Winter Biathlon Shooting
practical applications to use in Laser-Run Training

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This is what happens when sport scientists and performance staff can't communicate
What is Biathlon?

- Cross country skiing
- Prone shooting
- Standing shooting
Small caliber rifle

- Repose tête
- Dioptre + œilleton
- Cache
- Porte chargeur
- Guidon + ring
- Cache
- Canon
- Bretelles dos
- Bretelle de couche
- Brassard
The targets: (distance 50m)

Ø
Standing : 11.5 cm

Ø
Prone : 4.5 cm
The aiming in biathlon shooting
(Wick, 1992)

- Prone shooting
  - Discrimination
  - Fine motor control
    (Sattlecker et al., 2016)

- Standing shooting
  - Postural control
  - Short reaction time
    (Sattlecker et al., 2016)
## The Competitions

### SENIORS HOMMES

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20km individuel 4Tirs CDCCD</td>
<td>(pénalité : 1mm)</td>
</tr>
<tr>
<td>15km individuel court 4Tirs CDCCD</td>
<td>(pénalité: 45 secondes)</td>
</tr>
<tr>
<td>10km sprint 2 Tirs CD</td>
<td>(pénalité : 1 tour de 150m)</td>
</tr>
<tr>
<td>7,5km  sprint court 2 Tirs CD</td>
<td>(pénalité : balle de pioche + tour de 75m)</td>
</tr>
<tr>
<td>Poursuite 12,5km 4 Tirs CCDD</td>
<td>(pénalité : 1 tour de 150m)</td>
</tr>
<tr>
<td>Mass Start 15km 4 tirs CCDD</td>
<td>(pénalité : 1 tour de 150m)</td>
</tr>
<tr>
<td><strong>Super Sprint</strong> (Qualif 2 tirs CD+ Finale 4 tirs CCDD)</td>
<td></td>
</tr>
<tr>
<td>Relais 3 x 6km CD</td>
<td>(pénalité : balle de pioche + tour de 150m)</td>
</tr>
<tr>
<td>Relais mixte (D 4,5km ; H 6km) CD</td>
<td>(pénalité : balle de pioche + tour de 150m)</td>
</tr>
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### SENIORS DAMES

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<tr>
<td>7,5km  sprint 2 Tirs CD</td>
<td>(pénalité : 1 tour de 150m)</td>
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<tr>
<td>6km  sprint court 2 Tirs CD</td>
<td>(pénalité : balle de pioche + tour de 75m)</td>
</tr>
<tr>
<td>Poursuite 10km 4 Tirs CCDD</td>
<td>(pénalité : 1 tour de 150m)</td>
</tr>
<tr>
<td>Mass Start 12,5km 4 tirs CCDD</td>
<td>(pénalité : 1 tour de 150 m)</td>
</tr>
<tr>
<td><strong>Super Sprint</strong> (Qualif 2 tirs CD+ Finale 4 tirs CCDD)</td>
<td>(pénalité : balle de pioche + tour de 60 a 75m)</td>
</tr>
<tr>
<td>Relais 3 x 4,5km CD</td>
<td>(pénalité : balle de pioche + tour de 150m)</td>
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<td>Relais mixte (D 4,5km ; H 6km) CD</td>
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What are the differences and similarities between Laser Run and Biathlon?

https://www.youtube.com/watch?v=petaKIQTAOM
<table>
<thead>
<tr>
<th></th>
<th>Laser Run</th>
<th>Biathlon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shooting equipment</td>
<td>pistol (handgun) 600g</td>
<td>Rifle 3.5 kg</td>
</tr>
<tr>
<td>Impact</td>
<td>Optical (laser)</td>
<td>Balistic (wind, outdoor temperature)</td>
</tr>
<tr>
<td>Aiming system</td>
<td>« V »</td>
<td>Diopter and cercle</td>
</tr>
<tr>
<td>Distance</td>
<td>10 m</td>
<td>50 m</td>
</tr>
<tr>
<td>Shooting position</td>
<td>Standing</td>
<td>Standing and prone</td>
</tr>
<tr>
<td>Penalty</td>
<td>Hit 5 targets in maximal 50s</td>
<td>5 target with 5 bullets, additionnel time or penalty lap</td>
</tr>
</tbody>
</table>
## Similarities

