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Effects of Autogenic and Imagery Training on the Shooting Performance in Biathlon

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Biathlon is a winter sport that combines cross-country skiing with rifle marksmanship. Biathlon competitions typically involve two–four periods of shooting, which are preceded and followed by cross-country skiing over distances of 2.5–5 km. The shooting position alternates between the prone and standing positions at each shooting period. In individual biathlon competitions, the participant is allowed five shots to hit the targets, which are 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.

Biathlon shooting is a complex motor activity requiring good postural stability and rapid execution (Simoneau, Bard, Fleury, Teasdale, & Boulay, 1997). However, the skills required for prone and standing shooting are not identical (Wick, 1990). Shooting performance in the prone position requires the ability to discriminate (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 characteristic variable in biathletes (Nitzsche & Stolz, 1981). However, it has been reported that standing shooting was significantly affected after the skiing exercise, because it

decreased the biathlete's postural control (Gros Lambert, Grappe, & Rouillon, 1998; Hoffman, Gilson, Westenburg, & Spencer, 1992). Authors have reported a significant correlation between the postural control and the shooting performance in the standing position (Gros Lambert, Candau, Hoffman, Bardy, & Rouillon, 1999; Gros Lambert et al., 1998; Nitzsche & Stolz, 1981).

Most of the research on the effects of imagery training, whether alone or combined with relaxation techniques such as stress inoculation training (Meichenbaum, 1985) or visuomotor behavior rehearsal (Suinn, 1993), indicates that these training programs improve performance. Positive effects have also been observed in several sports, such as soccer (Blair, Hall, & Leyshon, 1993), pistol marksmanship (Hall & Hardy, 1991; Kim & Tennant, 1993), and archery (Zervas & Kakkos, 1995). Moreover, in karate and pistol marksmanship it has been reported that training programs combining relaxation with imagery training give better results than programs containing relaxation or imagery training alone (Hall & Hardy, 1991; Weinberg, Seabourne, & Jackson, 1982). Lénárt (1991) observed that shooting training associated with autogenic and imagery training (AT+IM) can significantly improve both the stability of hold and accuracy in elite rifle marksmen. Referring to some of the major psychophysiological changes observed by Feltz and Landers (1983; i.e., decrease in muscular tension and respiration and heart rates), Gieremek, Osialdlo, Rudzinska, and Nowotny (1994) reported that the regular practice of autogenic training may enhance both the stability of hold and shooting performance. However, these investigations of shooting accuracy examined the participants under ideal resting conditions and unlimited shooting time. It is possible that under exercise conditions and with limited time, the magni-

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tude of the positive psychophysiological responses caused by autogenic training would be diminished. Couture et al. (1999) approached this problem by investigating the effects of a relaxation program on shooting accuracy following a 16-km march. The authors reported that the relaxation training program did not significantly affect heart rate or rifle shooting accuracy. It also appears that research on the influence of a mental training program pertaining to a shooting task performed immediately after intense physical exertion may provide inconsistent results.

The aim of this study was to examine the effects of a shooting training program, including autogenic and imagery training, on the stability of hold, heart rate, and the standing shooting performance after heavy physical exercise. It was hypothesized that biathlon shooting accuracy performed under exercise conditions could be improved after a program combining both shooting and mental training.

Method

Participants

Sixteen expert biathletes belonging to the French national team (12 men, 4 women, M age = 21.5 years, M experience in biathlon = 6 years) participated in this study. The volunteers signed an informed consent before starting the experiment. They were randomly assigned to an experimental ($n = 8$) or a control group ($n = 8$).

Apparatus

Participants performed a tremometer test adapted for the rifle (Gros Lambert et al., 1999) to measure stability in the standing position (TT-S). With this test, each participant attempted to maintain a stylet mounted to the end of the rifle barrel within a 6-mm diameter ring. Each test consisted of five trials lasting 4 s each. During each trial, a computer recorded the number of times the stylet touched the ring. The total number of touches during the five trials was used in data analysis.

Biathlon shooting performance (SP) was determined as the number of missed targets from a trial of five shots in the standing position. Participants performed the shooting in a covered shooting range, minimizing the light and wind changes. Targets were 50 m from the firing line and 110 mm in diameter.

