



A STUDY OF CORRELATION OF CLARKE'S ANGLE IN DOMINANT FOOT AND NON-DOMINANT FOOT IN AIR RIFFLE SHOOTERS.

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ABSTRACT

Background: Precision, control, and seamless coordination between the eye, nervous system, and musculoskeletal system are essential in the sport of shooting. Foot alignment affects balance and stability, crucial for air rifle shooting. Clarke's angle measures foot alignment. Performance and injury risks to the lower extremity musculoskeletal system in sports can vary based on the diverse midsole characteristics of shoes, including hardness, materials, and structure, influencing their functions. Dominant leg is used to lead out in movement or to manipulate an object and non-dominant leg. The alignment and structure of the foot's arches, especially the medial longitudinal arch, greatly influence an athlete's capacity to maintain a stable shooting stance. **Methodology:** A cross-sectional study. In this cross-sectional study, 80 participants (age: 17.78 ± 2.86) 35 male and 45 female rifle shooters were included. They were assessed for foot dominance by waterloo footedness questionnaire and Clarke's angle measurement using static foot print impression. Using ruler and protractor angle was measured. Clarke's angle were obtained of dominant and non-dominant foot and interpretation was made. **Results:** study found that the significant correlation of Clarke's angle in the dominant and non-dominant foot among air rifle shooters. these findings revealed a statistically significant correlation, with a p-value of < 0.0001 , indicating a highly significant relationship. the correlation coefficient ($r = 0.88$) suggests a strong positive correlation, indicating that the arch of the dominant foot is closely related to that of the non-dominant foot. this suggests that shooters exhibit a balanced foot posture, which may contribute to stability and performance during shooting. **Conclusion** The study conducted among rifle shooters including participants aging from 12 to 24 years in rifle shooter academy reveals, that there is significant correlation of Clarke's angle in dominant and non-dominant foot in air rifle shooters The results of the study show that among air rifle shooters, Clarke's angle in the dominant and non-dominant foot has a significant positive correlation ($r = 0.879$). This implies a close relationship between the arch structures of the two feet, which could help with balance and postural stability while shooting. A symmetrical foot position is probably essential for maximizing effectiveness when shooting an air rifle, given the strong connection. These findings

emphasize the importance of foot mechanics in sports requiring for precise balance and control. Future research should examine how foot asymmetry affects players' injury avoidance techniques and shooting accuracy.

KEYWORDS Dominant and non-dominant foot, Air rifle shoot

INTRODUCTION

Air rifle shooting sport required a high level of accuracy, concentration, and stability of posture. Athletes must be holding a steady and firm stance while aiming target and shooting, relying heavily on balance and stability. The mechanism of the sport involves a coordinated effort of musculoskeletal, neurological, and structural systems, where foot posture plays a vital role in maintaining overall stability throughout the performance of shooting. ^[1]

Athletes in shooting sports have to maintain an action for a certain time thus Better static balancing leads to a higher level of performance. Extended periods of standing during shooting events may induce prolonged muscle contractions, contributing to fatigue and impairing balance and stability. ^[2] Performance and injury risks to the lower extremity musculoskeletal system in sports can vary based on the diverse midsole characteristics of shoes, including hardness, materials, and structure, influencing their functions. ^[3]

Maintaining a fixed posture for an extended period, especially a one-sided stance, places excessive strain on the muscles of that side. Prolonged use can lead to muscle overload and imbalance. Additionally, incorrect training techniques during one-sided exercises may alter body alignment and result in various health issues, such as muscle strain, back pain, and postural deformities. ^[4] Person's stability and Balance can affect due to shoes thus changes in center of pressure. Hardness of sole is important factor for making shooting shoes different from Sports Shoes also, Research has indicated that footwear can influence an individual's balance and stability, leading to alterations in the center of pressure (COP). Studies suggest that varying sole hardness affects the ankle joint and the first metatarsophalangeal joint, Increasing the mid-sole hardness of shoes can potentially reduce the maximum ankle dorsiflexion angle, enhance stability, and reduce fatigue. ^[2] In rifle shooters low back pain is very common due to shifting of hips to maintain proper position and rifle weight, ^[5] pronated feet can lead to low back pain ^[6]

Posture of air rifle shooters

Sport shooting, with its asymmetrical stances, may cause risks to male and female young athletes whose bodies are still developing and adults who engage in prolonged daily practice. For example, during training or competitions, rifle shooters adopt a posture that places them at an anatomical disadvantage due to the spinal column's alignment and the considerable weight (~5 kg) of the firearm. ^[7] Athletes participating in rifle sports are required to adhere to uniform guidelines, which specify regulations regarding the material, fabric thickness, and sleeve width. Similarly, shoe regulations encompass aspects such as shoe length, overall height, sole thickness, length, area, and width of the top material. It has reported that core muscle exercises increased the stability of the muzzle, thus improved the scoring and reduced time of aiming among college and high school athletes. ^[4]

