International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Correlation Between Upper Extremity Muscle Strength and Vertical Jump Performance in Volleyball Players

Dr. Prahlad Priyadrshi[1], Dr. Anuradha Lehri[2], Dr. Gurvinder Singh[3], Rahul Nautiyal[4]

[1]Ph.D. Research Scholar, Department of Sports Sciences, Punjabi University, Patiala
[2]Head and Associate Professor, Department of Sports Sciences, Punjabi University, Patiala
[3]Consultant Sports Physiotherapist, Pro Osteorehab, Dehradun, Uttarakhand
[4]Sports Physiotherapist, Cricket Association of Uttarakhand, Dehradun, Uttarakhand

Abstract

Background - To date, we know that lower limb is the primary force producer for vertical jump, but it is still unclear that which muscle plays the most significant role in producing effective jumping. In previous studies the roles of rectus femoris and vastus medialis has been reported in extending the knees during vertical jump height predictor. However, the act of vertical jump requires the whole-body participation. Hence the information regarding the contributions of arm and trunk muscles are lacking, even though these muscles seem to play an important part in the vertical jump. Their relation to vertical jump performance however, remains to be explored. Therefore, the purpose of this study is to determine a correlation between upper limb muscle strength and the vertical jump performance.

Methodology - A sample of 50 volleyball players (mean age = 22.88 ±2.909 years, mean height =170.308 ±6.52 cm, mean weight =65.542 ±4.809 kg, mean BMI = 21.834 ±1.349 kg/m²) participated. The participants were accessed for upper limb muscle strength by using hand held dynamometer and their vertical jump height by Sargent jump test were measured.

Result - A correlation analysis showed significant correlation between upper limb muscle strength and vertical jump height.

Conclusion - The main finding of the study suggests that upper limb involvement and its role during vertical jump. By developing a strength protocol for upper limb muscle vertical jump performance can be enhanced.

Keywords: Volleyball, Vertical jump, Upper Extremity strength, Jump Performance

1. Introduction

Court games are popular across the world, but one of the most friendly and safest one is Volleyball, which is being played in every country through wide range of population including children to older adults. Volleyball is popular worldwide and has attracted wide range of population including players and its spectators because of its characteristics of team sport (1). In a volleyball game the main actions are overhead throwing of ball to the basket and the most repetitive one, the vertical Jump (VJ) which is

being performed by the players. In a study done by McInnes et al. on an average, a volleyball player performs 46 VJ per game, while Ben Abdelkrim; El Fazaa reported an average of 44 VJ. (2) Vertical jump looks simply to do but it is a complex movement requiring coordination of several muscles of the body mainly legs, trunk, arms and even head & neck. During a VJ, primary muscle force is produced by quadriceps, soleus, gastrocnemius, back extensors, and gluteus maximus and their ground reaction forces which helps to push body vertically upwards against the gravity. Lower limb muscles are very necessary for production of force, but vertical jump execution is enhanced by swinging the arms. The use of arm swing increases the velocity at the time of take off by building an extra amount of energy which allows the jumper to gain larger amount of joint momentum helpful for vertical jump. 60% of increase in VJ performance is due to an increase in take-off velocity (3). It has been widely reported that by swinging the arm there is 6-10% enhancement in the take -off velocity (4,5). A jump with arm swing jump enhances the height of CM at take-off by 0.024 m and at the apex by 0.086 m of the flight. During a counter movement jump use of arm swing enhances the height of CM by increasing the take-off velocity (6). In Previous studies, elevation of arm raises the position of CM vertically at the time of take-off which is responsible for 28-54% of the increase in vertical jump height. And increase in the vertical velocity of CM at the time of take-off which is responsible for 46-72% of the increase in vertical jump height (7,8)

To date, we know that lower limb is the primary force producer for vertical jump, but it is still unclear that which muscle plays the most significant role in producing effective jumping. In previous studies the roles of rectus femoris and vastus medialis has been reported in extending the knees during vertical jump height predictor. Several previous investigations focused their studies only on the muscles of lower extremities (9). However, the act of vertical jump requires the whole-body participation. Hence the information regarding the contributions of arm and trunk muscles are lacking, even though these muscles seem to play an important part in the vertical jump. A study done by Charoenpanicha et al, (2013) analyzed vertical jump by principal component analysis (PCA) method and area under curve (AUC) and detected the activity of latissimus dorsi, anterior deltoid (AD) and biceps brachii (BB). Their relation to vertical jump performance however, remains to be explored. Therefore, the purpose of this study is to determine a correlation between upper limb muscle strength and the vertical jump performance.

