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Differences in EMG of Trunk and Lower Limb According to Attack Method and Phase During Volleyball

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Abstract

The purpose of our study is to confirm the trend of the muscle activity of the trunk and lower limb muscles by the attack method and phase during volleyball exercise. To achieve this purpose, spike serve and spike were conducted for 9 male middle school students, and at that time, it was divided into four phase, such as run jump, take off, impact, and follow, and the rectus abdominis, erector spine, and left rectus femoris, left biceps femoris, left anterior tibialis, left gastrocnemius midialis, right rectus femoris, right biceps femoris, right anterior tibialis, right gastrocnemius midialis, were examined. Spike serve and spike were each performed three times, and randomly cross-allocated to extract accurate data. We was no difference in all muscles according to the attack method, and the muscle activity of the rectus abdominis was highest in the impact phase and the muscle activity of the vertebral spine muscle was highest in the close-up phase. In addition, all of the measured left and right lower limb muscles showed the highest muscle activity between the assisted devices. As a result, We found out that regardless of the method of spike serve and spike, the lower limbs in the run-up phase for a high jump, the vertebrae in the take off phase, the preparation phase for hitting the ball strongly, and in the impact phase at the moment of hitting the ball. It can be seen that it exerts the greatest power in the rectus abdominis.

Keywords: *Volleyball, Spike serve, Spike, EMG(Electromyogram)*

1. Introduction

Skills in volleyball are divided into offensive skills and defense skills. Attack skills include spike blocking and serve, and defense skills include receive, pass, and toss [1]. Spike is a technique that obtains most points in volleyball game [2]. In addition, after the rule was revised so that even if the serve was hit, it was recognized as a score, and the risk for criminals was reduced, and the rate of score earned by scoring increased, so the frequency of use of spike serve is increasing [3].

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The spike and spike serve have an impact at more than 3m, so jumping and landing are important [4, 5, 6]. Landing motion after jumping is an unavoidable motion due to free fall [7]. Jumping motion is achieved through explosive muscle contraction of multi-joints [8], and it is a motion to lift the body into the air with the force pushing the ground through the extension motion of the lower limb joints [9], as it is an important factor in the game result, studies on methods to improve the jump height have been actively conducted [10, 11].

Research on volleyball exercise is not only the above-mentioned research on jumping, but also research on the relationship between landing and injury is being actively conducted because the landing motion accompanying the jump motion is closely related to motor injuries [12-14]. In addition, found that the right foot knee joint angle in the take off phase in the take off phase showed a rapid increase before leap in the analysis of the volleyball spike, whereas the continuous increase of the knee joint angle of the left foot showed the efferent contraction of the left foot. It was said to have a greater influence on the height and speed of the jump. In addition, there was a high correlation between the height of the jump and the vertical speed at the time of the jump, and in order to increase the height of the jump, it was suggested that the foot roll time, the right ankle at landing, and the knee joint angle at landing should be made smaller.

As such, the importance of spikes and spike serve in volleyball sports has become more prominent since the revision of the rules, and the importance of them is being emphasized for interesting games as well. However, it can increase the risk of injury because it emphasizes a powerful and vigorous form of motion. Therefore, it is thought that analysis and research on spike serve and spike motion during volleyball exercise will be necessary. Therefore, this study attempts to examine the EMG response of each phase during spike and spike serve during volleyball exercise.

2. Experiment Materials and Methods

2.1 Subject

The subjects of this study were 9 male volleyball players from middle school located in Chungcheongbuk-do. The subjects were selected as players who did not have injuries because they used spikes and spear serve accurately, and who were able to perform with constant movements. The subjects were fully explained about the contents and methods of the experiment before the experiment, and the consent to voluntarily participated was signed. The subjects explained that the experiment could be stopped by a voluntary doctor during the experiment. The characteristics of the study subjects are shown in Table 1.

Table 1. The characteristics of the subjects

N	Age(year)	Weight(kg)	Height(cm)	Career(year)
9	15±0.67	66.67±6.32	181.11±6.27	73.56±13.16

M±SD

2.2 Study Design

In order to measure the muscle activity of the lower limb and trunk muscles for each phase during the spike and spike serve motion during volleyball exercise, an experimental design was conducted as follows. On the day of the experiment, before the experiment, the subjects warmed up through stretching and light jogging for 15 minutes. Nine subjects performed spike and spike serve 3 times each through random cross-allocation, and at the same time, the erect vertebrae, rectus abdominis, right rectus femoris, right biceps femoris, right anterior tibialis, right gastrocnemius medialis, and EMG of the rectus femoris, left biceps femoris, left anterior tibialis, and left gastrocnemius medialis muscles were measured. The measured data were analyzed using the SPSS 22.0 statistical program.

