Validation of Simple Tests of Biathlon Shooting Ability

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The aim of this study was to validate three simple tests of biathlon shooting abilities. Twelve expert biathletes performed visual reaction time tests adapted for the rifle in the standing (RT-S) and prone positions (RT-P), and a tremometer test adapted for the rifle in the standing position (TT-S). Six consecutive days' measurements showed an acceptable reproducibility for these tests (coefficient of variation = 1.2% for RT-S, 1.1% for RT-P and 6.5% for TT-S). A significant difference was observed between TT-S at rest and after roller skiing 2.1 km at 90% of maximal heart rate. This finding demonstrates the sensitivity of TT-S to discriminate the effects of fatigue on postural control. Among 24 biathletes of regional to expert level, significant correlations were observed between resting RT-P and prone shooting performance after roller skiing (r² = 0.23; p = 0.01) and between resting TT-S and shooting performance in the standing position after roller skiing (r² = 0.68; p = 0.0001), demonstrating the specificity of these tests. From these results, we conclude that TT-S is a valid field test of biathlon shooting performance.

Key words: Biathlon, validation, shooting abilities

Introduction

Biathlon is a winter sport that combines cross-country skiing with rifle marksmanship. Biathlon competitions typically involve four to five periods of shooting, which are preceded and followed by cross-country skiing distances of 2.5 to 5 km. The shooting position alternates between the prone and standing positions with each shooting period. In individual biathlon competitions, five shots are allowed to hit the targets positioned 50 m from the firing line. A penalty lap or penalty time is assessed for each missed target, and the lowest cumulative time wins.

The physiological factors affecting the cross-country skiing performance in biathlon have been examined in a number of studies [1, 2, 7, 9]. Fewer studies have been directed towards the shooting tasks in biathlon. It is clear that biathlon shooting is a very complex motor activity requiring good postural stability and rapid execution [13, 17]. Yet, the skills required for prone and standing shooting are not identical [21]. In prone shooting, the stability of the rifle is increased by the use of a shooting-strap, so a relatively long aiming time is used. Shooting performance in the prone position requires discrimination ability (i.e. discrimination between perfect and approximate aiming), and fine motor control (i.e. triggering action without hand or arm movement).

In standing shooting, the stability of the body-rifle system is an important variable that characterizes both elite shooters [3, 5, 11, 19, 20] and elite biathletes [14]. However, it has been reported that there are significant differences in shooting strategies between shooters and biathletes [10]. Shooters attempt to control body and rifle sway, while biathletes use coincidence-anticipation strategies. It has been reported that the mean duration of the target appearance in the rifle ring prior to shooting is only 200 ms for elite biathletes during standing shooting [13, 15]. Therefore, shooting performance in the standing position is thought to require fine postural control combined with a short visual reaction time. Both the stability of the rifle hold [8] and the visual reaction time [12] have been previously demonstrated to be adversely affected by intense physical exercise.

Previous investigations of biathlon shooting have used complex laser shooting systems [8, 17] or a video-shooting-stimulator [4, 21] that cannot be easily used outside the laboratory. The aim of this study was to examine tests that can easily be used in the field to evaluate the shooting ability of biathletes. The tests offer the possibility to obtain information about the stability of hold and visual reaction time. The reproducibility, specificity and sensitivity of the tests were investigated in this study.

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Methods

Subjects

Twelve expert biathletes of the French National Team (10 males, 2 females) served as subjects to test the reproducibility and sensitivity of the shooting tests. They had a mean (± SD) age of 20 ± 1 years.

An additional 12 non-expert biathletes who were members of a regional team (9 males, 3 females) participated in testing the specificity of the shooting tests. They had a mean (± SD) age of 19 ± 1 years.

Instruments

Three psychomotor tests were examined in this study. Reaction time tests adapted for the rifle were performed in the standing (RT-S) and prone (RT-P) positions. These tests used a Duffour Chronoscope (Laroche Ollainville, 91290 Arpajon, France) that was adapted for each subject's biathlon rifle. The device includes a diode that emits a randomized simple visual stimulus during 30 s. During each test, the biathlete aimed his/her rifle at the diode positioned 1.5 m from the firing line. The subject reacted to the visual stimuli as quickly as possible by triggering a push-button mounted on the rifle trigger. The average reaction time for the eight stimuli was used in data analysis.

A tremometer test adapted for the rifle was also performed in the standing position (TT-S). This test used the Duffour computer (Laroche Ollainville, 91290 Arpajon, France). With this test, the subject attempted to maintain a styler mounted to the end of the rifle barrel with a 6 mm diameter ring. The styler and mounting support weighed a total of 30 gm. Each test consisted of five trials lasting 4 s each. The subjects were instructed to pace the trials in the manner they normally shoot during biathlon competitions. A new trial began when the styler was not hitting the ring. During each trial, the computer recorded the number of touches of the styler to the ring. The total number of touches during the five trials was used in data analysis. This test was only performed in the standing position because pilot tests revealed the stability to be too great for testing in the prone position to be worthwhile.

