Studia Kinanthropologica, XXV, 2024, (3), 129–137
The Scientific Journal for Kinanthropology
doi: 10.32725/sk.2025.002

POSTURÁLNA STABILITA V ZÁKLADNOM STRELECKOM POSTOJI S A BEZ ZBRANE V DISCIPLÍNE SKEET

POSTURAL STABILITY IN BASIC SHOOTING STANCE WITH AND WITHOUT SKEET SHOTGUN

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Abstract

In this work, we point out the level and interactions of postural stability (PS) with the sports performance of shooters (SP) in the Skeet discipline. 86 men and 20 women participated in the research. Active sports shooters ranged in age from 12 to 45 years old from Slovakia. We determined PS in the ready shooting position with and without a weapon using the Star Excursion Balance Test (SEBT). The sporting performances of the shooters were recorded from the system of the Slovak Shooting Association. PS level was characterized by descriptive statistics. The differences between the dominant and non-dominant leg, or with a weapon and without a weapon were assessed statistically (t-test) as well as objectively (Cohen's d). We determined the relationship between PS and SV using the correlation coefficient „r" according to Pearson.

The results showed differences in PS with and without a weapon in all directions, with unarmed shooters achieving greater ranges. The ranges between the dominant and non-dominant leg were the same for both armed and non-armed exercises.

Interactions of SP with PS are rare. When testing without a weapon on the non-dominant standing leg, we find interactions in the tested position Posterior ($p<0.05$), Posteromedial ($p<0.05$) and Anteriolateral ($p=0.05$). With the weapon on the dominant standing leg, we noted positive interactions of SV with PS in the tested Posterior position ($p<0.05$) and on the non-dominant leg with the Lateral position ($p<0.05$).

Differences in PS in the standby shooting position with a weapon and without a weapon, or rare interactions with the SP point to the need for a balanced and stable shooting stance in both cases. The perfect balance and stability of the shooter limit the swings created by holding the weapon and the shooting movement (stance - aiming - aiming - aiming - triggering) and facilitate their execution without any changes in the stabilized position.

The contribution is part of the project VEGA 1/0460/23, Postural health in children and adolescents and the possibilities of influencing it.

Keywords: skeet; postural stability; weapon; dominance; sports performance; differences; interactions

Súhrn

V práci poukazujeme na úroveň a interakcie posturálnej stability (PS) so športovou výkonnosťou strelcov (ŠV) v disciplíne Skeet. Výskum bol realizovaný na súbore športových strelcov zo SR. PS v pohotovostnom streleckom postavení so zbraňou a bez zbrane sme zisťovali pomocou Star Excursion Balance Test (SEBT). Športové výkony strelcov boli evidované zo systému Slovenského streleckého zväzu. Úroveň PS bola charakterizovaná deskriptívnymi štatistikami. Rozdiely medzi dominantnou a nedominantnou nohou, resp. so zbraňou a bez zbrane boli posúdené štatisticky (t-test) ako aj vecne (Cohenovo d). Vzťahy medzi PS a ŠV sme zisťovali korelačným koeficientom „r" podľa Pearsona.

Výsledky preukázali rozdiely v PS so zbraňou a bez zbrane vo všetkých smeroch, pričom bez zbrane dosahovali strelci väčšie rozsahy. Pri cvičení so zbraňou aj bez zbrane boli rozsahy medzi dominantnou a nedominantnou nohou rovnaké.

Interakcie ŠV s PS sú ojedinelé. Pri testovaní bez zbrane na nedominantnej stojnej nohe nachádzame interakcie v testovanej pozícii Posterior ($p<0,05$), Posteromedial ($p<0,05$) a Anteriolateral ($p=0,05$). So zbraňou na dominantnej stojnej nohe sme zaznamenali pozitívne interakcie ŠV s PS v testovanej pozícii Posterior ($p<0,05$) a na nedominantnej nohe s pozíciou Lateral ($p<0,05$).