2.3 Sipke Serve & Spike Method

Spike and Spike Serve were each performed 3 times, a total of 6 times, and the order was randomly intersected. A break of at least 3 minutes was taken between each spike and spike serve. The step was the most common 3 step, and the landing was performed with both feet. The subjects of the study were selected as left strikers who mainly used the right side of the team. The appearance and implementation of the spike serve method in this study is shown in Figure 1 and Table 2.

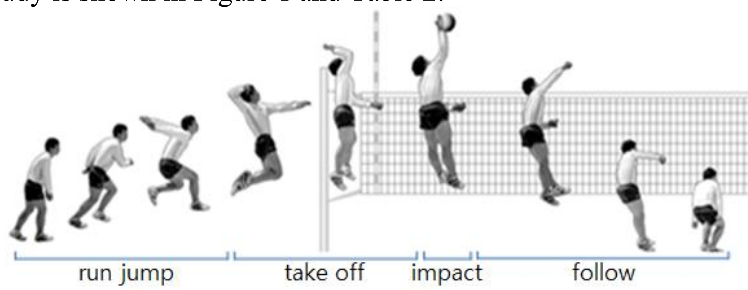

Figure 1. Spike serve & Spike Phase

Table 2. Spike serve & Spike Phase

Dvision	Run jump	Takeoff	Impact	Follow
Explanation	The moment the right foot falls when jumping.	Just before impact after jumping.	The moment the right hand hits the ball.	After the ball leaves the hand until it lands.

2.4 Electromyogram Measurement Method

The EMG measurement was performed using a wireless EMG from Cometa, Italy. The measurement sites were left and right biceps femoris, left and right rectus femoris, left and right anterior tibialis, left and right gastrocnemius medialis and right rectus abdominis, and erector spinae. The hair on the o uter layer of the skin was removed by shaving, and after shaving, the skin surface was disinfected with an alcohol cotton. Two surface electrodes were attached at a distance of 1 cm from the insertion site of the needleing electrode, referring to the guideline. The description and appearance of the exact attachment location are as in Figure 2 and Table 3. The data processing process was set at 2,000Hz, and the data processing of the calculated data was analyzed with a band-pass filter of 20~450Hz and a root mean square (RMS) window size 100ms. The iEMG value per one time is the value obtained by dividing the iEMG extracted once by time and means the amount of exercise units mobilized per unit time.

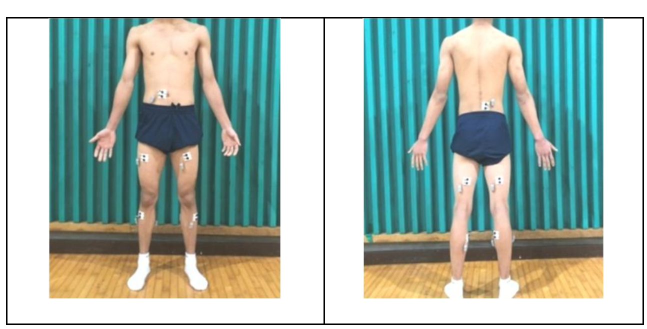

Figure 2. Electrode attachment

Table 3. Electrode attachment site

Separation	Region	Attachment region
Trunk	Erector spinae External oblique	Mid-point of lumbar 4-5. 2 cm below the medial side of the ASIS.
Lower	Rectus femoris	Midpoint of anterior inferior iliac spine patella

limb	Biceps femoris	The midpoint of the line between the fibula head and the sciatic nodule
	Tibialis anterior	The width of 4 fingers down from the tibia rough surface, and 1 finger wide from the tibia ridge.
	Gastrocnemius	The point that is 5 fingers wide inside the calf below the popliteal line.

2.5 Statistical Analysis

The data processing of this study was analyzed using the SPSS (ver 22.0) statistical program, and the mean and standard deviation were calculated for all variables. In addition, to analyze the difference in iEMG measured according to the EMG response of the trunk and lower limb according to the operation during spike and spike serve, repeated measurements two-way ANOVA were used. The simple and repeated methods of were applied, and the statistical significance level was set to α=0.05.

