

## STUDY REGARDING THE IMPORTANCE OF MONITORING PHYSIOLOGICAL PARAMETERS IN ELITE FENCING

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**ABSTRACT. Introduction.** Fencing is a sport that requires psychomotor skills, explosive power, movement speed, reaction speed and physical endurance. Épée and foil fencers have higher aerobic capacity than sabre fencers, whereas épée and foil fencers have similar aerobic capacity. In fact, this can be due to more aerobic nature of épée and foil weapons compared with sabre. Measurement of maximum oxygen uptake ( $VO_2\max$ ) is the standard index of cardiorespiratory fitness, but is practical only in a laboratory setting. Over time, numerous  $VO_2$  tests have shown that  $VO_2\max$  is a quantifiable and reproducible parameter of the cardiorespiratory system's ability to meet maximum oxygen requirements. **Objective.** The *aim* of this study is to show the importance of monitoring physiological parameters by the Bruce protocol in elite fencing, specifically women's épée, in order to manage the physical training plan. **Methodology.** Cardiopulmonary fitness is monitored in dynamic conditions by testing  $VO_2\max$  with the Bruce protocol of the *COSMED treadmill Ergometer*. This study was carried out over period of 8 weeks in 2021. It should be mentioned that these tests were performed after a specific training plan adapted to the pandemic period. Were included 4 female épée fencers, members of the Romanian National Fencing Team, aged between 22 and 36 years and with outstanding results at national and international levels. **Results.** From the total of tested physiological parameters were selected the protocol parameters (speed, treadmill incline, time) and metabolic parameters (absolute oxygens consumed (ml/min), maximum oxygens consumed (ml/min/kg), metabolic equivalents, respiratory coefficient, heart rate). These indicators were assessed for anaerobic threshold, respiratory compensation point and at the end of the test. The evolution of these parameters was followed between tests for each subject.

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**Discussions and conclusions.** The Bruce Protocol estimates maximal oxygen consumption ( $VO_2$  max) as a measure of the athlete's aerobic capacity during sustained effort. In this context, the obtained results highlight an increase of the cardiorespiratory fitness to the women's *épée*, an efficient distribution of the oxygen to the tissues and a better adaptation of the cardiac function to the effort. In conclusion, the cardiorespiratory capacity monitoring through the Bruce Protocol can be an important guideline for the physical training to the elite *épée* fencers.

**Keywords:** *cardiopulmonary fitness, Bruce protocol, women's épée, elite fencing*

**REZUMAT. Studiu privind importanța monitorizării parametrilor fiziologici în scrima de performanță. Introducere.** Sportivii care practică spadă și floretă au o capacitate aerobă mai mare decât cei care practică sabie, întrucât scrimerii de spadă și floretă au o capacitate aerobă similară. **Obiective.** Scopul acestui studiu este de a demonstra importanța monitorizării în dinamică a parametrilor funcționali la sportivele lotului național de scrimă, mai precis spadă, în vederea dirijării planului de pregătire. **Mijloace și metode.** Capacitatea cardiorespiratorie a fost monitorizată în dinamică, prin aplicarea protocolului Bruce COSMED treadmill Ergometer. S-au evaluat 4 spadasine, cu vârste între 22 și 36 de ani, membre ale lotului național de scrimă și cu performanțe mondiale și olimpice, pe o perioadă de 8 săptămâni, în 2021. Trebuie menționat faptul că aceste testări s-au efectuat după un program de antrenament adaptat perioadei pandemice. **Rezultate.** Din totalul indicatorilor înregistrați prin protocolul Bruce s-au selectat parametrii de testare (viteza de alergare, gradul de înclinare al platformei, timpul) și parametrii metabolici (consumul absolut de oxigen (ml/min),  $VO_2$  maxim (ml/min/kg), frecvența cardiacă, echivalentul metabolic și coeficientul respirator). Acești indicatori au fost apreciați pentru pragul anaerob, punctul de compensare respiratorie și la finalul testului. Pentru fiecare subiect s-a urmărit evoluția acestor indicatori între testări. **Discuții și concluzii.** Testul Bruce estimează absorbția maximă de oxigen ( $VO_2$  max), ca măsură a capacității aerobe a atletului în efort susținut. Toate sportivele s-au adaptat rapid la planul de pregătire după „blocajul” pandemic, reușind în 8 săptămâni de pregătire fizică să-și îmbunătățească sau să-și mențină capacitatea cardiopulmonară la pragul „excelent” conform normelor de referință standard. În acest context, rezultatele obținute evidențiază și o distribuire eficientă a oxigenului la țesuturi corelată cu o bună adaptare a funcției cardiace la efort. În concluzie, monitorizarea funcției cardiorespiratorii prin protocolul Bruce poate reprezenta un important criteriu în dirijarea pregătirii fizice a spadasinelor din lotul național.