<table>
<thead>
<tr>
<th></th>
<th>Laser Run</th>
<th>Biathlon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exercise</strong></td>
<td>Legs exercise prior to shooting</td>
<td>Leg and arm exercises prior to shooting</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>direct confrontation with opponents</td>
<td>Most of the time direct confrontation with opponents</td>
</tr>
<tr>
<td><strong>Motor skills</strong></td>
<td>Postural control&lt;br&gt;Arm control&lt;br&gt;Fine motor control (triggering)</td>
<td>Postural control&lt;br&gt;Absence of arm control requirement&lt;br&gt;Fine motor control (triggering)</td>
</tr>
<tr>
<td><strong>Physiological adaptations</strong></td>
<td>High respiration rate and HR, muscular tremor</td>
<td>High respiration rate and HR, muscular tremor</td>
</tr>
<tr>
<td><strong>Mental skills</strong></td>
<td>Concentration&lt;br&gt;Dealing with stress</td>
<td>Concentration&lt;br&gt;Dealing with stress</td>
</tr>
</tbody>
</table>
What do we know about the components of biathlon shooting performance?
Performance in biathlon

Skiing performance strongly correlated \( (r = 0.88) \) to final (Rundell, 1995)

Skiing-shooting interactions:
- Significant (Hoffman, 1987)
- No-significant (Niimina, 1988)

Components of biathlon shooting performance

Shooting performance requires various postural and cognitive regulations (Nitsche, 1990)

Specific habilities for prone and standing shooting (Wick, 1992)
Components of biathlon shooting performance

Motor skills and cognitive regulations in biathlon shooting (Nitzsche & Stolz, 1990)

AP: Approach
AS: Analyse of the situation
Ss: Shooting strategy
Inst: Installation period

Pos: postural control
Aim: Aiming the target
Ap: Apnea
Trig: Triggering

Kr: knowledge of the result
Cs: Change of strategy
Components of biathlon shooting performance

Fig. 1: The three system approach applied to biathlon shooting on the action and on the ability level  Finkelsteller et al., 2016
What we would like to know about the components of biathlon performance?
What are we would like to know about the components of biathlon performance?

- What is the respective influence of skiing and shooting in the biathlon performance?
- What is the influence of the shooting range approach and the shooting time on the shooting performance?
- What is the influence of reaction time and postural control in standing shooting performance after intense exercise?
- What are the physiological adaptations during standing shooting?
- Is it possible to increase shooting performance with mental training?
- Is there a relationship between shooting velocity and accuracy?
Influence of the duration of the different biathlon phases on the performance of the athletes of the 1992 Olympic game

Question 1:
- What is the respective influence of skiing and shooting in the biathlon performance?
- What is the influence of the shooting range approach and the shooting time on the shooting performance?

**Design**

**Subjects**: 24 elite biathletes

**Competition**: relay 4 x 7.5 km Men

**Performance measurement**: Official race time

**Video recording**:

- Approach time (s) : last 50m before the shooting range
- Installation time (s) : from stop to the first shoot
- Shooting time (s): from the first to the last shoot
There is a significant correlation between skiing time and the final performance ($R^2 = 0.88; p<0.05$).

For both prone and standing shooting, no significant relationship was observed between approach time and shooting precision.

There is a significant negative relationship between the installation time and the standing shooting performance ($\rho=-0.57; P<0.01$).
Discussion

High level performance in biathlon requires to be at first a great cross country skier and secondary a great shooter.

The decrease of the skiing velocity before shooting doesn’t influence shooting precision => maintain a constant velocity until the shooting range.

