IS THERE A CORRELATION BETWEEN POSTURAL BALANCE AND PISTOL SHOOTING PERFORMANCE IN LASER RUN EVENT?

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Abstract

The aim of the study was to assess the occurrence of a correlation between the body sways and the shooting performance of pentathletes in subsequent shooting series in the Laser run event. The study involved 25 pentathletes (12 women and 13 men; mean age: 18.6 ± 1.7 years). All the athletes competed at the national or both the national and international levels. Testing took place at a laser shooting range. During each shooting series the Zebris FDM-2 Force Distribution Measuring System recorded centre of pressure movement and Pentashot shooting result system recorded shooting performance. The sequence of tasks followed the order detailed by the highest level of competition of Laser Run organized by the Union Internationale de Pentathlon Moderne. The correlation analysis did not show any significant relationship between postural balance and pistol shooting performance in Laser run event. There were no statistically significant differences in shooting performance between the series. The heart rate was significantly higher for the second, third and fourth shooting series compared to the first series. In the Laser Run event, the postural balance disturbances caused by the running effort do not have a negative impact on the shooting performance of the athletes.

Key words*: laser run event, postural balance, shooting position, fatigue, modern pentathlon*

Introduction

The Laser run is the final discipline of the modern pentathlon competition which combines the shooting and running. In accordance with the Union Internationale de Pentathlon Moderne (UIPM) Laser Run Competition Guidelines (2018) during the Laser Runner, each athlete is required to participate in the shooting and running phases 4 times, hitting the targets 5 times in each shooting phase, and to run an 800 m course in each running phase. The overall Laser Run event performance is determined by: (1) the running time and speed during the running phase and (2) the shooting time and accuracy, but there is no consensus among researchers on which factors are decisive (Le Meur et al. 2010; Lim et al. 2018). While the study by Le Meur et al. (2010) revealed that the shooting factors are the key, Lim et al. (2018) indicated that running time and speed are the most important determinants.

There are very few reports on modern pentathlon in the literature; therefore, researchers often refer to the results of studies conducted among similar disciplines, such as shooting sports and biathlon. Numerous previous studies conducted among rifle shooters indicated that shooting accuracy is determined by the postural balance and hold stability (Ball et al. 2003; Era et al. 1996; Konttinen et al.1998). However, the impact of the postural balance seems to be greater, as this parameter influences the shooting accuracy both directly and indirectly, due to the improvement of hold stability (Ihalainen et al. 2016; Mononen et al. 2007). In our previous study on the postural balance of pentathletes during the Laser Run, we observed that the fatigue that occurs after the first 800 m of the running distance (during the second shooting series) significantly impairs the stability of the shooting position, and that these disturbances persist during subsequent shooting series (Sadowska et al. 2019a). Similar results were obtained in a study conducted in the group of biathletes (Sadowska et al. 2018). Physical exercise, regardless of the intensity, resulted in the postural balance disturbances in the standing shooting position of biathletes but increasing the exercise intensity did not affect the extent of the disturbances.

Different observations of pentathletes participating in combined events were made by Dadswell et al. (2016). The authors observed no significant mediolateral or anteroposterior centre of pressure (COP) range changes between the shooting series. It should be stressed, however, that the authors

used a research protocol in accordance with the pre-2013 modern pentathlon rules, which differed significantly from the current rules.

A crucial and, so far, unrecognized issue is the influence of postural balance disorders caused by the running effort on the shooting performance during a Laser run event. So far, similar studies have been conducted mainly among biathletes. The results of the studies showed that the negative effects of physical exercise (altered stability of the hold (Hoffman et al. 1992), decreased cleanness of triggering (Ihalainen et al. 2016), increased rifle sways (Sadowska et al. 2018) are of fundamental importance in connection with the shooting performance.

Considering the substantial differences in the shooting position of biathletes and pentathletes, the type of weapon used and how it is held, it would be a mistake to generalise the conclusions of biathletes' study onto the modern pentathletes. Therefore, the aim of this study is to assess the occurrence of a correlation between the body sways and the shooting performance of pentathletes in subsequent shooting series in the Laser run event.

Methods

Participants

The study involved 25 pentathletes (12 women and 13 men; mean age: 18.6 ± 1.7 years), who were members of the Polish Association of Modern Pentathlon. All the athletes competed at the national or both the national and international levels. The body height and mass of the pentathletes were 177.1±8.3 cm and 66.5±8.2 kg, respectively. Written informed consent was sought from all participants or legal guardians in the case of underage subjects. The protocol of the study conformed to the recommendations of the Declaration of Helsinki and was approved by the local Ethics Committee.