3. Result

3.1. Difference in Muscle Activity of the Trunk Muscles According to the Attack Method During Volleyball

There was no significant difference in the muscle activity of the erectile vertebrae according to the attack method, and there was a significant difference according to the interval ($p<0.001$). There was no interaction effect on the attack method and phase. During spike serve, the vertebral spinal column showed higher muscle activity than the take off phase, and the impact phase showed higher muscle activity than the follow phase. During the spike, the run-up, take off, and impact phases all showed higher muscle activity than the follow phase. The muscle activity of the rectus abdominis was not significantly different according to the attack method, and there was a significant difference according to the interval ($p<0.01$). There was no interaction effect on the attack method and phase. During spike serve, the rectus abdominal muscle showed higher muscle activity in the impact phase than in the follow phase. During the spike, the follow phase and the take off phase showed higher muscle activity than the impact phase in the rectus abdominal muscle. Table 4 shows the difference in muscle activity of the trunk muscles according to the attack method during volleyball exercise.

Table 4. Difference in muscle activity of the trunk muscles

*M±SD, Significant differences between time of before: *p<0.05, **p<0.01, ***p<0.001*

		Run jump	Takeoff Phase	Impact	Follow		F	P	contrast
ES	Sv	36.41 ±38.56	32.72 ±42.54	42.65 ±28.97	10.04 ±8.97	Attack Method(AM)	5.283	.051	①*>②③*>④
	Sp	41.75 ±49.33	25.22 ±13.67	67.35 ±41.88	20.79 ±27.91	Phase(P)	8.666	.000	①*②**③**>④
						AM×P	.881	.465	
EO	Sv	36.41 ±38.56	32.72 ±42.54	42.65 ±28.97	10.04 ±8.97	Attack Method(AM)	1.569	.246	①②③*>④
	Sp	41.75 ±49.33	41.75 ±49.33	67.35 ±41.88	20.79 ±27.91	Phase(P)	5.758	.004	①②<③**>④
						AM×P	2.591	.076	

ES: Erector spinae, EO: External oblique Sv: Spike serve, Sp: Spike

3.2. Difference in Muscle Activity of the Right Lower Limb According to the Aattack Method During Volleyball

The muscle activity of the right rectus femoris, biceps femoris, anterior tibialis, and gastrocnemius medialis muscles did not show any significant difference according to the attack method, but showed significant difference according to the interval (p<0.001, p<0.01). There was no interaction effect on the attack method and phase. The muscle activity of the right rectus femoris by phase was significantly higher in both the spike serve and spikes than in the follow phase, in the run-up phase, the take off phase, and the impact phase. The muscle activity of the right thigh biceps muscle by phase was significantly higher in the run-up phase, the take off phase, and the impact phase than the follow phase during serving, and significantly higher in the trailing phase and impact phase than the follow phase during spikes. The muscle activity for each phase of the right anterior shin muscle was significantly higher in the run-up phase and the take off phase than the follow phase when serving, and significantly higher in the run-down phase, the take off phase, and the impact phase than the follow phase during spikes. appear. The muscle activity of each phase of the right gastrocnemius medialis muscle was significantly higher in the run-up phase than the impact phase and the follow phase when serving, and the impact phase was significantly higher than the follow phase. The results of the difference in muscle activity of the right lower limb muscle according to the attack method during volleyball exercise are shown in Table 5.

Table 5. Difference in muscle activity of the Right Lower limb muscles

*M±SD, Significant differences between time of before: *p<0.05, **p<0.01, ***p<0.001*

		①Run jump	②Take off	③ Impact	④ Follow		F	P	contrast
RF	Sv	114.62 ±71.86	63.49 ±33.43	66.07 ±36.28	33.51 ±16.49	Attack Method(AM)	.423	.533	①**>②*③**>④
	Sp	115.12 ±69.79	72.64 ±40.47	78.08 ±40.15	35.59 ±29.50	Phase(P)	11.130	.000	①**②*③**>④
						AM×P	.236	.870	
BF	Sv	103.96 ±65.48	62.68 ±22.49	70.18 ±16.88	27.87 ±13.12	Attack Method(AM)	2.139	.182	①**②**③***>④
	Sp	102.18 ±40.92	66.71 ±17.50	97.00 ±55.11	40.81 ±35.85	Phase(P)	12.620	.000	①**>②③**>④
						AM×P	1.028	.398	
TA	Sv	164.53 ±43.59	59.5 ±19.63	41.62 ±25.58	29.76 ±18.1	Attack Method(AM)	.165	.695	①***>②*③>④
	Sp	169.35 ±80.38	60.99 ±14.71	47.21 ±21.53	30.07 ±7.89	Phase(P)	36.100	.000	①**>②**③*>④
						AM×P	.047	.986	
GM	Sv	104.20 ±21.59	59.85 ±21.25	53.26 ±16.22	30.14 ±10.94	Attack Method(AM)	4.465	.068	①***>②③**>④
	Sp	90.56 ±30.13	58.32 ±12.11	44.93 ±17.96	28.16 ±16.72	Phase(P)	47.157	.000	①***>②**③**>④
						AM×P	.621	.608	