The standing shooting performance is linked to a «long» installation time. However, more recent observations (2000) revealed that the best biathletes minimize the installation time and are able to shoot accurately.
### Determination of the respective influence of running/skiing and shooting in the laser run and biathlon performance

<table>
<thead>
<tr>
<th>Event</th>
<th>Biathlon</th>
<th>Laser Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event</td>
<td>IBU World Championship HOCHFILZEN, 19.02.2017 MEN 10 KM SPRINT (2 Shoots)</td>
<td>UIPM WC Vilnius LTU 2017, Modern Pentathlon 4 shoots</td>
</tr>
<tr>
<td>Observations</td>
<td>n= 36</td>
<td>n= 36</td>
</tr>
<tr>
<td>Average time of the Race (s)</td>
<td>24 min 20 s ± 26 s</td>
<td>11 min 02 s ± 22 s</td>
</tr>
<tr>
<td>Average time of skiing</td>
<td>21 min 58 s ± 23 s</td>
<td>10 min 31 s ± 21 s</td>
</tr>
<tr>
<td>Average time in the shooting range (s)</td>
<td>128 ± 26 s</td>
<td>52 ± 12 s</td>
</tr>
<tr>
<td>Impact of shooting in race</td>
<td>8 %</td>
<td>8 %</td>
</tr>
<tr>
<td>Impact of Skiing in the race</td>
<td>92%</td>
<td>92%</td>
</tr>
</tbody>
</table>

**Practical applications:**

- It seems that running (as skiing) has a major influence on performance and secondary shooting => talent detection and training.
- Maintaining running velocity until the shooting range
Influence of exercise on reaction
time and shooting accuracy in biathlon

Design

Subjects

10 national level biathletes

age: 18.5 ± ans

Measurements

Exercise: Heart rate + blood lactats

Shooting performance: standing shooting; score /50

Visual reaction time: Multipsy system
Visual reaction time Test

- Computer
- diode
- Push button
First day

- Standing shooting (rest)
- 3km ski (85% HR max)
- Standing shooting
- 3km ski (HR max)
- Standing shooting

Second day

- Visual reaction time test (rest)
- 3km ski (85% HR max)
- Visual reaction time test
- 3km ski (HR max)
- Visual reaction time test
## Results

<table>
<thead>
<tr>
<th></th>
<th>Shooting score/50</th>
<th>Reaction Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rest</strong></td>
<td>26.9±1</td>
<td>203±20</td>
</tr>
<tr>
<td>85 % HR max</td>
<td>23.3±2 (*)</td>
<td>198±12 (NS)</td>
</tr>
<tr>
<td>HR Max</td>
<td>20.5±2 (*)</td>
<td>199±12 (NS)</td>
</tr>
</tbody>
</table>

(* P < 0.05 compared to rest)
Discussion

The shooting accuracy is decreased after exercise.

The shooting performance decrease is not associated to a decrease of visual reaction time.

What about postural control?
Question 2: What is the influence of reaction time and postural control in standing shooting performance after intense exercise?

**Effects of exercise on postural sway in biathlon standing shooting**

Design

Subjects:
12 international level and 12 regional level biathletes
Age: de 20 ± 1 years

Measurement:
Postural control test
Shooting performance
Tremometer test for standing shooting

6 mm diameter circle

Computer

Stylet
Tremometer performance

![Bar chart showing the comparison between Standing and Repos for Number of Touches, with an asterisk indicating p<0.05.](image)

* p<0.05
Number of missed targets vs. Number of touches.

$r^2 = 0.68$
$p < 0.0001$
$n = 24$
• The postural sway seems to have a major influence on standing shooting performance. These results have been recently reported by Sattlecker et al. (2016).

Practical application:
Specific training to increase postural control and arm sway (balance and strength training are encouraged)
Question 3: What are the physiological adaptations during standing shooting?

Cardio-respiratory responses of biathletes during standing shooting

Design

Subjects: 4 top level biathletes
Exercise: incremental running test until exhaustion
Physiological variables measured during shooting:
Venilatory flow (VE) Ti/Ttot, VE*, HR
Shooting performance (Noptel ST 2000):
. Shooting precision (score /50),
. Postural control (time spent on the target (s)).
Cardio-respiratory responses during standing shooting at rest

![Graph showing HR (bpm) and Respiratory rates with indices Ti/Tot over time for different shoots.](image)
Réponses cardio-respiratory responses after exercise
Results

- No Apnea phases were observed
- Significant relationship \((p<0.05)\) between respiratory flow and stability
- Significant relationship \((p<0.001)\) between accuracy and stability
- No significant correlation between HR and accuracy \((\text{Vickers et al. 2007})\)
In summary

Respiratory rate

Respiratory flow ($V_E$)

Exercise intensity

Postural control

Shooting precision

Practical applications:
- Shooting training with high HR and respiratory flow (yoga, relaxation) +++
- Apnea is not necessary (for brain oxygenation)
Question 6: Is it possible to increase shooting performance with mental training?