2. Aim of the Study

- To investigate the relationship between upper limb muscle strength and vertical jump performance in volleyball players.

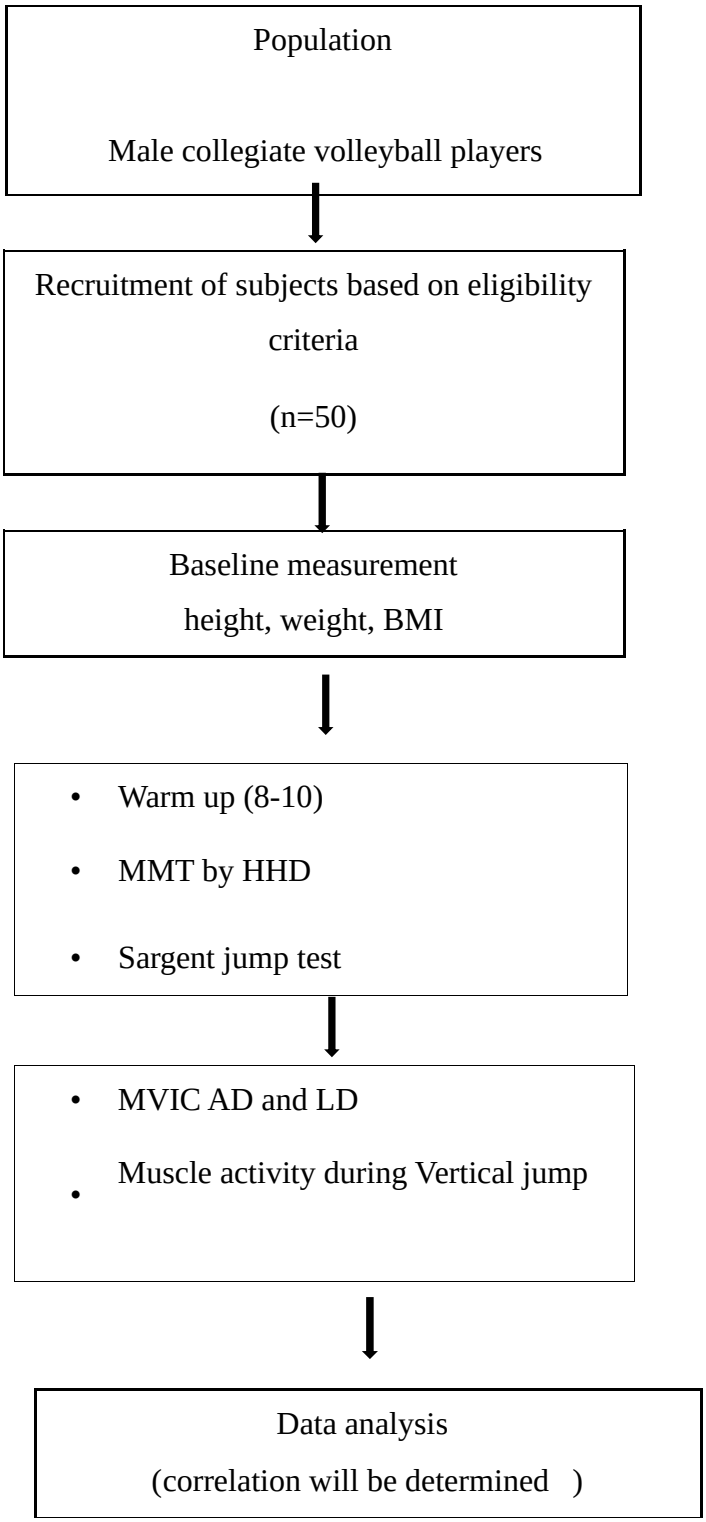
3. Objective of Study

- To determine the correlation between upper limb muscle activity (anterior deltoid and latissimus dorsi) and vertical jump performance

4. Methodology

Academy volleyball players were recruited from Sports Academy, New Delhi. A sample of 50 volleyball players (mean age = 22.88 ±2.909 years, mean height =170.308 ±6.52 cm, mean weight =65.542 ±4.809 kg, mean BMI = 21.834 ±1.349 kg/m²) participated. The participants were accessed for upper limb muscle strength by using hand held dynamometer and their vertical jump height by Sargent jump test

were measured. The MVIC of anterior deltoid (AD) and latissimus dorsi (LD) were measured and activity of these muscles were recorded during vertical jump, with arm swing through EMG and their % MVIC were calculated and reported.



