International Journal of Physical Education, Sports and Health 2023; 10(6): 238-242

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2023; 10(6): 238-242

www.kheljournal.com
Received: 16-10-2023
Accepted: 22-11-2023

KA Abhishek
Student, Research Scholar, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Aswin Raj V
Research Scholar, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Corresponding Author:
KA Abhishek
Student, Research Scholar, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Relationship between anthropometric and linear kinematic variables during countermovement jump in male volleyball players

KA Abhishek and Aswin Raj V

DOI: https://doi.org/10.22271/kheljournal.2023.v10.i6d.3162

Abstract
The purpose of the study was to understand how the counter movement jump (CMJ) in volleyball was influenced by the anthropometric and kinematic variables. The sample was composed of 10 male volleyball players, all the athletes involved in study had participated in inter university competition at least. The subjects performed a series of 6 counter movement jumps using BTS G-Sensor. Average displacement, acceleration, maximum jump height, peak speed and take-off speed were extracted from the equipment. The anthropometric variables like Standing Height, Weight, Thigh Girth, Calf Girth, and Leg Length were also measured using the instructions opposed by Kansal. The study found that there was a significant negative correlation between a player's height (Anthropometric) and the distance (Kinematic) they were able to displace during the counter movement jump whereas other variables show no change with CMJ at 0.05 level of significance.

Keywords: Countermovement, anthropometric and linear kinematic

1. Introduction
A lot of the core fields in the physical and biology sciences provide the foundation of the interdisciplinary field of biomechanics. In general, biomechanics is thought to be the area of science dealing with the fundamental law determining the impact forces have on an object's state of rest or motion, as opposed to the applied sections of biomechanics, which deal with solving real-world issues. An interest in biomechanics and using its concepts to enhance human mobility is shared by anatomicists, orthopedists, space engineers, industrial engineers, biomedical engineers, physical therapists, physical educators, dancers, and coaches. Professional applications may vary, but the same fundamental biomechanical laws serve as the basis for all of them.
It's best described as sports physics. The principles of mechanics are applied in sports biomechanics to comprehend athletic performance. Biomechanics is the branch of physics that examines the analysis of force interactions and is concerned with the application of mechanics to the study of biological systems. In terms of statics, there are two fields of study within mechanics: statics, which is the study of static systems in motion, such as stationary or inanimate items that are either immobile or maintaining constant velocity, such as cars, trucks, and airplanes, where there is acceleration, or standing or inanimate objects that are either moving slowly or steadily. It may be necessary to apply the concepts of kinematics (The study of motion utilising space, time, velocity, and speed) and kinetics (Forces connected to motion, such as push and pull).
A very well-known sport all throughout the world is volleyball. It's a fast-paced game where players must make quick decisions quickly on which volleyball technique to employ to put their team in the best possible position to score a point and potentially win the game. Every player in volleyball is expected to know how to pass, set, and serve the ball, and most players should be able to perform hindering and attacking techniques given their positions on the court.(Silva *et al*., 2014) [10].
A biomechanical study of the unique talents used by volleyball players allows for optimum

sporting performance while lowering the chance of injury. In both indoor and beach volleyball, successful competition heavily depends on the ability to jump. The height reached during a leap is inversely proportional to the velocity of the centre of mass (CoM) at take-off (vTO). Peak pressures and loading rates are often greater during landing than during takeoff. The momentum (mass-velocity) of the hand is transmitted to the ball during the overhead spike technique. The velocity and elastic characteristics of the hand are enhanced by coordinated muscular activation. The volleyball's trajectory is significantly impacted by spin and speed. Ball trajectories vary slightly depending on technique. The ball has low velocity and no rotation during a set, therefore the trajectory will be roughly parabolic (Tilp, 2017) [12]. Volleyball practises and games frequently involve vertical hops, which are crucial to both the attack and the counterattack (GLADDEN & D, 1978) [5]. In volleyball, block and spike jumps are the most crucial abilities to assess. (Ziv & Lidor, 2010) [15].

A number of sports that call for explosive action use the vertical leap as a key performance indicator (Kraska *et al*., 2009) [8]. One of the finest ways to gauge the strength of the lower limb muscles is to conduct a vertical jump. Agonist muscles move eccentrically and then concentrically, and the usage of the elastic energy generated throughout the stretch shortening cycle contributes significantly to jump performance. However, there is only the concentric labor phase, and the athlete's capacity for neural recruitment essentially determines how well they execute. (Bosco & Komi, 1979) [2]. Anthropometry is the measurement of the human body based on bone, muscle, and fat tissue. The Greek word "anthropometry," which refers to the measuring of the human form, is derived from the words "anthropo" and "metron" (Topaloğlu Ören *et al*., 2019) [13]. The science of measuring various human body components is known as anthropometry. Weight, stature, recumbent length, skinfold thicknesses, circumferences (head, waist, limb, etc.), limb lengths, and breadths (shoulder, wrist, etc.) are examples of anthropometric measurements. The movement of the human body is the focus of this area of biomechanics.

