# THE DIFFERENCES BETWEEN MODERN MODES OF BIATHLON TRAINING AT THE OLYMPIC WINTER GAMES

*AS DIFERENÇAS ENTRE OS MODOS MODERNOS DE TREINAMENTO DE BIATLO NOS JOGOS OLÍMPICOS DE INVERNO*

*LAS DIFERENCIAS ENTRE LAS MODALIDADES MODERNAS DE ENTRENAMIENTO DE BIATLÓN EN LOS JUEGOS OLÍMPICOS DE INVIERNO*

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## ABSTRACT

Introduction: The biathlon is a snow sport that combines cross-country skiing and shooting, originating in Scandinavia. It requires athletes to not only have the ability to glide quickly over long distances but also to have the ability to shoot quickly and accurately. There is little research on biathlon characteristics and analysis of influencing factors and training strategies in China. Objective: This study analyzes modern biathlon athletes' specific explosive power, endurance and training effects at the Winter Olympics. Methods: Twenty biathlon athletes were selected as research volunteers. Physiological and biochemical indicators of the athletes were experimentally tested after training. Results: There was a correlation between maximum speed and the height of the athletes' double stand test (SD) ($p < 0.05$). The heavier athletes skied relatively faster. However, the excessive body fat rate is not conducive to maintaining high-intensity skiing in the long term. The athletes' VO2max was closely related to their skiing performance and shot hit percentage ($p < 0.05$). Conclusion: Maintaining gun ski training can positively improve the competitive level of world-class biathletes. The athlete's muscles have a solid ability to generate high mechanical power in a short time. It is beneficial to take advantage of a favorable position after the start of the competition. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

**Keywords:** Skiing; Athletes; Exercise; Athletic Performance.

## *RESUMO*

*Introdução: O biatlo é um esporte de neve que combina esqui entre as montanhas e tiro, originário da Escandinávia. Requer que os atletas não só tenham a capacidade de deslizar rapidamente por longas distâncias, mas também que tenham a capacidade de atirar com rapidez e precisão. Existem poucas pesquisas sobre características do biatlo e análises de fatores de influência e estratégias de treinamento na China. Objetivo: Este estudo analisa o poder explosivo específico, a resistência e os efeitos do treinamento dos atletas modernos de biatlo nos Jogos Olímpicos de Inverno. Métodos: Selecionou-se 20 atletas de biatlo como voluntários de pesquisa. Os indicadores fisiológicos e bioquímicos dos atletas foram testados experimentalmente após o treinamento. Resultados: Houve uma correlação entre a velocidade máxima e a altura do teste de duplo suporte (DP) dos atletas ($p < 0,05$). Os atletas mais pesados esquiam relativamente mais rápido. Porém a taxa excessiva de gordura corporal não é propícia para manter o esqui de alta intensidade a longo prazo. O VO2max dos atletas mostrou-se intimamente relacionado com seu desempenho de esqui e porcentagem de acertos no tiro ($p < 0,05$). Conclusão: A manutenção do treinamento de esqui com armas pode desempenhar um papel positivo na melhoria do nível competitivo dos biatletas de classe mundial. Os músculos do atleta têm uma sólida capacidade de gerar alta potência mecânica em um curto período de tempo. É benéfico aproveitar uma posição favorável após o início da competição.* ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

***Descritores:*** *Esqui; Atletas; Exercício físico; Desempenho Atlético.*

## *RESUMEN*

*Introducción: El biatlón es un deporte de nieve que combina el esquí entre las montañas y el tiro, originario de Escandinavia. Requiere que los atletas no sólo tengan la capacidad de deslizarse rápidamente por largas distancias, sino también la capacidad de disparar con velocidad y precisión. Hay poca investigación sobre las características del biatlón y el análisis de los factores que influyen y las estrategias de entrenamiento en China. Objetivo: Este estudio analiza la potencia explosiva específica, la resistencia y los efectos del entrenamiento de los atletas de biatlón moderno en los Juegos Olímpicos de Invierno. Métodos: Se seleccionaron veinte atletas de biatlón como voluntarios para la investigación. Los indicadores fisiológicos y bioquímicos de los atletas fueron comprobados experimentalmente después del entrenamiento. Resultados: Hubo una correlación entre la velocidad máxima y la altura de la prueba de doble apoyo (DP) de los atletas ($p < 0,05$). Los atletas más pesados esquiaron relativamente más rápido. Sin embargo, la excesiva tasa de grasa corporal no es propicia para mantener el esquí de alta intensidad a largo plazo. Se demostró que el VO2max de los atletas estaba estrechamente relacionado con su rendimiento en el esquí y el porcentaje de* *aciertos en el tiro (p < 0,05). Conclusión: El mantenimiento del entrenamiento de esquí de pistola puede desempeñar un papel positivo en la mejora del nivel competitivo de los biatletas de categoría mundial. Los músculos del atleta tienen una sólida capacidad para generar una gran potencia mecánica en un corto período de tiempo. Es beneficioso aprovechar una posición favorable tras el inicio de la competición.* ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