The condition of the foot arch in sport shooters serves as the foundation of the kinetic chain, playing a important role in their training and competitive performance. ^[7] foot posture is a key factor in the biomechanics of rifle shooting, as it is essential for maintaining stability and balance to achieve precision. Acting as the body's foundation, the foot plays a crucial role in weight distribution and postural stability. The alignment and structure of the foot's arches, especially the medial longitudinal arch, greatly influence an athlete's capacity to maintain a stable shooting stance. Proper foot posture facilitates effective weight distribution and reduces sway, both of which are critical for accuracy in shooting sports. ^[8]

It is crucial to highlight the importance of the foot arch's postural condition while also gaining a deeper understanding of the mechanisms that contribute to postural stability. ^[7] Plantar oscillation refers to the small, continuous shifts in weight distribution across the feet, which can be quantified

by monitoring the COP. The COP represents the point on the surface of the foot where the resultant of ground reaction forces is applied. [8]

Accuracy and consistency in the sport of air rifle shooting depend on mastering the right shooting posture. The essential principles are listed below.

Foot placement and stance The fundamental element of accurate shooting is a steady stance. Shooters should stand with their weight evenly distributed, their feet shoulder-width apart, and their bodies angled about 90 degrees toward the target. Although a small forward lean helps with balance, too much leaning should be avoided to prevent pressure on the muscles. [9] Asia-Shooting.Org

Balance and Body Alignment Proper body alignment is ensured by keeping the spine straight and the torso upright. Longer shooting sessions with improved accuracy are made possible by relying on skeletal support rather than straining the muscles, which decreases fatigue. [9]

Arm Positioning and Rifle Support For shooters who are right-handed, the rifle is supported by the left arm, with the elbow resting on the side or hip to provide a stable basis. To improve stability and absorb recoil, the rifle's butt should be firmly placed against the right shoulder, and the right hand should hold the stock comfortably but firmly. [9]

Positioning of the Head and Eyes

To ensure a steady sight picture and prevent neck strain, the head should stay erect and raise the gun to eye level. For a clear target acquisition, the dominant eye should naturally line up with the rifle's sights. [9]

Breathing Control Proper breathing is crucial for shooting accuracy. Shooters should practice controlled breathing by taking a deep breath, exhaling halfway, and then holding their breath momentarily while taking the shot. This technique minimizes movement caused by natural respiration. [10]

The Role of Ankle and Foot Stability in Professional Rifle Shooting: Ankle and foot stability is one of the most important aspects affecting shooting performance since it helps with balance, reduces body sway, and improves overall shooting accuracy. [11] In sports like 10m air rifle and 50m three-position rifle shooting, where even slight postural changes can have a big impact on shot placement, the capacity to maintain a stable posture for prolonged periods of time is crucial. [12] The shooter's posture is supported by the ankle joint, which modifies micromovements to preserve balance. [13] According to research, rifle shooters use both static and dynamic balancing techniques to minimize sway and improve shooting performance, resulting in distinctive postural adjustments. [14]

Dominant and non-dominant foot: Leg dominance is a topic that both healthy and injured athletes frequently address. Peters (1998) defined the dominant leg as "the leg that leads a movement or is used to control an object or to manipulate" The definition of the non-dominant leg naturally leads to: The leg that serves as the supporting or stabilizing component. [15]

Muscle strength, functional usage, and personal preference may all be used to determine which leg is dominant, and these factors may affect balance. Lower-limb dominance has an impact on postural balancing functional activities, such as maintaining balance, and should be assessed based on which leg the person uses and prefers to do these tasks. [16] In humans, preference of using one side for unimanual task is well recognized as self-evident aspect of human motor control. lower limb unlike upper limb has inherent function of supporting the body weight and performing locomotion which require effective coordination between leg. Preferred leg differs between dynamic task several studies already reported. The occurrence of this phenomena is a manifestation of bilateral asymmetry in the motor control circuitry between the right and left hemispheres, which can be observed in both upper and lower limbs. [17] Balance performance may vary between the dominant and non-dominant leg, as the dominant side often bears more weight and engages in more demanding functional activities. This variation should be accounted for when analysing test results that compare both legs. [18]

METHODOLOGY

Materials: waterloo footedness questionnaire, blank paper, pen and pencil, insoluble ink, protractor, ruler, consent form, demographic data collection sheet.

