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THE POSTURAL STATUS OF SPORT SHOOTERS FOOT ARCH IN CORRELATION WITH THEIR COMPETITIVE DISCIPLINE AND GENDER

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SUMMARY

The objective of this study was to assess variations in the arch status of the foot among 99 participants in the senior championship of Serbia in sports shooting, held in Niš in 2021, with a focus on their respective disciplines and gender. The Pedic podoscope instrument from Hungary, along with relevant software, was utilized to determine the postural status of the foot arch. Results revealed that among the 99 subjects, 40 (40.4%) exhibited a normal foot arch, 53 (53.5%) had flat feet, and six (6.1%) had hollow feet. In the air pistol discipline, 36% of the 25 male participants had a normal foot arch, while 64% had flat feet. Among the 16 female participants in the same discipline, 43.8% had a normal foot arch, and 53.3% had flat feet. In the rifle discipline, 34.6% of the 26 male participants had a normal foot arch, 50% had flat feet, and 15.4% had hollow feet. For female participants in the rifle discipline, 46.9% had a normal foot arch, 46.9% had flat feet, and 6.3% had a hollow foot. Statistical analysis indicated no significant gender differences in the air pistol (p=.620) and air rifle disciplines (p=.426). Additionally, there was no statistically significant difference in postural deviations of the foot arch among subjects practicing air pistol and rifle disciplines of both genders (p=.082). The findings underscore the importance of addressing foot arch posture concerns among sport shooters of diverse genders and disciplines through preventive and corrective measures.

Key words: sport shooters, flat foot, foot deformity, clubfoot

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INTRODUCTION

The capacity to maintain an erect body position, commonly referred to as postural control, stands out as a defining attribute of human beings. This ability to regulate the upright alignment of the body is crucial for the exhibition of motor skills and serves as a prerequisite for the diverse physical activities individuals engage in daily (Demeši-Drljan, & Mikov, 2012). Examining the intricacies of the mechanisms governing upright body posture reveals a highly complex system. For this system to operate effectively, it necessitates the integration of diverse components, with a primary emphasis on motor and sensory elements (Horak, Nashner & Diener, 1990).

The maintenance of balance during standing is significantly influenced by information gathered from three sensory systems: the visual, vestibular, and proprioceptive systems. The requisite degree of postural stability varies depending on the nature of the sport and sports discipline, leading to the development of specific balance control strategies. Sports training plays a pivotal role in enhancing sensorimotor skills, thereby contributing to improved upright balance maintenance. Moreover, there is ample evidence suggesting that engagement in sports can alter balance, with the extent of this change being sport-specific and contingent upon the training regimen. For instance, shooters undergo training to sustain a stable bipedal stance for extended durations to stabilize their rifles. Existing research indicates superior balance during upright stance in elite athletes, particularly pistol and rifle shooters, compared to untrained individuals (Zemková, 2014; Park, Hyun, & Jee, 2016). However, investigations into the postural stability of sport shooters are notably scarce (Aalto, Pyykkö, Ilmarinen, Kähkönen & Starck, 1990; Paterno, Myer, Ford, & Hewett, 2004; Bressel, Yonker, Kras, & Heath, 2007).

Shooting, by its inherent characteristics, falls within the category of static sports, emphasizing the utmost significance of high postural stability, coordinated body segments, and heightened concentration during shooting for achieving optimal performance. To attain superior results, shooters are advised to enhance their shooting position by focusing on improving postural stability, controlling breathing, and refining trigger techniques (Mon, 2006; Mon, 2009).

Sport shooting, characterized by asymmetrical stances, presents potential risks for both the developing bodies of young athletes and adults engaged in prolonged daily shooting practices. For instance, rifle shooters assume an anatomically disadvantageous body position during training or competitions, given the spinal column's orientation and the substantial mass (≈ 5 kg) of the firearm. However, rifle shooters can benefit from shooting equipment such as a shooting suit, gloves, and specialized shoes. The shooting suit, constructed from robust canvas, provides structural support to the shooting stance, alleviating the shooter's physical strain. In contrast, pistol shooters enjoy a more favorable body position during training and competition, with a shoulder-width stance and a slight backward trunk lean, effectively balancing the weight of the firearm and aligning the body's center of balance between the feet (Iskender, 2010; Mikec, 2017; Mikec, 2019).

