Relationship of Foot Arch Height and Lower Limb Muscle Strength with Vertical Jump Height in Recreational Basketball Players: A Correlational Study

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Abstract

Context: *Basketball is an intermittent game that requires high intensity activities, agility and has explosive muscle power which is manifested through different jumps. Arches of foot act as spring which helps in shock absorption during fast walking, running, and jumping. Muscle strength is important for explosive power, agility & speed activity. It is crucial to know whether any change in foot arch height and lower limb muscle strength affects vertical jump height.*

Aim: *To find the correlation of Foot Arch Height and lower limb strength with Vertical Jump Height in recreational basketball players.*

Methods and Material: *An observational study was conducted in sports club of Pune city on 60 recreational basketball players, aged 18-30 years. Players were assessed for foot arch height using navicular drop test, lower limb muscle strength by manual muscle testing and vertical jump height.*

Result: *Data was analyzed statistically by Pearson's Correlation Coefficient suggesting good correlation between foot arch height and vertical jump height (r=0.89) and between the lower limb muscle strength and vertical jump height.*

Conclusion: *The study concludes that any change in foot arch height and lower limb muscle strength affects the vertical jump height.*

Key-words: Navicular Drop Test, explosive jump power, muscle strength, Basketball Player

Introduction:

Basketball is an intermittent game incorporating quick and repeated adjustments in the direction of movement[1] and includes high-intensity team play with alternating excessive load phrases[2]. It is an aerobic based anaerobic sport which requires explosive movements of jumping, turns, dribbles, sprints, screens, walking and jogging[3]. Explosive power in basketball is manifested via distinct jumps, start acceleration and the change of direction, and the passing of ball[2]. The vertical jump test is a common field test used to assess anaerobic fitness improvements and the height achieved has a direct correlation with the amount of force produced by the muscle fibers. The greater force produced via the muscle fibers that are part of the vertical jump is related to a greater maximum height achieved during jump performance[4]. The three phases of vertical jump are the preparatory phase, the propulsive phase, and the flight phase.The preparatory phase consist of ankle dorsiflexion knee and hip flexion and shoulder hyperextension.in propulsive phase, the ankle is in plantarflexion knee and hip extension. The flight phase includes knee and hip in extension[5,6].

Vanezis A et al determined that the better jumpers have greater joint moments, power and work done at the lower extremity. This superior performance was greater muscle capability in terms of strength and rate of strength development in all lower limb joints rather than to technique[7].

In basketball, the muscles of the foot are subjected to a strong load which affects the sole of the foot[8]. The arches of the foot are helpful in fast walking, running, jumping, weight bearing & providing upright posture. Determining the foot arch is crucial for impact sports such as jumps or sprint. They are supported by intrinsic & extrinsic muscles of the sole along with ligaments, aponeurosis & shape of the bone. Arches can be classified as Longitudinal and Transverse, which can be further classified as medial & lateral and anterior & posterior [9]. The navicular height is considered the best way to determine the foot arch height[10]. Based on the structure of medial longitudinal arch; three types of foot are seen namely normally aligned foot, low arched (pronated foot or pes planus) & high arched (supinated foot or pes cavus)[11].

Study done by Zhao X et al showed the relation of strength to arch height i.e., the decreased the arch have a greater ankle muscle strength whereas increased arches have a lower ankle muscle strength. Good powerful muscle strength in the lower extremity is required for the excellent performance in vertical jump and the foot arch also changes for compensation[12]The vertical jump element is basically the measurement of the strength and speed of the lower extremities[13].A large foot will have a greater muscle strength of the ankle joint and will have a better performance[11]. Researchers also stated that the foot arch structure, foot arch height (FAH) and the lower limb muscle strength affects the vertical jump height (VJH) [4,10,12]. Ayola Aiyegbusi et al proved that the weight, height, BMI and foot length has a significant impact on vertical jump height in recreational basketball players[4]. Also Hu Y has shown the correlation of arch height index with VJH in male college students[10]. However, there is a lack of evidence showing the correlation between the Foot Arch height and the lower limb muscle strength with Vertical Jump height in recreational basketball players.