Rozdiely v PS v pohotovostnom streleckom postavení so zbraňou a bez zbrane, resp. ojedinelé interakcie so ŠV poukazujú na potrebu vyváženého a stabilného streleckého postoja v oboch prípadoch. Dokonalá rovnováha a stabilita strelca obmedzujú výkyvy vytvárané držaním zbrane a streleckým pohybom (postoj - zalícenie - mierenie - zamierenie - spúšťanie) a uľahčujú ich vykonanie bez akýchkoľvek zmien v stabilizovanej polohe.

Príspevok je súčasťou projektu VEGA 1/0460/23, Posturálne zdravie u detí a adolescentov a možnosti jeho ovplyvňovania.

Kľúčové slová: skeet; posturálna stabilita; zbraň; sominancia; športový výkon; diferencie; interakcie

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Úvod

Shooting is a sport where the difference between success and failure represents stability (Čech, 2010).

Postural stability is a key element in the success of sports shooters. It represents the ability to maintain and control the correct position of the body during the entire shooting process, which includes holding the weapon, aiming at the target and the shot itself. The ability to maintain a stable position without unnecessary movements or jerks allows shooters to achieve greater accuracy and consistency of their shots (Ball, Best, & Wrigley, 2003).

Experienced shooters have better body posture and can stabilize the body in the last seconds before the actual shot (Era et al. 1996).

This stability is the result of a combination of physical fitness, muscle strength, coordination and neuromuscular control. In practice, this means that the shooter must effectively use his body to minimize the influence of external and internal distractions, thereby maximizing his performance (McGinnis, 2020).

Thus, postural stability is not only about a firm stance, but also about dynamic balance, which enables quick and accurate response to different conditions during competition or training (Zatsiorsky & Aktov, 1990).

Balance and stability are closely related concepts that relate to the body's ability to maintain balance and stability in various postural situations (Kasa 2004; Vařeka 2002a). A correct understanding of the following two terms is important: balance is the act of achieving or maintaining a state of equilibrium, while stability is the ability to maintain balance by resisting external forces and stresses (Vařeka 2002b).

Instability can be caused by various factors such as biomechanical parameters, sensory components, central nervous system, chronic pain, age and gender. Postural stability is the body's ability to maintain balance and stability in various situations, which is important for ensuring overall stability and increasing movement efficiency (Zemková, 2004).

A balanced and stable position allows the shooter to maintain perfect balance in the waiting position, which minimizes the natural fluctuations of the body, which are naturally created, to a minimum, which facilitates the execution of the entire movement without any changes in the position itself (Aalto et al. 1990; Brych 2008; Nováková 1996). Furthermore, the possibility of shortening the activation time of muscle chains involved in technical gestures and improving recoil control increases (Sližik et al. 2017).

Sports shooting is now part of the program of the modern Olympic Games and is divided into three disciplines - rifle, pistol and shotgun (Brych, 2008).

Skeet is a discipline in which you shoot with a shotgun at flying asphalt targets that are thrown from two towers (high and low) in the same direction. The shooter moves along the shooting stations arranged in a semicircle and shoots at targets alternately from left and right, or at two targets at

once, which are simultaneously thrown from a high and a low tower. The shooter can only fire one shot at each target (Valter, 2006).

Shooting is a sport requiring high precision, where success at the top level depends on controlling all body movements. Skeet performance is influenced by many factors, such as the shooter's experience and skill, upper limb and core strength, postural control, proper posture, and coordination between the eye, nervous system, and musculoskeletal system. Heart rate, anxiety level, anthropometric measurements, health status, and sport-specific physical performance parameters such as endurance, balance, coordination, and reaction time are also believed to directly affect shooting (İskender, 2010).

In terms of movement, shooting, with the exception of Trap and especially Skeet, is characterized by a small number of movement skills, but is very demanding on accuracy, coordination and concentration. High finesse and precision require perfect concentration and sensorimotor coordination. The workload of a sports shooter is complex, affecting both the somatic and psychological aspects (Valter, 2006).