To attain optimal postural stability among sport shooters, it is essential to underscore the significance of the arch of the foot's postural status, in addition to understanding the mechanisms supporting postural stability. Given its harmonious and aesthetically structured nature, the foot plays a pivotal role, both statically and dynamically, holding crucial importance for locomotion and various human physical activities (Aalto, Pyykkö, Ilmarinen, Kähkönen & Starck, 1990; Radisavljević, 2001). The insights gleaned from this perspective underscore the need to assess the postural status of the foot arch in sport shooters, recognizing it as the starting point of the kinetic chain in their competitive and training endeavors. Furthermore, considering potential gender-based differences, inherent physiological distinctions, such as variations in the weight of competition props, should be taken into account.

Aligned with the previously mentioned considerations, the objective of this study is to assess the postural status of the foot arch among shooters of diverse genders participating in the air pistol and rifle disciplines and to determine differences by gender and discipline.

METHOD

A sample of participants

The participant pool comprises individuals engaged in the senior championship of Serbia in sports shooting, held in Niš in 2021., totaling 99 participants categorized into four groups: G1, encompassing pistol competitors (41 subjects); G2, comprising rifle competitors (58 subjects); G3, consisting of male shooters (51); and G4, consisting of female shooters (48).

Sample measuring instruments

The assessment of the arch of the foot's postural status involved utilizing the podoscope instrument («Pedic», Budapest,Hungary), in conjunction with essential software (Milenković et al. 2011; Bubanj, Đorđević, Milenković, Stanković, Vidojević, & Đokić, 2021). This methodology enabled the determination of various foot variables, including Pes Nor (normal arch of the foot), PesPlL (first degree of flat foot deformity), PesP2L (second degree of flat foot deformity), PesP3L (third degree of flat foot deformity), and Pes CAV (hollow foot).

Measurement procedure

The measurements of the arch of the foot's postural status were conducted at the shooting range on the actual day of the competition. Optimal conditions, including suitable illumination, temperature, and air humidity, were ensured during the measurements. The assessments took place in the morning hours, specifically from 8:00 am to 12:00 pm. To facilitate the process, participants presented themselves before their scheduled performances to the assessors who carried out the foot arch diagnosis. This arrangement allowed for a streamlined procedure where participants

could seamlessly transition from the measurement process to their competitive engagements. Both the measuring assistants and the measuring staff were well-acquainted with the measurement protocols and procedures. The measurement process involved subjects reporting to the meter, where they removed their shoes and socks before stepping onto the podoscope. After a 5-second interval, the subjects stepped off the podoscope and proceeded to the competition, while the meter software analyzed the acquired data (Milenković et al., 2011).

The measurements adhered to a predetermined schedule communicated in advance to both the measuring team and the participants.

The measurements conducted in this research adhered to the ethical principles governing human research, as outlined in the Declaration of Helsinki from 2008 (World Medical Association, 2011).

Data analysis

The results obtained from the testing were analyzed using the statistical processing program SPSS «version 20». Descriptive statistics, including percentage and frequency, were employed to illustrate the postural status of the foot arch in shooters across various genders and disciplines. To assess variations in the prevalence of deformities among shooters in different disciplines and genders within disciplines, the Chi-square test for independence was applied.

