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Inter limb symmetry of selected foot anthropometric measures and its relationship to vertical jumping ability

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***Abstract*---**Aim: The study was intended to examine the symmetry between right and left foot; and to analyse the degree of relationship of selected foot anthropometric measurements on different vertical jumping performance. Methods: The criterion variables right foot length, left foot length, right foot breadth, left foot breadth, arch of right foot, arch of left foot, right foot index, left foot index, and foot symmetry index, vertical jump height, counter movement jump height, and squat jump height chosen for the study were measured using the sliding caliper, protractor, Microgate OptoJump, and Microgate Gyko. Descriptive analysis is performed to compute the percentage of inter limb variation, 't' ratio for the existence of significant difference, and Pearson product moment correlation coefficient to determine association among criterion variables. Results: It is found that foot length, foot breadth, and arch of the foot are asymmetrical between limbs, and furthermore shows very little to no considerable association between foot anthropometry and vertical jumping ability. Conclusion: Thus, we conclude that the individuals with broader foot breadth, greater foot index and corresponding foot symmetry impacts largely than foot length and arch of the foot.

***Keywords*---**foot anthropometry, arch foot, vertical jump.

Introduction

The success of an athlete is obviously depending upon a range of multifaceted factors comprising physiological, biomechanical and skill traits within different sports. The athlete's anthropometric dimensions play a vital role in determining the potential for success in a chosen sport. The vertical jumping is an explosive

physical exertion executed in isolation or in combination of movements in different sports. Various forms of vertical jumping involve counter movement jump and squat jump. The performance in vertical jump can be influenced by various anthropometric and biomechanical factors. Anthropometry consists of the measurement of body dimensions such as length, width and height. In sport science, foot dynamic anthropometry has a major role. Yet, certain anthropometric measures like body mass, height, and length of lower extremity affects vertical jump height (Fattahi *et al.*, 2012; Aouadi *et al.*, 2012). The stability of human body largely relied on foot structure and strength, which works for the principle functions of propulsion and support; specifically during upright locomotion (Tam *et al.*, 2014); and dissipate the forces acting upon the body with ground contact at landing (Chou *et al.*, 2009). The foot acts like a flexible lever for propulsion, and like a firm structure that holds up the whole body for support. Propulsion is one's ability to effectively advance the body forward during locomotor tasks (Perry & Burnfield, 2010).

It is quite likely to have great variation in human foot length, width and height in males and females owing to genetic, natural and environmental factors. Moreover, most people have diverse sized feet. The symmetry of human limbs is not perfect, and thus numerous differences can be assessed between the left foot and right foot. It is fairly uncommon that the length of the left foot and right foot is identical, and this is supposed to be the case with any foot anthropometric measurements. And, there are numerous reasons for feet to be asymmetrical.

To examine the factors determining the performance in running and jumping, the measurement of lower extremity precisely foot anthropometry is imperative in human being. There are numerous research studies on foot anthropometry and its influence on different locomotion components. Studies performed to determine the effect of height, leg length, body mass, etc. on jumping tasks. Some studies made efforts to verify the relationship the foot and sprinting (Scholz *et al*, 2008; Baxter *et al*, 2011). However, the scarcity in research studies that shows the relationship among performance in vertical jumping, counter movement jumping, squat jumping to different foot anthropometry.

Apart from assessing the foot anthropometrical symmetry; determination and explanation of the relationship of various foot anthropometric measures such as foot length, foot breadth, arch of foot, foot index, and foot symmetry index that influences the jumping ability can be justified as the major aspects of this applied research work. Hence, the purposes of the study were to examine the symmetry between right and left foot; and analyze the degree of relationship of selected foot anthropometric measurements on different vertical jumping performance.

Methodology

To achieve the purposes of the present study, twenty-nine (29) untrained male college students aged between eighteen and twenty-two were selected as study participants among those volunteered. The selected study participants were subjected to the assessment of chosen foot anthropometric measurements (*right foot length, left foot length, right foot breadth, left foot breadth, arch of right foot, arch of left foot, right foot index, left foot index, and foot symmetry index*); and

vertical jumping ability (*vertical jump height, counter movement jump height, and squat jump height*).The following standardized tests and procedures were used to assess the criterion variables confined to this study.

