ANALYSIS OF METHODS FOR ASSESSING THE AIMING PROCESS IN BIATHLON SHOOTING

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In rifle shooting disciplines coaches and athletes are interested in the motion of the rifle just before and immediately after shooting. Normally, commercial laser systems (e.g. Noptel, Finland) are used to measure and store the hit point of the shot and the on-target trajectory of the alignment of the weapon. A major drawback of this method lies in the necessity of attaching the laser device to the rifle. The purpose of this study was to analyse the usefulness of a video-based system developed by Baca & Kornfeind (2006), which is able to track the 2D-movement of the muzzle of the weapon automatically. The results show considerable correspondence of the on-target-trajectory and the 2D-movement of the muzzle, in particular in vertical direction. However, translation movements of the shoulder during aiming, which are rather difficult to diagnose, may cause differences in the horizontal plane.

KEY WORDS: feedback system, aiming process, biathlon, shooting.

INTRODUCTION: Coaches and athletes in biathlon are interested in the motion of the barrel of the rifle just before and immediately after shooting. This is a crucial factor because of the preceding high exertions of the athletes. Nitzsche & Koch (2000) emphasize the importance of a small range of muzzle fluctuations for shooting performance.
In general, optoelectronic feedback systems (e.g. Noptel, Finland; see Figure 1, left) are used to measure and store the hit point of the shot and the on-target-trajectory of the alignment of the weapon. A drawback of the method lies in the necessity of attaching the laser device to the rifle and in the expenditure for calibrating the system. Alternatively, automatic tracking systems can be applied to track and record the 3D-movement of the rifle and / or the athlete (Heller, Baca & Kornfeind, 2006). Such systems are, however, rather expensive and difficult to use outdoor. Baca & Kornfeind (2006) developed a low-cost video-based system, which is able to track the 2D-movement of the muzzle automatically (see Figure 1, right). Preliminary results were promising, even with a resolution of video cameras usual in trade (720×576 pixels).
A shortcoming of both the laser-device-based and the video-based method is the missing information of the movement of the rifle butt pressed against the shooter's shoulder, which affects the fluctuation of the weapon (Zatsiorsky & Aktov, 1990).
The aim of this study is to compare those measuring techniques in performance diagnosis.

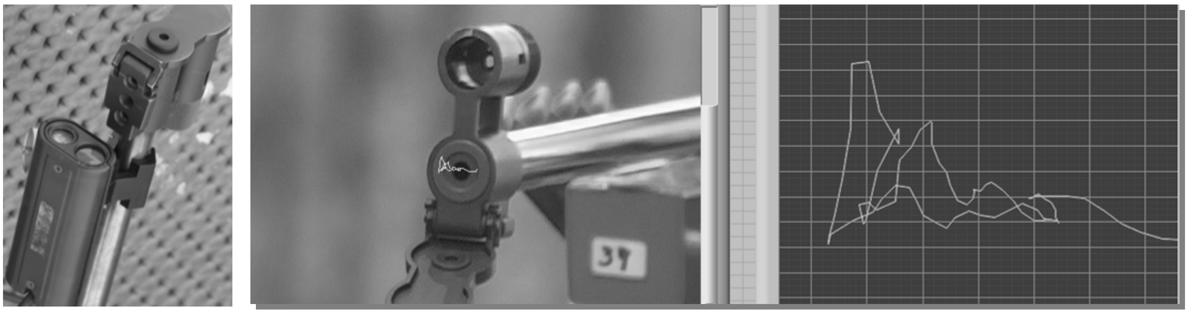

Figure 1: Left: optoelectronic feedback system Noptel. Right: video-based system. The plotted line in the diagram represents the trajectory of the muzzle obtained from the video (Baca & Kornfeind, 2006)

METHOD:

Subjects: Four biathletes from the Austrian Junior-Team (one woman and three men, aged between 16 and 19 years) participated in the study. Each biathlete shot with his/her own weapon from the standing position 15 times (three series of five shots per series) in competition like conditions: shooting distance of 50 m, target diameter of 110 mm (paper target).

Data Collection: The motion of the rifle was measured using two systems: a commercial laser system (Noptel ST-2000, Noptel Oy, Oulu, Finland) and a video-based system (Baca & Kornfeind, 2006). The laser based system (67 samples/sec) measures the gun orientation path on the target surface both before and after the shot, and records the shot itself. The video-based system (25 fps) obtains the movement of the muzzle using a video camera set up in a distance of about 5 m in front of the athlete in a laterally displaced position (1 m). The time of shot is detected from the audio line. After capturing the video the muzzle is tracked using image processing algorithms from LabVIEW© (NI, TX) (Figure 1). Figure 2 shows a schematic assembly of the whole recording system.

