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RELATIONSHIP OF LIMB GIRTH, SEGMENTAL LIMB LENGTH, HAMSTRING FLEXIBILITY WITH VERTICAL JUMP IN MALE SPORTS PLAYERS

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ABSTRACT

Objective: To determine if upper and lower body segment length, girth and hamstring flexibility contributes to vertical jump (VJ) displacement.

Methods: Two hundred male sports players aged between 18 to 25 years were recruited. Upper limb length (humerus, ulna, hand), lower limb length (femur, tibia, foot), upper limb girth (arm, forearm), lower limb girth (thigh, calf) and hamstring flexibility were assessed. The subjects were asked to perform VJ and the average of 3 readings was calculated.

Results: Data was analyzed using Pearson's correlation. The results showed a moderate positive correlation of lengths of humerus, ulna, femur, tibia, foot with VJ ($p<0.05$). Thigh girth, calf girth, and hamstring flexibility showed a weak positive correlation with VJ ($p<0.05$). However the length of ulna and girth of arm did not show any significant correlation with VJ.

Conclusion: Segmental limb length (humerus, hand, femur, tibia, foot), limb girth (forearm, thigh, calf) and hamstring flexibility may contribute to a higher VJ.

Key Words: Vertical Jump, Limb length, Limb girth, Hamstring Flexibility

INTRODUCTION

Vertical jumping is an important aspect of various sports such as basketball, volleyball, and football. Performance of jumping has now become an important part in testing physical abilities in sports players[1]. In particular, it has been shown that the height of various types of VJs could serve for assessment of muscular strength and power[2] and muscle fiber composition[3].It has been found that a jump height can be affected by various factors, such as muscle mass[4-7], flexibility, isometric muscle strength, age, height, weight[8], and level of expertise[9].

During a VJ, muscle force is produced primarily from the back extensors, gluteus maximus, quadriceps, gastronemius, and soleus resulting in a powerful ground reaction force that propels the body upward against gravity. Greater muscle girth may lead to greater production of propulsive force and may have a beneficial influence on VJ.

It is theorized that body segment length (trunk, femur, tibia, and foot) may influence vertical jump displacement. As in any lever system, the length of the lever arm affects joint torque, with longer lever arms possessing the ability to impart greater force[10]. Take-off velocity during a vertical jump was approximately 10% higher while a jump is performed with arms compared to when the arms are restricted[11]. Research has shown that 60% of the increased performance were due to an increase in take-off velocity[12].It has been widely reported that take-off velocity can be enhanced by 6–10% or more when using an arm swing[11,13,14]. The arms can be used while jumping to create a rotary force, or torque, which is the product of force and the perpendicular distance from the line of axis to the axis of rotation. There is increased torque at the hip and knee joints during the propulsive phase of jumping when using an arm swing[12]. A body segment length that improves the arm torque during initiation of a VJ could improve the height of the jump.

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Flexibility of muscle is the ability of muscle to lengthen, allowing one joint or more than one joint in a series to move through a range of motion[15]. Good muscle flexibility will allow the muscle tissue to accommodate the imposed stress more easily and allow efficient movement. Enhancing the hamstring muscle flexibility may be another factor that can assist in improving VJ performance and may prevent or minimize injuries[16,17]

From the literatures reviewed there are conflicting results regarding the influence of above mentioned factors on VJ.[21,23]Very few studies have been done to find the correlation between hamstring flexibility and VJ. So this study aimed to find the relationship of hamstring flexibility, limb length and limb girth on VJ among sports players.

MATERIAL AND METHODS

This was a cross-sectional study conducted on 200 male sports players aged between 18 to 25 years who participated in at least one tournament of one or more sports such as basketball, football and cricket in the last one year. Subjects were excluded if they had any history of recent surgery, recent fracture, immediate post-operative status and pain, musculotendinous injury, joint pathologies (such as arthritis, bone bruise or chondral injury), ligament or tendon injury, any neurological deficits, any spinal pathology, joint instability, any type of acute or chronic pain which restricted movements of upper limb, lower limb and trunk.

Institutional ethical committee approval was taken and verbal advertisement was done in the university. After screening informed consent was obtained. The subjects were asked to perform arm-reach height and VJ and the following variables were measured.

1. Length measurement of Aram, Forearm, Hand, Thigh, Leg, and Foot were measured using the length of Humerus, Ulna, Hand, Femur, Tibia and Foot respectively [18]

a. Humerus - Humerus length was measured from the lateral lip of the greater tuberosity to the lateral epicondyle.
b. Ulna - The subject was asked to flex the elbow to 90 degrees and the ulna measurement was taken from the olecranon down the ulnar ridge to the ulnar styloid process.
c. Hand - The hand was held palm up and measurement was taken from the proximal palm at the level of lunate to the distal end of the third phalanx.
d. Femur – This was measured from the greater trochanter of the femur to the lateral joint line of the knee.
e. Tibia - Tibia length was measured as the distance from the medial joint line of the knee to the medial malleolus.
f. Foot - Foot length was measured from the posterior heel to the longest toe.

2. Girth measurement[18]

a. Arm – Palm up, arm straight and extended in front of the body, measurement taken at the midpoint between the shoulder and elbow.
b. Forearm – Measurement was taken at maximum girth with the arm extended in front of the body and palm up.
c. Thigh – Measurement was taken at upper thigh just below the buttocks.
d. Calf – Measurement was taken at widest girth midway between the ankle and knee.