The TT-S and SP were examined immediately after roller skiing 2.1 km (requiring 6–7 min) at 90% of maximal heart rate. The order of performance of the 2 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 (Hoffman & Street, 1992). A portable heart rate monitor (BHL 6000, Baumann & Haldi, Fleurier, Switzerland) was used to allow each participant to adjust the exercise intensity to achieve the desired heart rate. Maximal heart rates were determined on a separate day prior to the experiment with an incremental maximal roller skiing test. The mean heart rate values were examined during the roller skiing (HR_{SK}), TT-S (HR_{TT-S}), and SP (HR_{SP}).

Design and Procedure

We investigated the effects of a shooting training associated with autogenic and imagery training (AT+IM) on postural control, heart rate, and the shooting performance. A baseline measurement (Time 1) of the TT-S, SP, HR_{SP} , and HR_{TT-S} was used in both groups. Then, for 6 weeks participants of both groups received standard instruction from an expert shooting instructor and followed a 24-hr instructional process of classical shooting training (1-hr training sessions four times per week over a 6-week period) based on precision shooting. After this training period, intermediate measurements (Time 2) of TT-S, SP, HR_{SP} , and HR_{TT-S} were recorded in both groups. Following this, the experimental and control groups received their specific shooting training. At the end of the program (Time 3), the same variables were measured in both groups (see Figure 1).

Experimental Group

For 6 weeks, the participants were trained by an expert shooting instructor and underwent the process of a 12-hr instructional training program in classical shooting (1-hr training sessions twice a week over a 6-week period) completed by a 12-hr instructional program of AT+IM (i.e., four 30-min training sessions per week over a 6-week period). This mental training program consisted of learning how to reduce muscular tension (Maupas, 1988). An experienced AT+IM instructor asked participants in a standing position to think about their upper and lower limbs, stomach, chest, and face. They were asked to feel warmth and relaxation in these parts of the body. Then they were asked to decrease their respiration and heart rate. This procedure lasted 15 min.

The second part of the AT+IM was devoted to internal visual imagery. For 15 min, the participants were asked to imagine their body sway decreasing in the standing position. When the participants felt they could control their body stability, they were asked to imagine a successful biathlon shoot. After each training session, participants were asked to fill in a checklist provided by the instructor to ensure they were relaxed and had used correct biathlon shooting images.

Control Group

During the 6 weeks, participants received standard instruction in classical shooting training for 24 hr (i.e., four 1-hr training sessions per week over a 6-week period) from an expert shooting instructor based on the shooting precision. After their training program, both groups performed for a final measurement (Time 3) by using tests similar to those previously described. The experimental protocol was performed during a recovery period (April–June), characterized by less physical training (3 hr per week), to minimize possible effects of physical training on the shooting performance.

Data Analysis

As the data from the present study meet the statistical assumptions for using parametric statistics (i.e., homogeneity of variance and normality of the sample distribution), a 2 x 3 (Groups x Time) analysis of variance for repeated measurements and Scheffé post hoc tests were used. Statistical significance was accepted at the $p < .05$ level.

Results

Tremometer Test

The number of touches in TT-S indicated no significant effect for groups, $F(1, 14) = 1.795, p > .05, \eta^2 = .11$. However, a significant main effect for time (see Table 1) was found, $F(2, 28) = 12.166, p < .0002, \eta^2 = .47$. Post hoc analysis indicated that Time 3 ($M = 15.37, SD = 5.29$) was significantly better than Time 2 ($M = 20.56, SD = 6.23$) and Time 1 ($M = 20.94, SD = 5.8$). A significant interaction was observed between groups and time, $F(2, 28) = 10.494, p < .0004, \eta^2 = .43$. In the Time 3, the experimental group ($M = 10.25, SD = 3.6$) was significantly better than the control group ($M = 20.5, SD = 6.9$).

