**The Effect of Dominant Side on Lower Extremity Flexibility in Adolescent Shooting Athletes**

***Mahmut BEŞLİ1,[[1]](#footnote-1)\*[C:\Users\Abdullah\AppData\Local\Microsoft\Windows\INetCache\Content.Word\ORCID-iD_icon-16x16.gif](https://orcid.org/xxxx-xxxx-xxxx-xxxx), Burak Ulusoy2[C:\Users\Abdullah\AppData\Local\Microsoft\Windows\INetCache\Content.Word\ORCID-iD_icon-16x16.gif](https://orcid.org/xxxx-xxxx-xxxx-xxxx), Hatice Reyhan BEŞLİ3, Dilara ÇAĞLAR4, Bahar ANAFOROĞLU5[C:\Users\Abdullah\AppData\Local\Microsoft\Windows\INetCache\Content.Word\ORCID-iD_icon-16x16.gif](https://orcid.org/xxxx-xxxx-xxxx-xxxx)***

***1*****0000-0001-5311-7390,** *Institute of Health Sciences, Ankara Yildirim Beyazit University, Ankara, Türkiye*

***2* 0000-0003-3951-3041,** *Departmant of Physical Therapy, Faculty of Health Sciences, Çankiri Karatekin University, Çankiri, Türkiye*

*3* *Sports Physiotherapy, Provincial Directorate of Youth and Sports, Çankiri, Türkiye*

*4* *Shooting Coach, Çankiri, Türkiye*

*5* **0000-0002-2148-0979,** *Departmant of Physical Therapy, Faculty of Health Sciences, Ankara Yildirim Beyazit University, Ankara, Türkiye*

|  |
| --- |
| **Abstract**  Shooting athletes are observed to maintain a static posture for long periods during training and competitions. There are no studies yet examining the effect of the dominant extremity on lower extremity flexibility (LEF) in air rifle shooters (ARS). The purpose of this study was to investigate the effect of the dominant extremity on LEF and the relationship between LEF and core muscle strength (CMS) in ARS. This study included adolescent ARS in Çankırı. The athletes were questioned about their age, height, weight, experience levels, and dominant shooting extremities. They were evaluated using sit-and-reach tests for right and left lower extremities, trunk flexion endurance tests, plank tests, and the Sorensen test. The average age of the athletes was 15 (±0.51) years. The average BMI was 21.63 (±1.04) kg/m², and the average duration of shooting experience was 27 (±6.52) months. The right side was the dominant extremity for all athletes in the study. According to the sit-and-reach test results, the right LEF was greater than the left LEF (p<0.001). No correlation was found between LEF and CMS (p>0.05). The results of this study show that the LEF of the dominant side is greater in ARS, and that LEF is not correlated with CMS. Similar to this study other studies found no correlation between CMS and flexibility in shooting athletes. Research found that the effect of flexibility on shooting success is 34%. It is shown that flexibility plays a crucial role in shooting athletes and can directly affect shooting performance, considering the importance of posture during shooting. Although no relationship was found between LEF and CMS, we suggest that flexibility and strength exercises should be incorporated to improve body symmetry and enhance shooting performance, considering the athletes’ young age and relatively short experience. |
| Keywords: Shooting athletes, Lower extremity flexibility, Core muscle strength, Dominant extremity |

1. **Introduction**

Flexibility is known to be influenced by personal characteristics such as age, gender, and body type, as well as by the specific sport (1). Some researchers have suggested a negative relationship between flexibility and muscle strength in athletes (2,3). However, research does not provide a consensus on the relationship between flexibility and trunk strength in shooting athletes (4,5). Yapıcı et al. reported a relationship between flexibility and trunk strength in shooting athletes (6).

Shooting athletes are observed to maintain a static posture for long periods during training and competitions (4,6). Air rifle shooters shoot in a position involving head and trunk rotation and lateral flexion and typically do not move much between rounds. The highest level of technical proficiency is required to perform at an elite level. Target stability, postural control, emotional condition, and mental skills are all crucial (7).

There are no studies yet examining the effect of the dominant extremity on lower extremity flexibility in air rifle shooters. The purpose of this study was to investigate the effect of the dominant extremity on lower extremity flexibility and the relationship between lower extremity flexibility and core muscle strength in air rifle shooters.

1. **Materials and Methods**

This study included adolescent air rifle shooters from Çankırı. The athletes’ demographic information—age, height, weight, sports experience, and dominant extremity used for shooting—was collected. Body mass index (BMI) was calculated based on height and weight data. In addition to demographic information, lower extremity flexibility and core muscle strength were assessed. The sit-and-reach test was used to evaluate lower extremity flexibility, with measurements taken for both the right and left lower extremities and recorded in centimeters (8). Core muscle strength was assessed using the trunk flexion endurance test, the right and left side plank tests, and the Sorensen test. Results were recorded in seconds (9). Examples of the tests are shown in Figure 1.



