ISSN 2618-1576 Vol. 6, Issue 1: 66-71, DOI: 10.25236/FSR.2024.060111

Research Status of EMG of Lower Limbs Taking off for Blocking at Different Angles of Knee Joints in Volleyball

Shuai Geng

Sichuan Minzu College, Kangding, Sichuan, 626001, China

Abstract: *The research scope of surface EMG technologies applied to the lower limbs is broad and extensive, encompassing a wide range of activities such as cycling, sprinting, diving, Tai Chi, and parachuting. The comprehensive array of experimental methodologies employed in previous studies, as well as the resulting data, have provided valuable reference and insight for the composition of this paper. Specifically, in the investigation of the take-off technique for blocking in volleyball, the use of full-range surface EMG testing on athletes' lower limbs allows for the analysis and comparison of activation sequences, mobilization ratios, and levels of engagement, as well as the interrelationships between muscles such as quadriceps femoris, sartorius, biceps femoris muscle, semitendinosus, semimembranosus, medial thigh muscle and gastrocnemius muscle, at varying knee joint angles during the take-off. Such analysis elucidates the muscular characteristics at work during the blocking and take-off movement, offering physiological guidance for technical refinement and force training of athletes. These findings provide technical support for the further development of volleyball in our country and serve as a reference for research in other specialized fields.*

Keywords: *Volleyball; Knee Joint; Take-off and blocking; EMG of Lower Limbs*

1. Introduction

Volleyball, invented in 1895 by William Morgan, a YMCA official from Holyke, Massachusetts, has evolved over the past century and a half. With the rapid advancement of competitive volleyball, the technique and tactics have reached unprecedented levels.

It is an urgent priority to promote scientific research in volleyball, serve the sport, and provide technical support for its development worldwide. Research has found that among the countries which have been part of the world's top volleyball teams, those that have increased their research efforts in volleyball have stood among the strong ranks of world volleyball and maintained a sustained momentum of development at corresponding stages. However, in the study of volleyball, the application of interdisciplinary knowledge from training, management, physiology, biochemistry, psychology, and biomechanics is prevalent, mostly focusing on the EMG of the upper limbs and waist and abdomen, as well as the assessment of physiological and biochemical indicators and the improvement of training methods. Yet, research on the EMG of lower limbs is notably scarce. As volleyball technique and tactics become increasingly mature and with the rapid transition between attack and defense in intense matches, under the system of scoring a point per goal, there is an urgent need to strengthen the study on the EMG of lower limbs. This is essential for athletes to better utilize the force of their lower limbs and to enhance their spiking or blocking effects.

Upon reviewing the pertinent literature, it has been observed that there has been a preponderance of research conducted on the lower limbs of athletes, spanning various disciplines, employing diverse methodologies, and examining the working process of lower limbs from numerous perspectives. However, research specifically focused on the EMG of volleyball players' lower limbs remains limited, with the studies often being monolithic in nature, revolving around investigations of EMG changes under varying speeds of movement, post-different training regimens, or muscle activation patterns. Despite a plethora of literature on the EMG of lower limbs, which offers a foundation for further research on the EMG of volleyball players' lower limbs, there is a scarcity of studies on the EMG of lower limbs in volleyball, let alone those that analyze the EMG of lower limbs at different angles of take-off and blocking.

Therefore, it is imperative to enhance the research on the EMG of volleyball players' lower limbs in

ISSN 2618-1576 Vol. 6, Issue 1: 66-71, DOI: 10.25236/FSR.2024.060111

blocking techniques. The research aims to analyze the changes in EMG during the process of take-off and landing from various angles, the sequential force exertion of all muscles, their respective mobilization ratios, the involvement of different types of muscle fibers, and their interrelationships. The significance of this study lies in its potential to inform volleyball coaches on training methodologies for physical, strength, and specialized power training in the process of volleyball teaching and training, aiding in the prevention of sports-related injuries, and providing physiological references for speed, fundamental techniques, and tactical training. It aims to offer technical support for the development of volleyball in China and to serve as a reference for research in other specialized fields.

