BIOMECHANICAL AND PHYSIOLOGICAL ASPECTS OF RIFLE SHOOTING IN SIMULATED BIATHLON COMPETITION

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INTRODUCTION: In biathlon competition heart rate levels are commonly approximately 93 % of individual maximum heart rate during skiing. During the shooting heart rate level usually decreases to 61-73 % of maximum (Hoffman & Street, 1992). The result of biathlon competition is mostly affected by VO2max and upper body capacity (Rundell & Bacharach, 1995) and shooting performance including shooting time and accuracy (Hoffman, Gilson, Westenburg & Spencer, 1992). Shooting performance is affected by stability of shooting stance and rifle hold, especially in standing shooting (Groslambert, Candau, Hoffman, Bardy, & Rouillon, 1999). Physical loading diminishes shooting performance the more upper body muscles are involved in exercise (Hoffman, et al. 1992; Groslambert, Candau, Gillot & Rouillon, 1996; Groslambert, et al. 1999). Physical exercise and increasing muscle fatigue results poorer control of balance and shooting posture. Balance control agilities of biathlon athletes have been investigated only by Bozsik, Bretz and Kaske (1995), but connection between balance agilities and shooting result have not been established by any research.
The aim of this project was to develop methods for measuring shooting performance in biathlon.

METHOD: Seventeen biathlon athletes (8 men and 9 women) participated this project during years 2004 and 2005. Measurements were done twice in both years: August and October in 2004 and June and August in 2005. Simulated biathlon competition was carried out in a 200-m indoor track with roller skis. The length of the competition was 3 x 1600 m for women and 3 x 2000 m for men athletes. Competition was performed as an individual single performance and athletes were asked to use competition-like effort level. After each skiing leg athlete performed normal five standing shots with the laser-based Noptel -optical shooting system attached to the rifle (Noptel Oy, Finland). Distance to the target was 10 m and by using Noptel-system no bullets were needed. The parameters measured and recorded during shooting were shooting result, path of aiming, total shooting time, 5 shots time, triggering force, balance of posture, breathing, heart rate and video images (front- and side view). The measured parameters were available for coaches already during the competition, right after the competition or later on in the form of multimedia-based feedback cd-rom.

RESULTS: Measured variables and calculated results were saved to a feedback cd-rom after each measurement and delivered to athletes and coaches. Multimedia feedback provided KihuViewer database including videos and signals of the shooting performances. Cd-rom included also special KihuViewer™ –video and signal player which made possible synchronized viewing of all videos and signals of shooting performances (Figure 1).
In addition, 5 shot time and total shooting time, as well as, heart rate levels were recorded from each shooting performance (Table 1). More detailed analyses of triggering, path of aiming and balance of posture are in progress and results will be presented later. Possible interactions between shooting accuracy and physiological parameters (heart rate, VO2max and blood lactate) will be investigated by using statistical methods, as well.

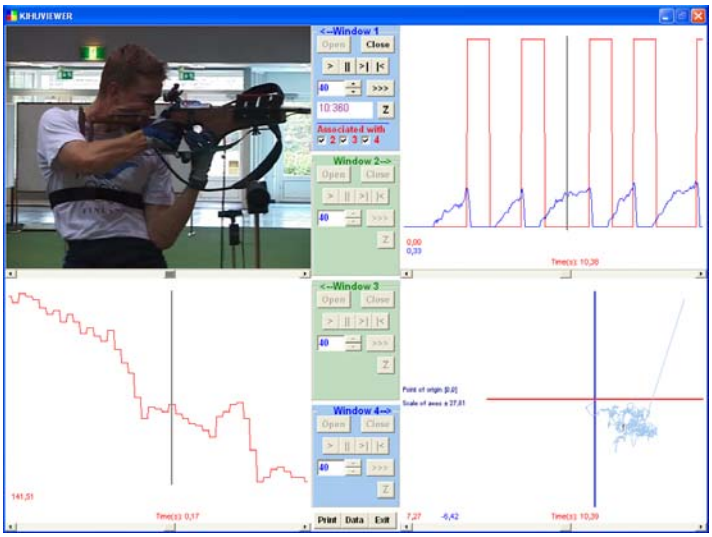

Figure 1: A single view of multimedia-based measurement feedback to athletes and coaches presented in Kihuviewer™ software.

Table 1 An average values of 5 shot time, total shooting time and heart rate levels during different shootings in simulated competition. Values represent an average of four different measurements, total N=18.

	1. shooting	**2. shooting**	**3. shooting**
5 shot time (s) a	13.5	13.6	13.7
Total shooting time (s) b	58.3	57.3	46.2
HR at start (beats/min)	178	183	184
HR at end (beats/min)	143	150	158
HR change (beats/min)	-36	-33	-26

a time from the first shot to the last shot.
b time from arrival to shooting place to leaving from shooting place.

DISCUSSION: Measured parameters in shooting performances were selected according to previous investigations to represent the most important factors of successful shooting performance. Noptel-system gave a good picture about the overall aiming path, aiming approach and follow-through, which is important especially in the real biathlon shooting with bullets and distance of 50 m. In some cases loading movements caused errors and extra shots to the Noptel-system, which hindered synchronizing of aiming information and other data signals.

Shooting performance in biathlon with skis lays big requirements on controlling the balance of posture. Common problem seemed to be, that athlete's centre of gravity moved too much forward during shooting. By watching combined view of video images and balance curve athletes got useful information on their shooting posture and were able to correct their mistakes in aiming.

Triggering curves helped to recognize for example too vigorous triggering, which in many cases lead to a missed shot. Technique used in triggering force measurement was affected by the place of the finger on trigger. Consequently, values between different shooters or shooting times were not comparable.

In the future, measuring of shooting agility should consist three different phases and measurements: basic shooting agility at rest, biathlon shooting agility at rest and biathlon shooting agility in competition. By recording heart rate in various test situations, it could be possible to find out individually optimal heart rate levels for the best shooting result.

CONCLUSION: The measurements used in this project during shooting made it possible to follow-up occasionally and develop the basic shooting technique of each individual. Versatile parameters clearly showed both strong and weak areas in each athlete's shooting technique. The methods analyzing shooting performance in biathlon should be further developed and regularly used in high-level athlete's training.

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