Materials and Methods:

An observational study was conducted after ethical approval from Institutional Ethical Committee with the objectives to measure the Foot Arch Height and find the correlation of it

with vertical jump height, secondly to assess the lower limb muscle strength and find correlation of it with vertical jump height.

Sixty recreational basketball players aged 18-30 years both males and females, willing to participate in the study were included. The players who had any history of recent surgery or fracture, acute or chronic pain, musculoskeletal injuries, neurological deficit were excluded. Written informed consent was taken from all participants. Each player was assessed for Foot Arch Height by Navicular Drop Test, for lower limb muscle strength by Manual Muscle Testing and then vertical jump height was performed.

Navicular Drop Test: The players were asked to sit comfortable with both feet on ground. The neutral position of subtalar joint was obtained with palpation method and then navicular tuberosity was marked and measured by the scale. Then the players were asked to stand by taking full weight equally on both the lower limbs and again the neutral position of subtalar joint was achieved. The position of the Navicular tuberosity was measured and the difference was calculated (fig.1). If the difference in the two measurement >10mm denotes significant excessive foot pronation. The foot arch is classified as High/ Supinated arch – 0-5mm, Normal arch – 5-10mm, Low/ Pronated arch - >10mm.[13]

Fig.1.Foot arch height by Navicular drop test

Vertical Jump Height (VJH): To assess the vertical jump height, the subjects were asked to stand by the side of wall with dominant shoulder facing the wall with equal weight taken on both lower limbs. The players were instructed to reach as high as possible with a piece of chalk in the hand and to mark on the wall (standing reach height) which was recorded as a zero (starting position). Next the subjects were asked to jump by flexing knee approx. 120^0 along with swinging of arms and place a second chalk mark as high as possible on the wall (jumping height). The difference between the two chalks marks were measured in meters. Three readings were taken, and the best jump height was recorded. The difference in distance between the standing reach height and the jump height is the VJH (fig.2)[14]. The average value of VJH is 0.41-0.50m in males and 0.31-0.40m in females[4].

Fig.2. Measurement of Vertical Jump Height

Manual Muscle testing (MMT): Group muscle testing was done for hip flexors (fig.3) hip extensors, knee flexors and extensors, ankle dorsiflexors and plantar flexors[15].

Fig.3. Manual Muscle Testing for hip flexors

Results:

All the data was statistically analyzed with statistical package MedCalc 18.2.1. The demographic data like age, number of male and female participants was calculated. A Pearson correlation was employed to assess the relationship of Vertical Jump Height with Foot Arch Height and Lower Limb Muscle strength.

The mean age of 60 participants in the study was 21.58 ±1.48, 25 were females with the mean age of 21.42±1.57 and 35 were males with the mean age of 21.80±1.35.

Table 1 presents the correlation of VJH with FAH which suggested a positive correlation with $r=0.89$ and $p<0.0001$. It indicated that, as difference of the FAH was more, which means subjects with low foot arch (Pronated foot) had increased Vertical Jump Height and subject with high foot arch height had decreased Vertical Jump Height

Table 2 shows that VJH has a positive correlation with the strength of HF, HE, KF, KE, AD and AP with a p <0.001 which was highly significant. This indicated that when the strength of lower limb was more, the power generated by the lower limb muscles was more leading to an increase in the VJH.

Table 1 : Distribution of the mean foot arch height in the level of foot and the vertical jump height

Mean FAH (cm)	Mean VJH(m)	VJH(m)
0.40±0.10	0.24±0.036	<0.31(L)
1.05±0.289	0.40±0.048	0.31-0.50(N)
1.33±0.25	0.54±0.029	>0.50(H)