2. Definition of Related Concepts

EMG signals are determined by the changes in recruitment and excitation frequency within the neural-muscular system. Muscle contraction is initiated by the motor neurons of the α-motor unit in the central nervous system. It involves the guidance, amplification, and recording of the electromotive potential changes that occur during skeletal muscle excitation, resulting in the electromyogram. iEMG represents the sum of areas under a given section of EMG signals, measured in V·s. It is the sum of EMG output over a period of time and is often used to evaluate the degree of muscle activity. As the electromyogram is used to record changes in electrical activity of muscles, it often reflects the activity of the central nervous system. The electromyogram can capture parameters such as amplitude under varying loads, the timing of muscle discharge, the sequential involvement of different muscles, frequency, and the intensity of muscle contractions, all of which elucidate the neural-muscular characteristics and differences associated with different loading conditions and training movements.

There are two methods of acquiring the electromyogram: needle electrode and surface EMG electrode. The needle electrode method yields reliable and genuine EMG but is invasive and difficult to manipulate. The surface EMG, on the other hand, offers non-invasive and real-time advantages, making it suitable for objective assessments of neural-muscular activity in specific muscles under various exercise conditions, including static, dynamic, and functional states. It can quantify the functional activity of working muscles, indicate the sequence of muscle activity, coordinate patterns, and levels of excitation, commonly used to assess the functional status of the neuro-muscular system.

The lower limbs chiefly refer to the bones of the lower limbs and muscular components below the hip joint in the human body. The bones of the lower limbs primarily consist of the hip bone, femur, focile, and bones of foot, while the muscles of the lower limbs are those that attach to these bones.

The EMG of lower limbs refers to the potential changes in the skeletal muscles of the lower limbs during movement. This paper employs surface EMG, a method of acquiring EMG, to conduct experiments on the changes in the EMG of lower limbs at different knee joint angles during take-off for blocking of volleyball-specific students, the experiment objects.

3. Research Status of the EMG of Lower Limbs

The most commonly used method is surface electrodes, which feature the distinct characteristic of being directly applicable in sports practice without affecting the completion of the athlete's movements. The recorded EMG signals genuinely reflect the EMG information during the athlete's movements, allowing for non-invasive and real-time measurements in practice, hence its prevalent use in current research.

Surface EMG technology in the study of lower limb muscles encompasses a wide range of aspects:

Niu Wenxin, Wang Yang[1], et al. stated in the "Effects of Ankle Stabilizers on Electromyographic Activities of Lower-Extremity Muscles during Simulated Half-Squat Landing" that ankle joint protection and gender have no significant effect on the duration of the EMG of lower limbs before all muscles touch the ground, and there is no significant cross-effect between the two factors. After wearing ankle protector, the EMG amplitude of the tibialis anterior muscle increased significantly before touching the ground, while the EMG amplitude of the lateral gastrocnemius muscle before touching the ground is not significantly affected by ankle joint fixation.

Zhang Guofeng's [2]"Analysis of The Lower Limb EMG of The Sprinters between The Steady Phase of Sprint and Part of Power Training Means" reveals that gluteus maximus and biceps femoris muscle show obvious discharge phases in the whole process of running on the way. The rectus femoris

ISSN 2618-1576 Vol. 6, Issue 1: 66-71, DOI: 10.25236/FSR.2024.060111

has two distinct discharge phases, one is that the thigh leads the calf to swing forward, and the other is that it supports thrusting against the ground. The discharge of the medial part of the gastrocnemius muscle is higher in the support phase. The intensity and frequency of discharge of gluteus maximus, biceps femoris muscle and semitendinosus and semimembranosus are even greater than those in the support phase.

Sun Ke's[3] experiment "Effect of Different Seat Height on Lower Limb Movement of Cyclists" concluded that too high or too small seat height will increase the discharge of some muscles and easily result in muscle fatigue. The change of seat height has no significant effect on the average root-mean-square values of gluteus maximus and tibialis anterior muscle, but it has significant effects on biceps femoris muscle, rectus femoris, musculi vastus lateralis and gastrocnemius muscle, and shows a certain regularity. For the tibialis anterior muscle, the discharge capacity gradually increases along with the increase of seat height, but there are no significant differences between seat heights.

Lu Chunyan and Zhai Xuefeng[4] said in the experiment "Comparison Through the electromyography Movement of the Lower Limbs - Explore the Training Method of Swinging the Leg Power under the Maximum Strength" that: in the EMG analysis of the leg swing exercise before pulling the tape - the intensity of the electric activity of rectus femoris is relatively low at the beginning of the swing, and it increases with the tightening of the tape. At the beginning of the leg swing, the rectus femoris shows strong EMG activity until it reaches the highest point.

