Comparison of Lower Limb Muscles Electromyography Activity Between Vertical and Long Jumps as a Certified Test of Muscle Power in Athletes

Dr/ Mosaid N. Alalyani[*]
Dr/ Abdulazeem Saud Alotaibi[**]
Dr/ Mohammed M. Abdelaziz Ahmed[***]
Dr/ Basman Abdul Jabbar[****]
Dr/ Hani Abdul Aziz Ibrahim Saleh[*****]

Abstract:

The aims of this study were to compare the difference of the EMG signal for the lower limbs Between Vertical and Long Jumps as a Certified Test of Muscle Power in Athletes. The performance of 14 Saudi elite athletes in different sports, the authors collected data by measuring EMG using DELESYS, one of the leading products in electrical activity measuring equipment by conducting vertical and long jump test, the main experiment was conducted on November 2019 in the biomechanics lab located inside the Biomechanics and Motor Behavior Department of the College of Sport Sciences and Physical Activity at King Saud University. The results of this study included that femoral muscles contributed most during the long jump test, tibial muscles contributed most during the vertical jump test, all muscles except for the anterior tibial muscle had high contribution rates in the long and vertical jump tests.

Keywords: Explosive strength, Biceps femoris, Rectus femoris, Tibialis

[*]King Saud University, Department of Biomechanics & Motor Behavior, College of Sport Sciences & Physical Activity, Riyadh, Saudi Arabia
[**] Associate Professor in Physical Education & Movement Science Department, Al Qassim University, Saudi Arabia
[***] King Saud University, Department of Biomechanics & Motor Behavior, College of Sport Sciences & Physical Activity, Riyadh, Saudi Arabia
[****] Lecturer, University of Edinburgh, British Scotland
[*****] Assistant Professor in Sports Training and Movement Science Department, Faculty of Physical Education for (Men – Girls) in Port-Said, Port-Said University, Seconded to work as Associate Professor in Physical Education & Movement Science Department, Al Qassim University, Saudi Arabia

Introduction:

The importance of the muscular power in sporting activities highlighted as the main factor in achieving achievement in many sports activities, the importance of the muscular power distinguished to be one of the important factors of high achievement in many sports activities.

Muscles power mean the force applied by the time which mean the velocity of movement[1], muscular strength has been defined as the ability to exert force on an external object or resistance[2], an individual's sport or event, he or she may have to exert large forces against gravity in order to manipulate their own body mass (e.g., sprinting, gymnastics, diving, etc.)[2] , power described in many papers as a dynamic force is a desirable variable in many sport disciplines[3].

The common misuse of the term "power" in the literature has apparently led to the misleading concept that "fast" speed muscular force output tests measure "power," while "slow" speed force output tests measure strength power is generated and can be measured in any dynamic movement associated with an applied force, regardless of speed[4].

The mathematical expression of power is (Force × Distance) / Time. In a jumping motion, the distance and time over which force are applied occur when force is exerted against the ground when the individual extends their hips, knees, and ankles[5].

Power is the ability to move weight with speed Being strong does not always translate to being powerful. For example, a strong lower body can do a heavy squat slowly, but it can't necessarily generate the power to do the same lift with speed. Power is explosiveness[6].

Mechanical power is the mechanical principle of the rate at which the athlete does work or transfers energy to complete a movement task, A mechanical power balance analysis can provide valuable insight in the capability of athletes to generate power, and also in technique factors affecting the effective use of power for performance, the estimates of mechanical power are usually limited by the capabilities of motion capture systems, resulting in the necessity to use simplified

power models. However, due to the introduction of these simplified models and thus variation in how power is calculated, the overview in literature in the terminology and estimation of mechanical power is disordered, furthermore, the validity of the simplifications is often disregarded[7].

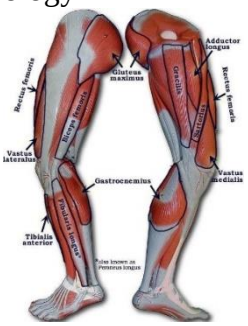

Fig (1)
Legs Muscles

Muscular power depends on a multitude of factors, among them neuromotor, and biomechanical ones (e.g., muscle contraction characteristics Herein lies the difficulty in pointing at one or a few characteristics that predict a person's capacity to exert muscular power[8].

Many studies indicate to the relationship that may encapsulate some of the major aspects involved in the generation of muscle power is the Force-Velocity relationship, according to Hill's model, muscle fibers cannot develop maximal force at maximal speed and vice versa, it is only at an optimal combination of muscle contraction force and velocity that maximal power levels P max can be achieved[8].

Vertical jumping is regarded as an important and attractive element of many sports such as basketball and volleyball and it is common in Physical Education, Fitness or Sports programs to use the vertical jump tests[9].

