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The Influence of Shoe on Posture and Performance of Rifle Shooters – A Comparative Study

Seoung Eun KIM*

Center for Sport Science in Chungnam, Chungnam Sports Council, South Korea.
**(ORCID ID :0000-0002-0042-7157)*

Abstract

Shooting sports includes different disciplines: rifle, handguns, and shotguns. This sports activity requires accuracy, precision, consistency, and speed. Various factors influence the performance of any shooters. This study considered the influence of shoe on the rifle shooters performance. In this comparative study, four female middle school rifle shooter with more than two years of rifle shooting experience have participated. Foot plantar pressure and center of pressure (COP) were measured using commercially available insole sensors and compared in two conditions (shooting with or without the shoe). The results were: the mean force at left foot interface was increased by 7.23 N (1.7 %), and the mean force at right foot interface was significantly ($p < 0.05$) increased by 32.87 N (12.9 %) after shooting with shoe compared without wearing the shoe. There was 0.716 mm (66.7 %) significant ($p < 0.01$) in COP distance in the right foot while shooting with the shoe. The lateral body moved enhanced while shooting with the shoe, which increased the shooter's stability and balance. These results confirm that wearing the shoe in rifle shooting sport could increase the stability and balance, which lead to an improvement in aiming and performance of shooters.

Keywords : Air rifle, Center of Pressure, Shooting, Stability, Shoe.

I. INTRODUCTION

Shooting sports is a collection of competitive and recreational activities which proves the accuracy, precision, consistency, and speed of shooters. In shooting competition, the target is hit using a gun either rifle, handguns, shotguns, etc. Various disciplines are coming under this sports activity, including the type of equipment, shooting distances, types of targets, time limits, shooting position, etc. [1]. This sport requires good physical fitness, mental ability, control on breathing, stable posture, attention, and concentration from shooters [2]. In particular, stable position plays a vital role in deciding the outcome of a match, numerous studies on shooting reported that the stability of shooters body affects the aiming and triggering in a static state. To improve the performance of shooting athletes, multiple studies have been carried out, focusing on the stability of shooting. Ju and Kim [3] compared the skilled with the unskilled and said that the experienced had better stability than the unskilled. Therefore, it can be said that a player with better stability can perform better.

Kim [2] reported that core muscle exercises increased the stability of the muzzle, positively improved the scoring and reduced the aiming time among college and high school athletes. Numerous studies reported the effect of posture on aiming, stability, and performance of shooters [4-6]. Kim and Jeon [7] concluded that the college athletes reduced the left-right movements and their stable support of guns by moving the COP backward, which affected the outcome of the shooting. Among the shooting sports, the air rifle game takes a standing posture which requires the weight of the rifle to be tolerated by the muscles of the shoulder or arm, so cramps caused by muscular fatigue will hurt aiming.

There are physical and psychological training methods exist to improve the stability in a shooting activity by minimizing the movement of the body. It is necessary to keep a stable posture for a prolonged period, particularly one-sided posture need to be maintained for an extended period. This extended usage of muscles leads to overload or burden to the muscles of the side. If wrong training methods adopted during the one-sided training guide to a change in body shape and numerous health effects, including muscle pain, back pain, etc. [8]. The changes in body shape will negatively affect the shooting ability [9]. To maintain proper body posture and shape, various aids, including shooting suits and shoes, are needed.

Today's modern age, development of sports equipment's and its accessories increased day by day. The shooting sports industry focused on developing shoes and suits. Kwang et al [10] studied the effects of shooting suits and shoes on shooters performance and reported that the shooting suit had a significant influence on the game record than the shooting shoes. Also, the muzzle movement was consistent when shooting with outfits and shoes. Although these sports aids can help to improve the performance and efficiency of shooters, there are regulations to prevent the vast differences in the equipment. Rifle sports athletes must wear uniforms, and there is no regulation for weight, but there are regulations for the material, the thickness of the fabric, and width of the sleeve. In terms of shoes, there are regulations for the length, height of whole shoes, and the thickness, length, area of sole and width of material on the top of the shoe.