***Descriptores*****:** *Esquí; Atletas; Ejercicio Físico; Rendimiento Atlético.*

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## INTRODUCTION

### Biathlon consists of two consecutive alternate groups of cross-country skiing and shooting

In the combined field snow sports event, the competitive performance of athletes is not only affected by subjective factors such as physical fitness, skills, psychology, and tactics, but also by objective factors such as competition venue conditions, climate temperature, and altitude during competition.[1] The athletes' high-intensity skiing was interrupted 2 to 4 times during the competition. The athlete shoots five targets at 50m with a small-bore rifle prone or standing position. The diameter of the target hole is 11.5cm for a vertical shot and 4.5cm for a horizontal shot. The difference between the shooting conditions of biathlon and other shooting sports is that athletes are required to shoot with extreme physical fatigue after skating a certain distance according to the prescribed line. The improvement of the anaerobic metabolism of biathletes is the main content of the training. There are few types of research on biathlon characteristics and analyses of China's influencing factors and training strategies. Therefore, this paper analyzes the specific explosive power, endurance, and stage training effects of modern biathlon athletes in the Winter Olympics.

## METHOD

### Research objects

This paper selects eight biathlon athletes as research subjects, including four men and four women.[2] Age was 26.00±1.31. The training years (years) were 12.13±1.64. Height (cm) was 163.38±2.26. Bodyweight (kg) was 61.63±2.51. Body fat (kg) was 13.44±1.96. Physiological and biochemical indicators of athletes were tested experimentally after spinning training.

### Research methods

In this paper, the anaerobic work of biathletes for 10 seconds, 30 seconds, and 60 seconds was measured by spinning bicycles. In this paper, the lactic acid analyzer was used to measure the blood lactic acid of athletes immediately after 60 seconds of anaerobic work, 1 minute, 3 minutes, and 5 minutes.

### Overall kinetic model of oxygen metabolism

Assuming constant oxygen exchange, tissue diffusion along the axial direction is negligible. thus we have the equation describing the oxygen partial pressure $P_{O2}$ in the tissue

$$K\left(\frac{d^2P_{O_2}}{dr^2}+\frac{1}{r}\frac{dP_{O_2}}{dr}\right)-\frac{\dot{V}_{O_2}}{\pi R^2 l}=0 \quad (1)$$

Where $K$ is the oxygen diffusion coefficient. $\frac{\dot{V}_{O_2}}{\pi R^2 l}$ represents the oxygen consumption per unit volume of tissue. The capillary equivalent length $l$ is taken as 1. Solving this differential equation can obtain the oxygen partial pressure value $P_{XO2}$ at each point in the interstitial space.[3] $x$ is the vertical distance from the capillary. $P_{rO2}$ is the partial pressure of oxygen on the vessel wall. $r$ is the microvessel radius. $R$ is the tissue radius of the vascular oxygen supply domain.

$$P_{XO_2}=P_{rO_2}-\frac{\dot{V}_{O_2}}{\pi K}\left(\frac{1}{2}\ln\frac{x}{r}-\frac{x^2-r^2}{4R^2}\right) \quad (2)$$

Alveolar oxygen partial pressure $P_{AO2}$ under different parameters can be calculated by equation (2). Assumed partial pressure of oxygen in pulmonary arterial blood

$$P_{aO_2}=\alpha P_{AO_2}=\alpha\left(FIO_2-\frac{\dot{V}_{O_2}}{V_A}\right)(P_B-P_{H_2O}) \quad (3)$$

Where coefficient $\alpha$ is the quantity related to alveolar oxygen diffusion to the blood and unventilated pulmonary blood flow. Typically, there is no pulmonary diffusion disorder and the blood flowing through the lungs undergoes gas exchange with the alveoli $\alpha = 1$. In the presence of pulmonary diffusion disturbance and unventilated pulmonary blood flow $\alpha < 1$. Equation (3) shows that $P_{AO2}$ is linearly related to the oxygen concentration $FIO_2$ of the inhaled gas. In the physiological range, it always increases with the pulmonary ventilation volume $V_A$. According to equation (2) and the expressions of blood oxygen partial pressure and oxygen concentration, the venous blood oxygen partial pressure $P_{VO2}$ can be obtained

$$f(P_{VO_2})=f(P_{aO_2})-\frac{\dot{V}_{O_2}}{SV*C_{Hb}} \quad (4)$$

From equation (2), we can see that $P_{VO2}$ is not only positively correlated with $P_{aO2}$, but also affected by $SV$ and $C_{Hb}$.