The linear distance between the pternion and akropodion was assessed to quantify the length of the right and left foot. The distance between most medial point on the head of the first metatarsal to the most laterally placed point on the head of the fifth metatarsal bone was measured to quantify the breadth of right and left foot. For the purpose of measuring arch of the right and left foot, the impression of the feet was taken in paper by stamping on the inked sponge placed in a tray. The foot's medial boundary line between the sites of imprint at the base of the first metatarsal bone and the calcaneus is identified and marked. From the point where medial boundary line first touches the imprint on the inner side of the big toe, swing the ruler down from the toes until it just touches the edge of the print on the inside of the arch, and then draw a line from the point across the print. Thereafter measure the angle of the foot arch.

The foot index of both legs were estimated using the formula:

$$\frac{Breadth}{Length} x \quad 100.$$

The foot symmetry index is appraised using the formula:

$$\frac{(Right\ Foot\ Index - Left\ Foot\ Index)}{[0.5\ x\ (Right\ Foot\ Index + Left\ Foot\ Index)]} x100$$

The vertical jump was assessed using Microgate OptoJump by placing the Rx and Tx bars two metres apart. The subjects from standing position bends his knees and immediately tries to accomplish a jump vertically as high as possible, with arms swings. The Countermovement jump and Squat jump were assessed using the instrument Microgate Gyko. The Gyko meter was fixed on the back of the subjects using Gyko belt. For the purpose of assessing countermovement jump height, the subjects from standing position with hands on the hip, squat down until his knees are bent at 90 degrees, then leaps vertically as high as possible, and lands with both feet simultaneously. Whereas, for the purpose of assessing squat jump height, the subjects from squat position with hands on the hip, leaps vertically as high as possible, and lands with both feet simultaneously. The descriptive analysis, 't' ratio, and Pearson product moment correlation coefficient are quantified utilizing SPSS package, to derive conclusions corresponding to the objectives of the present study. The level of significance was set at α 0.05 in all cases.

Results

The data collected from twenty-nine (29) untrained male college students on different vertical jumping ability, in addition to selected foot anthropometric measurements have been statistically analyzed. To ascertain the degree of relationship Pearson product moment correlation was used, and the level of significance was set at 0.05, which was considered adequate for this study.

The mean and standard deviation on the variables confined to this study is presented in table – I.