On arriving at the laboratory, all subjects were assessed for baseline measurement namely weight, height etc. After that each subject performed an 8–10-minute warm-up which included. After that subject's isometric muscle strength were measured for anterior deltoid and latissimus dorsi by handheld dynamometer 3 readings were recorded for each muscle and the mean of them were documented. After that subjects were asked to practice the vertical jump with arm swing for familiarization not more than 3 times.

And then the vertical jump height was measured.

After this the subject's skin was prepared accordingly and electrodes were placed over muscles and were asked to perform maximal isometric contraction and the rms values were recorded for both the muscles for 5 seconds with rest period of 3 seconds between each reading after then the leads were stabilized with micropore tapes. Subject were asked to stand facing dominant side to the wall with leads attached. Subjects were asked to take position in standing for 2 seconds and then were provided the commands to performed vertical jump with arm swing to reach maximum height for three times and the rms values were recorded for 3 seconds with 2 seconds of rest in between each jump and the mean value were calculated and documented. Data from each muscle will be full-wave rectified and low-pass filtered using a fourth-order Butterworth filter with a 10 Hz cut off frequency. The maximal value for EMG from each muscle will be used to normalize the EMG data for analysis. (10)

5. Result

Analysis of data was done by using SPSS 17.0. In which correlation analysis has been done using bivariate model and Pearson's correlation coefficient was calculated at significance level of 0.05 and 0.01.

Results were quite impressive which shows significant correlation between upper limb muscle strength between vertical jump height. Pearson correlation coefficient, r and significance level, p for VJH and ISO AD ($r = 0.836$, $p=0.01$) and for VJH and %MVIC AD ($r =0.466$ at $p= 0.01$) And for VJH and ISO LD ($r =0.869$ at $p = 0.01$) and for VJH and % MVIC LD ($r = 0.649$ at $p = 0.01$).

The demographic data age, height, weight, BMI are given (Table 5.1)

Table 5.1 - The demographic data

Variables	Mean ±SD
Age (years)	22.88 ±2.909
Height (cm)	170.308 ±6.52
Weight(kg)	65.542 ±4.809
Body mass index (kg/m^2)	21.834 ±1.349

The descriptive data of variables are given in Table 5.2

Table 5.2

Variables	MEAN ±SD
VJH	23.39 ± 2.022
ISO AD	252.34 ±38.133
MVIC AD	0.612 ±0.1461

ACTIVITY AD	0.40168 ±0.1266
% CHANGE AD	64.87±12.319
ISO LD	237.617843 ±34.4699
MVIC LD	0.38572±0.1098
ACTIVITY LD	0.2332 ±0.0839
%CHANGE LD	60.20 ±9.647

VJH: vertical jump height; AD: Anterior deltoid; LD: Latissimus dorsi ISO: Isometric strength; Activity: Muscle activity during jump; % MVIC: % Of maximum voluntary isometric concentration

The value of Pearson correlation coefficient (r) and significance level (p) for respective variables are is given in Table 5.3.

Table 5.3

Variables	VJH	P value
Iso AD	** .836	.000
Mvic AD	** .883	.000
Activity AD	** .910	.000
% Value AD	** .466	.001

VJH: vertical jump height; AD: Anterior deltoid Iso: isometric strength; activity: muscle activity during jump; % value: normalized value

Variables	VJH	P value
Iso Ld.	** .869	.000
Mvic Ld	.161	.263
Activity Ld	** .408	.003
% change Ld	** .649	.000

VJH: vertical jump height; LD: Latissimus dorsi; Iso: isometric strength; activity: muscle activity during jump; % value: normalized value