As mentioned earlier, the stability of the shooter is essential to ensure positive performance in shooting sports. Few studies were reported the effect of wearing shooting suits on shooters performance. However, limited reviews only found on the impact of shoes on the performance of rifle shooters. Hence, this study aimed to investigate the influence of shoes on rifle

shooters performance (aiming and triggering), foot pressure, and center of pressure.

II. MATERIALS AND METHODS

II. I. Subjects

In this study, four female middle school rifle athletes with more than two years of rifle shooting training experience participated. The study purpose and procedure clearly explained to all the participants, and they had given written consent to participate. The physical characteristics of the participants shown in Table 1.

Table 1. Characteristics of the subjects

Group	Age (Years)	Height (cm)	Weight (kg)	Experience (Years)
	Mean ± SD			
Female (n = 4 subjects)	15.50 ± 0.55	158.35 ± 3.30	53.15 ± 3.49	2.31 ± 1.12

II. II. Equipment and Analysis Condition used

The OpenGo sensor insoles from Moticon GmbH, Munich, Germany, was used in this study (refer Fig 1). Thomas and Alex [11] validated the OpenGo sensor insoles and reported that it could be applied in both clinical and research purpose to measure foot pressure and body balance while doing motion studies. In this study, the changes in COP in X and Y-axis and foot pressure (both left and right foot) were measured using OpenGo sensor insoles. To analysis the changes in COP in X and Y-axis, the foot force were measured while shooters were shooting the target with and without wearing shoes. Participants with and without wearing shoes performed a total of 10 triggering's. The interface pressure details were measured for the 10-sec duration and further analyzed to extract necessary information. The sampling rate for measurement was 50 Hz. The experiment environment and foot force measurements are shown in Fig 2. For the three dimensional accelerometer the Z-axis point to the normal direction about the ground plane, the Y-axis is in the line of walking and the X-axis is in medial/lateral direction (Fig 2).

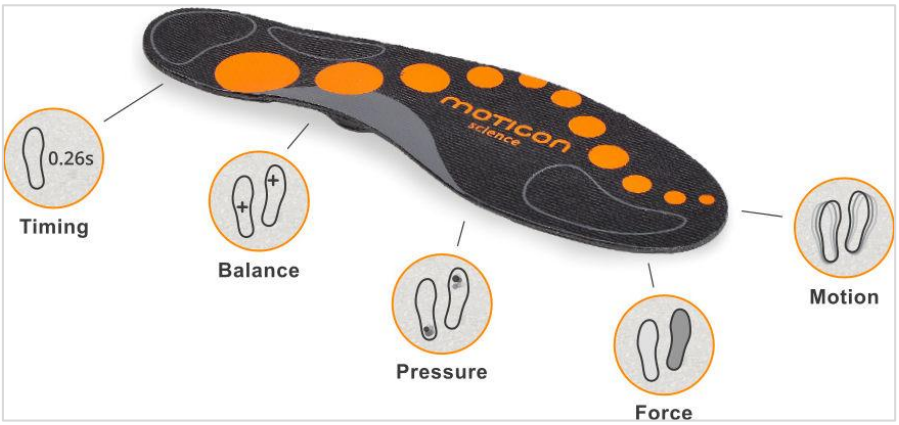

Fig 1. OpenGo Sensor Insoles (Moticon GmbH, Germany)