Shooting Performance

The shooting performance revealed no significant main effect for groups, $F(1, 14) = .646, p > .05, \eta^2 = .04$. However, a significant main effect on time (see Table 1) was obtained, $F(2, 28) = 11.245, p < .0003, \eta^2 = .45$. Post

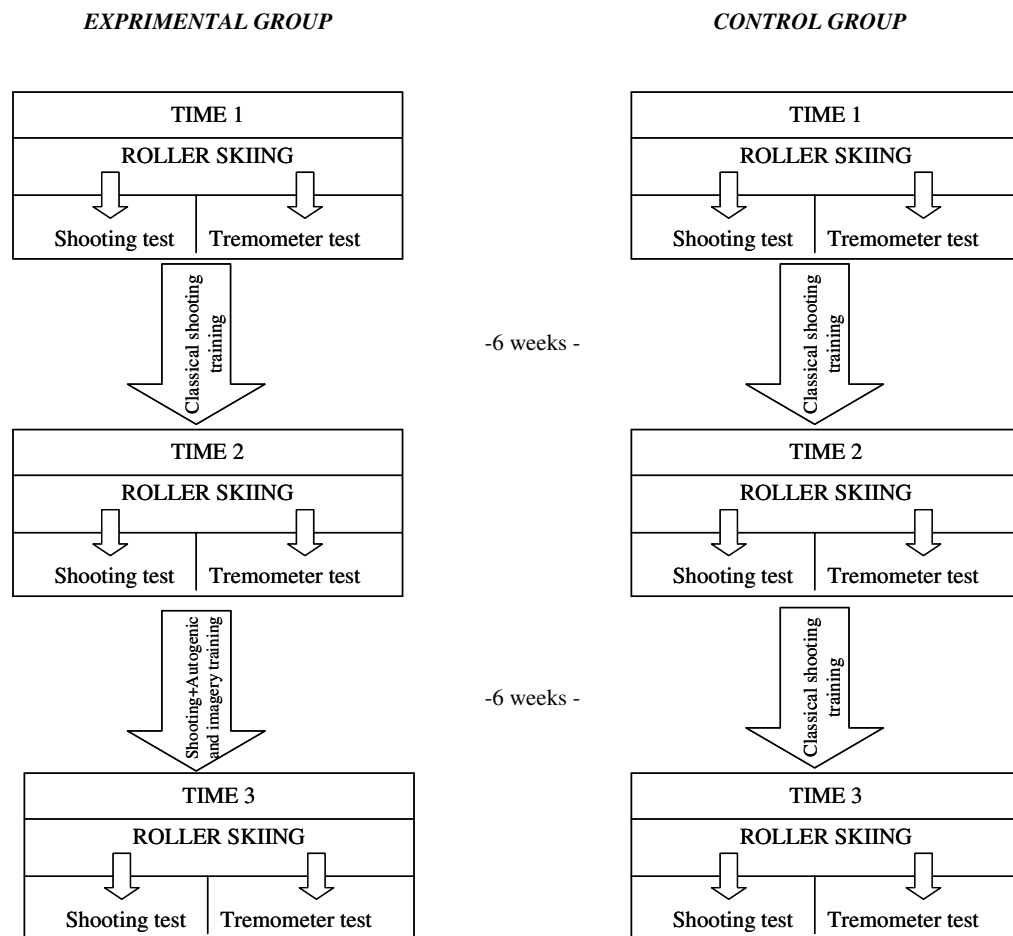


Figure 1. Design of the study.

hoc analysis indicated that Time 3 ($M = 1.75$, $SD = .5$) was significantly better than Time 2 ($M = 2.31$, $SD = .5$) and Time 1 ($M = 2.65$, $SD = 0.5$). No significant interaction was observed between groups and time for the shooting performance, $F(2, 28) = 5.85$, $p > .05$, $\eta^2 = .30$.