**Cuvinte cheie:** *capacitate cardiorespiratorie, protocol Bruce, scrima de performanță*

## Introduction

Fencing is a combat sport that requires psychomotor skills, explosive power, movement speed, reaction speed and physical endurance. At the same time, reaching the tournament finals involves both anaerobic and aerobic performance during bouts. (Bhatt et al., 2021)

Fencing belongs to a group of martial arts with variable conditions of competitive activities that determine priority in the training structure of athletes' opportunities for the effective achievement of tactical and technical set of moves (Semeryak et al., 2013).

Fencing competitions take place throughout a whole day (often lasting around 10 hours) and consist of about 10 bouts, with resting time between them ranging from 15 to 300 minutes. Roi & Bianchedi, 2008 provide data on the time-motion characteristics of winning fencers in women's épée, men's épée and men's foil at an international competition as follows: on average, an action lasts 5 seconds in foil and 15 seconds in épée (during which time the exercise is mostly submaximal) before each resting or interruption period. Moreover, during a bout, the fencer covers a total distance of 250-1000 meters, attacks 140 times and changes direction nearly 400 times in women's épée and about 170 times in men's épée and foil. In addition, Roi and Pittaluga (1997) reported a significantly higher number of changes of direction when comparing female athletes with high and low technical abilities, suggesting the existence of different tactical levels.

Abdollah et al. (2017) found that both épée and foil fencers had higher aerobic capacity than sabre fencers, whereas épée and foil fencers had similar aerobic capacity. In fact, this can be due to more aerobic nature of épée and foil weapons compared with sabre. This finding is also supported by other specialists (Aquili et al., 2013; Lavoie et al., 1985; Roi & Pittaluga, 1997) who analysed the action-pause ratio and highlighted different values for the three weapons: 1:1 for épée, 1:3.5 for foil and 1:6.5 for sabre.

Urzeală et al. (2015) highlight that valuable results can be obtained in any sport if computerised devices are used to measure cardiovascular fitness. This allow identifying the effectiveness of different training methods for the development of aerobic and anaerobic performance, monitoring the consumed energy during various motor or routine activities and determining biomechanical efficiency in performing motor skills such as walking and running.

Hill and Lupton (1923, as cited in Hawkins et al., 2007) pointed out that  $VO_2$ max measurements helped define the limits of the cardiovascular and respiratory systems to transport oxygen. Over time, numerous  $VO_2$  tests have shown that  $VO_2$ max is a quantifiable and reproducible parameter of the

cardiorespiratory system's ability to meet maximum oxygen requirements. According to Hawkins et al. (2007)  $VO_2\text{max}$  is a valid index measuring the limits of the cardiorespiratory system's ability to transport oxygen from the air to the tissues at a given level of physical conditioning and oxygen availability.

Therefore measurement of maximum oxygen uptake ( $VO_2\text{max}$ ) is the standard index of cardiorespiratory fitness, but is practical only in a laboratory setting. Current cycle ergometer tests to estimate  $VO_2\text{max}$  are difficult for inactive adults because most of these tests are lengthy and require a high initial exercise rate (Siconolfi et al., 1982).

## Objective

The *aim* of this study is to show the importance of monitoring physiological parameters by the Bruce protocol in elite fencing, specifically women's épée, in order to manage the physical training plan.

## Materials and methods

The participants of this study are 4 female épée fencers, members of the Romanian National Fencing Team with aged between 22 and 36 years. The athletes have outstanding results at national and international levels, and their competitive experience is at least 12 years.

Cardiopulmonary fitness test was performed by *the Bruce protocol of the COSMED treadmill Ergometer* to measure  $VO_2\text{max}$  consumption and heart rate. This study was carried out over a period of 8 weeks in 2021. It should be mentioned that these tests were performed after a specific training plan adapted to the pandemic period.