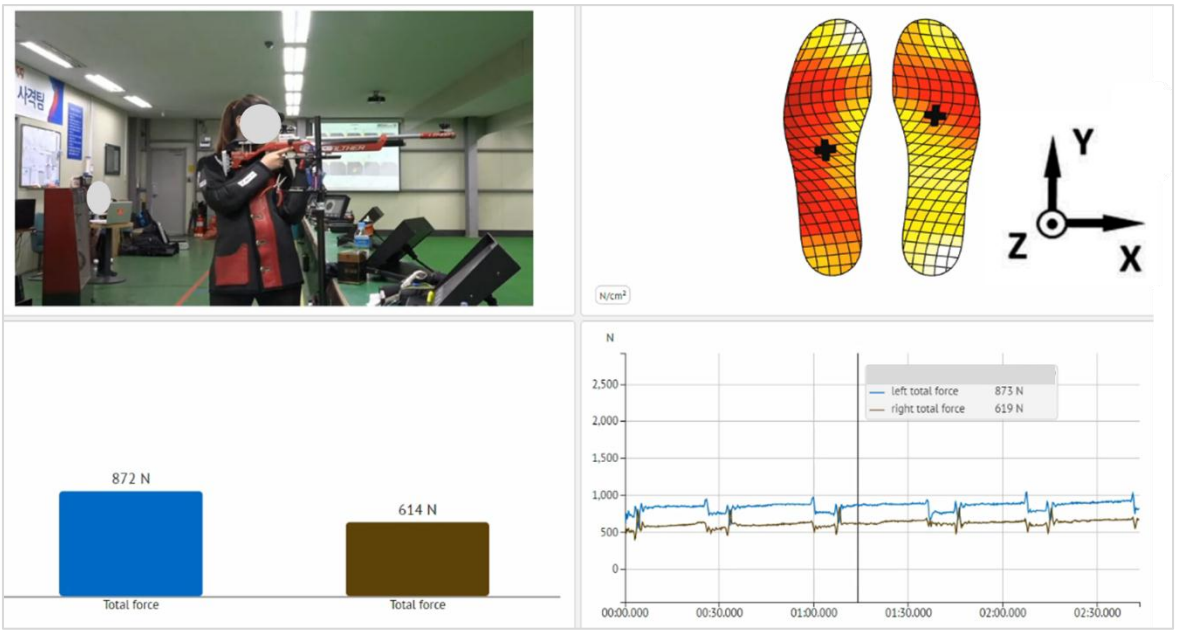

Fig 2. Experiment (female athlete performing shooting activity and plantar force measurement) scene

II.III. Statistical Analysis

An independent T-test was conducted to compare the study results for statistical significance, with the significance level set at $p < 0.05$ at SPSS 18.0.

III. RESULTS

III. I. Foot COP Measurement

The measured COP in X (medial/lateral) and Y (line of walking) axes are presented in Table 2 and Fig 3. The average left foot COP in X-axis (LCX) was 0.573 mm while shooting without the shoe, which was 0.388 mm while shooting with the shoe. There was 0.185 mm (32.3 %) reduction in COP distance LCX while shooting with the shoe. The average left foot COP in Y-axis (LCY) was 4.018 mm while shooting without shoe, which was 2.435 mm while shooting with the shoe. There was 1.583 mm (39.4 %) reduction in COP distance LCY while shooting with the shoe. However, there was no significant difference found in COP, whether shooting with and without wearing the shoe in LCX and LCY. But the reduction in COP, i.e., bringing COP closure to the body would increase the stability and increase the shooters' focus and performance. Hence, we could say that shooting with shoe would assist the shooters in improving their stability.

The average right foot COP in X-axis (RCX) was 1.074 mm while shooting without the shoe, which was 0.358 mm while shooting with shoe. There was 0.716 mm reduction (66.7 %) (Significant reduction, $p < 0.01$) in COP distance RCX while shooting with the shoe. The average right foot COP in Y-axis (RCY) was 4.109 mm while shooting without the shoe, which was 2.531 mm while shooting with the shoe. There was 1.578 mm (38.4 %) reduction in COP distance RCY while shooting with the shoe. However, there was no significant difference found in COP, whether shooting with and without wearing the shoe in RCY. The significant ($p < 0.01$) reduction in COP in right foot medial/later direction, bringing COP closure to the body would increase the stability and increase the shooters focus and performance. Hence, with the evidence of left and right foot COP data, we could say that shooting with shoe would assist the shooters to improve the stability.