There is no need for a code of ethics for this type of study.

## RESULTS

### 10-second and 30-second anaerobic metabolic capacity test results and analysis

It can be seen from Table 1 that the average work of Athlete A and Athlete B is higher. This shows that their explosive power, starting ability, and kicking power are more substantial. The average work of other athletes is lower.[4] This indicates that these athletes have poor explosive power, starting ability, and kicking power. The 30-second average anaerobic power of Athlete A and Athlete B is much higher than the test results of elite speed skaters who require higher explosive power. This shows that their explosiveness has reached a high level. In the actual test, it was found that although their peak anaerobic power was significantly lower than that in 2019, their performance was significantly improved. This shows that the evaluation of peak anaerobic power is of little significance.

### 60-second anaerobic metabolic capacity test and analysis of biathletes

It can be seen from Table 2 that the relative values of the 60-second average work of Athlete A and Athlete B are significantly different from other athletes. Their glycolysis energy supply and speed endurance capacity are more substantial than other athletes.[5] Sports performance is also significantly better than other athletes. This indicates that glycolytic functional capacity and speed endurance capacity are essential factors affecting biathlon performance.

### Physical, morphological characteristics

There was a correlation between the maximum speed and height of the athletes' double support (DP) test ($p < 0.05$). Heavier athletes ski relatively faster. The average body fat percentages of world-class male and female biathletes range from 7.1% to 10.5% and 12.7% to 14.96%, respectively. Excessive body fat rate is not conducive to maintaining long-term, high-intensity skiing.[6] The body fat rate is significantly higher than that of world-class biathlon athletes, which may be a fundamental reason restricting the improvement of the biathlon competition level in China. Athletes' VO2max was closely related to their particular skiing time and shooting percentage ($p < 0.05$).

**Table 1.** 10-second and 30-second anaerobic work tests for biathletes.

| | | 10 seconds | | | |
|---|---|---|---|---|---|
| | | Peak anaerobic power | | Average anaerobic work | |
| NO. | | Absolute (w) | Relative (w/kg) | Absolute (w) | Relative (w/kg) |
| A | Male | 1099.75 | 13.35 | 751.56 | 9.99 |
| B | | 1090.61 | 13.99 | 700.12 | 9.71 |
| C | | 799.55 | 10.77 | 510.22 | 6.97 |
| D | | 679.11 | 9.67 | 397.23 | 6.95 |
| E | Female | 619.39 | 12.13 | 393.91 | 7.73 |
| F | | 659.39 | 11.97 | 310.76 | 7.37 |
| G | | 597.59 | 9.05 | 399.26 | 6.05 |
| H | | 565.53 | 10.29 | 356.62 | 6.39 |
| Mean ± SD | | 953.39±139.66 | 11.99±1.97 | 559.03±105.61 | 7.79±1.30 |
| | | 30 seconds | | | |
| | | Peak anaerobic power | | Average anaerobic work | |
| | | Absolute (w) | Relative (w/kg) | Absolute (w) | Relative (w/kg) |
| A | Male | 1029.93 | 13.66 | 659.06 | 9.75 |
| B | | 999.15 | 13.72 | 601.22 | 9.33 |
| C | | 705.23 | 9.63 | 359.13 | 6.27 |
| D | | 729.15 | 10.39 | 501.22 | 7.15 |
| E | Female | 590.69 | 11.39 | 357.59 | 7.01 |
| F | | 630.27 | 11.36 | 397.23 | 7.22 |
| G | | 603.51 | 9.13 | 313.39 | 6.29 |
| H | | 593.03 | 10.79 | 366.59 | 6.67 |
| Mean ± SD | | 792.39±135.22 | 11.03±1.67 | 531.33±65.63 | 7.31±0.72 |