Figure 1: Presentation of mean foot arch height with vertical jump height

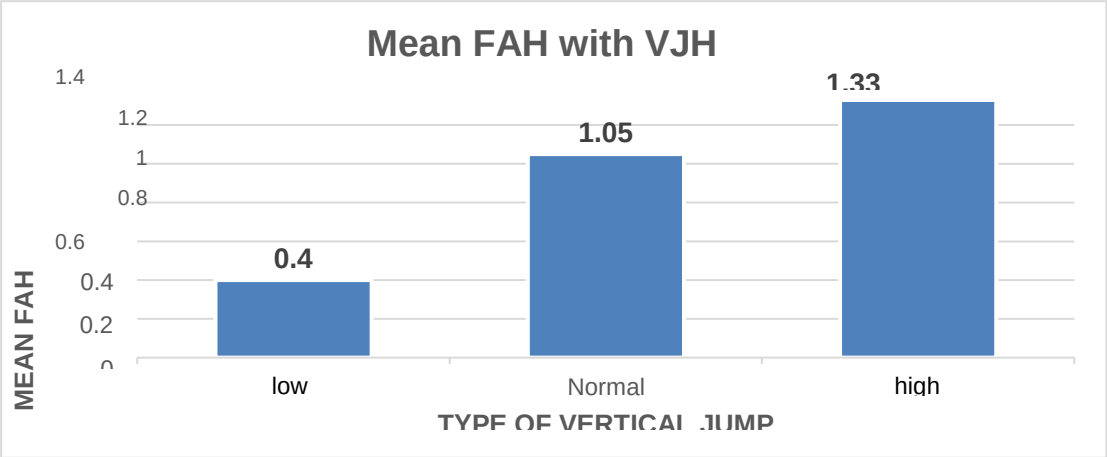

Table 2: Correlation of the vertical jump height with the foot arch height

Parameter	Group	Mean ±SD	Median	P value	Pearson's Correlation Coefficient (r)
VJH and FAH	VJH	0.38±0.10	0.40	<0.0001	0.89
	FAH	0.91±0.40	1.00	<0.0001	

Figure 2: Correlation of vertical jump height with the foot arch height

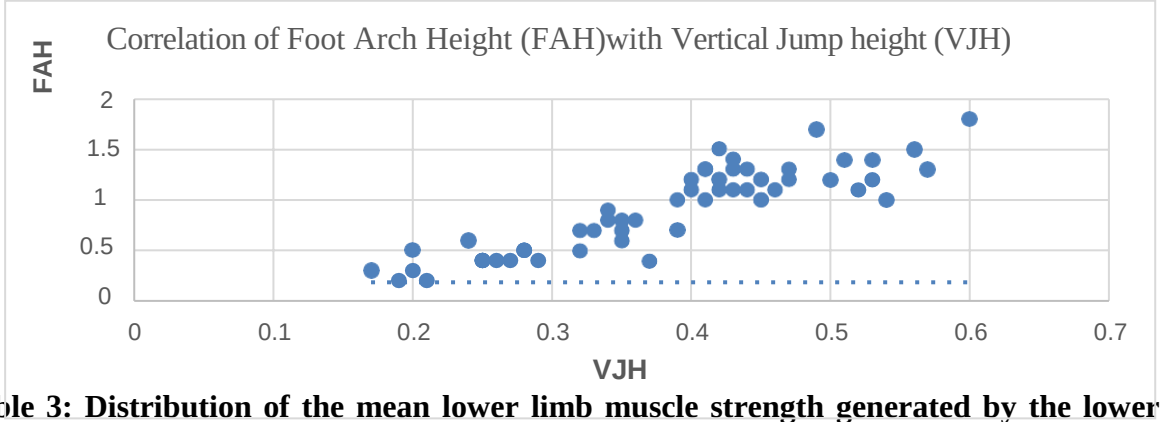

Table 3: Distribution of the mean lower limb muscle strength generated by the lower limbs with the vertical jump height

VJH (m)	Mean lower limb muscle strength					
	HF	HE	KF	KE	AD	AP
<0.31(L)	3.43± 0.62	3.43±0.51	3.12±0.34	3.37±0.61	3.18±0.40	3.87±0.50
0.31-0.50(N)	4.72± 0.51	4.55±0.69	4.66±0.63	4.55±0.69	4.69±0.57	4.63±0.48
>0.50(H)	5±0.00	4.87±0.35	5±0.00	5±0.00	5±0.00	4.87±0.35

Table 4: Correlation of VJH with Lower Limb Muscle Strength (by MMT)