Table 2. Foot COP Movement results

	Without shoe	With Shoe	t	p
	Mean ± SD in mm	Mean ± SD in mm		
LCX	0.573±0.308	0.388±0.114	1.388	0.195
LCY	4.018±2.596	2.435±0.694	1.443	0.180
RCX	1.074±0.442	0.358±0.143	3.786	0.004**
RCY	4.109±1.668	2.531±0.988	2.208	0.052
** $p < 0.01$				
LCX: Left foot COP in a medial/lateral direction LCY: Left foot COP in line of walking RCX: Right foot COP in a medial/lateral direction RCY: Right foot COP in line of walking				

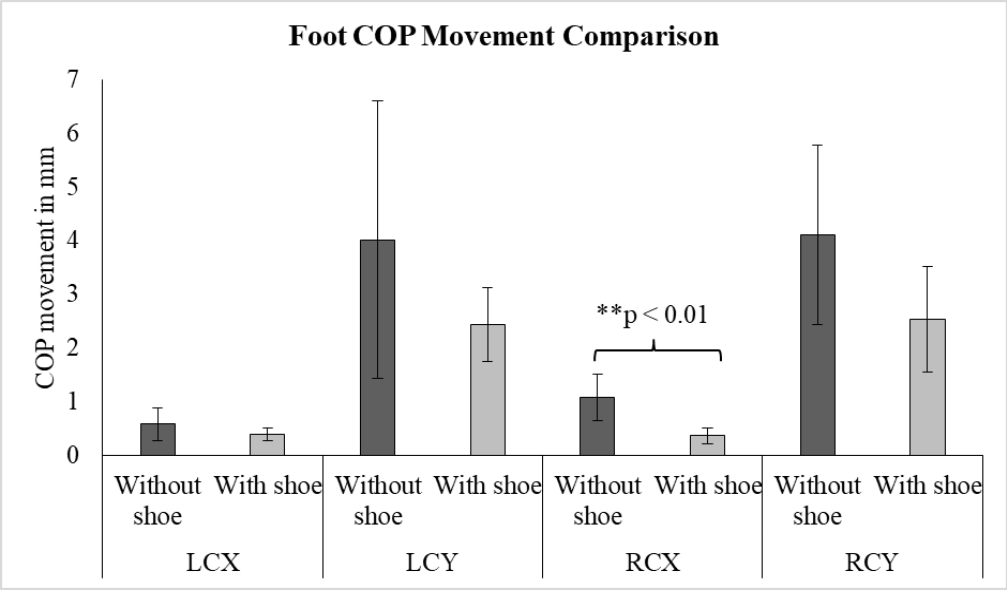

Fig 3. Foot COP movement (in lateral and line of walking direction) comparison while shooting without and with wearing the shoe.

III. II. Plantar force measurement

The left and right foot plantar average force are presented in Table 3 and Fig 4. The average left foot plantar force was 419.17 N while shooting without the shoe, which was 426.40 N with the shoe. There was no significant increase in left foot plantar force 7.23 N (1.7 %) while shooting with the shoe. The average right foot plantar force was 254.33 N while shooting without the shoe, which was 287.20 N with the shoe. There was significant ($p<0.05$) increase in right foot plantar

force 32.87 N (12.9 %), while shooting with the shoe. In the case of balance measurement, the ratio between left to right foot was 62.24: 37.76 while shooting without the shoe. However, it was 59.75: 40.25 with shoe. Though there was no significant improvement in left to right foot balancing after wearing shoe, balancing got improved compared with shooting without the shoe. Hence, with the evidence of left and right foot plantar force measurement, we could say that shooting with the shoe would assist the shooters in improving their balance.

Table 4. Plantar Force Measurement

	Without shoe	With Shoe	t	p
	Mean ± SD in N	Mean ± SD in N		
Left foot	419.17 ± 147.20	426.40 ± 126.07	-0.044	0.517
Right foot	254.33 ± 88.32	287.20 ± 92.43	-0.018	0.049*
Left: Right Foot Ratio (%)	62.24 : 37.76	59.75 : 40.25	0.796	0.244
* $p < 0.05$				

