

ORIGINAL ARTICLE

Gender-specific determinants of the cardiorespiratory system and energy supply for working capacity in sport dance athletes

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ABSTRACT

Aim: To identify specific functional characteristics of male and female partners in the semi-finals and finals of the standard European program.

Materials and Methods: Twenty-one professional standard European dance couples were assessed during semifinal and final performances; $\dot{V}O_2$, $\dot{V}CO_2$, VE, and lactate were measured using MetaMax 3B and Biosen+. To compare independent samples, the Mann–Whitney U test was applied; data are presented as mean, median, SD, min–max, Q1–Q3, and IQR.

Results: No significant differences were found between SF and F in $\dot{V}O_{2\max}$, $\dot{V}O_{2\max}/\text{kg}$, VE, EqO_2 , $\dot{V}CO_2$, $\dot{V}CO_2/\text{kg}$, or EqCO_2 . A significant difference was observed for lactate ($p < 0.05$). These findings indicate stable functional support across competitive rounds, while higher lactate values in the final reflect greater glycolytic load, particularly in female partners.

Conclusions: In most dancers, in F SEP, there was found an increase in aerobic metabolism in partners and glycolytic capacity in female partners. The reactive properties of the cardiorespiratory system are reflected in the efficiency of oxygen consumption per unit of pulmonary ventilation (EqO_2) and the stability of the respiratory compensation response to metabolic acidosis.

KEY WORDS: energy supply, sport dances, functional capabilities, Standard European Program

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INTRODUCTION

Studies conducted over three decades show high requirements to the level and large specific features of the functional support of competitive activity of dancers [1, 2]. There is a clear understanding that the level of physiological stress of dancers that occurs during the performance of dance programs reaches a limit, which affects the level of demonstration of technical, artistic and choreographic skills of dancers [3, 4]. This puts forward certain requirements for the functional orientation of special physical training. Most of the means of special physical training of other sports [5–7] contradict the target guidelines for the functional provision of special working capacity of dancers. Contradictions cause physiological states that arise under the influence of work modes that are inadequate to the physiological stress of the competitive activity [8–11]. Means that develop specialized manifestations of neurodynamic functions and properties of the musculoskeletal system are in a significant deficit [12, 13]. In most cases, the training system for athletes uses exercises that

do not correspond to the static and dynamic stresses of the dancers' posture [14, 15].

A particular problem is the uncertainty of functional training target guidelines in sport [16–19]. Orientation to the generalized factors of functional preparedness forms an energy supply structure that is inadequate to the requirements of the special working capacity of dancers, which significantly affects the effectiveness of competitive activity. The presence of high $\dot{V}O_{2\max}$ and La concentration is often misleading in assessing the effectiveness of functional preparedness of dancers. The uncertainty of the conditions for the development and implementation of $\dot{V}O_{2\max}$ and La max, in real practice, often leads to the rapid development of fatigue and overstrain of the body. The functions of endurance are transformed into "functions of the ability to tolerate fatigue", which does not contribute much to the realization of the existing special skills of dancers.

At the same time, research in recent years has contributed to understanding the structural requirements for the functional support of competitive activity [20, 21,

22]. The outlined factors that influence the structure of energy supply of competitive activity of dancers form the functional focus of the training process of dancers. Data from specialized literature indicate special conditions for the implementation of VO_2 max, glycolytic power and capacity, and mechanisms for regulating functions during competitive activity [23-25]. Identifying quantitative and qualitative characteristics that reflect these processes remains relevant. Contradictions are caused by the quantitative characteristics of the energy supply of dancers' competitive activity, which determine the quality and functional orientation of the training process.

AIM

To identify specific functional characteristics of male and female partners in the semi-finals and finals of the standard European program.

MATERIALS AND METHODS

Material: Qualified athlete dancers specializing in the standard European program (SEP). Age of male partners is $25,3 \pm 2,2$ y. o. and female partners – $23,4 \pm 2,2$ y. o.; the body weight and height of male partners were $78,1 \pm 3,0$ kg and $181,8 \pm 2,1$ cm, female partners – $51,8 \pm 1,5$ kg and $162,2 \pm 1,9$ cm.

Quantity of dancers: 21 male partners and 21 female partners (21 couple). All couples are highly qualified athletes, prize-winners and winners of prestigious tournaments in Ukraine and abroad.