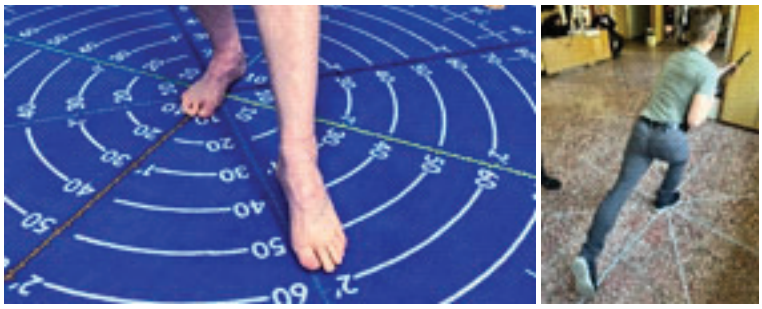
The evaluation of the level of physical abilities is one of the key issues in contemporary sports, while tests are used to monitor the effectiveness of training programs. An objective method of identifying deficiencies and improving dynamic postural stability is the Star Excursion Balance Test (SEBT) performed in eight directions, which is also used in clinical research.

Methods

The research was carried out on a group of sports shooters from Slovakia (n=106). Dynamic postural stability was determined using the eight-position Star Excursion Balance Test (SEBT), and the shooters' sports performances (maximum number of targets shot) were taken from the system of the Slovak Shooting Association.

The SEBT test was performed in the directions Posterior, Posteromedial, Medial, Anteromedial, Anterior, Anterolateral, Lateral, Posterolateral on the dominant and non-dominant training leg (Figure 1) without a shotgun and in the skeet standby position with a shotgun. Measurements of both legs were assessed from the point of view of the maximum measured value (cm).

Obrázok 1./ Figure 1.
Osemsmerový test Star Excursion Balance Test (SEBT)./ Eight-way Star Excursion Balance Test (SEBT).



The level of PS and sports performance of the shooters was characterized by descriptive statistics (M, SD, Max, Min). Statistical and material significance of the differences between the dominant and non-dominant training leg, respectively. between unarmed and armed DPS was assessed by t-test and Cohen's „d".

We determined the relationships between the individual directions of PS and SP using Pearson's correlation coefficient „r". Statistical significance of differences and relationships was assessed at the 5% and 1% significance levels. The substantive significance of the „d" coefficient was assessed according to $d<0.2$ trivial effect, $d>0.2$ small effect, $d>0.5$ medium effect and $d>0.8$ large effect.

Results

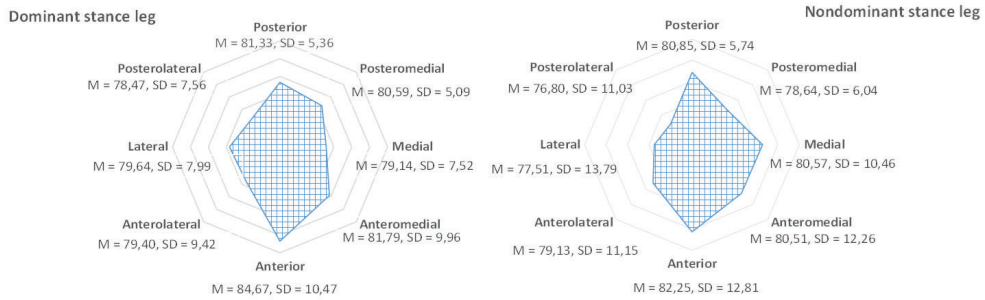
The results showed differences in the postural stability of the shooters when practicing with a weapon and without a weapon in all diagnosed directions (Table 1 and 2; Figure 2 and 3). Differences between positions were confirmed statistically as well as objectively (Table 4).

No significant differences were found between the dominant and non-dominant standing leg (p=n.s., d<0.2) when exercising in the ready stance with a weapon (Table 3).

Tabuľka 1./ Table 1.
Úroveň posturálnej stability bez zbrane a športovej výkonnosti u strelcov v skeete./ Level of postural stability without a weapon and sports performance in skeet shooters.