RESEARCH RESULTS

General statistics of frequencies and percentages

Table 1. ***Number of respondents by discipline, gender and frequency of foot arch deformities among respondents***

Discipline			**Gender**			**Frequency of foot arch deformity of the subjects**		
	Number	%		Number	%		Broj	%
pistol	41	41.4	male	51	51.5	Normal foot arch posture	40	40.4
rifle	58	58.6	female	48	48.5	Flat foot	53	53.5
total	99	100.0	total	99	100.0	Hollowed out foot	6	6.1
						Total	99	100.0

Examining the data presented in Table 1, it is evident that among the 99 participants, 41 (41.4%) are engaged in pistol shooting, while 58 (58.6%) are involved in rifle shooting. The gender distribution reveals that 51 (51.5%) participants are male, and 48 (48.5%) are female. In terms of foot arch posture, 40 (40.4%) respondents exhibit a normal arch, 53 (53.5%) have flat feet, and six (6.1%) have hollowed out feet.

Percentage statistics by groups

Table 2. ***Number of subjects by gender in the pistol and rifle disciplines***

Discipline	Gender	Frequency
pistol	male	25
	female	16
rifle	male	26
	female	32

Among the 99 respondents, there are 25 male participants engaged in pistol shooting and 26 in rifle shooting. Among female respondents, 16 participate in the pistol discipline, while 32 are involved in the rifle discipline.

Table 3. ***Frequency of normal arch posture, flat foot and arched foot among subjects according to gender and the discipline in which they compete***

Discipline	Sex/No. of the respondent	Normal foot arch posture		Flat foot		Hollowed out foot	
		Number	%	Number	%	Number	%
pistol	men / 25	9	36	16	64	/	/
	women / 16	7	43.8	9	53.3	/	/
rifle	men / 26	9	34.6	13	50	4	15.4
	women / 32	15	46.9	15	46.9	2	6.3

Among the 99 respondents, 25 male participants compete in pistol shooting, with nine (36%) seniors having a normal foot arch, while 16 (64%) have flat feet. In the same discipline, 16 female participants are observed, where seven (43.8%) senior women exhibit a normal foot arch, and nine (56.3%) have flat feet. For the rifle discipline, 26 male participants are identified, with nine (34.6%) seniors having a normal foot arch, 13 (56.50%) having flat feet, and four (15.4%) seniors competing with rifles having hollow feet. Among the 32 female participants in the rifle discipline, 15 (46.9%) senior women display a normal foot arch, 15 (46.9%) have flat feet, and two (6.3%) senior women competing with rifles have hollow feet.

The difference in the representation of deformities between shooters of different disciplines, as well as gender within disciplines

Table 4. ***Variations in the postural status of the foot arch between subjects who compete with a pistol and those who compete with a rifle***

Chi-Square Tests

	Value	df	p
Pearson Chi-Square	4.998[a]	2	.082
Likelihood Ratio	7.165	2	.028
Linear-by-Linear Association	.438	1	.508
N of Valid Cases	99		

a- two cells (33.3%) have an expected number less than 5. The minimum expected number is 2.48.

Table 5. ***A measure of the association between two nominal variables***

Symmetric Measures

		Value	p
Nominal by Nominal	Phi	.225	.082
	Cramer's V	.225	.082
N of Valid Cases		99	

The analysis reveals that there is no statistically significant difference in the postural status of the arch of the foot between participants competing with a pistol and those engaged in rifle competitions.

Table 6. ***Gender disparities in the postural status of the foot arch within the pistol discipline***

Chi-Square Tests

	Value	df	p
Pearson Chi-Square	.246[a]	1	.620
Continuity Correction[b]	.028	1	.867
Likelihood Ratio	.245	1	.620
Fisher's Exact Test			
Linear-by-Linear Association	.240	1	.624
N of Valid Cases	41		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.24.
b. Computed only for a 2x2 table.

Table 7. ***A measure of the association between two nominal variables***

Symmetric Measures			
		Value	**p**
Nominal by Nominal	Phi	-.078	.620
	Cramer's V	.078	.620
N of Valid Cases		41	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

There are no statistically significant gender differences in the pistol discipline.