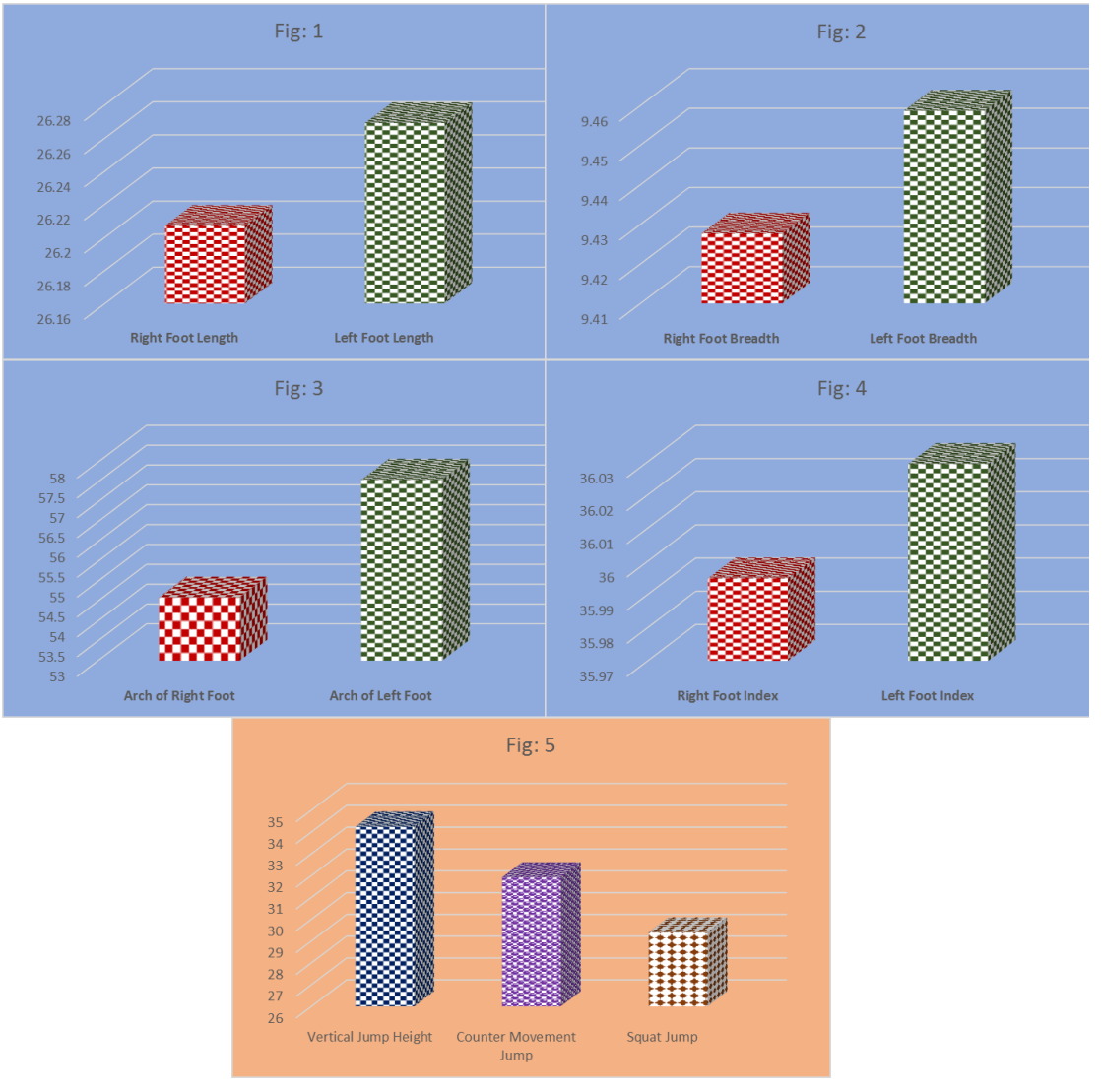
Table-I: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Right Foot Length	29	24.40	28.10	26.207	.963
Left Foot Length	29	24.80	28.30	26.269	.938
Right Foot Breadth	29	8.40	10.40	9.428	.520
Left Foot Breadth	29	8.40	10.50	9.459	.510
Arch of Right Foot	29	40.00	62.00	54.586	5.206
Arch of Left Foot	29	49.00	70.00	57.552	4.800
Right Foot Index	29	32.38	40.47	35.995	1.944
Left Foot Index	29	32.51	40.86	36.029	1.947
Foot Symmetry Index	29	.00	1.07	.232	.353
Vertical Jump Height	29	22.14	47.23	34.237	5.993
Counter Movement Jump	29	19.04	46.23	31.918	6.595
Squat Jump	29	20.21	46.83	29.401	6.684

Table – I exhibit that on average left foot length is 0.24% longer than right foot length; similarly left foot breadth is 0.33% broader than right foot breadth; and arch of the left foot is 5.51% greater than that of the arch of the right foot. While, the variation between left and right foot with regard to foot index is less than 0.1%. In the case of jumping ability among untrained male college students, performance in counter movement jump and squat jump is affected by 6.77% and 14.13% respectively as compared to the performance in vertical jump.

The graphical illustration of data is given in figure 1 through 5.

Fig. 1: Graphical Illustration of Data



The data on selected foot anthropometric measures were subjected to the evaluation of inter limb symmetry. The results thus obtained is tabulated and given in table-II.