	SEBT without weapon							
	Dominant standing leg				**Non-dominant standing leg**			
	M	SD	Max	Min	M	SD	Max	Min
Anterior (cm)	84.67	8.71	103.40	63.40	82.25	10.05	102.40	60.00
AnteroLateral (cm)	79.40	11.12	102.60	33.50	79.13	10.20	100.00	55.40
Lateral (cm)	79.64	12.82	100.50	37.00	77.51	12.21	100.10	36.40
PosteroLateral (cm)	78.47	11.08	99.40	54.80	76.80	9.19	98.00	54.10
Posterior (cm)	81.33	11.59	103.60	32.50	80.85	9.65	100.20	45.30
PosteroMedial (cm)	80.59	10.02	101.20	54.00	78.64	8.79	98.60	58.30
Medial (cm)	79.14	12.00	100.30	31.40	80.57	11.41	107.70	45.30
Anteromedial (cm)	81.79	10.40	102.40	59.50	80.51	10.33	100.00	49.00
Sports performance (n)	111.52	7.00	123.00	65.00				

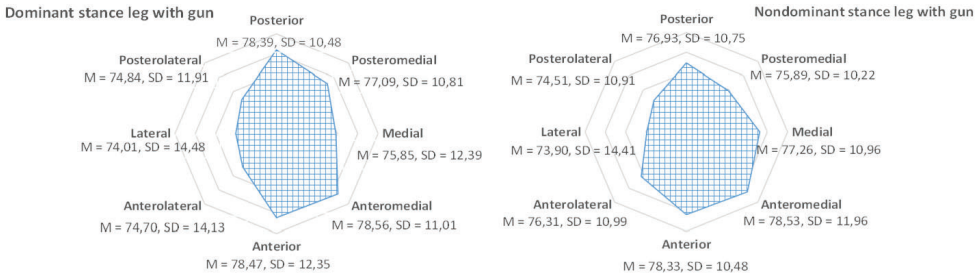
Obrázok 2./ Figure 2.
Úroveň posturálnej stability strelcov v disciplíne Skeet./ Postural stability level of shooters in Skeet discipline.



Tabuľka 2./ Table 2.
Úroveň posturálnej stability so zbraňou a športový výkon strelcov v disciplíne Skeet./ Level of postural stability with a weapon and sports performance of shooters in the Skeet discipline.

	SEBT with weapon							
	Dominant standing leg				**Non-dominant standing leg**			
	M	SD	Max	Min	M	SD	Max	Min
Anterior (cm)	78.47	12.35	102.40	42.30	78.33	10.48	101.40	40.60
AnteroLateral (cm)	74.70	14.13	100.30	26.30	76.31	10.99	100.20	43.50
Lateral (cm)	74.01	14.48	99.60	25.60	73.90	14.41	99.00	25.40
PosteroLateral (cm)	74.84	11.91	97.00	40.20	74.51	10.91	98.40	45.20
Posterior (cm)	78.39	10.48	101.70	53.40	76.93	10.75	98.70	35.70
PosteroMedial (cm)	77.09	10.81	95.60	38.60	75.89	10.22	98.70	40.90
Medial (cm)	75.85	12.39	98.60	35.00	77.26	10.96	99.60	53.40
Anteromedial (cm)	78.56	11.01	102.4	46.80	78.53	11.96	105.20	33.70
Sports performance SKEET (n)	111.52	7.00	123.00	65.00				

Obrázok 3./ Figure 3.
Úroveň posturálnej stability strelcov v disciplíne Skeet./ Postural stability level of shooters in Skeet discipline.



Tabuľka 3./ Table 3.
Rozdiely v posturálnej stabilite medzi dominantnou a nedominantnou nohou./ Differences in postural stability between dominant and non-dominant leg.