RF:Rectus femoris, BF:Bicepsfemoris, TA:Tibialis anterior, GM:Gastrocnemius medialis, Sv:Spike serve, Sp: Spike

3.3. Difference in Muscle Activity of the Left Lower Limb According to the Attack Method During Volleyball

There was no significant difference in the muscle activity of the left rectus femoris, biceps femoris, anterior tibialis, and gastrocnemius medialis muscles according to the attack method, but showed a significant difference according to the interval (p<0.001, p<0.01). There was no interaction effect on the attack method and phase. The muscle activity of the left rectus femoris and left rectus femoris was significantly higher than the follow phase in the spike serve, in the runway phase, in the take off phase, and in the spike phase, and in the spike, in the take off phase and spike. The phase was significantly higher than the follow phase. During spike serve, the muscle activity of the left biceps femoris was significantly higher than the follow phase in the run-up, take off, and spike phases, and in the spikes, the doe-close phase and the spike phase were significantly higher than the follow phase. The muscle activity of the left anterior tibialis by phase was significantly higher in the run-up phase and the take off phase than in the follow phase in both spike serve and spike. The muscle strength of the gastrocnemius medialis by phase was significantly higher in both the spike serve and the spikes in the run-up, take off, and spike phases than the follow phase. The results of the difference in muscle activity of the left lower limb muscle according to the attack method during volleyball exercise are shown in Table 5.

Table 6. Difference in muscle activity of the Left Lower limb muscles

*M±SD, Significant differences between time of before: *p<0.05, **p<0.01, ***p<0.001*

		①Run jump	②Take off	③ Impact	④ Follow		F	P	contrast
RF	Sv	82.43 ±62.76	85.81 ±45.76	88.71 ±43.98	26.97 ±12.19	Attack Method(AM)	.063	.808	①*②**③**>④
	Sp	76.66± 52.72	80.59± 38.32	93.45± 42.92	39.30 ±22.34	Phase(P) AM×P	8.147 .778	.001 .518	①②*③**>④
BF	Sv	125.28± 73.16	57.82 ±30.70	60.30 ±22.14	30.05 ±15.61	Attack Method(AM)	.003	.958	①**>②*③**>④
	Sp	135.51± 52.53	53.89 ±16.90	60.38 ±33.76	25.65 ±10.28	Phase(P) AM×P	31.560 .313	.000 .816	①***>②③**>④
TA	Sv	155.85± 50.85	63.78 ±26.58	45.82 ±32.52	24.62 ±15.06	Attack Method(AM)	.003	.955	①***>②*③>④
	Sp	153.73± 60.73	54.53 ±18.53	43.91 ±16.54	39.44 ±15.50	Phase(P) AM×P	48.984 .487	.000 .694	①**>②**③*>④
GM	Sv	135.22± 25.91	70.09 ±23.37	68.55 ±24.89	34.11 ±14.64	Attack Method(AM)	.120	.068	①***>②③**>④
	Sp	136.79± 37.85	69.61 ±9.70	65.73 ±33.40	41.48 ±14.80	Phase(P) AM×P	68.887 .138	.000 .936	①***>②**③**>④

RF:Rectus femoris, BF:Bicepsfemoris, TA:Tibialis anterior, GM:Gastrocnemius medialis, Sv:Spike serve, Sp: Spike

4. Discussion

During the volleyball game, Spike Serve and Spike have become more powerful and dynamic due to the recently stipulated rules. However, this change is thought to be a situation where players need to consider physical problems, risk of injury, and even changes in training methods. Therefore, this study aimed to investigate the trend of the use of the agonist muscles by examining the EMG responses of the trunk muscles and lower limb during spike and spike serving in 9 middle school volleyball players, and the discussion of the results appeared as follows.