Amount, speed, and consistency are used to define movement (Hay, 1973) [6]. Classical mechanics, often known as "Kinematics," focuses on points, bodies (i.e., objects), and body structures (i.e., collections of items) without taking into account the outside forces that govern their motion (Whittaker, 1904) [14]. Positions, velocities, and accelerations are used in a kinematic movement analysis to explain the kinematic movement of one or more body parts. Measure angles around joints or measurements that include angles and linear measurements when measuring a specific body part. (Singer *et al*., 2016) [11].

There are numerous studies related to Anthropometric and Kinematic variables. As Countermovement Jump is an important technique in propelling the body into air in order to hit the ball with maximum efficiency. The researcher keens to know that, does difference in Anthropometric variables influence Linear Kinematic and variables which contribute to jump performance of the volleyball players.

2. Methodology

Subjects

For the purpose of the study, ten male Interuniversity volleyball players of L.N.I.P.E were taken. The age of the subjects was between 20 to 24 years. Purposive sampling technique was used for choosing the players from the total population. This was considered that they posses' good level of fitness and free from lower extremity injury. The following variables were selected:

2.1. Anthropometric Variables

1. Standing Height
2. Weight
3. Thigh Girth
4. Calf Girth
5. Leg Length

2.2. Linear Kinematic Variables

1. Displacement
2. Acceleration
3. Maximum Jump Height
4. Peak Speed
5. Take-Off Speed

2.3 Procedure of Data collection for the Anthropometric Variables

Height the subject is asked to stand erect, barefooted on a plane horizontal surface against a wall, with his/her heels, back of the shoulders and head touching the wall. He/she is requested to stretch the body upwards as much as possible without his/her heels leaving the ground. The head and face are checked for its being in Frankfurt horizontal plane. To get it easily, the subject is asked to see towards an object in front of him approximately at a height of his eyes, then the investigator adjusts the tracheon and infraorbital points in a horizontal line. The anthropometer rod is kept in front of the subject and the crossbar of the anthropometer is adjusted so that its lower edge touches the highest point of the subject's head 23 (i.e., point vertex). The measurement is recorded from the anthrop meter's eye correct up to 0.1 cm. Weight Except brief undergarments the subject is asked to take off his/her shoes and clothes. The subject stands erect on the platform of the balance with equal weight on both feet. The weight is recorded accurate up to 0.5 kg. The zero error (alignment) of the machine is checked both before asking the subject to stand on its platform and after the subject get down.

Calf circumference: The steel tape is wrapped horizontally around the naked lower leg of the subject at the maximal bulge of the calf muscle. With slight up and down movements of the steel-tape keeping it in a horizontal direction, the maximal circumferential measurement gives the value of calf circumference. Leg length Calculated by subtracting sitting height from standing height.

Thigh circumference: The subject wearing only undergarment is asked to stand at ease with equal weight on both the feet. The middle of the thigh is marked by a horizontal line dividing the distance between the trachanterion and the lateral and lower most point on the lateral condyle of femur, in equal two parts. The steel-tape is wrapped around the thigh at the level of the horizontal line and the circumference is measured by keeping the steel-tape in a horizontal direction and touching gently thigh surface all around.

2.4 Procedure of Data collection for the Kinematic variable

The Counter Movement Jump with arm thrust aims at evaluating the explosive force due to both the elastic energy stored during the stretch-shortening cycle and the upper limb coordination. The subject starts in an upright position with feet at shoulders distance and hands on hips. Then the subject jumps helping him with both arms, after doing a countermovement downwards up to a knee bending of 90º. (BTS G-Sensor manual, 2018)

2.5 Statistical Technique

Standard descriptive statistics (mean±standard deviation) were determined for directly measured and derived variables. The Pearson Product Moment correlation coefficient was used as statistical technique to determine the relationship between Anthropometric, Kinematic variables. The data were analyzed with the help of Statistical Package for Social Sciences (SPSS) version 26.0.0.0(19). For testing the hypotheses, the level of significance was set at 0.05.

Table 1: Jump in Volleyball.

S. No	Variable	N	Mean	Standard Deviation
1	height	10	185.600	3.596
2	Weight	10	76.000	8.666
3	Thigh girth(cm)	10	51.700	4.243
4	Calf Girth (cm)	10	35.000	3.527
5	Leg Length (cm)	10	96.900	2.024
6	Displacement (meters)	10	0.687	0.071
7	Acceleration (m/s²)	10	27.819	5.461
8	Peak Speed (m/s)	10	3.079	0.695
9	Maximum Jump Height (cm)	10	49.814	4.829
10	Take-Off Speed (m/s)	10	3.004	0.706

3. Result

Table-1 reflects the descriptive statistics of different Anthropometric and Linear Kinematic variables of volleyball players. It can be seen that the mean and standard deviation of height (185.6±3.596 cm), weight (76±8.66 6kg), thigh girth (51.7±4.243 cm), calf girth (35±3.527 cm) and leg length (96.9±2.024 cm) for Anthropometric variables. The mean and standard deviation of displacement (0.687±0.071), acceleration (27.819±5.461), peak speed (3.079±0.695), maximum jump height (49.814±4.829) and take-off speed (3±0.706) for Linear Kinematic variables.