	Differences between dominant and non-dominant standing leg					
	With weapon			**Without weapon**		
	t	p	d	t	p	d
Posterior	**2.72**	**0.008**	**0.258**	0.13	0.900	0.012
Posteromedial	0.27	0.787	0.026	1.68	0.097	0.127
Medial	**2.00**	**0.048**	**0.170**	0.10	0.920	0.008
Anteromedial	1.93	0.057	0.164	0.31	0.761	0.029
Anterior	0.44	0.659	0.045	1.52	0.130	0.138
Anterolateral	**2.26**	**0.026**	**0.207**	1.37	0.175	0.114
Lateral	1.23	0.221	0.122	1.46	0.148	0.121
Posterolateral	1.41	0.163	0.123	0.04	0.971	0.003

Explanations. t - t-test; p - value; Cohen d

Tabuľka 4./ Table 4.
Rozdiely v posturálnej stabilite medzi dominantnou a nedominantnou nohou./ Differences in postural stability between dominant and non-dominant leg.

	Differences without a weapon and with a weapon					
	Dominant			**Non-dominant standing leg**		
	t	p	d	t	p	d
Posterior	6.93	0.000	0.581	4.87	0.000	0.382
Posteromedial	5.32	0.000	0.370	3.63	0.000	0.266
Medial	5.08	0.000	0.411	4.99	0.000	0.270
Anteromedial	5.36	0.000	0.315	2.55	0.012	0.227
Anterior	4.32	0.000	0.266	3.86	0.000	0.384
Anterolateral	4.10	0.000	0.335	3.08	0.003	0.288
Lateral	3.76	0.000	0.270	4.20	0.000	0.296
Posterolateral	4.17	0.000	0.301	2.52	0.013	0.178

Explanations. t - t-test; p - value; Cohen d

While exercising without a weapon (table 3), we did note statistically significant differences in favor of the range on the dominant standing leg in the tested position Posterior ($p<0.008$; $d=0.258$)

and Anterolateral (p<0.026; d=0.207), respectively. in favor of the extent of the non-dominant leg in the Medial direction (p<0.048; d=0.170), however, due to the very low factual significance of the „d“ coefficient, we cannot practically confirm the observed differences.

By correlating the values of postural stability and sports performance in the Skeet discipline, rare significant relationships were found (Table 5, Figure 4 and 5). The expected higher frequency of interactions (p<0.05) in the more stable dominant standing leg compared to the non-dominant leg was not confirmed either in the exercise with or without a weapon.

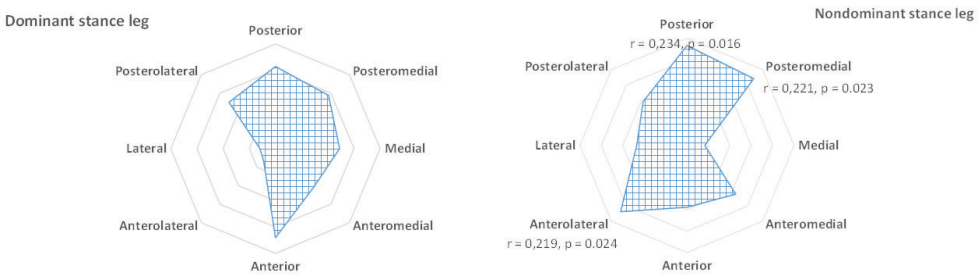
Interactions of sports performance with postural stability values when testing without a weapon on the non-dominant standing leg are found in the Posterior (r = 0.234; p = 0.016), Posteromedial (r = 0.221; p = 0.023) and Anteriolateral (r = 0.219; p = 0.024) positions.

In the standby position with a weapon on the dominant standing leg, we noted positive interactions of sports performance with postural stability in the tested Posterior position (r = 0.198; p = 0.042) and on the non-dominant leg with the Lateral position (r = 0.228; p = 0.019).