$VO_2\text{max}$  testing with the Bruce protocol is a specialised and advanced investigation that offers complex information about the athlete's exercise capacity. This protocol provides a common, parallel analysis of the data that allow a complete assessment of the cardiovascular, respiratory, muscular and metabolic systems during exercise. The main function of the cardiovascular and respiratory systems is to ensure the exchange of gases between the body cells and the external environment.

Breathing is performed through a mask while simultaneously monitoring the athlete's heart rate, the dynamics of respiratory gases during exercise, the relationship between them and their relationship with heart rate and lung ventilation.

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Endurance capacity indicators are maximum oxygen consumption ( $VO_2$ ) and ventilation thresholds (VT1 and VT2). In addition, the athlete's anaerobic capacity, economy of motion and mechanical efficiency can be determined by gas exchange measurements.

With the help of cardiopulmonary tests, the exercise intensity zones are also defined and subsequently used in the training sessions. These intensity levels can be and are actually individualised for each tested athlete, which greatly reduces the risk of chronic fatigue and decline in performance.

$VO_{2max}$  testing with the Bruce protocol is performed on a treadmill in five different speed stages of 3 minutes each, and its total length does not exceed 15 minutes (Figure 1). At each stage, the speed and gradient of the treadmill are elevated to increase work output, and thus the test becomes increasingly difficult and exhausting.



**Figure 1.** The Bruce protocol

The international ethical guidelines were respected: the participants' informed consent was obtained, and the anonymity and confidentiality of the data were ensured.

## Results

The Bruce Protocol is used as an effort test meant to investigate the cardiovascular capacity. The main benefit of this assessment tool is the identification of the fitness level by means of the cardiac function and maximum oxygen consumption. Also, it is considered an indirect maximal oxygen uptake test because it estimates  $\text{VO}_2\text{max}$  using a formula and the person's performance on a treadmill as the workload is increased.

From the total of the Bruce test parameters were selected the protocol parameters: time (s), speed (Kmh), treadmill incline (grade %) and metabolic parameters: absolute oxygen consumption (ml/min), maximum oxygen consumption (ml/min/kg), metabolic equivalents (MET), respiratory coefficient (RQ), heart rate (bpm). Were singled out the indicators for anaerobic threshold, respiratory compensation point and at the end of the test. The time spent on the treadmill represent test score and can be used to estimate the  $\text{VO}_2$  maxim. The evolution of these parameters was followed between tests for each subject (table 1, 2, 3, 4).

**Table 1.** The values of the Bruce test parameters for subject 1 (V.G.)

Parameters	Evaluation 1			Evaluation 2		
	AT	RCP	Maxim	AT	RCP	Maxim
<i>Protocol</i>						
Time (s)	10:17	11:08	11:55	5:59	9:19	11:56
Speed (Kmh)	6.8	6.8	6.8	4	6.8	6.8
Grade (%)	16	16	16	12	16	16
<i>Metabolic</i>						
$\text{VO}_2$ (ml/min)	2697	2614	2741	1610	2251	2570
$\text{VO}_2$ (ml/min/kg)	43.5	42.2	44.5	26	36.3	41.4
MET	12.4	12	12.7	7.4	10.4	11.8
RQ	1.03	1.1	1.01	0.96	1.17	1.21
HR (bpm)	194	198	201	135	179	196

According to the norms of the Bruce protocol, related to the aged and sex, we notice that for the athlete V.G. was registered 44.5 ml/min/kg oxygen consumption at the first assessment, which corresponds to a "excellent" standard for cardiopulmonary fitness and 41.4 ml/min/kg oxygen consumption corresponding to an "good" standard at the second evaluation.

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**Table 2.** The values of the Bruce test parameters for subject 2 (B.B.)

<i>Parameters</i>	<i>Evaluation 1</i>			<i>Evaluation 2</i>		
	<i>AT</i>	<i>RCP</i>	<i>Maxim</i>	<i>AT</i>	<i>RCP</i>	<i>Maxim</i>
<i>Protocol</i>						
Time (s)	07:34	10:56	13:15	05:39	09:30	12:50
Speed (Kmh)	5,5	6,8	8	4	6,8	8
Grade (%)	14	16	18	12	16	18
<i>Metabolic</i>						
VO <sub>2</sub> (ml/min)	2404	2921	2963	1424	2614	3096
VO <sub>2</sub> (ml/min/kg)	37.6	45.6	46.3	21.9	40.2	47.6
MET	10.7	13	13.2	6.3	11.5	13.6
RQ	0.96	1.1	1.18	1.01	1.12	1.37
HR (bpm)	150	180	188	115	158	182

For the fencer B.B. was registered 46.3 ml/min/kg oxygen consumption at the first assessment, which corresponds to a “*excellent*” standard for cardiopulmonary fitness and 47.6 ml/min/kg oxygen consumption corresponding to a “*excellent*” standard at the second evaluation.