Procedure

Prior to the study, each participant was provided with detailed information about the test procedures and the research methodology. Each participant was examined individually.

Testing took place at a laser shooting range. The participnats used Pentashot laser pistols homologated according to the standards of the UIPM. The sequence of tasks followed the order detailed by the highest level of competition of Laser Run organized by UIPM (2018) (Table 1). Participants began the Laser run with a short 20 m sprint that preceded the first shooting series and were instructed to complete each phase at a pace similar to that which they would use in a competition.

Table 1. The sequence of tasks in the Laser Run during testing in accordance with The Union Internationale de Pentathlon Moderne (2018)

Running sequences	Total distance	Shooting sequences	Distance to the targets
4 x 800 m	3200 m	4 x 5 hits	10m

Postural balance was examined using the Zebris FDM-2 Force Distribution Measuring System from the Body Posture Laboratory at the Regional Centre for Research and Development of the University College in Biała Podlaska. As the subject stood on the platform (dimensions: 212 x 60.5 x 2.1 cm; number of miniature force sensors: 15,360), the force exerted by their feet was recorded by the sensors at a sampling rate of 120 Hz. The postural balance was evaluated four times during each shooting series. The coordinates of the instantaneous centre of pressure (COP) were calculated with WinPDMS processing software v1.2.1 (Zebris GmbH, Isny, Germany) (Table 2). During each shooting series, heart rate (HR) was monitored with a Polar S610i monitor (Electro Oy, Finland). The shooting performance (shooting time, shot time, number of errors, number of shots) were recorded using Pentashot shooting result system (Pentashot EU, Czech Republic, Ostrava).

Table 2. A specification of the analysed posturographic measures

Indicator	Description of the indicator
	CoP shifts
V [s/m]	Average velocity of the COP
	Surface area of the COP
AoE [mm^2]	Area of the centres of pressure (calculated from the COP shifts in such a way that 95% of the data are within the ellipsoid and 5% are outside)
WoE [mm]	Width of the ellipse (the length of the ellipse in medial-lateral direction)
HoE [mm]	Height of the ellipse (the length of the ellipse in anterior-posterior direction)

Statistical analysis

Statistical analyses were carried out with STATISTICA 13.0 software (Dell Inc. 2013). The statistical significance of all tests was defined as $p<0.05$. Mean and standard deviations were used to describe posturographic measures in each shooting series. The shooting performance (shooting time, shot time, number of errors, number of shots) and heart rate were presented as means of median

values and interquartile range (IQR), representing the middle 50% of values achieved across all athletes. The effects of the running effort on the shooting performance in the consecutive shooting series were determined by means of one-way Friedman's ANOVA with four repeated measures (series 1, series 2, series 3, series 4). Spearman's Rank correlation coefficients (r) were calculated to determine the relationship between the postural balance and the shooting performance in each shooting series. For all analyses, significance was accepted at $p < 0.05$.

Results and discussion

The mean values and standard deviations of the posturografic measures recorded in the subsequent four shooting series are shown in Table 3.

Table 3. Means and standard deviations for the postural balance measures recorded by the pentathletes in each shooting series during the Laser run

Series		V [mm/s]	AoE [mm^2]	WoE [mm]	HoE [mm]
1	Mean	78.6	1559.4	30.8	63.01
	SD	22.9	595.6	5.8	20.9
2	Mean	88.3	1768.2	35.3	61.6
	SD	28.5	783.7	9.3	17.4
3	Mean	82.4	1961.5	34.4	73.0
	SD	34.4	881.7	9.1	29.6
4	Mean	82.7	1840.5	36.8	61.1
	SD	26.6	929.4	8.9	21.2

V - average velocity of the COP; AoE – ellipse of the COP shifts area; WoE - width of the COP ellipse; HoE - height of the COP ellipse

Since the time spent on the shooting range and the number of shots taken by each athlete was different, the differences in the postural balance between the series were not analysed. This analysis is set out in our previous study (Sadowska et al. 2019a).