Figure 1 Examples of the tests. a) Right sit-and-reach test; b) sorensen test; c) right side plank test; d) trunk flexion endurance test.

Data analysis was performed using SPSS 24.0 (IBM SPSS Statistics for Windows, Version 24.0, IBM Corporation, Armonk, NY, USA). The normality of the data distribution was tested using the Shapiro-Wilk test. Mean and standard deviation values were reported for normally distributed data, while median and interquartile ranges were reported for data that were not normally distributed. Paired sample tests were used for comparisons. Pearson correlation analysis was employed for normally distributed data, while Spearman correlation analysis was used for non-normally distributed data. Statistical significance was accepted as p≤0.05.

1. **Results**

The average age of the athletes (8 female, 6 male) was 15 (±0.51) years. The average BMI was 21.63 (±1.04) kg/m², and the average sports experience was 27 (±6.52) months. The right side was the dominant extremity for all athletes in the study. Demographic information of the athletes included in the study is shown in Table 1 and Table 2.

Table 1. Demographics of the athletes included in the study

|  |  |  |  |
| --- | --- | --- | --- |
| Demographic Information | | Number | Percent |
| Gender | Female | 8 | 57.2 |
| Male | 6 | 42.8 |
| Dominant Shooting Extremities | Right | 14 | 100 |
| Left | 0 | 0 |

Table 2. Demographics of the athletes included in the study (n=14)

|  |  |  |
| --- | --- | --- |
| Demographic Information | Mean | Standard Deviation |
| Age (years) | 15.00 | 0.51 |
| Weight (kg) | 59.57 | 3.05 |
| Height (cm) | 166.00 | 2.26 |
| BMI (kg/m²) | 21.63 | 1.04 |
| Sports Experience Level | 27.00 | 6.52 |

cm: centimeter; kg: kilogram; kg/m²: kilogram per square meters; n: number.

The sit-and-reach test results showed that the flexibility of the right lower extremity was 32.79 (±1.62) cm, while the flexibility of the left lower extremity was 30.18 (±1.57) cm. The flexibility of both lower extremities was 27.86 (±1.44) cm. The data for lower extremity flexibility are shown in Table 3.

Table 3. Lower extremity flexibility values (n=14)

|  |  |  |
| --- | --- | --- |
| Sit and Reach Test | Mean (cm) | Standard Deviation |
| Both Lower Extremities | 27.86 | 1.44 |
| Right Lower Extremities | 32.79 | 1.62 |
| Left Lower Extremities | 30.18 | 1.57 |

cm: centimeter; n: number.

The core muscle strength test results showed that the median duration of the trunk flexion endurance test was 69.00 (IQR: 56.75) seconds. The mean duration of the right side plank test was 63.29 (±12.32) seconds, the mean duration of the left side plank test was 59.79 (±10.70) seconds, and the mean duration of the Sorensen test was 174.93 (±28.49) seconds. The core muscle strength results are shown in Table 4.

Table 4. Core Muscle Strenth tests values (n=14)

|  |  |  |
| --- | --- | --- |
| Core Muscle Strength | Mean (sec) | Standard Deviation |
| Trunk Flexion Endurance Test1 | 94.93 | 23.49 |
| Right Side Plank Test | 63.29 | 12.32 |
| Left Side Plank Test | 59.79 | 10.70 |
| Sorensen Test | 174.93 | 28.49 |

n: number; sec: second; 1: this data were not normal distribution, median: 69.00, interquartile range: 56.75.

In the comparison of the right and left sides, the sit-and-reach test results showed significantly greater flexibility in the right lower extremity compared to the left (p<0.0001). No significant differences were found between the right and left side plank tests (p>0.05). The results of the comparison tests are presented in Table 5.

Table 5. Comparisons of right and left side values (n=14)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Right Side | Left Side | p-value |
| Sit-and-Reach Test (cm) | 32.79 (±1.62) | 30.18 (±1.57) | 0.000\* (t:5.52) |
| Side Plank Test (sec) | 63.29 (±12.32) | 59.79 (±10.70) | 0.730 (t: 0,.45) |

cm: centimeter; n: number; p: statistical significance value; sec: second; \*: p<0.05, statistically significant.

When evaluating the relationship between flexibility and core muscle strength tests, no significant correlation was found between flexibility and core muscle strength (p>0.05). The correlation table is shown in Table 6.