**Table 3.** The values of the Bruce test parameters for subject 3 (A.T.)

<i>Parameters</i>	<i>Evaluation 1</i>			<i>Evaluation 2</i>		
	<i>AT</i>	<i>RCP</i>	<i>Maxim</i>	<i>AT</i>	<i>RCP</i>	<i>Maxim</i>
<i>Protocol</i>						
Time (s)	10:06	12:15	14:07	10:31	12:22	13:29
Speed (Kmh)	6,8	8	8	6,8	8	8
Grade (%)	16	18	18	16	18	18
<i>Metabolic</i>						
VO <sub>2</sub> (ml/min)	2776	3123	3086	3257	3613	3571
VO <sub>2</sub> (ml/min/kg)	41.4	46.6	46.1	49.3	54.7	54.1
MET	11.8	13.3	13.2	14.1	15.6	15.5
RQ	0.98	1.03	1.17	0.96	1.02	1.1
HR (bpm)	185	194	198	181	190	194

For the athlete A.T. was recorded 46.1 ml/min/kg oxygen consumption at the first assessment, which corresponds to an “*excellent*” standard for cardiopulmonary fitness and 54.1 ml/min/kg oxygen consumption corresponding to a “*superior*” standard at the second evaluation.

**Table 4.** The values of the Bruce test parameters for subject 4 (A.P.)

Parameters	Evaluation 1			Evaluation 2		
	AT	RCP	Maxim	AT	RCP	Maxim
<i>Protocol</i>						
Time (s)	07:40	09:55	11:47	03:15	07:42	11:22
Speed (Kmh)	5.5	6.8	6.8	4	5.5	6.8
Grade (%)	14	16	16	12	14	16
<i>Metabolic</i>						
VO <sub>2</sub> (ml/min)	2033	2776	2618	1285	2021	2867
VO <sub>2</sub> (ml/min/kg)	31.5	43	40.6	19.9	31.3	44.4
MET	9	12.3	11.6	5.7	9	12.7
RQ	1	1.04	1.18	0.96	1.16	1.41
HR (bpm)	161	180	186	88	137	178

According to the norms of the Bruce protocol, related to the aged and sex, we notice that for the athlete A.P. was registered 40.6 ml/min/kg oxygen consumption at the first assessment, which corresponds to a “*good*” standard for cardiopulmonary fitness and 44.4 ml/min/kg oxygen consumption corresponding to an “*excellent*” standard at the second evaluation.

## Discussions

It has been demonstrated that, although the VO<sub>2</sub> threshold cannot be observed every time during testing, the obtained VO<sub>2</sub>max is very useful in determining cardiorespiratory fitness during exercise/training.

According to Lee & Zang (2021) VO<sub>2</sub>max values increase as a result of short-term high-intensity training, but hereditary, genetic factors should not be neglected either.

Koutedakis et al. (1993) have found that VO<sub>2</sub>max has significant seasonal variations in performance related to fencers’ physiological parameters, with in-season values lower than off-season values. Given that, the athlete’s performance

lasts 3 minutes per bout in the *épée* and foil events, aerobic capacity has an important contribution to athletic success. A decrease in the  $VO_{2max}$  level can lead to lower performance in elite fencing. This reflects a non-systematic approach to extended training sessions.

The presence of aerobic training during the competition period is normally associated with: demanding competition hours - increase in workload, increasing concentration and the time scheduled for sport-specific technical and tactical training, limited encouragement from fencing coaches.

## Conclusions

Fencing is a predominantly anaerobic sport, the energy contribution of aerobic exercise being lower and mainly involved in the submaximal movements performed in the “en-guard” position and during recovery periods.

The computerized Bruce treadmill test, as an effort test, investigate the cardiovascular capacity in order to identified the fitness level by means of the cardiac function. Applying the Bruce protocol we can identify, at the same time, the effort intensity zones, energy expenditure during physical training or metabolic rate. In conclusion, the monitoring of these parameters leads to the individualization of the physical training reducing the risks of chronic fatigue and the decreased of sport performance.

## Authors contribution

All authors have equally contributed to this study

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