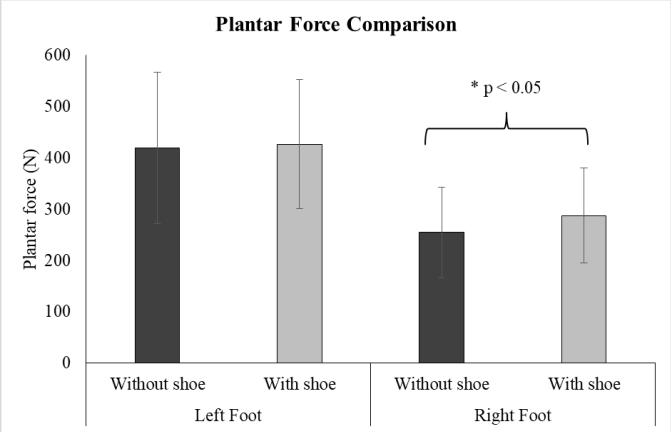

Fig 4. Right and Left foot plantar force comparison while shooting without and with shoe

III. III. Average Score

The shooter's performance also recorded for comparison. The score was given for each participant after each shooting trails in both conditions (Table 3). The average rating for subject A and B got increased, however, for Subject C and D got reduce a bit. However, there was no significant increase nor decrease in their score were found. However, for subject A and subject B got an increased score. With this evidence, we could say that shooting with the shoe could increase the performance score.

Table 3. Participants' scores for ten trails while shooting without and with the shoe

	Subject A		Subject B		Subject C		Subject D	
Shot count	Without Shoe	With Shoe	Without Shoe	With Shoe	Without Shoe	With Shoe	Without Shoe	With Shoe
1	8.6	10.4	8.8	8.9	10.3	10.5	9.1	10.9
2	10.7	9.6	9.5	8.7	11	10.5	10.8	9.5
3	10.2	10	10.3	10.5	8.6	9.2	10.8	9.2
4	9.5	8.7	9.1	9.9	10.8	10.2	10.7	9.9
5	9.3	9.9	10.4	8.6	9.3	8.8	9.2	10.3
6	8.6	9.9	10.1	10.3	10.3	10.8	9.7	8.6
7	10.6	10.4	8.9	10.2	9.7	9.8	9.3	9.6
8	9.7	10.7	9.7	10.3	10.4	10.7	9.6	9.7
9	9.4	8.8	10.6	9.2	10.5	9.8	9.9	9.2
10	10	8.8	8.7	10.5	10	10.5	10.8	9.9
Mean	9.66	9.72	9.61	9.71	10.09	10.08	9.99	9.68
SD	0.73	0.73	0.71	0.77	0.72	0.67	0.72	0.64

IV. DISCUSSION

Shooting sports test shooters accuracy, precision, consistency, and speed. This sport carried out by maximizing the static stabilization; hence, the change of COP was considered as one of the most critical parameters. A study by Kim and Jeon [7] reported that the anteroposterior body movement affected while rifle shooting carried out laterally. In particular, the COP was shifted to the back during aiming and triggering to ensure a more stable basal posture. Ju [3] concluded that there was a high correlation between aiming and body stability, scoring, and body stability. In our study, there was a significant difference in X-axis, i.e., medial/lateral movement of the right foot. Also, there was a significant difference in right foot plantar force while shooting with the shoe. These right foot COP movement and plantar pressure increased the stability and balancing, which enhanced the shooter's performance and rating while wearing the shoe. To conclude, the shoe currently being worn in rifle shooting sports improve the stability and balance of the shooters, and enhancing the shooters aiming performance, and scores.

V. CONCLUSION

This study quantitatively analyzed the effect of wearing shoes on shooters body balance, stability, and performance. Experiments were conducted for measuring COP in the medial/lateral direction, line of walking direction, and body balance using commercially available insole sensors. Four high school going female rifle shooters were considered and their performance tested with wearing the shoe and without wearing the shoe. The results conclude that the shoes enhance the shooter's lateral body movement, increased stability, and balance. These could improve the performance and scores of the shooters. However, we could not generalize this study results for all sports. Hence, this study only considered four subjects. Future research would consider more subjects and other physiological parameters like muscle activities using EMG sensors and body movement using motion sensors need to be studied.

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