Sr.No	Parameters with Groups	MEAN± SD	Median	Min	Max	Statistics with Pearson's Correlation
1	VJH	0.38± 0.1	0.40	0.17	0.60	r = 0.78
	Strength of Hip Flexors	4.41± 0.78	5.00	3.00	5.00	p <0.001
2	VJH	0.38±0.10	0.40	0.17	0.60	r = 0.73
	Strength of Hip Extensors	4.30±0.80	5.00	3.00	5.00	p <0.001
3	VJH	0.38±0.10	0.40	0.17	0.60	r = 0.84
	Strength of Knee Flexors	4.30± 0.88	5.00	3.00	5.00	p <0.001
4	VJH	0.38±0.10	0.40	0.17	0.60	r = 0.77
	Strength of Knee Extensors	4.32±0.83	5.00	3.00	5.00	p <0.001
5	VJH	0.38±0.10	0.40	0.17	0.60	r = 0.80
	Strength of Ankle Dorsiflexors	4.33±0.85	5.00	3.00	5.00	p <0.001
6	VJH	0.38±0.10	0.40	0.17	0.60	r = 0.69
	Strength of Ankle Plantarflexors	4.46±0.59	5.00	3.00	5.00	p <0.001

Discussion:

The present study was conducted to find the relationship of foot arch height and lower limb muscle strength with vertical jump height in recreational basketball players. The study composed of 60 participants who were recreational basketball players. For assessing foot arch height, navicular drop test was performed and the lower limb muscle strength was taken using manual muscle testing. Following which vertical jump power was assessed. Then data analysis was done. The results showed a positive correlation with $r=0.89$ and $p<0.001$ of the foot arch height and vertical jump height. Also, positive correlation with $p<0.001$ of lower limb muscle strength and vertical jump height.

The correlation of foot arch height with the vertical jump height stated that as difference in the foot arch height was more, greater power was generated by the lower limb muscles which resulted in a greater vertical jump height. A low arch with flexible foot would absorb ground reaction forces generated during activities or sports with a greater ability than the high arch with stiffer foot. Greater compensation would be seen to in low arches due to increased ground reaction force and therefore greater efforts will be required. Zhao X et al stated that the individuals with low arch have reported to have greater ankle muscle strength[12]. Also, a study conducted by Ho M, Kong PW et al found that the individuals with low arch used possible compensatory movement strategy to maximize the jump performance as they generated a smaller propulsion ground reaction force and lower hip flexion velocity and power[16]. Sahar Boozari et al stated that a greater amount of effort is required by individuals with a low arch (i.e., ankle strength) to maintain a similar level of performance than 33 the normal arched counterparts[17].

The correlation of lower limb muscle strength with vertical jump height stated that the participants with a greater lower limb muscle strength will have more power generated at the lower limbs which resulted in a greater vertical jump.

The muscle strength was a strong determinant of vertical jump performance and It has been considered that to obtain high sport performance level,it was essential to generate maximal strength in the shortest period. It was due to greater muscle strength and rate of development of strength in all lower limb joints rather than to technique[14]. . Athanasios Vanezis and Adrean Lees stated that the height of the vertical jump depends on the proportion of fast twitch muscle fibres[7]. The fast twitch fibres use anaerobic metabolism, provides short burst of speed and fires rapidly. In the male participants one of the contributing factors may be the hormonal influences such as increased adrenergic stimulation of the muscle fibres. [18]

Anne Delextrat and Daniel Cohen stated that the playing position of players affected jump performance. They stated that forwards and guards showed better performance than centers and they also stated that male basketball players had a higher power output during vertical jump due to their large body mass[19]. Also, a study conducted by Gledson et al found that forwards performed the jump shot more frequently and accurately and had a greater performance than the guards. Also the forwards are linked to specific game demands which required the athletes to reach higher jump height during the shots[20]. Jay Dawes et al stated that an increased lean body mass produces a faster change of direction and sprinting performance which will help to achieve a greater VJH. It also stated that the anthropometric characteristic including body weight and height would vary depending upon the player position[21]. Ziv & Lidor stated that it

is advantageous to include exercises to develop leg muscle power as explosive leg muscle power plays an important part in increasing vertical jump performance in overall conditioning program[22].

Conclusion:

Thus, the vertical jump height has a strong correlation with the Foot arch height which means as the foot arch height decreases Vertical Jump height increases and vice versa also it is strongly correlated with Lower limb muscle strength in recreational basketball players. So, during the training sessions, one can focus on the strength of the lower limb muscles and foot mechanics. Further studies considering the player position, body mass index and training period can be considered for more accurate results.

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