Methodology an observational cross-sectional study done on air rifle shooters data collected from air rifle shooters academy. participants fulfilling inclusion criteria and exclusion criteria were selected for study. study done using convenience sampling with sample size: 80 for a duration of 1.6 years.

Inclusion Criteria: All gender, Age: 12-24, Player not less than 3 years of experience in shooting

Exclusion Criteria: Player with any foot injuries, Player with any recent surgeries of lower limb, Congenital pes planus.

PROCEDURE

This study was an observational study which was conducted in air rifle shooters, Inclusion and exclusion criteria were considered. The study protocol was presented for approval in front of institutional ethical committee and protocol committee of D. Y. Patil Education Society, deemed to be university Kolhapur and D.Y. Patil College of Physiotherapy, Kolhapur and Ethical approval was granted by the committee. The observational study titled "Correlation of Clarke's angle in dominant foot and non-dominant and dominant foot in air rifle shooters" was conducted in rifle shooter academy. Potential subjects were approached and provided with an explanation of the study's purpose. Participants for the study were recruited and they underwent assessment using waterloo footedness questionnaire and Clarke's angle. The study was focused on more than 3 years of experience in air rifle shooters practicing for 2 hours daily, including both male and female individuals age not less than 12 years. Eligible subjects meeting these criteria were included in the study. The study excluded participants who has congenital pes planus, any history of surgery, history of trauma or fracture of lower extremity. These exclusion criteria aimed to focus specifically on lowering of foot arch because of shooting sports with hard thickness of sole, flexibility, static standing and practicing daily for 2 to 3 hours. The nature of the study was explained to interested subjects, and written consent was obtained from all participants. Demographic data including name, age, and gender were collected using a standardized data collection sheet.

The dominance of foot obtained by using waterloo footedness questionnaire and foot impression was obtained using soluble ink on plane sheet and measurement of clarkes angle with protractor was done for 80 participants. The questionnaire was explained in Marathi or English to each participant. It was provided individually, and they were asked to complete it independently, freely and honestly to all items. The participants asked to tick on right or left option also to tick yes or no according to questions. For measuring Clarke's angle, a static footprint was obtained. Each participants was instructed to step onto a felt pad soaked with water-soluble ink using both feet and apply firm pressure. The participants stepped forward, placing their right foot on a graph sheet labelled with their ID number, followed by their left foot. They were asked to stand in a relaxed, balanced stance with equal weight on both feet, looking forward for two seconds before stepping forward to clear the graph sheet. Clarke's angle (CA) was calculated using a marker pen, ruler, and a protractor marked at one-degree intervals. CA was obtained by measuring the angle between the medial tangential line (AB), which connected the medial edges of the first metatarsal head and heel (the AC line), and the line representing the highest point of the medial longitudinal arch (MLA) concavity. Clarke's angle classifications were as follows: "normal" (CA 42°–54°), "mild flat foot" (CA 35°–41°), "moderate flat foot" (CA 30°–34.9°), "severe flat foot" (CA < 30°), and "high arched foot" (CA > 54°). The statistical analysis utilized appropriate biostatistical tools and was conducted using the master chart data. This analysis aimed to calculate the correlation of Clarke's angle in dominant and non-dominant foot in air rifle shooters.

Finally, study declared the results, discussion and conclusion.

RESULTS

a total of 80 air rifle shooters were involved in this study. the mean age group of the participants were 17.78 ± 2.47 years and mean score of number of standing hours was 2.86 ± 0.55 . maximum of 56% (45) female and 44% (35) were male.

No. of hours practicing	Frequency (n)	percentage (%)
2 hours	43	53.75%
3 hours	24	30%
2.5 hours	6	6.50%
3.5 hrs	7	7.50%
Total	80	100%

Table3: frequency and percentage of no of hours practicing daily

In given population 53.75% (43) air rifle shooters practicing for 2 hours, 30% (24) are practicing for 3 hours, 7.50% (7) are practicing for 3.5 hours and only 6.50% (6) are practicing for 305 hours. Table 4.no of years of experience its frequency and percentage.

YEARS OF EXPERIENCE	Frequency (n)	Percentage (%)
<5 Years	19	23.75%
>5 Years	61	76.25%
Total	80	100.00%

Table 4.no of years of experience its frequency and percentage.

In given population years of experience participants has less than 5 years 23.75% (19) and 76.25% (61) more than 5 years of experience in air rifle shooting performance [table:4, figure4].