Data Analysis: The on-target-trajectory of the alignment of the weapon (laser system) and the trajectory of the muzzle (video-based system) were analysed for each athlete as follows: horizontal and vertical magnitude of the trajectories were computed using the standard deviation of the horizontal (dev_x) and the vertical component (dev_y) of the trajectories during the last second before the shot (Zatsiorsky & Aktov, 1990). Note that the absolute values for the standard deviations have a different meaning (laser: the unit of calculation is the space between the hit rings on target surface, video: trajectory of the muzzle). For each athlete data were reported as mean value ± standard deviation. Pearson's product-moment correlation coefficients were determined to estimate the dependencies between calculated deviations of both feedback systems for each individual.

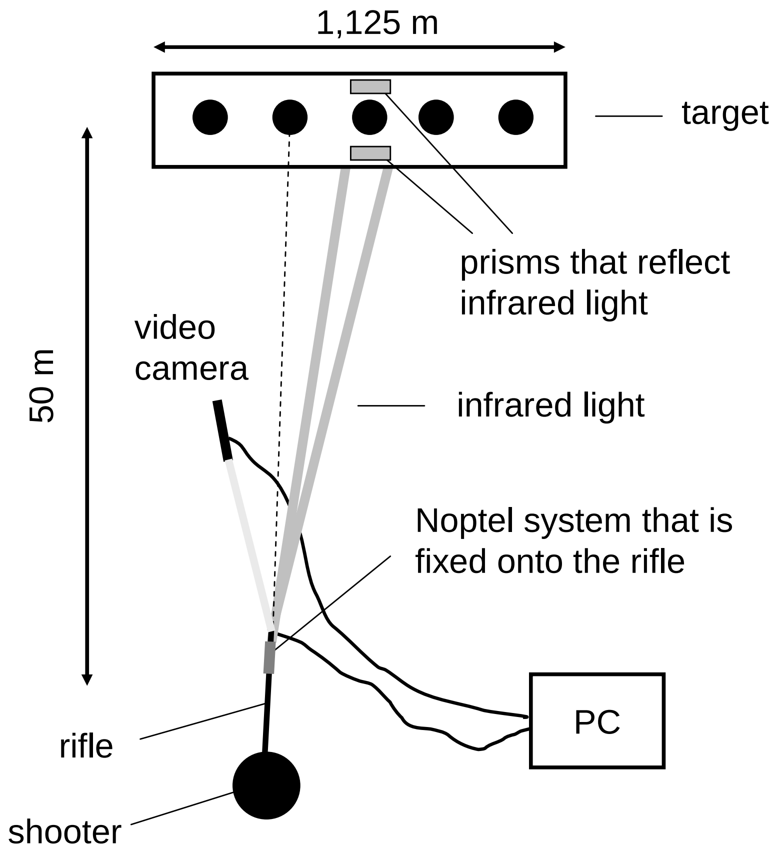

Figure 2: Schematic assembly of the system

RESULTS AND DISCUSSION: The horizontal and vertical standard deviations of the trajectories are shown in Table 1.

Table 1 Horizontal (dev_x) and vertical (dev_y) standard deviations of the trajectories during the last second before the shot and correlation coefficients r.

	dev_x			dev_y		
athlete	**laser [hit ring]**	**video [mm]**	**r**	**laser [hit ring]**	**video [mm]**	**r**
I	0.59 ± 0.22	0.95 ± 0.52	-0.26	0.45 ± 0.23	0.28 ± 0.13	0.83*
II	0.64 ± 0.14	1.02 ± 0.50	-0.02	0.74 ± 0.17	0.55 ± 0.47	0.05
III	0.64 ± 0.20	1.22 ± 0.71	-0.03	0.59 ± 0.26	0.31 ± 0.15	0.84**
IV	0.60 ± 0.25	0.88 ± 0.58	0.18	0.52 ± 0.15	0.22 ± 0.06	0.89**

Figure 3 shows on-target-trajectories (laser device) and muzzle trajectories (video) of two shots of one athlete during the last second before the shot.

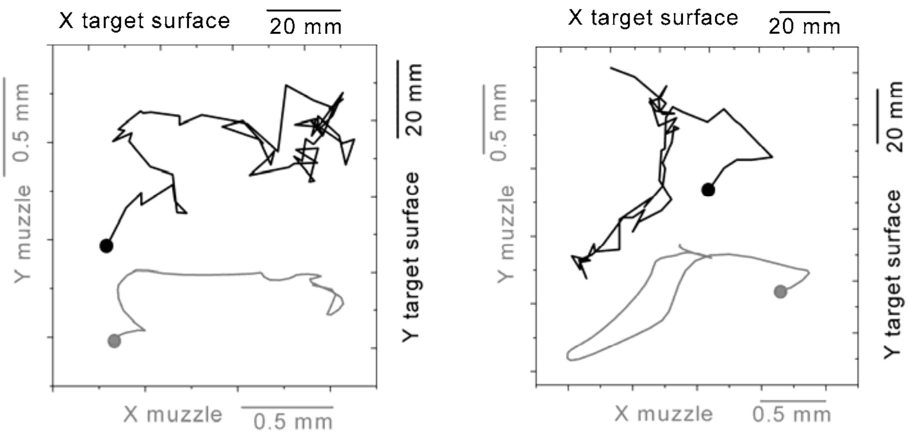

Figure 3: Sample 2D-trajectories and hits of two different shots. The muzzle trajectory in X-direction is shown mirror-inverted. Note that relative trajectories are obtained only.