Table 5.4 correlation matrix of vertical jump height and anterior deltoid muscle

Table 5.4

Variables	VJH	ISO AD	MVIC AD	ACTIVITY AD % MVIC AD
VJH				
ISO AD	.836**			
MVIC AD	.883**	.724**		

ACTIVITY AD	.910**	.805**		
% MVIC AD	.466**	.488**	.232	.678**

VJH: vertical jump height; AD: Anterior deltoid ISO: Isometric strength; Activity: Muscle activity during jump; % MVIC: % Of maximum voluntary isometric contraction

**. Correlation is significant at the 0.01 level (2-tailed).

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

Table 5.5 Shows correlation matrix of vertical jump height and latissimus dorsi muscle.

Table 5.5

Variables	VJH	ISO LD		MVIC LD	ACTIVITY LD	% CHANGE LD
VJH ISO LD	.869**					
MVIC LD	.161		.139			
ACTIVITY LD	.408**	.391**		.898**		
% MVIC LD	.649**	.651**		.165	.567**	

VJH: vertical jump height; LD: Latissimus dorsi; ISO: Isometric strength; Activity: Muscle activity during jump; % MVIC: % Of maximum voluntary isometric concentration

**. Correlation is significant at the 0.01 level (2-tailed).

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

Figure 5.1 Relationship between vertical jump height and isometric strength of anterior deltoid

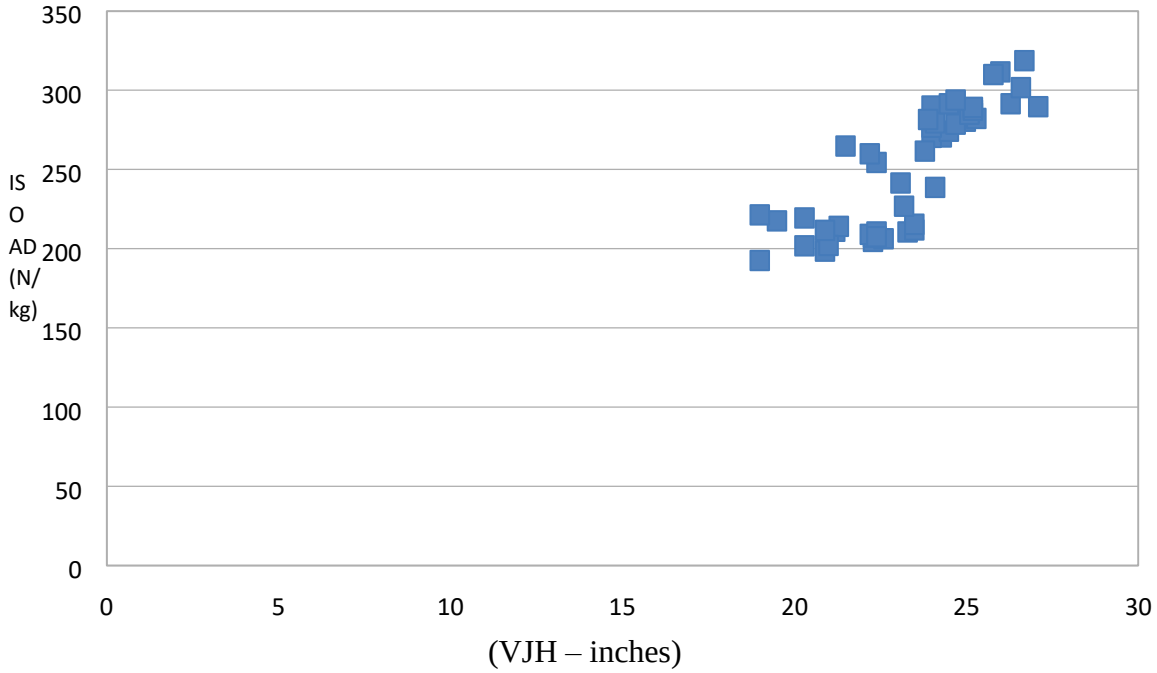


Figure 5.2 Relationship between vertical jump height and % MVIC of anterior deltoid

