\# S-913104

Research Quarterly for Exercise and Sport

Vol. 74, No. 3, pp. 337–341

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

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Key words: elite athletes, mental training, psychological skills training, visualization

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 (Groslambert, 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 (Groslambert, Candau, Hoffman, Bardy, & Rouillon, 1999; Groslambert 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). Lénàrt (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 magnitude of the

Submitted: April 30, 1999
Accepted: June 25, 2001

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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

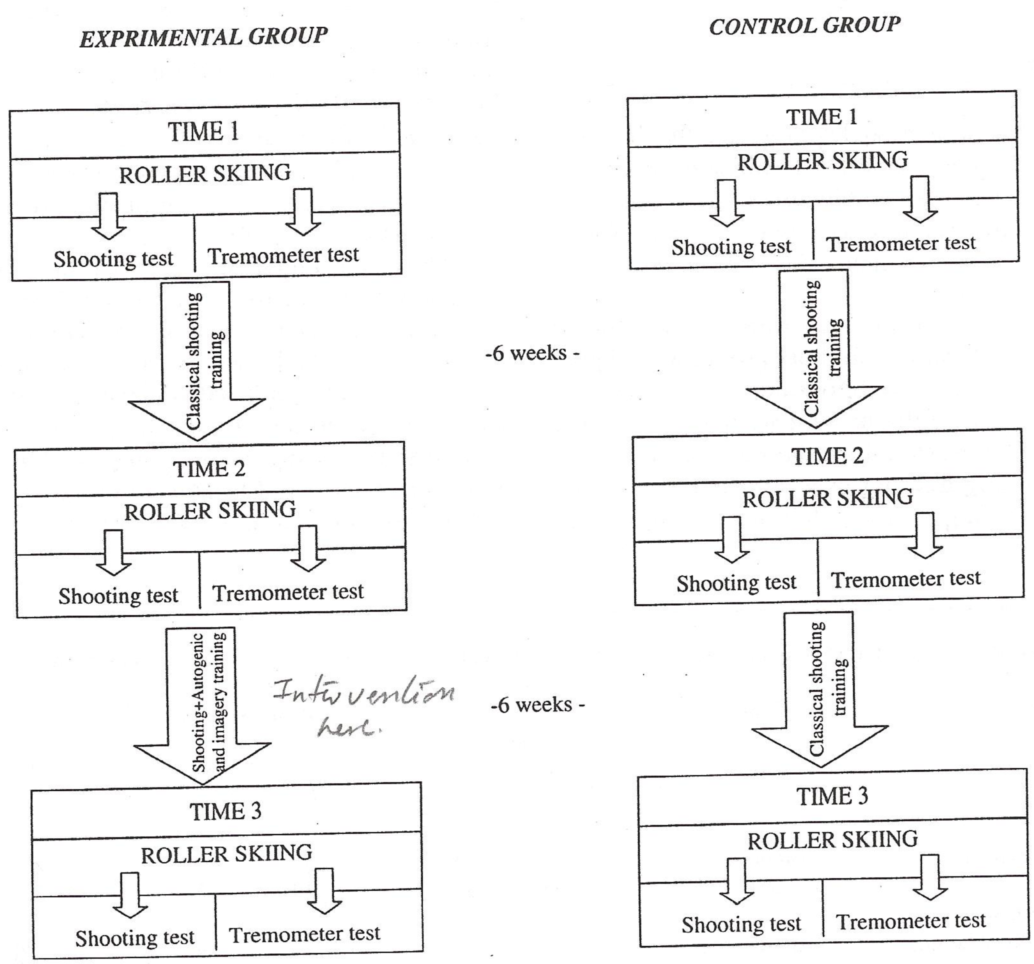

Figure 1. Design of the study.

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 $HR_{TT\text{-}S}$ 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 (Lénârt, 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 $HR_{TT\text{-}S}$ 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	Time 1 *M*	Time 1 *SD*	Time 2 *M*	Time 2 *SD*	Time 3 *M*	Time 3 *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 biahletes. 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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The authors would like to thank Christian Torjussen of the CLA of Besançon for his assistance in this study.
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