Among 80, 36.25% (29) were found to be left foot dominant and 63.75% (51) participants were having right foot dominance which was assessed by using waterloo footedness questionnaire (WFQ) [figure:4, table:5]

WFQ	Frequency (n)	Percentage (%)
Left	29	36.25%
Right	51	63.75%
Total	80	100.00%

Table 5: Frequency and percentage of outcome measure: WFQ

VARIABLES	MEAN	SD
DOMINANT FOOT	29.18	7.24
NON-DOMINANT FOOT	31.47	5.72

Table 6: Mean and SD of dominant and non-dominant foot

Among 80, the mean of Clarke's angle in dominant foot is 29.18 ± 7.24 and mean of Clarke's angle in non-dominant foot participants is 31.47 ± 5.72 [table:6].

There is correlation of Clarke's angle in dominant and non-dominant foot in air rifle shooters with correlation coefficient (r) 0.883 and P-value < 0.001

Correlation coefficient (r):0.833

P-value:<0.001

A Pearson correlation analysis was used to determine the relationship between Clarke's angle of the dominant and non-dominant foot.

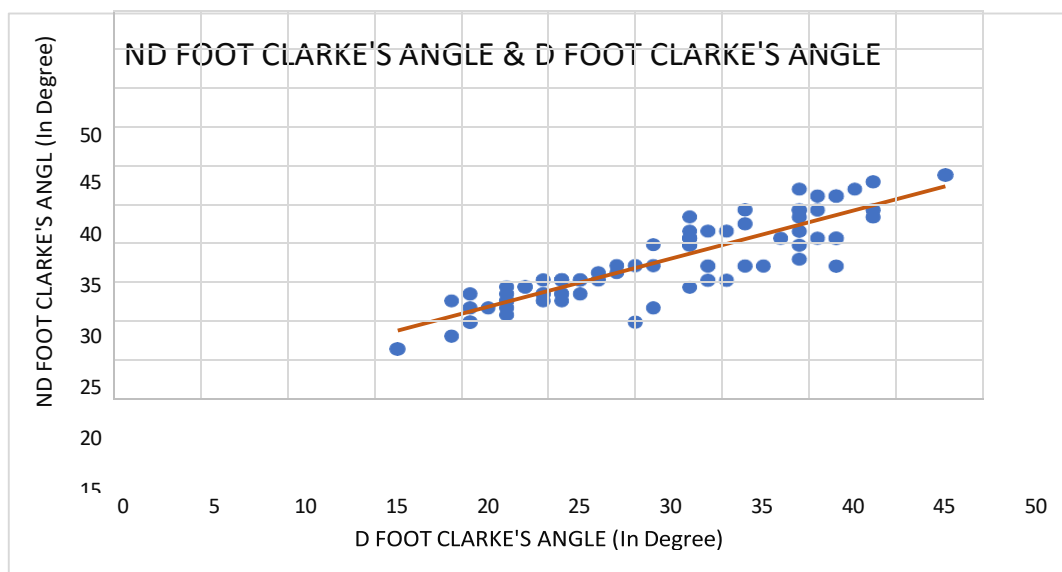


Fig 4: Correlation of Clarke's angle in dominant and non-dominant foot

These results indicate a strong positive correlation between the $p < 0.001$. This result suggests about the foot arch of the dominant foot has close relation to that of the non-dominant foot.

This study has observed correlation is statistically significance as p-value is < 0.001 . [figure, table:7]

VARIABLE	N	CORRELATION COEFFICIENT(R)	P-VALUE
ND FOOT CLARKE'S ANGLE IN DEGREE	80	0.883	< 0.001
D FOOT CLARKE'S ANGLE IN DEGREE			

Table 7: Correlation of Clarke's angle in dominant and non-dominant foot.

The results of this study showed that the dominant and non-dominant feet's Clarke's angles had a substantial positive association ($r = 0.883$, $p < 0.001$), suggesting that air rifle shooters' arch structures are comparable in both feet. This finding implies that stability is vital in precision sports like shooting, where maintaining a balanced foot stance is critical [5,16].

Clarke's Angle and Postural Stability in Sports Shooting

Extreme postural control is necessary for shooting since even slight body wobble can have a big impact on accuracy [47]. The alignment of the foot, which forms the basis of postural stability, has a direct impact on an athlete's capacity for balance [2]. According to this study, rifle shooters should establish bilateral foot arch symmetry, which lessens postural sway and improves shooting accuracy, given the strong association between Clarke's angles in both feet. The importance of foot dominance in load distribution has been highlighted by earlier studies [6]. Usually, the non-dominant foot offers stability, while the dominant foot is in charge of fine motor control. However, both feet play an equal role in maintaining balance in static sports like rifle shooting. The strong association seen in this study is consistent with a relationship between rifle stability and postural balance, indicating that shooters regulate their foot stance to improve performance [48].