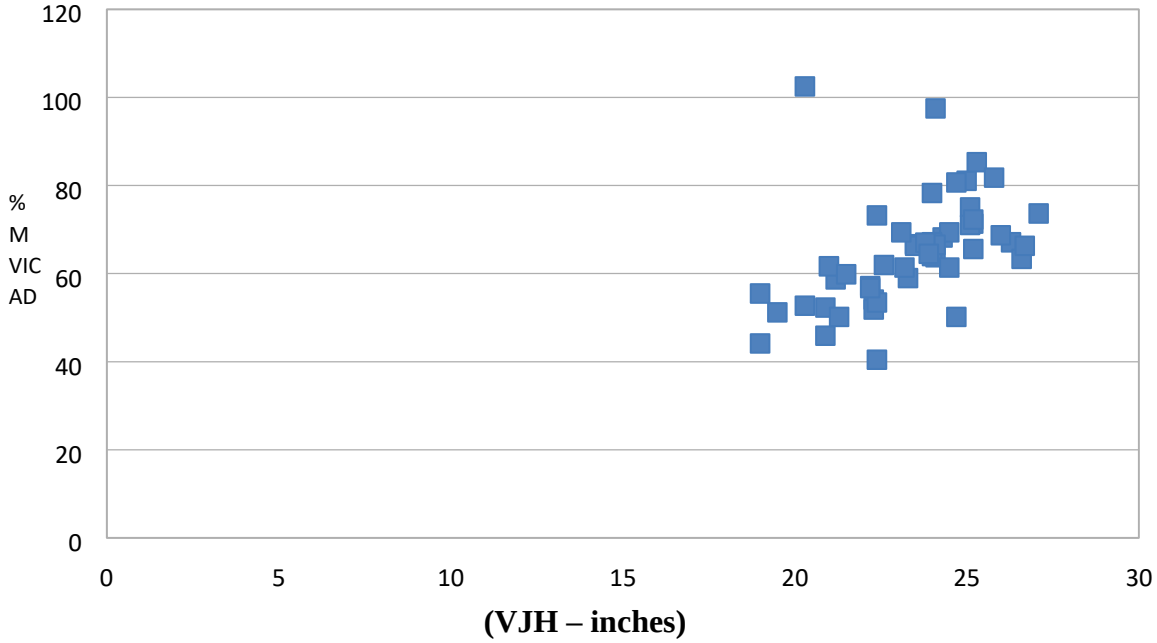


FIGURE 5.3 Relationship between vertical jump height and Isometric strength of Latissimus dorsi