Procedures

To examine test reproducibility, the three tests were performed by the 12 expert biathletes during six consecutive days. The three tests were performed under resting conditions and at the same time of day for a given subject.

The sensitivity of RT-S, RT-P and TT-S was examined by comparison of results at rest with those immediately after roller skiing. Each expert biathlete first performed each test under resting conditions. Then, a 2.1 km loop was roller skied at 90% of maximal heart rate (requiring 6–7 min) immediately prior to performing each of the three tests. The order of performance of the tests was randomized. The exercise intensity of 90% of maximal heart rate was selected because it corresponds to the intensity adapted by biathletes during competition [7]. A portable heart rate monitor (BFL 6000, Baumann and Haldi, Fleurier, Switzerland) was used to allow each subject to adjust the exercise intensity to achieve the desired heart rate. Maximal heart rates were determined on a separate day prior to this test with an incremental maximal roller skiing test.

Test specificity was examined through comparisons of the shooting ability tests with biathlon shooting performance among the entire 24 subjects. Biathlon shooting performance was determined as the number of missed targets from five shots in each shooting position immediately after roller skiing 2.1 km at 90% of maximal heart rate. The shooting was performed in a covered shooting range, minimizing the light and wind changes. Targets were positioned 50 m from the firing line, and were 40 mm and 110 mm in diameter for the prone and standing positions, respectively. The shooting ability tests were performed on the same day with the biathletes in a rested condition.

Statistical treatment

The data are reported using ordinary statistical methods including mean, standard deviation, and coefficient of variation (CV) expressed in percentage. One-way repeated measures analysis of variance (ANOVA) and Fischer post-hoc tests were used to compare the day-to-day test results. Paired t-tests were used to compare the resting and post-exercise test results. Correlation analyses were used to identify possible associations between the three tests and biathlon shooting performance. Statistical significance was accepted at the p < 0.05 level.

Results

No significant differences were observed in the day-to-day measurement results for RT-S, RT-P and TT-S (Fig. 1). CV values were 1.2% and 1.1% for RT-S and RT-P, respectively. For TT-S the CV was 6.5%.

No significant effect of exercise was noted for either RT-S or RT-P (Fig. 2). However, a significant difference (p < 0.05) was observed between resting and exercise conditions for TT-S.

![Fig. 1 Mean day-to-day variability of the visual reaction time test adapted for the rifle in the standing (solid bars) and prone (stipled bars) positions (top panel) and, mean day-to-day variability of the tremometer test adapted for the rifle (bottom panel). Brackets represent 1 SD. No significant differences were observed across the six days.](image-url)
Fig. 2 Mean values for the reaction time test adapted for the rifle in the prone (RT-P) and standing (RT-S) positions at rest and immediately after exercise (top panel), and mean values for the number of touches in the tremometer test adapted for the rifle at rest and after exercise (bottom panel). Brackets represent 1 SD. N.S. indicates where no significant differences were observed between the rest and exercise conditions. * Indicates where a significant difference (p<0.05) was observed between the two conditions.

Shooting performance in the standing position after roller skiing was significantly correlated with resting TT-S (Fig. 3), ($r^2 = 0.68$, $p = 0.0001$), but was not significantly correlated with resting RT-S. Prone shooting performance after roller skiing was significantly correlated ($r^2 = 0.23$, $p = 0.01$) with resting RT-P.

None of the biathletes indicated a problem with adjustment to the small additional mass and minor change in mass distribution of the rifle while performing RT-S, RT-P and TT-S.

Discussion

An important finding of this study is that RT-S, RT-P and TT-S showed acceptable reproducibility. The fact that no significant difference was observed across the day-to-day measurements and that a low CV was found, indicate the high reproducibility of these tests. This finding suggests that these tests are not affected by a learning effect in expert biathletes.

Previous research has demonstrated an effect of exercise on the stability of hold during standing biathlon shooting [8,17]. The present finding of a significant influence of physical exertion on TT-S demonstrates the sensitivity of this measure. In contrast, RT-S and RT-P were not affected by exercise. However, an inverted U-effect of exercise on simple reaction time has been observed [18]. It is possible that the high exercise intensity used in the present study (90% of maximal heart rate) may exceed optimal arousal threshold. This may explain the lack of significant difference between resting and exercise conditions.

The present finding of a significant correlation between resting TT-S and standing shooting performance after roller skiing suggests that postural control is a major determinant for shooting performance in the standing position. The importance of postural stability for standing shooting has been reported in previous studies involving shooters [11,19,20] and more recently in a study of biathletes [6]. The present study also identified a significant correlation between resting RT-P and prone shooting performance after roller skiing, but this correlation was lower than between TT-S and standing shooting performance. There was no correlation between resting RT-S and standing shooting performance after roller skiing. These findings suggest that reaction time has little connection to a task that uses anticipation strategies.

In conclusion, the acceptable reproducibility, specificity and sensitivity of TT-S observed in the present study suggest that this test is valid and could be used with biathletes in order to examine the shooting abilities required in biathlon. While RT-S and RT-P demonstrated good reproducibility, the lack of adequate sensitivity with RT-S and RT-P, and adequate specificity with TT-S make these tests appear less useful.
References


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