3. Test for hamstring flexibility[19]

Active knee extension test (AKE): The subjects had to lie supine on a bench with right hip and knee flexed to 90 degrees. They were then instructed to hold their femur by using their right hand and was asked to maintain this position throughout the test. The participants were then instructed to extend their right leg as far as possible, keeping their feet relaxed, and hold the position for five seconds. Each participant performed a single repetition of the movement to familiarize themselves with action. A second repetition was performed during which the angle of knee extension was measured at the end of 5 seconds hold period. The angle of knee extension was measured using a standard Perspex Goniometer (Physiomed, Manchester, UK). Center of the Goniometer was positioned over the axis point previously marked on the lateral joint line, and the Goniometer arms were positioned along the lines marked on the femur and fibula and the knee extension range in degrees was noted.

4. Vertical Jump Test (VJT)[20]

The VJT was done using a wall mounted inch tape.

The subjects were asked to stand straight with dominant side next to the wall, both feet firmly on the ground. The subjects' finger tips were marked with chalk powder and they were instructed to touch the wall as high as possible. Subjects performed a countermovement consisting of bending knees and hips while at the same time flexing the trunk. Each subject was instructed to lower themself to a most comfortable point at the same time moving their arms back into hyperextension. Then the subjects would leap vertically as high as possible using both arms and legs, assisting the body upwardsand the highest point reached was marked and recorded. Three readings were taken and an average was calculated.

STATISTICAL METHODS

The data collected was analyzed using SPSS version 17 software. Kolmogorov Smirnov test of normality was used. The mean of hamstring flexibility, limb length, and limb girth was calculated. Pearson's correlation coefficient test was used to analyze the relation of hamstring flexibility, limb girth, limb length with VJ. Level of significance was set at $p<0.05$.

RESULTS

As evident from table 1, there was a moderate positive correlation of humerus, hand, femur, tibia, foot length with VJ. There was a weak positive correlation of forearm girth, thigh girth, calf girth, and hamstring flexibility with VJ. No significant correlation between ulnar length, arm girth and VJ was noted.

Table 1: Correlation of limb length, girth & hamstring flexibility with VJ (n=200)

Variables	Mean	Standard deviation	Pearson Correlation (r)	p value
Humerus Length(cms)	12.07	0.98	0.552	<0.001**
Ulna Length(cms)	11.24	7.78	0.003	0.961
Hand Length(cms)	7.78	0.47	0.420	<0.001**
Arm Girth (cms)	11.90	1.75	0.077	0.227
Forearm Girth(cms)	10.35	1.10	0.213	0.002**
Femur Length(cms)	16.84	1.27	0.503	<0.001**
Tibia Length(cms)	15.08	1.32	0.467	<0.001**
Foot Length(cms)	9.21	0.70	0.492	<0.001**
Thigh Girth(cms)	19.12	1.88	0.324	<0.001**
Calf Girth (cms)	13.30	1.49	0.235	<0.001**
Hamstring flexibility (degrees)	67.32	8.88	0.389	<0.001**

**correlation significant at p<0.05

DISCUSSION

This study was conducted on male sports players between the age group of 18 to 25 years. The aim of the study was to provide knowledge about the important factors that influence the jumping ability. It was theorized that the limb length, limb girth, and flexibility of hamstring may lead to greater production of propulsive force and may have an influence on VJ.

The results of the present study showed that the lengths of the humerus, hand, femur, tibia, and foot had a significant correlation on VJ. These findings disagree with the results of the study done by Davis DS et al[21] in 2006 which reported that VJ displacement could not be predicted by skeletal length measures.

The girth measurements of the forearm, thigh, and calf had a significant mild correlation with VJ. These findings are supported by a study done by Fattahiet al[22]on the relationship between anthropometric parameters with VJ in male elite volleyball player. Crewtheret al[23] reported that greater calf circumference has a significant correlation with VJ and muscle size affects the force producing ability and jump performance. Perhaps, a greater physiological cross section of muscles contains more sarcomeres contributing in muscular contractile property which leads to more cross bridge formation and finally a greater force production. Athletes, particularly those specializing in jumping (e.g., high jump or long jump), train more for muscle strength and power specifically to achieve higher jumps.This study also showed that there is a weak positive correlation between hamstring flexibility and VJ. Turki B et al[24] in 2011 found that ten minutes of dynamic stretching were sufficient to potentiate VJ performance characteristics. This shows that flexibility is an important factor that influences VJ.

Various physiological and biomechanical parameters influence the amount of VJ[25]. Vertical velocity components and gravity determine the VJ. The result of generating torques transmission to the ground act as a ground reaction force in the form of an external force is necessary for the jumping process. Joint's Torque is generated from muscle contraction during structure displacement. Final torque in a joint is the difference of contractile forces in agonist and antagonist muscles. Moreover amount of force is also dependent on muscular properties. Ground reaction force should be greater than weight. Then, it will be transmitted to the body and determine the velocity of center of mass (COM). Consequent of five parameters including velocity, joint angle, COM height, air resistance and gravity force, all in takeoff phase, will lead to maximum of VJ[24]. Higher COM in jumpers is an advantage because it helps them to make more acceleration and force in a longer distance of the body, so by means of displacement, transmission of COM in vertical direction is easier.

CONCLUSION

Upper and lower body segment length (humerus, hand, femur, tibia, foot), girth (forearm, thigh, calf) and hamstring flexibility may contribute to a higher VJ. However the length of ulna and girth of arm did not show any significant correlation with VJ.

Scope for further studies

Further studies may be done to examine the interaction of more promising variables with VJ such as muscular strength and power, balance, coordination, body weight and composition, and jumping technique. Similar studies may be carried out in female sports players to check the influence of gender on VJ.

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