Effects of Autogenic and Imagery training on the shooting performance in Biathlon

Introduction

Autogenic Training+ Mental Imagery provides different psycho-physiological adaptations

- HR and respiratory responses (Blumenstein, 1995)
- Muscular tensions (Blumenstein, 1995)
- Performance in visual adjustment task (Chevalier, 1987)
Design

Subjects

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>level</th>
<th>body mass</th>
<th>height</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 M 4 F</td>
<td>21 ± 1 y</td>
<td>national</td>
<td>66 ± 3kg</td>
<td>172 ± 1cm</td>
</tr>
</tbody>
</table>

Variables

- shooting precision (number of missed target)
- Postural control (TT-S)
Mental training group

2 km roller skiing (85% HR max)

Shoot | Tremo

Shooting training

-6 Weeks-

2 km roller skiing (85% HR max)

Shoot | Tremo

Mental and shooting training

-6 Weeks-

2 km roller skiing (85% HR max)

Shoot | Tremo

Control Group

2 km roller skiing (85% HR max)

Shoot | Tremo

Shooting training

-6 Weeks-

2 km roller skiing (85% HR max)

Shoot | Tremo

Shooting training

-6 Weeks-

2 km roller skiing (85% HR max)

Shoot | Tremo
Shooting performance

- Baseline measurement
- After standardised shooting training
- After standardised shooting training + Mental training

* p<0.05
Postural test * p<0.05

- **Baseline**
- **Shooting training**
- **Shooting + mental Training**

![Bar chart showing number of touches for mental and control groups](image-url)
Discussion

Imagery Training

Positive effects on shooting learning and self confidence

Autogenic training (relaxation)

Muscular tensions (Blumenstein, 1995)

postural control

Shooting performance +++
(Laaksonen et al. 2011)

Practical application: training method complementary to actual shooting training and useful with injured athlete
Is there a relationship between accuracy and velocity in biathlon standing shooting?

Grebot C., Grosllambert A., Rouillon J.D. Relation vitesse précision au tir chez les biathlètes experts. Sci & Sports 2002, 1, 13-16
Design

Subjects

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<tbody>
<tr>
<td>4 M 4 F</td>
<td>22 ± 1 y</td>
<td>national</td>
<td>65 ± 8 kg</td>
<td>174 ± 13 cm</td>
</tr>
</tbody>
</table>

Variables

- Shooting precision (number of target hit)
- Shooting time(s)
- Heart rate
1 km à 85 % HR max
Shoot in 30 s
1 km à 85 % HR max
Shoot
1 km à 85 % FC max
Shoot
1 km à 85 % HR max
Shoot
1 km à 85 % HR max
Shoot
1 km à 85 % HR max
Shoot
1 km à 85 % HR max
Shoot
Shoot at maximal velocity
Design
Relation between shooting time and precision in standing position

$p < 0.05 ; r^2 = 0.24$
Discussion

• The relationship between velocity and shooting accuracy reveals:
  • shooting time < 15 s = difficulties of adjustment
  • shooting time > 20 s = difficulties of postural control

Practical application: determine for each athlete the optimal shooting time window.
In conclusion

Practical applications and suggestions:

- Talent detection in runners. Then you train them for shooting
- Maintaining running velocity until the shooting range
- Determine the optimal shooting time window
- Shooting with high level of fatigue and with opponents
- Using mental training (relaxation & mental imagery)
- Specific training to increase postural control and arm sway

There are a lot of similarities between Laser run and biathlon and scientific collaborations and coach meetings between both sports may be very interesting for everybody.