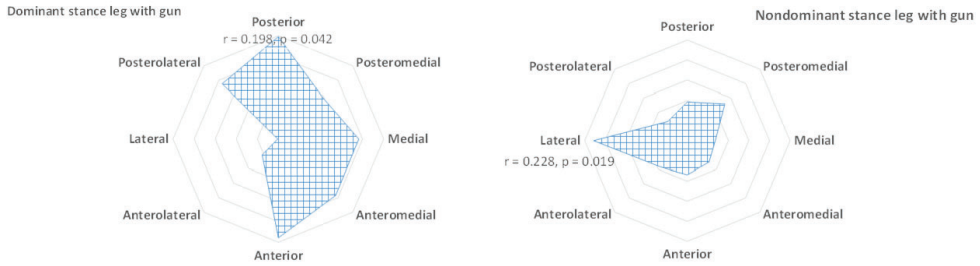
Tabuľka 5./ Table 5.
Korelácie medzi DPS a športovou výkonnosťou strelcov bez zbrane a so zbraňou (Pearsonov korelačný koeficient „r“, p<0.05⋆⋆)./ Correlations between DPS and sports performance of shooters without a weapon and with a weapon (Pearson's correlation coefficient „r“, p<0.05⋆⋆).

		Without weapon	With weapon		
		Dominant	Non-dominant	Dominant	Non-dominant
Posterior	r	0.157	**0.234⋆⋆**	**0.198⋆⋆**	0.097
	p	0.109	**0.016**	**0.042**	0.324
Posteromedial	r	0.144	**0.221⋆⋆**	0.096	0.129
	p	0.142	**0.023**	0.327	0.186
Medial	r	0.123	0.042	0.141	0.068
	p	0.211	0.671	0.150	0.490
Anteromedial	r	0.104	0.161	0.142	0.075
	p	0.289	0.099	0.146	0.446
Anterior	r	0.170	0.144	0.189	0.084
	p	0.081	0.141	0.052	0.393
Anterolateral	r	0.032	**0.219⋆⋆**	0.004	0.092
	p	0.742	**0.024**	0.968	0.346
Lateral	r	0.030	0.117	-0.049	**0.228⋆⋆**
	p	0.760	0.231	0.621	**0.019**
Posterolateral	r	0.125	0.145	0.138	0.067
	p	0.200	0.139	0.157	0.492

Obrázok 4./ Figure 4.
Štatisticky významné korelácie posturálnej stability so športovou výkonnosťou strelcov v disciplíne Skeet bez zbrane (p<0.05)./ Statistically significant correlations of postural stability with the sports performance of shooters in the Skeet discipline without a weapon (p<0.05).



Obrázok 5./ Figure 5.
Štatisticky významné korelácie posturálnej stability so športovou výkonnosťou strelcov v disciplíne Skeet so zbraňou (p<0.05)./ Statistically significant correlations of postural stability with sports performance of shooters in the Skeet discipline with a weapon (p<0.05).



Discussion

Controlling postural stability and weapon stability is a hallmark of sport shooting.

Peljha et al. (2021) investigated the relationships between selected anthropometric and fitness parameters with the shooting performance of Olympic clay target shooters and possible differences depending on skill level. 19 members of the Cyprus Shooting Federation participated in the research. The results showed significant, strong and moderately strong correlations between shooting performance and bilateral symmetry in shoulder mobility ($r = 0.80$, $p < 0.001$) and grip strength ($r = 0.61$, $p = 0.01$). When skill level was taken into account, significant differences in height ($p = 0.01$), weight ($p = 0.03$), posterior muscle chain flexibility ($p < 0.001$), dynamic ($p = 0.01$) and static balance ($p = 0.01$). In addition, increasing the symmetry of the upper body could improve shooting scores.

Čech (2010) assessed the influence of indicators of shooters' postural stability on aiming point fluctuation. The goal was to contribute to the expansion of knowledge in the field of stability of shooters and the possibility of its indirect influence on the result of shooting through the fluctuation of the aiming point in the interval of 5s and 1.5s before the shot. The study was conducted on shooters ($n = 8$) aged in the corresponding junior category. Using the stabilometric method, examination on the stabilometric platform of the FiTRONiC company and the fluctuation of the aiming point using the shooting analysis system SCATT Professional, he observed selected indicators of stability. The author found significant differences in the level of stability between the basic stabilometric examination and the stabilometric examination with shooting on the SCATT shooting simulator. The dependence between shooter stability and aiming point fluctuation was also confirmed.