Table 4 shows the descriptive statistics for shooting time, shot time, number of errors, number of shots and HR recorded for each of the four shooting series. Except for the heart rate, there were no statistically significant differences in the values of these parameters between the series. The HR was significantly higher for the second ($p=0.0045$), third ($p<0.0001$) and fourth ($p<0.0001$) shooting series compared to first series. Moreover, the HR for the second shooting series was significantly lower than for the fourth series ($p=0.0019$).

Table 4. Medians (Mdn) and interquartile (IOR) ranges for pentathletes shooting performance and heart rates for each shooting series during the Laser run along with the results of one-way Friedman's ANOVA with repeated measures

Series		Shooting time [s]	Shot time [s]	Number of		HR [beat /min]
				errors	shots	
1	Mdn	16.9	2.1	3.5	8.5	159
	IQR	11.6	0.5	3.5	3.5	12
2	Mdn	17.6	2.2	3.0	8.0	189
	IQR	8.6	0.4	3.0	3.0	15
3	Mdn	15.4	2.2	2.0	7.0	192
	IQR	8.4	0.4	3.0	3.0	13
4	Mdn	20.0	2.2	3.5	8.5	193
	IQR	14.8	0.6	4.0	4.0	12
p		0.7369	0.7369	0.3646	0.3646	0.0000

The correlation analysis did not show any significant relationship between postural balance and pistol shooting performance in Laser run event (Table 5).

Table 5. Spearman's correlation coefficients between pentathletes shooting performance and the postural balance measures in each shooting series during the Laser run

	Series	Shooting time [s]	Shot time [s]	Number of	
				errors	shots
V [mm/]	1	.33	.33	.28	.28
	2	-.02	-.02	-.13	-.13
	3	.04	.04	.08	.08
	4	.14	.14	.04	.04
AoE [mm^2]	1	.22	.22	.27	.27
	2	-.23	-.23	-.35	-.35
	3	.02	.02	.04	.04
	4	.29	.29	.20	.20
WoE [mm]	1	.20	.20	.29	.29.
	2	-.07	-.07	-.21	-.21
	3	-.06	-.06	-.11	-.11
	4	.13	.13	.02	.02
HoE [mm]	1	.09	.09	.06	.06
	2	-.31	-.31	-.34	-.34
	3	.04	.04	.08	.08
	4	.37	.37	.29	.29

V - average velocity of the COP; AoE – ellipse of the COP shifts area; WoE - width of the COP ellipse; HoE - height of the COP ellipse.

Conclusion

Laser run is a new, growing, and gaining in popularity worldwide competition, the rules of which have changed significantly in the recent years. Therefore, it is essential for an athlete and the coaches to identify the important factors to ensure a more directed training and to obtain better performance results.

The aim of our study was to evaluate the occurrence of a correlation between the body sway and the shooting performance in pentathletes in a Laser run event. The results we obtained showed that the shooting performance is not dependent on parameters describing COP shift and the surface area of the COP.

Bearing in mind the earlier studies conducted among biathletes, documenting the relationship between the shooting performance and the postural balance (Sadowska et al. 2018; Sadowska et al. 2019b), the results we have obtained may seem surprising. We assume that they result from the differences between the shooting position of the pentathletes and the biathletes. Pentathletes, like the pistol shooters, hold the weapon only with one completely outstretched hand. The weight of the arm and the pistol will substantially disturb the postural balance. The athlete has to bends the upper part of the body backwards to provide counterweight to the weight of the extended arm with the pistol and regain the optimal position of the body's centre of gravity. In turn, the specific body position during standing shooting in biathlon allows putting the centre of gravity of the rifle closer to the medium line of the body and placing the rifle above the centre of the support area what provides a better stability to the position.

Probably in contrast to the biathletes for whom the movements of the rifle when aiming at the target in the standing position are strongly coordinated with postural sways of their body (Sadowska et al. 2018; Sadowska, 2019b), the pentathletes' body sways do not correlate with pistol movements and thus do not affect the shooting performance.

In our previous research, we documented that the running effort disturbs the stability of the shooting position of the pentathletes during the Laser Run (Sadowska, et al. 2019a). Taking into account the results obtained in this study, we believe that post-effort postural balance disturbances in the Laser run competition do not negatively affect the shooting performance. This is confirmed by the observed lack of correlation between the postural balance and the shooting performance and the lack of differences in the shooting time, number of shots and number of errors between shooting series

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DECLARATION OF INTEREST STATEMENT

No potential conflict of interest was reported by the authors.

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