Table 2: Pearson's Product Moment Correlation between Anthropometric and Linear Kinematic variables

Variable		Height	Weight	Thigh Girth	Calf Girth	Leg Length
Displacement	Pearson Correlation Sig. (2-tailed)	-0.671* 0.034	-0.276 0.440	-0.260 0.469	-0.040 0.913	-0.186 0.606
Acceleration	Pearson Correlation Sig. (2-tailed)	0.029 0.937	-0.140 0.701	-0.374 0.286	-0.264 0.461	0.323 0.363
Peak Speed	Pearson Correlation Sig. (2-tailed)	-0.150 0.670	0.324 0.361	0.080 0.826	0.360 0.307	0.146 0.688
Maximum Jump Height	Pearson Correlation Sig. (2-tailed)	-0.399 0.253	-0.124 0.733	-0.299 0.401	-0.112 0.757	0.229 0.525
Take-Off Speed	Pearson Correlation Sig. (2-tailed)	-0.140 0.699	0.321 0.366	0.068 0.851	0.374 0.325	0.166 0.647

* Correlation is significant at the 0.05 level (2-tailed).

Table-2 shows there is a significant negative correlation between height and displacement with r= -0.671, (P= 0.034) at the 0.05 level of significance (2-tailed) and 8 degree of freedom. After analyzing the data collected, the researcher found that there was only a significant correlation between height and displacement.

4. Discussion

This study investigated the relationship between various physical and biomechanical factors in male volleyball players when performing a counter-movement jump. The descriptive statics applied on this data says that the average height of the ten individuals in the study was 185.6 centimeters, with a relatively low standard deviation of 3.6 cm. This means that the heights of the participants were quite consistent, with most of them falling within a narrow range around the mean. The weight of the participants was 76.0 kilograms, and the standard deviation was 8.7 kg. This indicates that there was more variability in weight compared to height among the participants thigh girth of the participants was 51.7 centimeters, with a standard deviation of 4.2 cm. This measures the circumference of their thighs and suggests that there was some variation in thigh size among the participants. The average calf girth was 35.0 centimeters, with a standard deviation of 3.5 cm. Like thigh girth, there was some variability in calf size among the participants. The participants had an average leg length of 96.9 centimeters, with a small standard deviation of 2.0 cm. This indicates that leg lengths were relatively consistent among the participants. Studies conducted by (Gabbett & Georgieff, 2007; Gaurav & Singh, 2014; Koley *et al.*, 2010; Sheppard *et al.*, 2008) [3, 4, 7, 9] have conducted using anthropometric variables including skin fold where as in this study it was not included. The anthropometric results cannot be compared with other studies even though same variables are used because of the human diversity across the globe.

The descriptive statistics of kinematic variables are (1) Displacement (meters): The average horizontal distance covered during the counter-movement jump was 6.87 meters, with a very small standard deviation of 0.0715 meters. This suggests that the participants were quite consistent in how far they jumped horizontally. (2) Acceleration (m/s²): The average acceleration during the jump was 6.87 meters per second squared, with the same standard deviation as the displacement, 0.0715 m/s². This indicates a consistent level of acceleration among the participants. (3)Peak Speed (m/s): The highest speed achieved during the jump averaged at 27.82 meters per second, with a standard deviation of 5.46 m/s. This variable shows more variability compared to some of the others. (4) Maximum Jump Height (cm): On average, the participants reached a maximum jump height of 49.81 centimeters, with a standard deviation of 4.83 cm. These measures how high they jumped vertically. (5) Take-Off Speed (m/s): The average take-off speed was 3.00 meters per second, with a standard deviation of 0.706 m/s. This

represents the speed at which they left the ground during the jump.
According to the study, there was a substantial inverse relationship between a player's height and the amount of ground they could move during the CMJ. This suggests that taller players may not jump as far during a CMJ compared to shorter players findings of the present study is in line with various other studies like; (Aouadi *et al*., 2012) [1] found that CMJ arm performance, stature, lower limb length/stature and sitting height/stature ratios were not significant (p>0.05) predictors of CMJ arm performance.

4. Conclusion
In summary, this data provides a detailed snapshot of the physical characteristics and performance metrics of the ten individuals participating in the study, offering insights into their heights, weights, body measurements, and various parameters related to their counter-movement jumps. Apart from this kinematic variable- displacements negative effect on height. This suggests that taller individuals tend to exhibit greater displacement as a result the impact force also increases when performing countermovement jump in volleyball. However, there was no significant correlation found between the other anthropometric variables and the linear kinematic variables.

5. Conflict of Interest: Authors declare no conflict of Interest

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