Heart Rate Responses

The analysis of variance on the HR_{sk} indicated no significant effect for groups, $F(1, 14) = .19$, $p > .05$, $\eta^2 = .01$, or time, $F(2, 28) = .39$, $p > .05$, $\eta^2 = .03$. No significant interaction was obtained between groups and time, $F(2, 28) = .46$, $p > .05$, $\eta^2 = .03$. During the HR_{sp} , no significant main effect for groups, $F(1, 14) = .35$, $p > .05$, $\eta^2 = .05$, or time, $F(2, 28) = .42$, $p > .05$, $\eta^2 = .03$, were observed. No significant interaction was obtained between groups and time, $F(2, 28) = .66$, $p > .05$, $\eta^2 = .05$. The heart rate during the HR_{TTS} indicated no significant effect for groups, $F(1, 14) = .04$, $p > .05$, $\eta^2 = .00$, or time, $F(2, 28) = .89$, $p > .05$, $\eta^2 = .06$. No significant interaction was obtained between groups and time, $F(2, 28) = .12$, $p > .05$, $\eta^2 = .01$.

Discussion

In the present study, we hypothesized that biathlon shooting performance could be significantly improved by using a program that combines shooting training with AT+IM. This program was expected to enhance shooting performance more than a classical shooting training program would.

The mean performances in the tremometer test and the shooting performance for both groups were significantly better at Time 3. In opposition to Couture et al. (1999) the results of the present study suggest that a program combining shooting training with AT+IM or a classical shooting training program significantly improves the shooting accuracy after intense exercise. In

addition, the significant interaction observed in the tremometer test between groups and time shows that biathletes who received the AT+IM program improved significantly more in their stability hold than those with a classical shooting training program. Previous studies performed under resting conditions in pistol shooters reported a similar finding (Hall & Hardy, 1991; Kim & Tennant, 1993), archers (Zervas & Kakkos, 1995), and rifle marksmen (Lénart, 1991). Therefore, the results of the present study confirm that this program also offers the same positive effects in the shooting task performed immediately after intense exercise. We speculated that the decrease in muscular tension might help increase the stability of hold. In addition, the autogenic training program may increase the concentration of a biathlete on the shooting task. So, it is likely that an imagery-training program allows participants to control their body sway.

Although no significant difference was observed between the different groups at Time 3, there was a tendency ($p < .06$) the performance level in the experimental group to improve, compared to the control group. Furthermore, the high η^2 value obtained ($\eta^2 = .30$) confirms this tendency. This result suggests that a shooting training program linked with AT+IM may have positive effects on the shooting performance. To improve sensibility to scoring when shooting, further research may measure the distance from the hit to the center of the target. It could be that this new approach to scoring reveals a significant influence of mental training on biathlon shooting performance.

The fact that no significant difference was recorded in heart rate during the skiing periods between the different measurements suggests exercise intensity was correctly controlled. Gieremek et al. (1994) found that autogenic training induced a decrease in the basal heart rate. However in the present study, the lack of significant heart rate changes during HR_{sp} and HR_{TTS} suggests minimal influence of AT+IM on heart rate response after intense exercise. Couture et al. (1999) found similar re-

Table 1. Tremometer test and the shooting performance in the experimental and control groups at Time 1, Time 2 and Time 3

Variables	Groups	Measurements					
		Time 1		Time 2		Time 3	
		M	SD	M	SD	M	SD
Tremometer test (number of touches)	Experimental	20.87	6.1	20.37	6.5	10.25	3.6
	Control	21.00	5.9	20.75	6.3	20.50	6.9
Shooting performance (number of missed targets)	Experimental	2.62	.5	2.25	.4	1.5	.7
	Control	2.62	.5	2.37	.7	2.0	.7

Note. M = mean; SD = standard deviation.



sults. However, it is possible that with more mental training, the experimental group could have gained better control over their heart rate during the shooting task. It may also be speculated that the effects of AT+IM on heart rate were significant only near the end of the training program. Future studies need to examine the effectiveness of mental training by recording heart rate continuously through each training session and increasing the duration of the training period.

In summary, a shooting training program combined with AT+IM offers valuable improvements in the standing shooting by increasing biathletes' postural control and hold stability. The tendency for improvement in the shooting performance level observed in the present study would lead to a time gain estimated at 35 s in a 10-km race and 70 s in a 20-km race. This time improvement could be important in competitions, where only a few seconds separate the best biathletes. These research findings may have important implications for biathletes, who can use mental training program, when the environmental conditions (e.g., wind or fog) make it impossible to train outdoors.

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