RESEARCH ORGANIZATION

The study was conducted at the end of the special training period. Before the start of the study, voluntary written consent from the athletes and approval by the local bioethics committee for scientific research were obtained. Simulation of the competitive activity was held in a dance hall of the National University of Ukraine on Physical Education and Sport; the registration of cardiorespiratory system and energy supply indicators was carried out by employees of the university's functional diagnostics laboratory.

All athletes confirmed their willingness to participate in the study. They declared the absence of the use of additional means of stimulating work capacity, in particular drugs of any origin, doping, etc.

RESEARCH PROGRAM AND INDICATORS

The modulation of dancers' competitive activity included the simulation of semi-final and final (with 20

minutes break) of SEP. This allowed to identify reaction characteristics, adequate to physiological stress of the competitive load.

During the performance of Slow Waltz, Tango, Viennese Waltz, Foxtrot and Quickstep, within SF and F SEP, the indicators of CRS and energy supply were registered in real time.

The procedure and course of the study complied with the ethical standards of the Helsinki Declaration. The study program was submitted to the local Biomedical Ethics Committee of National University of Ukraine on Physical Education and Sport (Dated 15.12.2025, Protocol No. 6).

EQUIPMENT AND INDICATORS

The consumption of O_2 (VO_2), release of CO_2 (VCO_2), level of pulmonary ventilation (V_E), blood lactate concentration were registered using MetaMax 3B gas analyser and Biosen+ device for biochemical research. Blood sampling to determine the lactate concentration level was performed at the 3rd and 5th minutes of the recovery period after the SF and F simulation. The highest indicators were registered.

Maximum aerobic capacity (VO_2 max), maximum pulmonary ventilation (V_E max), respiratory compensation reaction of metabolic acidosis (EqCO_2), oxygen utilization efficiency (EqO_2), anaerobic glycolytic capacity (La) were measured.

STATISTICAL ANALYSIS

To compare two independent samples, a Mann–Whitney U test criterion was applied – this is a nonparametric statistical test used to compare two independent samples of semifinal (SF) and final (F) indicators. There were used calculated statistical characteristics, Me (the median), S (the standard deviation), Max (the maximal indicator), Min (minimal indicator), percentiles Q1 (25%) and Q3 (75%); IQR – interquartile range (IQR – Interquartile Range).

AI STATEMENT

The author states that no AI tools were used in writing this article.

RESULTS

Quantitative and qualitative functional characteristics of male partners are represented in Table 1, female partners – in Table 2.

The control was carried out upon completion of pre-competition training, when the dancers reached

Table 1. Characteristics of the cardiorespiratory system response and energy supply of male partners

Statistics	VO ₂ max, l·min ⁻¹	VO ₂ max / kg, ml·min ⁻¹ ·kg ⁻¹	V _E , l·min ⁻¹	EqO ₂	VCO ₂ , l·min ⁻¹	VCO ₂ / kg, ml·min ⁻¹ ·kg ⁻¹	EqCO ₂	La, mmol·l ⁻¹
Data semifinal								
	4.4	55.6	146.8	33.6	4.5	56.7	33.0	9.6*
Me	4.4	55.0	146.0	34.2	4.4	56.4	33.2	9.8
S	0.2	3.6	5.8	1.9	0.2	3.6	1.8	0.8
Max	5.0	61.3	157.0	37.5	5.0	61.9	36.5	11.0
Min	4.0	49.8	135.0	30.4	4.1	51.0	29.9	8.0
Q1 (25%)	4.2	53.1	144.0	32.3	4.3	54.0	31.8	9.0
Q3 (75%)	4.5	59.7	150.0	34.8	4.6	61.1	34.1	10.1
IQR	0.2	6.6	6.0	2.5	0.3	7.1	2.3	1.1
Data final								
	4.6	58.8	149.5	32.4	4.6	58.6	32.5	12.5*
Me	4.6	58.7	149.0	32.2	4.5	58.7	32.4	12.8
S	0.3	4.2	5.7	1.8	0.2	4.1	1.6	0.7
Max	5.1	65.3	161.0	36.1	5.1	64.5	36.1	14.0
Min	4.2	50.6	141.0	30.0	4.2	49.4	30.0	10.9
Q1 (25%)	4.4	55.2	146.0	31.3	4.5	56.3	32.0	11.9
Q3 (75%)	4.9	62.8	151.0	32.9	4.8	62.8	33.1	12.9
IQR	0.5	7.6	5.0	1.6	0.3	6.6	1.1	1.0

* – the differences are statistically reliable $p < 0.05$

Source: compiled by the authors of this study

the competitive level of functional and special preparedness. This gives reason to interpret the obtained functional characteristics as a generalized model of energy supply of competitive activity in SEP. The model range is based on the indicators of the Q1 – Q3 range.