Wen Ailing[5] indicated in "The EMG Characteristic Analysis of the Lower Limb Muscles in 24-style tai chi chuan" that the EMG integrated value of muscles of the low-level group is lower than those of the high-level group. Among them, the integrated EMG values of the right gastrocnemius muscle, left gluteus maximus, right tensor fasciae latae and left tensor fasciae latae are lower than those of the high-level group, which constitute significant differences. No matter in the experimental group or the control group, there are no significant differences in the EMG values between the left and right muscles of lower limbs of the gastrocnemius muscle, the tibialis anterior muscle, the left rectus femoris, the left medial vastus muscle, the vastus lateralis muscle, the gluteus maximus, the tensor fasciae latae and the biceps femoris muscle within the group.

Zhang Yuan[6] put forward in the "Muscle Electricity Telemetry during Short-Distance Running": The EMG integrated value of the time course of lying on the ground reveals that the unit area of the biceps femoris muscle and the tibialis anterior muscle is more exciting. The obvious decrease of velocity at the pole is associated with the decrease of EMG amplitude in the process of biceps femoris muscle pressing forward and lying on the ground.

Zhan Jianguo and Dai Xinghong[7] wrote in "The Characteristic Analysis of Lower Limbs Electricity of Sprinter's Hip Muscle Group in Strength Training": In the hip-lifting movement, gluteus maximus first discharges with great intensity, and the EMG integrated value is also large at the beginning. When the hip joint angle is large, biceps femoris muscle and semitendinosus and semimembranosus discharge more, and the EMG integrated value is larger. The EMG characteristics of stretching rubber band after straight leg, in this exercise method, the athletes show the common discharge phenomenon of biceps femoris muscle, semitendinosus and semimembranosus and gluteus maximus. In the process of swinging the thigh from the back to the highest point in front of the body, the tibialis anterior muscle, tensor fasciae latae and posterior femoral muscle group show discharge phenomena.

In the "Research on Biomechanical Characteristics of Lower Limb Muscles in Drop Jump", Zhou Jiaying[8] obtained the activity characteristics of surface EMG of muscles measured before the feet landing; most muscles measured before the feet landing are pre-activated, and the amplitude of pre-activated EMG activity is different to some extent, which changes essentially with the increase of drop jump and falling height. No matter the athletes in ordinary group or excellent group, there is no obvious corresponding relationship between the change of average power frequency value of surface EMG of muscles of lower limbs measured and the drop jump and falling height. In other words, every time the falling height of drop jump increases by 20 cm on the original basis, the average power frequency value of surface EMG of muscles of lower limbs measured corresponding to each falling height does not all increase, but only some muscles increase, without certain regularity.

Luo Jiong[9] stated in "The Influencing Research About the Lower Limbs Muscles EMG Characteristics During Cycling at Different Pedaling Frequencies and Circadian Rhythm" that the physiological rhythm has a significant impact on the burst point of the rectus femoris, and the discharge length of the rectus femoris has obvious physiological rhythm. Along with the increase of pedaling frequency, the burst point and end point of biceps femoris muscle are significantly advanced, and there

ISSN 2618-1576 Vol. 6, Issue 1: 66-71, DOI: 10.25236/FSR.2024.060111

is a good linear relationship between them; the physiological rhythm has no effect on the linear trend of the forward movement of the burst point and end point of biceps femoris muscle, but it significantly affects the amplitude of forward movement, in which the burst point moves forward more in the morning than in the afternoon, while the end point shows the opposite.

Tao Ping and Liu Yunfa[10] pointed out in "The Kinetic Study on the Right and Wrong Actions on Knee Joint from tai chi chuan's "Parting the Wild Horse's Mane"" that the stress on the knee joint in the flexion state is more complicated, which easily causes fatigue, thus leading to knee joint injuries.Wang S J, Dong Q X, Jing X L concluded that tai chi chuan emphasized slow and continuous movement, including the shift of human body's center of gravity from bilateral to unilateral, the gradual flexion of knee joint, and the rotation of trunk and head and neck.

Wang Fanjia and Zhou Chenlei's[11] "Comparison of Lower Extremity Joint Kinematics and Muscle Activation between Asian Squat and Western Squat" elaborates that in the "Asian squat" where the soles of the feet touch the ground, the excitation degree of the tibialis anterior muscle is significantly higher than that of the "Western squat" which requires the human body's center of gravity to move forward.