The results of three athletes show a significant correlation of the vertical muzzle movement and the vertical spread on the target surface. No significant correlations were found between the horizontal components even though both trajectories are quite similar at nearly all shots (see Figures 3 and 4). The reason for this is that for all athletes as well high (see Figure 4, Top) as low (see Figure 4, Bottom) similarities in the horizontal trajectories could be found. These observations confirm with Zatsiorsky and Aktov (1990) who identify the angular movement relative to the butt rest point against the shoulder in the vertical plane and both translation and angular movement in the horizontal plane as most influential in shooting performance. To illustrate the consequences of both movements in the horizontal plane two contrary situations shall be considered: If during aiming there is only angular movement relative to the butt rest point against the shoulder a muzzle movement of one mm leads to an aim point movement of approximately 50 mm. By contrast, assuming there is only translation movement in the horizontal X-direction, a muzzle movement of one mm leads to an aim point movement of exactly one mm.

CONCLUSION: From the results it can be concluded that – at least in standing shooting – a low-cost video-based system tracking the 2D-movement of the muzzle is a useful tool to assess the aiming process in biathlon shooting.

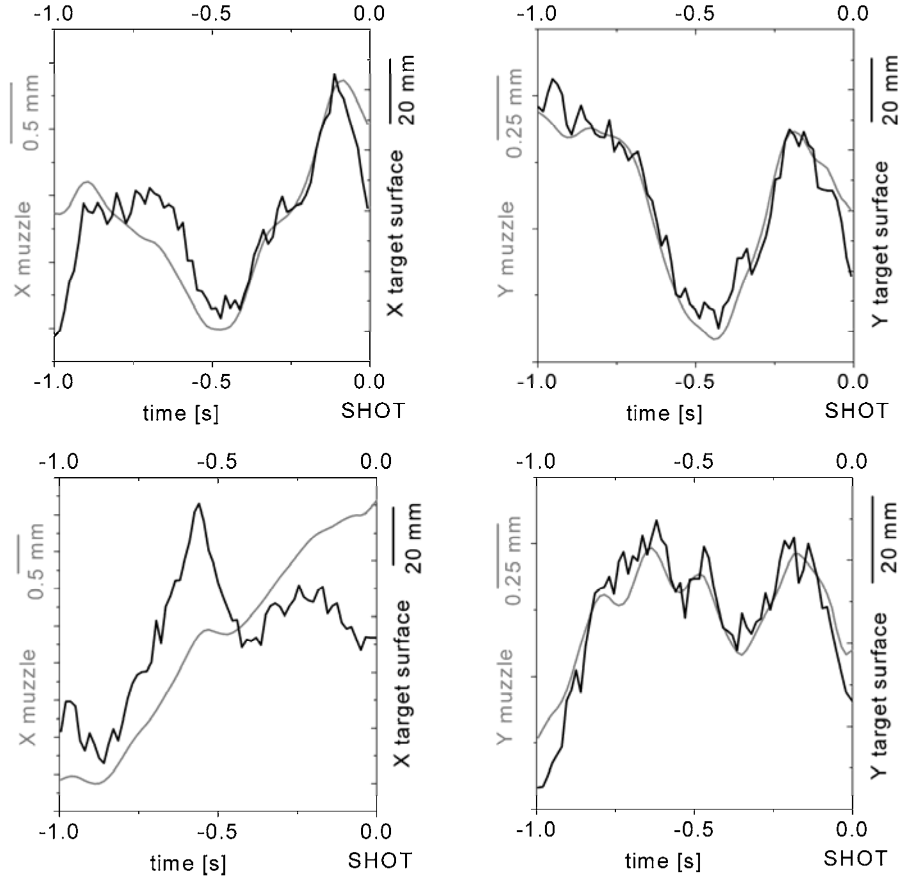

Figure 4: Sample trajectories of two shots as a function of time. Top: example shot for a high similarity in both X- and Y-direction. Bottom: example shot for a poor similarity in X-direction.

The exclusive use of a video-based system

1) provides qualitative information about the on-target-trajectory of the whole weapon,

2) indicates the vertical spread of the aiming point on the target surface,

3) specifies absolute values for the rifle movement in the area of the muzzle (and, moreover, the cant angle).

The combination of both methods provides additional information about the relation between the translation and angular rifle movement in the horizontal plane and their compensations for each other. Further research is necessary to understand the underlying mechanisms which provide a most efficient variant of aiming and to develop methods for assessing the aiming process.

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