Implications of Foot Arch Symmetry

The concept that shooters have asymmetrical foot mechanics, which is essential for sustaining a steady stance for extended periods of time, is supported by the high association discovered in this study [49]. The uniformity of the medial longitudinal arch (MLA) across both feet indicates even weight distribution, which is advantageous for stability [5]. The MLA is essential for absorbing and

distributing body weight.

According to a study by Hegazy et al. Clarke's angle is a very accurate indicator of an athlete's foot posture when compared to the Foot Posture Index (FPI-6). This reaffirms the significance of Clarke's angle in assessing shooters' postural changes and validates the results of the current investigation.^[47]

In previous study it was concluded that there was an explanation that years of spending a lot of time in shooting postures could affect the arch of the foot.

This study included 80 air rifle shooters from Olympic rifle shooter academy Kolhapur. In the current study we included the shooters age group between 14 to 35 years. The gender of the respondents, from which 56% were female and 44% were male. The reason could be due to the predominance of female population in the current study.

In this study, the correlation of Clarke's angle in dominant foot and non-dominant foot in air rifle shooters with correlation coefficient value 0.883 ($p\text{-value} \Rightarrow 0.001$). A study conducted by Đorđević S et al among air rifle shooters who reported the basic stance vaulters maintain during competitions may result in a longer static strain on the arch of the foot, which could be the primary source of the observed foot postural condition in these athletes. Furthermore, a detailed examination of the data revealed no statistically significant differences in foot arch postural deviations between participants in air pistol and rifle disciplines, regardless of gender ($p=.082$).^[7] There is a noticeable lack of study on the relationship between flat feet, performance and further risk of injury in the literature.

The author highlights the necessity for prevention and treatment of reduced arches in shooters and calls for more research on the subject of the notable variation in arch status between rifle and pistol shooters. Taking inspiration from Takata et al.'s (2013) study suggests that individual with pes planus for ground stability surface has positive of corrective insole, according to this study, if the postural issue is more severe on a structural basis, shooters may benefit from similar approaches.

on the positive effects of corrective insoles in individuals with flat feet on ground stability.

In our study, among 80 participants 51 was right dominant (63.75%) and 29 were left dominant (36.25%) Shooters are practicing for 2 hours are 43 (53.75%) and 24 participants were practicing for 3 hours are 24 (30%) Shooters are practicing for 2 hours are 43 (53.75%) and 24 participants were practicing for 3 hours are 24 (30%). There are 6.50% (6) participants who are practicing for 2.5 hours solely for competition purposes. Additionally, 7.50% (7) of participants are practicing for 3.5 hours solely for competition. Lastly, 6.50% (6) of participants are practicing for 2.5 hours.

Among these 80 (100%) populations, 56% (45) participants were female and 44% (35) participants were male. This could be attributed to the higher proportion of female in the present research.

According to Clarke's angle interpretation, the Clarke's angle <30 degree is considered as flat feet. Clarke's angle value ranges from 31-41 degree termed as feet with lower longitudinal arch, the score ranging from 42-54 degree considered as correct longitudinal feet arch and $<55\%$ is termed as hollow feet.

The correlation of Clarke's angle in dominant and non-dominant foot has strong correlation among air rifle shooters in our study, potentially due to static long standing, wearing of shoes for static stability for their improvement in performance. These participants often find themselves suffering with lower back pain due to posture attaining during shooting.

The combination of these factors underscores the multifaceted nature of the problem, highlighting the need for comprehensive strategies to address the correlation of Clarke's angle in dominant and non-dominant foot in air rifle shooters. Efforts to promote ergonomic practices and prevention of changes in foot arch could prove beneficial in mitigating the lowering arch due to posture as it bears uneven weight on foot on the newly practicing shooters in this field.

CONCLUSION

The study reveals, that there is strong positive correlation of Clarke's angle in dominant and non-dominant foot in air rifle shooters. We found that correlation coefficient value(r) 0.883 and value is <0.001 was seen among 80 participants. Lowering of foot arch can be prevented by arch support. Strong Positive Correlation A significant positive correlation ($r = 0.879$, $p < 0.001$) was found

between the Clarke's angles of the dominant and non-dominant foot. This indicates that shooters due to static posture for long period and exhibit asymmetrical foot arch structures, which may contribute to improved postural stability and balance during shooting.

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