In vertical jump the lower limbs muscles worked according to the torque levels which produces by the flexion and extension of the joints (knee, ankle and the hip), Muscle activation and isokinetic torque levels are often measured simultaneously[10], the studies reported 250–300 high power

activities of which 50% were jumps of various types that require hip extension, knee extension and ankle plantar flexion Knee extensors are maximally active during landing (deceleration and the control of knee flexion while working eccentrically) and during the take-off phase of the jump, while medium activity is observed during the amortization phase of the jump[11].

In vertical jump and long jump to measure the power of the leg muscles we use EMG because EMG is an experiment-based method for evaluating and recording a series of electrical signals that emanate from body muscles. The EMG signals are formed by physiological variations in the state of muscle fiber membranes, the EMG signals are based upon action potentials at the muscle fiber membrane resulting from depolarization and repolarization[12].

In vertical jump and long jump appear several characteristics of force, such as maximum force, time to reach maximum force and the rate of force development, are associated with performance which mean the distance of the jump[13].

Long jump is a standard test for the assessment of lower limb explosive strength, which is one of the determinants of success in all activities that require a demonstration of the maximum muscle force in the shorter period of time, this test is very often used in education, sport and recreation for measuring children, students, athletes[14].

Thus, the main aims of the present study were: (a) to identify the differences in the EMG of the lower limbs muscles in vertical and long jump, and (b) to identify the differences between the vertical and long jump as a certified test for the muscular power for athletes.

Materials and Methods:

Research Methodology: - The researchers used experimental method

Participants: - Fourteen male participants volunteered to participate in the study, they were chosen from elite players in different sports, as shown in table (1).

table (1)
Distribution of the study sample according to sports

Football	Basketball	Karate	Tennis	Track & field
4	4	2	2	2

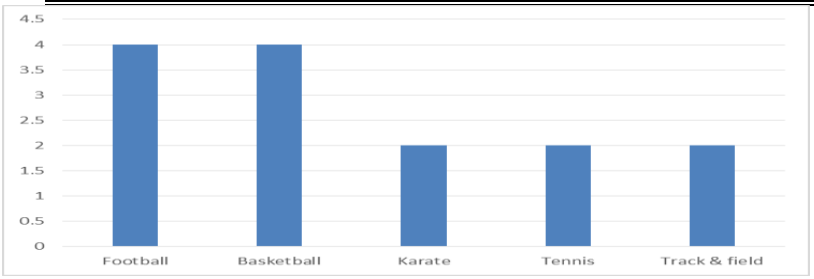

Fig (2)
Distribution of the study sample according to sports

The information about the research sample as shown in table (2):

Table (2)
The means and coefficients of skewness for the research sample

Statistical processing Variables	Lowest value	Highest value	Range	Mean	Coefficients of skewness
Age (years)	١٩	٢٦.٦	٧.٦	٢٣.٢	٠.٣٩٨-
Height (cm)	١٦٨	١٩٢	٢٤	١٧٦.٤	٠.٢١٦-
Mass (kg)	٦٦	٩٤	٢٨	٧٤.٣	٠.٢٤٣-

The range of the coefficients of skewness was -0.398, -0.216, which was evident in the homogeneity of the variables of age, height, and mass in the sample.

Devices and tools used:

- DELSYS Trigno wireless EMG measurement.

- Tape to install EMG electrodes on the skin.

- Razor blade.

- Weight scale.

- Measuring tape.

- Surface electrodes install on the skin .

Research Tests: -

1- Sargent vertical jump test.

2- Standing long jump test.

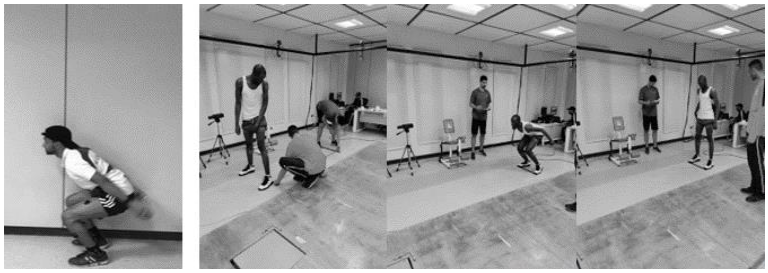

Fig (1)

(a) Vertical jump test. (b) Standing long jump test

The researchers completed a pilot study for the purposes of checking all the equipment and to clarify the aims of the study to the research sample and the working team.

Main experiment: -

The main experiment was conducted during the period from 10/2019 to 11/2019 in the Biomechanics Laboratory in the Department of Biomechanics and Kinetic Behavior - College of Sports Science and Physical Activity - King Saud University, each player performed two attempts for each test (vertical jump - long jump).

Ethical approval: -

1- All participants were informed about the benefits, discomforts, and possible risks of the study and signed a free and informed consent term before participation.

2- The approval of the Scientific Research Ethics Committee at King Saud University was taken to conduct the experiment.

3- The department and laboratory administration were approved to conduct the experiment.