Table-II: Computation of t Ratio on selected Foot Anthropometric Measures

	Mean	Difference between Mean (DM)	Std. Error of DM	t	Sig.
Right Foot Length	26.21	0.062	0.026	2.346	.026*
Left Foot Length	26.27				
Right Foot Breadth	9.43	0.031	0.011	2.768	.010*

Left Foot Breadth	9.46				
Arch of Right Foot	54.59	2.965	0.745	3.979	.000*
Arch of Left Foot	57.55				
Right Foot Index	35.99	0.034	0.027	1.241	.225
Left Foot Index	36.03				

*Significant at 0.05 level.

It is observed from Table-II that the 't' ratio for foot length, foot breadth, and arch of the foot, between feet (*right and left*) are 2.346 (p = 0.026), 2.768 (p = 0.010), and 3.979 (p = 0.000), indicates the existence of statistically significant differences between right and left foot. Thus, it implies that inter limb foot length, foot breadth, and arch of the foot are asymmetrical. Whereas, the obtained 't' ratio for foot index between feet (*right and left*) is 1.241 (p = 0.225), indicates the non-existence of statistically significant differences between right and left foot. Thus, it implies that inter limb foot index is symmetrical.

The coefficient of correlation between criterion and determinant variables and among determinant variables were computed and presented in table- III. Table – III, reveals that vertical jump height, countermovement jump height, and squat jump height have no statistically relationship with right foot length, left foot length, right foot breadth, left foot breadth, arch of right foot, arch of left foot, right foot index, left foot index, and foot symmetry index, since the obtained correlation coefficient were lesser than the "r" of 0.20 indicating the non-significance at 0.05 level. It also reveals that right foot breadth, left foot breadth, right foot index, left foot index, and foot symmetry index has a negative relationship with vertical jump height, counter movement jump height, and squat jump height, obviously not statistically significant.

Table-III: Inter Correlation Matrix

	RFL	LFL	RFB	LFB	ARF	ALF	RFI	LFI	FSI	VJ	CMJ	SJ
RFL	1	.989**	.348	.342	-.182	.017	-.305	-.291	.053	.065	.080	.126
LFL		1	.310	.317	-.185	.022	-.334	-.322	.138	.081	.094	.102
RFB			1	.993**	.130	.052	.786**	.792**	.016	-.048	-.025	-.055
LFB				1	.134	.058	.785**	.795**	.111	-.046	-.024	-.092
ARF					1	.681**	.254	.255	-.073	.063	.007	-.167
ALF						1	.047	.047	-.172	.059	.009	-.247
RFI							1	.997**	-.004	-.099	-.086	-.150

LFI								1	.036	-.104	-.091	-.166
FSI									1	-.079	-.067	-.128
VJ										1	.988**	.741**
CMJ											1	.763**
SJ												1

RFL - Right Foot Length; LFL - Left Foot Length; RFB - Right Foot Breadth; LFB - Left Foot Breadth; ARF - Arch of Right Foot; ALF - Arch of Left Foot; RFI - Right Foot Index; LFI - Left Foot Index; FSI - Foot Symmetry Index; VJH - Vertical Jump; CMJ - Counter Movement Jump; SJ - Squat Jump
*Significant at 0.05 level.
**Significant at 0.01 level.

Aouadi *et al.* (2012) found that stature is a significant predictor of vertical jump height. Jumping is a ballistic motion in which ground reaction force is a major factor determining vertical jumping heights (Johnston *et al.*, 2015). Fattahi *et al.* (2012) looked at seventeen different anthropometric measurements in relation to jump height, and found a significant relationship between foot length and vertical jump height of elite male volleyball spikers and setters. Whereas, Vandana *et al.* (2020) in their study examined acute anthropometric measure in relation to vertical jump performance, and found negative correlation between jump height and foot length. Cobb *et al.* (2014) in their study established that there is a reduction in single-leg balance, because of higher arches that decreases mediolateral control of a single-limb stance.

Conclusion

From the findings of this study, it is inferred that foot length, foot breadth, and arch of the foot are asymmetrical between limbs. Additionally, it is inferred that although foot anthropometry contributes very little to no considerable contribution to jumping ability. Accordingly, we conclude that the individuals with broader foot breadth, greater foot index and corresponding foot symmetry impacts largely than foot length and arch of the foot.

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