Table 6. Correlation of lower extremity flexibility and core muscle strength tests value (n=14)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Trunk Flexion Endurance Test | Right Side Plank Test | Left Side Plank Test | Sorensen Test |
| Sit-and-Reach Test | p: 0.59  r: 0.15 | p: 0.78  r: -0.08 | p: 0.77  r: 0.09 | p: 0.86  r: 0.05 |
| Right Sit-and Reach Test | p: 0.38  r: 0.26 | p: 0.73  r: -0.10 | p: 0.66  r: 0.13 | p: 0.73  r: -0.10 |
| Left Sit-and-Reach Test | p: 0.38  r: 0.25 | p: 0.74  r: -0.10 | p: 0.59  r: 0.16 | p: 0.77  r: -0.09 |

n: number; p: statistical significance value; r: correlation coefficient.

1. **Discussion**

This study found that the flexibility of the dominant lower extremity was greater in adolescent air rifle shooters, and that lower extremity flexibility did not correlate with core muscle strength. Similar to the study by Akınoğlu et al., no correlation was found between core muscle strength and flexibility in shooting athletes (5). Diler et al. suggest that flexibility influenced shooting performance (10). Ertürk et al. found that the effect of flexibility on shooting success was 34% (11). Although this study did not directly analyze shooting performance, it was clear that flexibility plays an important role in shooting athletes, especially given the static posture required during shooting.

Shooting athletes compete in different disciplines, making it challenging to draw consistent conclusions about trunk performance across these athletes. However, it is reasonable to assume that air rifle shooters and archery athletes share similar characteristics, and comparisons could be drawn between these sports. Research has shown that flexibility and muscle strength tend to be greater in the dominant sides of athletes in various sports (12,13). Mair et al. reported that athletes in asymmetric sports have greater range of motion in their dominant extremities (14). Core muscle strength is important in order to be successful during shooting and to tolerate the reaction force that occurs (15).

Air rifle shooters have the ability to reduce body sway before shooting. This can be achieved by affecting postural control, respiratory control, and pulse decreasing (16). The organization of trunk muscles, upper extremity muscles, pelvic muscles, and lower extremity muscles becomes important in postural control (17–19). Trunk muscles, in particular, continue to work actively to maintain body balance against unexpected biomechanical changes (20). In addition, when we consider the direct relationship between respiratory control and core muscles, it may be expected that core muscles are equally strong. This may explain why the side plank times of the athletes in our study were not affected by the dominant side.

Target stability is important in air rifle shooting (21). Kocahan et al. reported that different muscle strengths are expected in the upper extremity and related muscles due to the asymmetrical stance in the shooting posture, but the isometric strengths of the shoulder's muscles are similar (22). During shooting, the stiffness of the pelvic and leg muscles rather than active muscle contraction plays an important role in target stability (23). We think that the core muscles are not affected by the dominant extremity due to the importance of postural control, but the flexibility of the lower extremity is affected due to the asymmetrical posture.

This study has several limitations: Postural analysis was not performed on the athletes included in the study. The dominant side of all participants was the right side.

1. **Conclusion**

Based on the results, we conclude that lower extremity flexibility is influenced by shooting posture and the dominant extremity. Although no correlation was found between lower extremity flexibility and core muscle strength, we recommend incorporating flexibility and strength exercises to improve body symmetry and enhance shooting performance, particularly considering the athletes’ young age and limited experience.

**References**

1. Çon M, Akyol P, Tural E, Taşmektepligil MY. Voleybolcuların Esneklik Ve Vücut Yağ Yüzdesi Değerlerinin Dikey Sıçrama Performansına Etkisi. *Selçuk Üniversitesi Beden Eğitimi Ve Spor Bilim Dergisi.* 2012;14(2):202–7.

2. Alonso J, Mchugh MP, Mullaney MJ, Tyler TF. Effect Of Hamstring Flexibility On İsometric Knee Flexion Angle–Torque Relationship. *Scand J Med Sci Sports.* 2009 Apr 17;19(2):252–6.

3. Brockett Cl, Morgan Dl, Proske U. Predicting Hamstring Strain Injury İn Elite Athletes. *Med Sci Sports Exerc.* 2004 Mar;36(3):379–87.

4. Peljha Z, Michaelides M, Collins D, Carson H. J. Assessment Of Physical Fitness Parameters İn Olympic Clay Target Shooters And Their Relationship With Shooting Performance. *Journal Of Physical Education And Sport*. 2021;21(6).

5. Akınoğlu B, Kocahan T, Ünüvar E, Eroğlu İ, Hasanoğlu A. Investigation Of The Relationship Between Trunk Muscle Strength And Sit And Reach Flexibility İn Athletes. *Turkiye Klinikleri Journal Of Sports Sciences.* 2020;12(1):9–15.