Research variables: -

- Root Mean Square Value (RMS) for (EMG) measure unit is microvolt.
- Muscles tested were (Right and left Biceps femoris, Right and left Rectus femoris, Right and left Gastrocnemius, Right and left tibialis anterior)

Statistical analysis: -

Data for the two legs were analyzed using SPSS version 21 to determine the mean, standard deviation, Wilcoxon test, Friedman test, and ANOVA test.

Result:

Table (3)

Average ($\bar{X}$) results of EMG for lower limbs muscles

Research sample	Attempts	Right Rectus femoris		Left Rectus femoris		Right Biceps femoris		Left Biceps femoris	
		Vertical	Long	Vertical	Long	Vertical	Long	Vertical	Long
$\bar{X}$ (µV)		438.52	305.87	281.81	297.93	425.62	272.25	342.71	299.62
SD		١٠٢.٣	٩٨.٢	٢٠٦.٩١	160.5	٩٩.١	١٥٧.٤٨	١٠٥.٨١	٩٢.٥٢
Research sample	Attempts	Right Tibialis anterior		Left Tibialis anterior		Right Gastrocnemius		Left Gastrocnemius	
		Vertical	Long	Vertical	Long	Vertical	Long	Vertical	Long
$\bar{X}$ (µV)		255.93	241.25	240.37	233.50	388.71	482.00	236.71	359.06
SD		٨٠.٢٣	١٠٣.٤	٧٥.٠٩	٦٧.١٨	١٤٥.١٧	٢٩٠.٨١	١٠٤.٤	١٣٢.٩٨

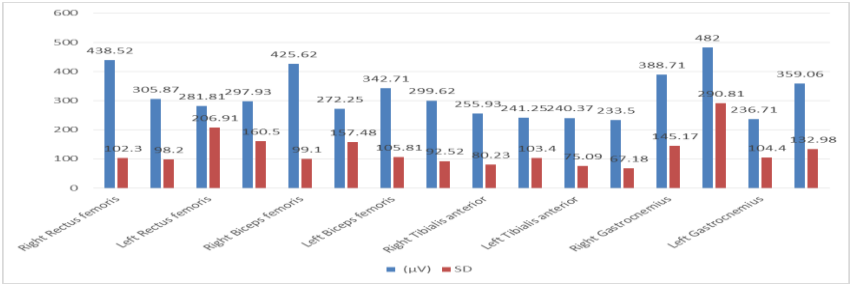

Fig (3)

The ratios of the contribution of EMG values of the selected lower limbs muscles in vertical and long jump

Table (4)

Williamson test for the significance of the statistical differences between the averages of EMG values for the lower limb's muscles for long jump and vertical jump test

EMG signal (µV)	average of ranks		Sum of Ranks		(Z) value	Significance level
	+	-	+	-		
Left Gastrocnemius	9.33	7.43	84.00	52.00	-0.828	0.408
Right Gastrocnemius	8.00	9.33	80.00	56.00	-0.621	0.535
Left Tibialis anterior	9.30	8.14	46.50	89.50	-1.112	0.266
Right Tibialis anterior	6.78	10.71	61.00	75.00	-0.362	0.717
Left Biceps femoris	10.00	10.00	46.00	90.00	-1.138	0.255
Right Biceps femoris	9.56	9.56	59.50	76.50	-0.440	0.660
Left Rectus femoris	9.60	9.60	40.00	96.00	-1.448	0.148
Right Rectus femoris	11.00	11.00	70.00	66.00	-0.103	0.918

Discussion:

From the table (3) and figure (2), which indicates the averages and standard deviation for the EMG signal for selected muscles, to analysis and identify goal (a) of this study which discuss the Average results of measuring the EMG of lower limbs muscles during the performance of the long jump and vertical jump test.

It appears that right Rectus femoris muscles recorded the highest for the EMG signal in the long jump test, and for the vertical jump test the highest signal was for the Left Biceps femoris muscles, Power-generating capacity is essential in explosive oriented physical test such as vertical or long jump, this will be generated by the lower limbs muscles15.

The high ratio of contribute for the femoris muscles because of the direction of task in long jump in comparison with the vertical jump the high ratio was for the Tibialis and Gastrocnemius muscles[16].

For aim (b) and identify the differences between the vertical and long jump as a certified test for the muscular power for athletes, it shows from the results in Table (4) there were no significant differences appeared between the vertical jump and long jump tests of the muscles EMG although there were differences in the muscle contribution ratios between the two tests, this may have been caused by the anatomical and mechanical differences between both jumps[17], and also it related to the different in the direction of the torque during the jump.

Conclusion: -

Through the aims of the study and the research results the researchers concluded the following: -

- During performing the long jump test, the femoral muscles is the are the most contributing.
- During performing the vertical jump test, the tibial muscles is the are the most contributing.
- All muscles have a high contribution rate in the long and vertical jump test except the anterior tibial muscle.

Conflict of Interest: -

The Researchers declare that they have no conflict of interest.

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