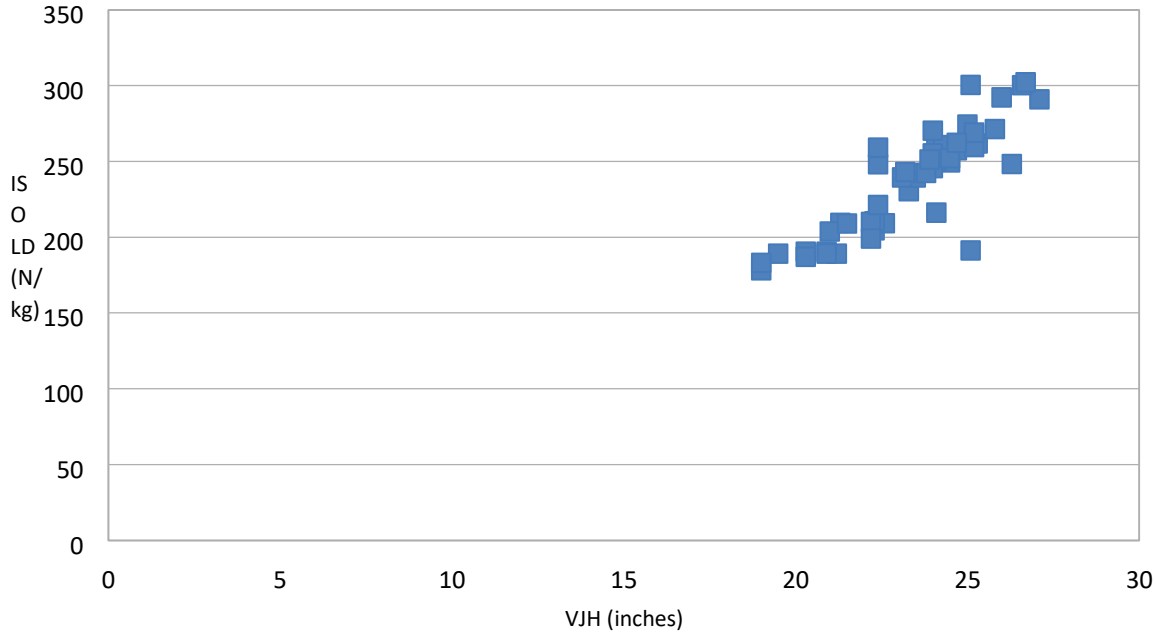
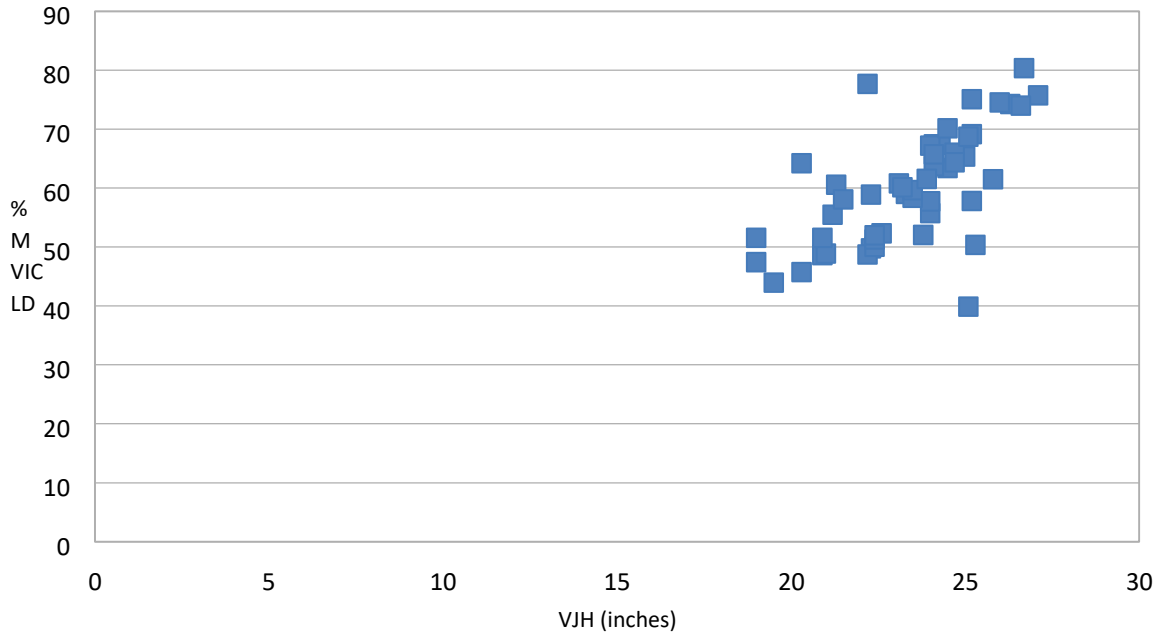


FIGURE 5.4 Relationship between vertical jump height and % MVIC Latissimus dorsi



6. Discussion

The purpose of this study is to find any relationship between upper limb muscle strength and vertical jump performance. Previous studies have attempted to determine relation of vertical jump height and lower limb muscle strength and anthropometrical measures.

Up to date few investigations have been done to check the importance of upper limb muscle strength in relation to vertical jump height. Finding of this study showed that the results are significant among vertical jump height and isometric muscle strength & moralized EMG values of upper limb muscles. And these findings are related to the previous findings of studies done by Lees et al, Herman et al & hara et al on contribution of upper limb use during vertical jump.

Vertical jump

Jump is the mother game of all the sports, without jumping no sports is complete. It is a complex movement which requires whole body participation from head to toe. Strength of lower limb muscle is the main predictor of the vertical jump height, but the participation of trunk and upper limb muscle cannot be neglected. Volleyball is a game which requires vertical jump and throwing frequently during the whole game. Which involves upper limb muscles activity too. Acc. to lees et al using the arm during vertical jump enhances the vertical jump height.

Vertical jump and upper limb

In another study lees et al found that vertical jump height with arm swing enhanced by 0.11m and the work done at the shoulder were more (0.63 J/kg) as compared to the jump without arm swing.