The data presented in the table and schematically in Fig. 1, Fig.2, Fig.3, Fig.4, Fig.5 indicate the absence of statistically significant differences in most indicators of SF and F of male and female partners. Statistically significant differences are noted between La indicators, registered in SF and F of SEP.

The results of statistical analysis indicate the stability of the functional support of competitive activity in changing conditions of SF and F. Differences in La of SF and F indicate rational use of anaerobic reserve during SEP and an increase in glycolytic load in F. This phenomenon is especially evident in female partners.

The presence of general positive conclusions of the statistical analysis is confirmed by the data of empirical reasoning, which indicate tendencies towards certain functional shifts, which affect the effectiveness of the functional support of the special working capacity of dancers. This is especially true for the increased level of F indicators.

It is important to note that the increase in CRS response and energy supply occurred within reference

values in response to the increase in physiological stress of load in F. The increase in response is considered as compensation for increasing metabolic shifts and progressive fatigue. This is naturally observed in the ratio of respiratory compensation indicators of metabolic acidosis (EqCO₂) and efficiency of oxygen consumption (EqO₂).

Consideration of individual functions allowed us to identify the same and individual features of functional support in SEP. On the Fig. 1, Fig.2, Fig.3, Fig.4, Fig.5 in the boxplots there schematically presented the statistical ranges, which provide opportunities to identify general trends and differences in functional support in SF and F for male and female partners.

Statistical distribution of VO₂ max / kg indicators in SF and F is presented on Figure I. In the absence of statistically significant differences in indicators, there is a tendency for aerobic power increase while performing F. The model range of Q1 – Q3 (IQR) corresponds to the generalized norms of aerobic energy supply capacity in professional dancers.

The characteristics of blood lactate concentration have static differences that characterize the redistribution of glycolytic load between SF and F of SEP is presented on Figure II. Changes in the median, reduced

Table 2. Characteristics of the cardiorespiratory system response and energy supply of female partners

Statistics	VO ₂ max, l·min ⁻¹	VO ₂ max / kg, ml·min ⁻¹ ·kg ⁻¹	V _E , l·min ⁻¹	EqO ₂	VCO ₂ , l·min ⁻¹	VCO ₂ / kg, ml·min ⁻¹ ·kg ⁻¹	EqCO ₂	La, mmol·l ⁻¹
Data semifinal								
	2.8	49.7	102.5	36.8	3.2	56.7	32.5	7.8*
Me	2.8	50.0	102.0	36.1	3.2	56.4	31.9	8.0
S	0.2	4.0	3.1	2.2	0.2	3.6	2.8	0.5
Max	3.0	58.0	109.0	41.6	3.6	61.9	38.2	8.6
Min	2.5	42.4	98.0	34.1	2.8	51.0	28.1	7.0
Q1 (25%)	2.6	47.3	100.0	34.8	3.0	54.0	30.9	7.6
Q3 (75%)	2.9	52.7	104.0	38.8	3.4	61.1	34.3	8.1
IQR	0.3	5.5	4.0	4.0	0.4	7.1	3.4	0.5
Data final								
	2.9	51.7	104.8	36.2	3.1	55.1	31.41	12.1*
Me	2.9	51.7	107.0	36.3	3.0	54.5	31.25	12.0
S	0.1	3.5	4.1	2.3	0.1	3.2	1.39	0.5
Max	3.0	60.0	109.0	40.0	3.3	61.5	33.75	13.1
Min	2.5	44.6	100.0	33.3	2.9	50.8	28.57	10.9
Q1 (25%)	2.8	49.2	101.0	34.8	3.0	51.8	30.61	11.9
Q3 (75%)	3.0	54.5	109.0	37.6	3.2	57.1	32.26	12.2
IQR	0.2	5.4	8.0	2.8	0.2	5.4	1.7	0.3

* – differences are statistically reliable $p < 0,05$
Source: compiled by the authors of this study

IQR, and min–max range in female partners in F indicate a significant factor of the dancers’ preparedness. These data confirm the results of the static comparison of glycolytic reserve indicators, corresponding to the assessment of the ratio of La SF and La F (%) given below.