**Table 2.** Anaerobic Work Tests and Peak Blood Lactic Acid for Biathletes.

| | Peak anaerobic power | | Average anaerobic work | | Peak blood lactate (mmol/L) |
|---|---|---|---|---|---|
| NO | Absolute (w) | Relative (w/kg) | Absolute (w) | Relativee (w/kg) | |
| A | 1017.5 | 13.65 | 573.68 | 7.61 | 16.3 |
| B | 1011.3 | 13.03 | 560.15 | 7.77 | 15.71 |
| C | 819.33 | 11.33 | 315.11 | 6.18 | 15.11 |
| D | 811.31 | 11.57 | 311.15 | 6.01 | 13.31 |
| E | 535.88 | 10.51 | 311.81 | 6.13 | 13.3 |
| F | 588.33 | 10.7 | 331.51 | 6.13 | 15.1 |
| G | 611.3 | 9.31 | 351.99 | 5.35 | 15.7 |
| H | 530.86 | 9.83 | 308.93 | 5.61 | 13 |
| Mean ± SD | 878.63±89.30 | 11.31±1.13 | 358.33±67.50 | 6.31±0.81 | 13.11±1.51 |

## DISCUSSION

Coaches need to improve athletes' aerobic capacity during daily training. 1) Under laboratory and field test conditions, coaches regularly monitor the VO2max level of athletes according to their gender, age, and training years.[7] This effectively evaluates athletes' cardiorespiratory endurance and training effects. In training, coaches use blood lactate value as a scientific standard to assess the degree of fatigue of athletes and control the training intensity corresponding to heart rate. This helps the trainer evaluate the aerobic capacity of the muscles. At the same time, athletes need to monitor changes in the anaerobic threshold closely.[8] Coaches consider the relationship between individual lactate threshold and exercise intensity, duration, training level, glycogen content, and hypoxia as the basis for formulating and revising training plans. Athletes increase the lactate threshold by adding anaerobic threshold intensity training to their daily training.

Endurance sports require athletes to have higher hemoglobin levels. Altitude training or hypoxic training can significantly increase hemoglobin levels in endurance athletes. Four weeks of high, high, and low training significantly and consistently improved the athlete's hemoglobin level and hematocrit. Therefore, coaches can use targeted altitude training or hypoxic training.[9] This increases aerobic capacity. At the same time, the adjustment of physiological and psychological factors should start from the balance of sympathetic and parasympathetic nerves in athletes. Athletes target individualized trainability windows for a day or week within which the athlete can handle the load during small, medium, and long periods of training.[10] The timing of training stimuli at the athlete's physiological and psychological level should take precedence over training load or volume. If it can be combined with hypoxic training, it can provide adequate guidance on the synergistic physiological and psychological effects on athletes.[11] Coaches need to arrange training plans according to individual differences, which significantly improves athletes' skiing speed, central nervous system regulation, parasympathetic nervous system activation, and VO2max. In addition, we recommend using targeted non-invasive functional state indicators such as blood perfusion, blood oxygen saturation, and cardiac output to evaluate the dynamic changes in athletes' physical states.

During shooting training, researchers should closely monitor the periodic changes in athletes' resting brain potential and heart rate variability. Athletes strengthen target-based strategy-based attention training.[12] We recommend that athletes reduce cognitive involvement in the aiming process when shooting. Athletes need to focus on key psychophysical and sensory information related to shooting tasks. Increased cardiovascular load in athletes before shooting affects visual control and psychological adjustment. We recommend adding breath control exercises to adjust body shake due to cardiac muscle contractions to find the best time to shoot under exercise load. At the same time, athletes can supplement biofeedback training, breathing training, and other methods to improve their parasympathetic activation efficiency.[13]

## CONCLUSION

The peak blood lactate test for a 60-second exercise can evaluate the anaerobic energy supply capacity, specific explosive power, specific speed, and speed endurance of biathletes. World-class biathletes have muscular statures and have significantly lower body fat percentages than Chinese biathletes. Bodily functions exhibit high levels of aerobic and anaerobic metabolic capacity. Flat and downhill skiing, dynamic and static, and shooting stages require high aerobic capacity. An anaerobic metabolism dominates the starting, uphill skiing, static turning and sprinting phases. Athletes with a high average power of 10s, the 30s, and 60s anaerobic work and low blood lactate peak performed better after the 60s anaerobic work test. Athletes with low average power at 10 seconds, 30 seconds, and 60 seconds, and high blood lactate peak after 60 seconds of exercise have poor explosive power and speed endurance. Athletes with 10 seconds, 30 seconds, and 60 seconds of average work and low blood lactate peak after 60 seconds of exercise have poor explosive power and poor glycolysis energy supply. Its results are not ideal.

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