Zeng Yuan's[12] "Analysis of Technical Issues Associated with Standing Long Jump" points out that there are numerous factors that influence the performance of standing long jump, including personal genetic quality (height, leg length and weight, etc.), take-off angle, ground-hitting force and aerial technique, particularly the force exertion of knee, ankle and hip joints directly influences the take-off height and coordination capability.

4. Research on the EMG of Lower Limbs in Volleyball

Given the persistently lackluster record of the Chinese men's volleyball team and the volatility of achievements of the women's team, these scenarios have drawn the attention of a broad spectrum of researchers. Consequently, substantial investments have been made in volleyball research in recent years, leading to a proliferation of scientific outcomes. These outcomes have shed light on various aspects, including physiological and biomechanical domains, with an emphasis on the EMG of movements such as spiking and spiking & take-off. The majority of these studies focus on the EMG of the lower limbs, while others extend to the analysis of EMG in the waist and abdomen, and muscles of upper limbs.

Hua Lijun and Song Jirui[13] states in the "Research on Muscle Force and EMG Characteristics of Volleyball Player's Lower Limbs" that the changes of the integrated EMG values of the three muscles of quadriceps femoris are measured at different testing speeds; the data shows that the integrated EMG values of the three muscles gradually decrease with the increase of testing speed, and there are no significant differences in the integrated EMG values of the three muscles at the same velocity.

Chen Ruirui's [14]"Discussion on EMG Analysis and Strength Training Methods of Whipping in Volleyball Spike" demonstrates that the timing sequence characteristics of muscles for the arm-pulling movement at the maximum velocity are arranged from the muscles with the earliest time of discharge: trapezius, anterior deltoid tract, posterior deltoid tract, latissimus dorsi, flexor muscle of wrist, extensor digitorum muscle, rectus abdominis, musculus obliquus externus abdominis, bicipital muscle of arm, triceps muscle of arm, pectoralis major. The timing sequence characteristics of muscles for arm-pulling movement at general velocity are arranged in the same way: anterior deltoid tract, posterior deltoid tract, musculus obliquus externus abdominis, trapezius, latissimus dorsi, triceps muscle of arm, flexor muscle of wrist, rectus abdominis, bicipital muscle of arm, extensor digitorum muscle, pectoralis major.

In "Biomechanical Analysis of Volleyball Spike", Xiong Feng[15] learns that in the active muscles during pedal-stretch, the EMG sum value of the front muscles is smaller than that of the back muscles, and the EMG sum value of the left muscles is smaller than that of the right muscles. The discharge of lower limb muscles is highly obvious in the phase of aerial shot, which is not less than that of upper limb muscles. That is, it is an important component to drive the movement of lower limb joints with the force exertion of lower limb muscles in the phase of aerial shot, and lower limb muscles play a critical role.

Hua Lijun[16] mentioned in "A Comprehensive Analysis of the Spike and the Special Power of Volleyball Players" that the maximum amplitude of the rectus femoris in the pedal-stretch phase is higher than that in the buffer phase, and gluteus maximus is the opposite; the maximum amplitude of biceps femoris muscle and semimembranosus in the buffer phase is obviously higher than that in the

ISSN 2618-1576 Vol. 6, Issue 1: 66-71, DOI: 10.25236/FSR.2024.060111

pedal-stretch phase, and the maximum amplitude in the pedal-stretch phase in the back and middle of gastrocnemius muscle is obviously higher than that in the buffer phase.

Yu Chonggan and Guo Quan's[17] "Comparative Study on Isokinetic Test of 3 Joint Muscles of Lower Limbs of Basketball and Volleyball Players" suggests that there are different take-off modes; basketball athletes mostly take off with one foot, while volleyball athletes mostly take off with both feet; the different take-off modes also bring forward different requirements for muscle force and its characteristics.

In "Comparative Analyses on Muscle Strength of Knee Between Volleyball Players and Bbasketball Players", Guo Quan[18]states that the centripetal contraction ability of extensors on both knee joints of volleyball athletes is slightly better than that of basketball athletes, while the centripetal contraction ability of flexors on both sides is obviously worse than that of basketball athletes.