The results of the statistical analysis of the ratio of La SF and La F (%) in male and female partners are schematically presented in the Figure III. According to the data presented on the Figure, the given differences are not statistically reliable. However, the general trend of Me redistribution and regulatory ranges Q1 – Q3 (IQR) indicates a persistent trend towards differences in the majority of dancers who participated in the study. The lack of reliable connections is due to the presence of a significant range of min-max, indicators that form highly individual manifestations of energy reactions. This is natural for the high-class athletes.

The results of the statistical analysis presented in Fig. 4 and in Fig. 5 indicate a significant range of differences in SF and F indicators in male and female partners. The general tendency towards a decrease in Me, a redistribution of the Q1 – Q3 and min – max ranges, indicates a decrease in the specific characteristics of the pulmonary ventilation response and oxygen consumption in the final part of the competitive activity.

The results of the statistical analysis also did not reveal statistically significant differences in SF and F indicators in male and female partners. The above differences are based on individual manifestations of the reaction, which is confirmed by the wide range of Q1 – Q3 and min – max and the stability of the median among the SF and F indicators in male and female partners. Certain differences of F indicators in male and female partners are connected with a more pronounced pulmonary ventilation response in men.

The presented results of functional control confirm the known data on regulatory requirements for potential aerobic (VO₂ max) and anaerobic (La max) reserve, at the same time, they provide grounds for reflection on ways to optimize the structure of energy supply for competitive activities of dancers.

DISCUSSION

In modern sports, there is a clear understanding that the capacity of aerobic energy supply is a potential functional reserve of the special performance of athletes in most sports. However, the importance of maximal oxygen consumption for dancers is actively discussed in the specialized literature. There are reasons to claim

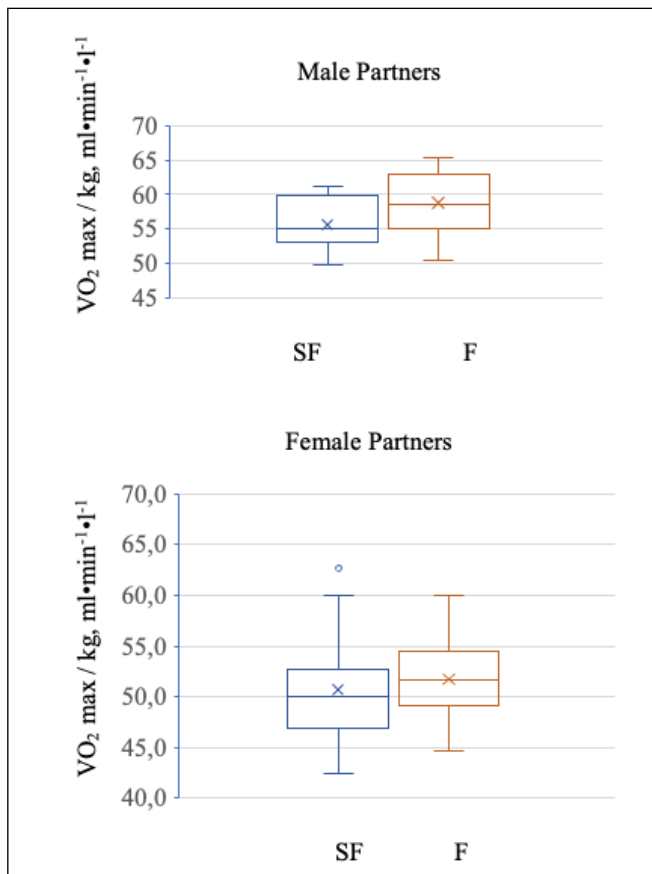


Fig. 1. Statistical characteristics of maximal oxygen consumption in the semi-final and final of the standard European program

Picture taken by the authors

that the debatable issues arise due to the unsuccessful interpretation and normative uncertainty of this component of preparedness. It is obvious that the statement of high $VO_2 \text{ max}$ provides certain characteristics of the energy capabilities of athletes, but it does not indicate much about the effectiveness of its use during competitive activity, especially when it goes about absolute indicators of ($VO_2 \text{ max}$, $\text{l} \cdot \text{min}^{-1}$) reaction. In this work, the increase in absolute aerobic power indicates the preservation of effective aerobic performance in the final. More informative indicator of aerobic power is its modification in relation to body weight ($VO_2 \text{ max} / \text{kg}$, $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$), which indicates the degree of oxygen consumption efficiency in relation to body weight. This characteristic is much more informative for determining the aerobic capacity of female partners.