Integral electromyography (iEMG) obtained by integrating electrical signals from muscle activity during exercise after full-wave rectification and filtering can be used to determine the amount of muscle activity by observing the amount of exerted muscle strength and exercise unit [15]. As the load increases or the fatigue increases, it increases [16], and at this time, a large unit of exercise is additionally mobilized to maintain exercise performance [17]. This is because the decrease in pH due to the accumulation of potassium ions and hydrogen ions due to the effect of anaerobic metabolism caused by exercise affects the binding power of calcium and troponin and the calcium affinity of the muscular reticulum [18]. In addition, Albuquerque & Thesleff [19] and Luff & Atwood [20] suggested that the action potential of the motor unit according to the muscle fiber type differs in size and conduction velocity. Kao et al [18] found that the ratio of type II fibers is high. It is said that the iEMG slope is high and fatigue occurs easily. Therefore, research on muscle activity has been conducted in various ways for motion analysis in the sports field, and in this study, the muscle activity of the torso and lower limb muscles according to the attack method during volleyball exercise was carefully examined.

As a result, there was no difference in muscle activity according to the attack method, and although there was a slight difference in significance for each muscle, there was a significant difference in each phase. These results were discussed as follows.

The muscle activity of each phase of the erectile vertebrae was the highest in the closed phase. It is known that the vertebrae erect muscle stretches the hip joint and torso [21]. Park Hong-gyun and Kim Seung-kwon [22] argued that the increase of the hip joint angle in the run-off phase is important to increase the vertical speed when jumping. Therefore, in this study, the greatest muscle activity was shown in the vertebral vertebrae in the run-up phase because the spike serve and the spike of volleyball have an impact at a height of 3m [23].

The muscle activity of each phase of rectus abdominis was highest in the closed phase. It was the highest in the impact phase. The rectus abdominal muscle acts to bend the body [21]. The impact phase is a phase in which direct force is transmitted to the ball at the moment of hitting the ball for attack while floating in the air after jumping. Jenkins et al [24] reported that iEMG tended to increase as the weight load increased. In addition, Kernell [25]stated that the number of exercise units mobilized depends on the firing rate, and that the amount of exercise units mobilized determines muscle strength. If you look at the angle of the body in the follow phase after the impact phase, you can see that it is bent and landed. It can be seen that the force to bend the body is strong in the impact phase. Therefore, it is thought that the highest muscle activity in the rectus abdominis muscle in the impact phase is accompanied by a strong force in the rectus abdominis muscle [26]. reported that the basic function of the kinematic process that accompanies landing on the ground in all movements is to reduce the impact [27]. measured the ground reaction force against different jumping methods during spikes in 86 volleyball players. The maximum ground reaction force of the jumping method of jumping using both feet at the same time was over 1500N [28]. stated that the bending and extension of the knees and ankles require a strong force when running and landing during volleyball games. In this study, both the spike serve and iEMG during spikes had slightly different mean and standard deviation depending on the interval, but all muscles had higher iEMGs in the run-up interval than in the take-up interval and in the spike interval than in the follow interval. appear.

In this study, the jump method of spike and spike serve was set to double-legged jump, and the double-legged jump method generated a large force [27]. Muscle activity increases when a large number of motor units are mobilized or when strong force is exerted [25]. In this study, the muscle activity of all muscles except the left thigh muscle tended to be the highest in the close-up phase. The run-and-run phase is a jump motion, from the start motion of the spike serve and the spike to the phase where the foot falls off the ground [29]. Therefore, it is thought that the highest muscle activity in the run-off phase during spike serve and spike in this study is that the stability of the lower limb in the run-out phase and a large force for high jump are required.

5. Conclusion

The purpose of this study was to analyze the muscle activity of each phase according to the attack method during volleyball exercise, and to observe the expression level of the trunk and lower limb muscles according to the spike serve and spike serve phase, and the following results were derived. Regardless of the attack method, the vertebral vertebrae and lower limb showed the highest muscle activity in the close-up phase, and when the rectus abdominal muscle was released, the greatest muscle activity was shown in the impact phase regardless of the attack method. In summary, there are spike serve and spike methods in volleyball attack methods. These two methods are the most powerful offensive methods of volleyball, and more effective exercise methods are needed through motion analysis. Therefore, We found out that as a result of analyzing the muscle activity of the active muscles during spike serve and spike in this study, explosive power is required for the lower limbs and erectile muscles for a higher jump in the close-up phase, and a strong force is transmitted to the ball at the moment of impact. For this, it was confirmed that the greatest force was applied to the rectus abdominis. Therefore, it is considered that follow-up research and research for improvement of attack ability and development of exercise methods are necessary.

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