5. Conclusion

In conclusion, the research scope of surface EMG technologies applied to the lower limbs is broad and extensive, encompassing a wide range of activities such as cycling, sprinting, diving, Tai Chi, and parachuting. The comprehensive array of experimental methodologies employed in previous studies, as well as the resulting data, have provided valuable reference and insight for the composition of this paper. Specifically, in the investigation of the take-off technique for blocking in volleyball, the use of full-range surface EMG testing on athletes' lower limbs allows for the analysis and comparison of activation sequences, mobilization ratios, and levels of engagement, as well as the interrelationships between muscles such as quadriceps femoris, sartorius, biceps femoris muscle, semitendinosus, semimembranosus, medial thigh muscle and gastrocnemius muscle, at varying knee joint angles during the take-off. Such analysis elucidates the muscular characteristics at work during the blocking and take-off movement, offering physiological guidance for technical refinement and force training of athletes. These findings provide technical support for the further development of volleyball in our country and serve as a reference for research in other specialized fields.

References

[1] Niu Wenxin, Wang Yang. Effects of Ankle Stabilizers on Electromyographic Activities of Lower-Extremity Muscles during Simulated Half-Squat Landing [J]. Journal of Medical Biomechanics (Special Column of Aviation Biomechanics). 2010.25 (4)

[2] Zhang Guofeng. Analysis of The Lower Limb EMG of The Sprinters between The Steady Phase of Sprint and Part of Power Training Means [D]. Beijing: Beijing Sport University. 2009 (5)

[3] Sun Ke. Effect of Different Seat Height on Lower Limb Movement of Cyclists [D]. Beijing: Beijing Sport University. 2007

[4] Lu Chunyan, Zhai Xuefeng. Comparison Through the electromyography Movement of the Lower Limbs - Explore the Training Method of Swinging the Leg Power under the Maximum Strength [J]. Journal of Changchun Normal University. 2001.20 (2)

[5] Wen Ailing. The EMG Characteristic Analysis of the Lower Limb Muscles in 24-style Tai chi chuan [D]. Beijing: Beijing Sport University. 2010

[6] Zhang Yuan. Muscle Electricity Telemetry during Short-Distance Running [J]. Journal of Wuhan Institute of Physical Education. 2008.42 (6)

[7] Zhan Jianguo, Dai Xinghong. The Characteristic Analysis of Lower Limbs Electricity of Sprinter's Hip Muscle Group in Strength Training [J]. Journal of Xi'an Physical Education University. 2011.28 (2) 227-323

[8] Zhou Jiaying. Research on Biomechanical Characteristics of Lower Limb Muscles in Drop Jump [D]. Shanghai: Shanghai University of Sport. 2007

[9] Luo Jiong. The Influencing Research About the Lower Limbs Muscles EMG Characteristics During Cycling at Different Pedaling Frequencies and Circadian Rhythm [J]. Journal of Southwest China Normal University (Natural Science Edition). 2010.35 (1)

[10] Tao Ping, Liu Yunfa. The Kinetic Study on the Right and Wrong Actions on Knee Joint from Taijiquan's "Parting the Wild Horse's Mane" [J]. Journal of Shanghai University of Sport, 2016, 40(6):84-90.

[11] Wang Fanjia, Zhou Chenlei. Comparison of Lower Extremity Joint Kinematics and Muscle Activation between Asian Squat and Western Squat [J]. Journal of Medical Biomechanics, 2021, 36(5):705-711.

ISSN 2618-1576 Vol. 6, Issue 1: 66-71, DOI: 10.25236/FSR.2024.060111

[12] Zeng Yuan. Analysis of Technical Issues Associated with Standing Long Jump [J]. Youth Sport, 2019 (6): 99-100.

[13] Li Jun, Song Jirui. Research on Muscle Strength and Electromyography Characteristics of Volleyball Player's Lower Limbs [J]. Journal of Shenyang Sport University.2007.26 (4)

[14] Chen Ruirui. Discussion on EMG Analysis and Strength Training Methods of Whipping in Volleyball Spike [D]. Beijing: Beijing Sport University. 2010

[15] Xiong Feng. Biomechanical Analysis of Volleyball Spike [D]. Beijing: Beijing Sport University. 2010

[16] Hua Lijun. A Comprehensive Analysis of the Spike and the Special Power of Volleyball Players [D]. Shanghai: Shanghai University of Sport. 2007

[17] Yu Chonggan, Guo Quan. Comparative Study on Isokinetic Test of 3 Joint Muscles of Lower Limbs of Basketball and Volleyball Players [J]. Journal of Sports Sciences: 2000, 20 (1): 73-75

[18] Guo Quan. Comparative Analyses on Muscle Strength of Knee between Volleyball Players and Basketball Players [J]. Journal of Xi'an Physical Education University [J]. 2003, 20(3): 41-44.