6. Yapıcı A, Bacak Ç, Çelik E. Relationshıp Between Shooting Performance And Motoric Characteristics, Respiratory Function Test Parameters Of The Competing Shooters In The Youth Category. *European Journal Of Physical Education And Sport Science [Internet].* 2018;4(10). Available From: Www.Oapub.Org/Edu

7. Spancken S, Steingrebe H, Stein T. Factors That İnfluence Performance İn Olympic Air-Rifle And Small-Bore Shooting: A Systematic Review. *Plos One.* 2021 Mar 31;16(3):E0247353.

8. Miyamoto N, Hirata K, Kimura N, Miyamoto-Mikami E. Contributions Of Hamstring Stiffness To Straight-Leg-Raise And Sit-And-Reach Test Scores. *Int J Sports Med.* 2018 Feb 30;39(02):110–4.

9. Elliott TLP, Marshall KS, Lake DA, Wofford NH, Davies GJ. The Effect Of Sitting On Stability Balls On Nonspecific Lower Back Pain, Disability, And Core Endurance. *Spine (Phila Pa 1976*). 2016 Sep 15;41(18):E1074–80.

10. Diler K, Kizilin Mm, Özal M. Havalı Tabanca Atıcılığı Ve Bu Disiplindeki Performans Faktörleri*. Rol Spor Bilimleri Dergisi.* 2022;1(1):11–26.

11. Ertürk C, Can İ, Bayrakdaroğlu S. Havalı Tüfek Sporcularının Bazı Fizyolojik Ve Motorik Özelliklerinin Atış Performansları Üzerine Etkisi. *Spor Bilimleri Araştırmaları Dergisi.* 2022 Dec 31;7(2):281–93.

12. Ellenbecker Ts, Roetert Ep, Baılıe Ds, Davıes Gj, Brown Sw. Glenohumeral Joint Total Rotation Range Of Motion İn Elite Tennis Players And Baseball Pitchers. *Med Sci Sports Exerc*. 2002 Dec;34(12):2052–6.

13. Ihalainen S, Kuitunen S, Mononen K, Linnamo V. Determinants Of Elite‐Level Air Rifle Shooting Performance. *Scand J Med Sci Sports.* 2016 Mar 8;26(3):266–74.

14. Mair SD, Uhl TL, Robbe RG, Brindle KA. Physeal Changes And Range-Of-Motion Differences İn The Dominant Shoulders Of Skeletally İmmature Baseball Players. *J Shoulder Elbow Surg.* 2004 Sep;13(5):487–91.

15. Zemková E, Zapletalová L. The Role Of Neuromuscular Control Of Postural And Core Stability İn Functional Movement And Athlete Performance. *Front Physiol*. 2022 Feb 24;13.

16. Era P, Konttinen N, Mehto P, Saarela P, Lyytinen H. Postural Stability And Skilled Performance—A Study On Top-Level And Naive Rifle Shooters. *J Biomech.* 1996 Mar;29(3):301–6.

17. Mononen K, Konttinen N, Viitasalo J, Era P. Relationships Between Postural Balance, Rifle Stability And Shooting Accuracy Among Novice Rifle Shooters. *Scand J Med Sci Sports.* 2007 Apr 3;17(2):180–5.

18. Tang WT, Zhang WY, Huang CC, Young MS, Hwang IS. Postural Tremor And Control Of The Upper Limb İn Air Pistol Shooters. *J Sports Sci.* 2008 Dec 15;26(14):1579–87.

19. Wojtków M, Korcz K, Szotek S. Assessement Of Body Posture And Feet Load Distribution İn Sport Shooters. *Curr Probl Biomech.* 2016;(10):91–8.

20. Horak FB, Nashner LM. Central Programming Of Postural Movements: Adaptation To Altered Support-Surface Configurations. *J Neurophysiol.* 1986 Jun 1;55(6):1369–81.

21. Ihalainen S, Linnamo V, Mononen K, Kuitunen S. Relation Of Elite Rifle Shooters’ Technique-Test Measures To Competition Performance*. Int J Sports Physiol Perform.* 2016 Jul;11(5):671–7.

22. Kocahan T, Akınoğlu B, Ünüvar E, Hasanoğlu A. Comparison Of Shoulder Joint Isometric Muscle Strength And Joint Position Sense Of Trigger Arm And Opposite Arm İn Air Pistol Shooting Athletes. *Turkiye Klinikleri Journal Of Sports Sciences.* 2018;10(3):116–22.

23. Day BL, Steiger MJ, Thompson PD, Marsden CD. Effect Of Vision And Stance Width On Human Body Motion When Standing: İmplications For Afferent Control Of Lateral Sway. *J Physiol.* 1993 Sep;469(1):479–99.

1. \* Corresponding author. *e-mail address: fzt.mahmutbesli@gmail.com* [↑](#footnote-ref-1)