increasingly active and powerful as they grow. Higher elastic leg strength in Group 3 players implies that muscle mass, lean body mass, and lower limb muscular strength are major variables in the assessment of physical strength in three age groups. The EMG findings of the lower limb's Vastus lateralis confirm successful neuromuscular actions and adequately explain why lower limb muscular strength has improved.

Volleyball requires elastic leg strength (cm) since the ball must be hit around the opponent on the opposite side of the net. Sargent Jump Test was used in the majority of reported research to test elastic leg strength. In three groups of volleyball players, the association between the Sargent Jump Test and electromyographical variables MVC (mV) and RMS (mV) during resting conditions were investigated. During the resting state of volleyball players, there is a substantial positive association between elastic leg strength (Sargent Jump Score) and both factors (Table 5). As a result of the study, it can be concluded that the Sargent Jump Test is highly connected with the evaluation of elastic leg strength in volleyball players while resting. The measurement of Vastus lateralis activity in the resting state could be a good predictor of a player's elastic leg strength.

The negative correlation between calf girth and electromyographic findings indicates that as muscle content increases, less muscular force and motor units are required to complete the task. As a result, calf girth measurement could be a valuable tool for evaluating hind limb improvement in terms of neuromuscular activities. However, elastic leg strength and calf girth in this study shows a negative correlation that is statistically significant ($P<0.05$). It's perplexing because a larger calf circumference indicates more neuromuscular activity in the Vastus lateralis muscle. Sargent jump, on the other hand, is a widely used test for determining elastic leg strength. If calf girth grows, elastic leg strength decreases, according to this result. Due to its limitations, this study is unable to provide convincing reasons for this perplexing finding. For this strategy to be justified, more research is required.

Conclusions

The anthropometric, physical, and electromyographic parameters of the lower limb in trained male volleyball players aged 14 to 19 years are examined in this study. The large differences in stature among the groups represent distinct developmental characteristics. Only trained male volleyball players are included in this study.

There are significant differences in myoelectric properties. As they grew older, their vastus lateralis activity during resting conditions increased. It could be because elderly people have more muscular mass and lean body mass. One of the main goals of this study was how far Sargent Jump test score and neuromuscular activities of vastus lateralis muscle were linked under resting settings. This study suggests that vastus lateralis activities are linked to elastic leg strength in 14–19-year-old volleyball players. This study also demonstrated that elastic leg strength may be assessed using the Sargent Jump Test score when EMG facilities are not available in a large population.

More study is needed to rationalize all of the aspects, not only in the field of volleyball, but also in a wide range of sports, in order to improve the research. In the Indian setting, research is critical for improving national and international performance.

Limitations

Even though this study only looked at one muscle, more research is needed into additional dominant or accessory muscle groups that have a role in volleyball. Apart from volleyball, there is a wide range of sports in the sports globe, thus there are always study opportunities to obtain more essential outcomes. Furthermore, because this study only includes young male volleyball players, there is always the possibility of studying persons of different ages and genders.

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