Gender differences in the rifle discipline

Table 8. ***Gender variations in the postural status of the foot arch within the rifle discipline.***

Chi-Square Tests			
	Value	**df**	**p**
Pearson Chi-Square	1.707[a]	2	.426
Likelihood Ratio	1.717	2	.424
Linear-by-Linear Association	1.533	1	.216
N of Valid Cases	58		

a. 2 cells (33.3%) have expected count less than 5.
The minimum expected count is 2.69.

Table 9. ***A measure of the association between two nominal variables.***

Symmetric Measures			
		Value	**p**
Nominal by Nominal	Phi	.172	.426
	Cramer's V	.172	.426
N of Valid Cases		58	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

There are no statistically significant gender differences in the rifle discipline.

DISCUSSION

The findings of this study revealed a 59.6% deviation from the normal arch posture of the foot in the overall sample of participants. The elevated percentage of postural deviations observed in this study cannot be directly compared to previous research due to a lack of available data. However, when compared to the non-sports-playing population aged 18 to 30, the observed percentage is notably higher (Chougala, Phanse, Khanna, & Panda, 2015; Aenumulapalli, Kulkarni, & Gandotra, 2017). Additionally, when examining other sports that are not of a static nature, the percentage of postural

deviations is significantly lower than in the sample of vaulters included in this study. The fundamental cause of the observed foot postural status in vaulters may be attributed to the prolonged static load on the arch of the foot, resulting from the basic position maintained during competitions.Furthermore, no statistically significant gender differences were identified in either the air pistol discipline (p=.620) or the air rifle discipline (p=.426). Additionally, a thorough analysis of the results demonstrated no statistically significant disparities in postural deviations of the foot arch between individuals engaged in air pistol and rifle disciplines, irrespective of gender (p=.082). These results underscore crucial insights, as the review of existing literature in English yielded no comparable studies on foot posture in sport shooters. While some studies have explored the correlation between injuries and foot type, there is a notable absence of research on the connection between flat feet and motor performance in the available literature.

This study marks the inaugural exploration into the foot status of athletes engaged in shooting sports in Serbia. It stands as the first examination of the variance in arch status between competition shooters using pistols and rifles. The rationale behind this investigation stemmed from the unique shooting stances and differences between rifle and pistol shooters. There was a warranted suspicion that prolonged hours in shooting positions over years, coupled with inadequate physical activity, might influence the arch of the foot. While the results indicated no statistically significant difference in the arch status between rifle and pistol shooters, the author advocates for further research on this topic, emphasizing the need for prevention and correction of lowered arches in shooters. Addressing this issue in the early stages of growth is crucial, as delaying solutions could lead to structural disorders later in life, significantly limiting athletes. Moreover, a potential solution involves incorporating appropriate physical activity into training processes to address the disorder or prevent it if it has not yet been diagnosed.

Drawing inspiration from Takata et al.'s (2013) study on the positive effects of corrective insoles in individuals with flat feet on ground stability, this research suggests considering and applying similar interventions for shooters, if the postural disorder is of a more severe, structural level.

Six competitive rifle shooters (four men and two women) exhibited a gouged foot, whereas none of the pistol shooters displayed this condition. These findings, in this specific representation of the population, cannot be attributed to the influence of the discipline type.

This study has gathered valuable data, which will play a crucial role in the ongoing monitoring of foot arch status among shooters. The findings are expected to serve as a precise and reliable source of information for coaches in conducting future postural measurements for athletes involved in sports shooting.

CONCLUSION

The outcomes of this research highlight a remarkably high prevalence of postural irregularities in the foot arch among shooters of varying genders and within the senior

category disciplines. These findings underscore the potential impact of prolonged competition on athletes, considering the necessity for a stable stance, where the feet serve as the starting point of the kinetic chain. The study not only offers insights to athletes and their coaches regarding potential challenges but also provides guidance on how to address these issues within their practices and training programs. In light of these results, it is recommended that researchers conduct a more in-depth analysis of this matter in younger categories for preventive measures. Additionally, researchers should explore strategies for addressing postural deformations in the feet among senior athletes after diagnosis.

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