Optoelectronic training systems provide the shooter with data and graphical information about the crosshair coordinates of the aiming point on the target. The SCATT system indicates the prognostic result of the actual shot, taking into account the time period from the trigger to the moment when the bullet leaves the barrel, as well as the lateral movement of the muzzle, since the bullet continues to move in the same direction as the muzzle after leaving the barrel.

The SCATT system was also used in their research by the authors Korostylova & Zanevkyy (2009), who tried to imitate the accuracy of shooting results using an optoelectronic training system. The aim of their research was to compare the coordinates of the bullet on the target with the coordinates of the imitation of the SCATT system trace within the framework of stability. The study method involves firing a Steyr LP-10 air pistol and 4.49mm Finale Match bullets using simultaneous recording on the SCATT system and firing the gun in a vise with bullets from the same box. A highly qualified shooter fired 10 shots from a distance of 10 m. T-test showed a big difference in average distances ($p<0.003$), i.e. j. imitation of the bullet mark on the target by the SCATT system is not relevant enough. However, this could be due to the incorrect modeling of the trajectory of the barrel as an imitation of the track, since the angular movement of the barrel relative to the barrel falsifies the calculation of its lateral velocity, and not the actual disturbance of the stability of the racer.

In early research by Era et al. (1996) investigated postural stability and skilled performance in professional and amateur shooters. They checked the aiming posture during the 7.5 seconds before the shot was conducted among national elite rifle shooters, as well as among national-level shooters

and amateur rifle shooters. Center of force (COF) movement was analyzed in terms of velocity and amplitude of movement. These calculations were performed in 1.5-s windows, with the first window starting 7.5 s and ending 6.0 s before the shot. The last window ended when the shutter was pressed. The postural control data distinguished the studied groups according to their level in competitive shooting. Male top-level shooters were able to stabilize their stance significantly better than female top-level shooters or male national-level shooters, who in turn were much more stable than amateur shooters. Experienced shooters were able to stabilize their posture even better during the last seconds before firing, while amateur shooters showed no significant differences when comparing consecutive windows. The authors concluded that among highly trained elite shooters, failure to stabilize the whole body position appears to be rarely the cause of a poor outcome.

The application of the dynamic balance test of the lower limbs (SEBT) appears to be an interesting parameter for determining the relationship with the sports performance of shooters in the discipline of Skeet or Trap. Postural stability can be disturbed by internal influences, such as heartbeats and respiratory muscle activity (Zemková, 2005). Inadequate cardiorespiratory adaptation may be one of the causes, especially in the case of the need to hold the breath during the shot.

A number of parameters affect the shooter's performance. Muscular strength, postural control, accuracy, experience, skill of the shooter, and strength of the upper limbs and core of the body can determine the accuracy of his shooting (Yapici et al., 2018).

Conclusion

The results showed differences in postural stability tested with and without a weapon in shooters competing in the Skeet discipline.

In the standby stance with a weapon on the dominant and non-dominant standing leg, smaller ranges in the tested directions were diagnosed than in the diagnosis of postural stability without a weapon. The ranges between the dominant and non-dominant standing leg were the same for both armed and unarmed exercises.

Interactions between sports performance and postural stability were rare. When testing without a weapon on the non-dominant standing leg, we find interactions in the tested posteroral and posteromedial directions as well as with the frontal anterolateral direction. With the weapon on the dominant standing leg, we recorded positive interactions in the posteroral direction and on the non-dominant leg in the lateral direction.

Postural stability is a significant factor affecting final performance in shotgun shooting, either directly or indirectly. Stability training should not be underestimated and implemented only as a partial component within some training sessions. Stability should be developed specifically from the point of view of laterality, dominance, with or without a weapon.

The perfect balance and stability of the shooter limit the fluctuations created by holding the weapon and the shooting movement (stance - aiming - aiming - aiming - triggering). They improve the efficient execution of a chain of movements without any changes in the stabilized position. Increased movement efficiency should subsequently be reflected in the improvement of the sports performance of shooters.

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