Which supports the strength of correlation between upper limb muscle strength and vertical jump height.

In a study done by lees et al in 2004 checked several theories to explain the reason behind enhancement in the jump performance with and without arm swing, in which they choose 20 adult males to perform jumps with and without swinging their arms and the result were quite impressive, athlete when jumped with arm swing, jumped higher (0.086 m)

In another study done by Feltner et all 2004 on kinetic and segmental contribution in vertical jump with and without arm swing 15 men were made to perform jump on force plate and concluded that peak

height of center of mass was 173 cm and 156 cm in jump with and without arm swing respectively, approximately 10.9percent difference.

In a study done by (Harman et al in 1990) to check the effect of countermovement and arm swing on vertical jump they recruited 18 males jumped on force platform with 4 different combination countermovement/ no countermovement and no arm swing /arm swing and they found that there is increase in the height with countermovement and arm swing jump, but the effect of arm swing was much better.

7. Future Scope of Study

- This study can be generalized over other jumping games after having new researches over other population like volleyball, badminton and soccer players.
- A training protocol can be framed out to strengthen upper limb muscles involved during jumping so that the performance of jump can be improved.
- Correlation for all muscles including lower limb, trunk and neck muscles along with the all-upper limb muscle on mixed athletic population performing in jumping activities so that all muscle could have been correlated with the vertical jump height.

8. Conclusion

There are higher positive correlations between jumping performance and upper limb muscle strength. Higher the strength of upper limb muscles namely anterior deltoid and latissimus dorsi higher will the vertical jump height during vertical jump with arm swing. But the primary production of force comes from the lower limb. Practical application of this study can be consideration of strength training of the upper limb musculature we further can enhance the vertical jump performance in all kind of games which requires jumping activity

References

1. Charoenpanicha, N., Boonsinsukhb, R., Sirisupc, S., & Saengsirisuwana, V. (2013). Principal component analysis identifies major muscles recruited during elite vertical jump. Age (yr), 22(2.9), 20-9.
2. Feltner, M.E., Frasceti, D.J., Crisp, R.J., 1999. Upper extremity augmentation of lower extremity kinetics during countermovement vertical jumps. Journal of Sports Sciences 17, 449–466.
3. Lees, A., Vanrenterghem, J., & De Clercq, D. (2004). Understanding how an arm swing enhances performance in the vertical jump. Journal of biomechanics, 37(12), 1929-1940.
4. Harman, E.A., Rosenstein, M.T., Frykman, P.N., Rosenstein, R.M., 1990. The effects of arms and countermovement on vertical jumping. Medicine and Science in Sports and Exercise22, 825–833.
5. Bobbert, M. F., Huijing, P. A., & van Ingen Schenau, G. J. (1987). Drop jumping. I. The influence of jumping technique on the biomechanics of jumping. Med Sci Sports Exerc, 19(4), 332-8.
6. Erčulj, F., & Štrumbelj, E. (2015). Basketball Shot Types and Shot Success in Different Levels of Competitive Basketball. http://doi.org/10.1371/journal.pone.0128885
7. Alemdaroğlu, U. (2012). The Relationship Between Muscle Strength, Anaerobic Performance,Agility, Sprint Ability and Vertical Jump Performance in Professional Basketball Players. Journal of Human Kinetics, 31, 149–158. http://doi.org/10.2478/v10078-0120016-6

8. De Salles, P. G. da C. M., Vasconcellos, F. V. do A., de Salles, G. F. da C. M., Fonseca, R, & Dantas, E. H. M. (2012). Validity and Reproducibility of the Sargent Jump Test in the 41 Assessment of Explosive Strength in Soccer Players.Journal of Human Kinetics,33,115–121. http://doi.org/10.2478/v10078-012-0050-4
9. Celik D1, Dirican A, Baltaci G J. Sport Rehabil. 2012 Feb 29; Technical Notes 3:1-5. Journal of Sport Rehabilitation, 2012 © 2012 Human Kinetics, Inc.
10. Pontillo, M., Orishimo, K. F., Kremenic, I. J., McHugh, M. P., Mullaney, M. J., & Tyler, T. F. (2007). Shoulder musculature activity and stabilization during upper extremity weight bearing activities. North American journal of sports physical therapy: NAJSPT, 2(2), 90.