Glycolytic reactions play a significant role in the overall energy balance of special performance of dancers. Modern concepts of the structure of anaerobic glycolytic reactions in professional dancers separate the characteristics of power and capacity [26, 27]. The redistribution of the load between SF and F forms the prerequisites for the rational use of glycolytic reactions throughout the dance program, which requires

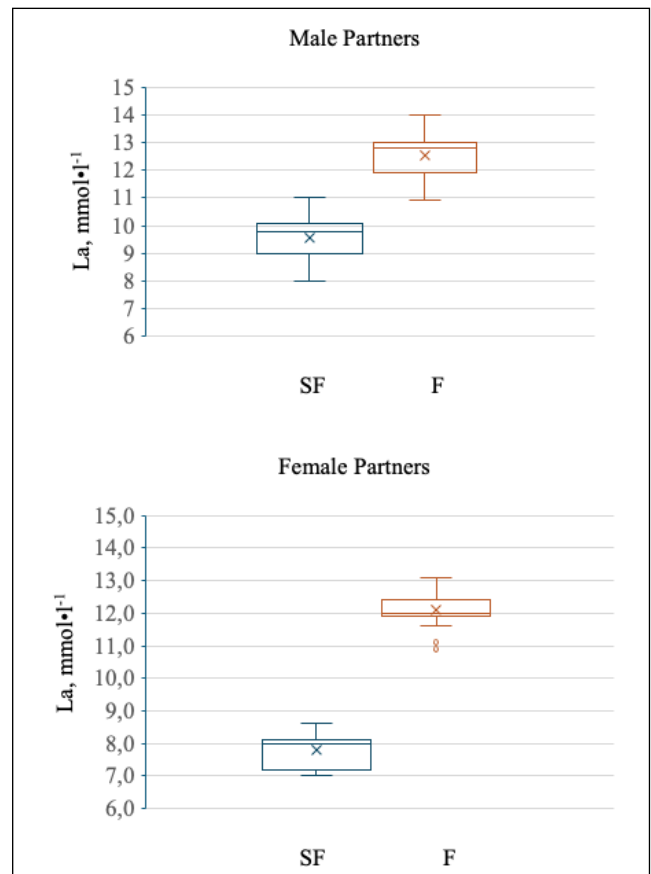


Fig. 2. Statistical characteristics of blood lactate concentration in the semifinal and final of the standard European program

Picture taken by the authors

appropriate characteristics of the anaerobic glycolytic capacity. This is proven in this study. Statistically significant differences between La SF and F correspond to the conditions of rational distribution of glycolytic reactions during SEP performance. An increase in the lactate concentration level in F (La , $\text{mmol} \cdot \text{l}^{-1}$) indicates the presence of glycolytic capacity reserve to maintain the level of performance of dancers in the final part of the competition. According to the data, represented in Figure 2, this component of functional preparedness is more pronounced in female partners.

The special literature provides data on the reactive properties of the cardiorespiratory system, which reflect adaptive processes and have a direct impact on the structure of energy reactions according to the requirements of competitive activity [28, 29, 30]. In sports dance, the reactive properties of CRS are manifested in the efficiency of breathing regulation according to the power of oxygen consumption (EqO_2) and respiratory compensation of metabolic acidosis ($EqCO_2$) [31, 32].

Data presented in the literature indicate the specificity of the pulmonary ventilation response in dancers. There is an opinion, that the frequency of respiratory cycles affects the aesthetic perception of dancing and the judges'

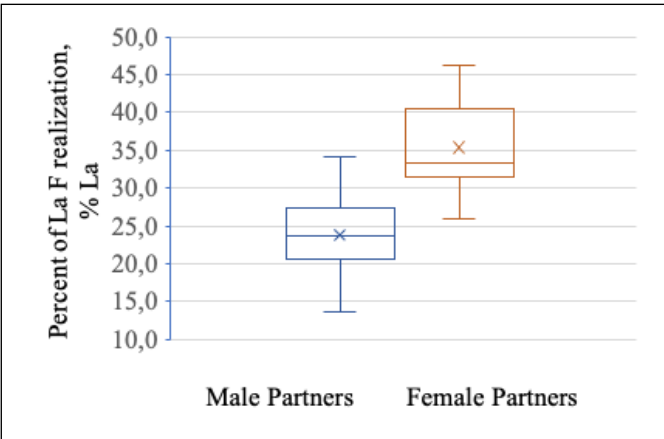


Fig. 3. Statistical characteristics of glycolytic reserve in the final of the standard European program
Picture taken by the authors

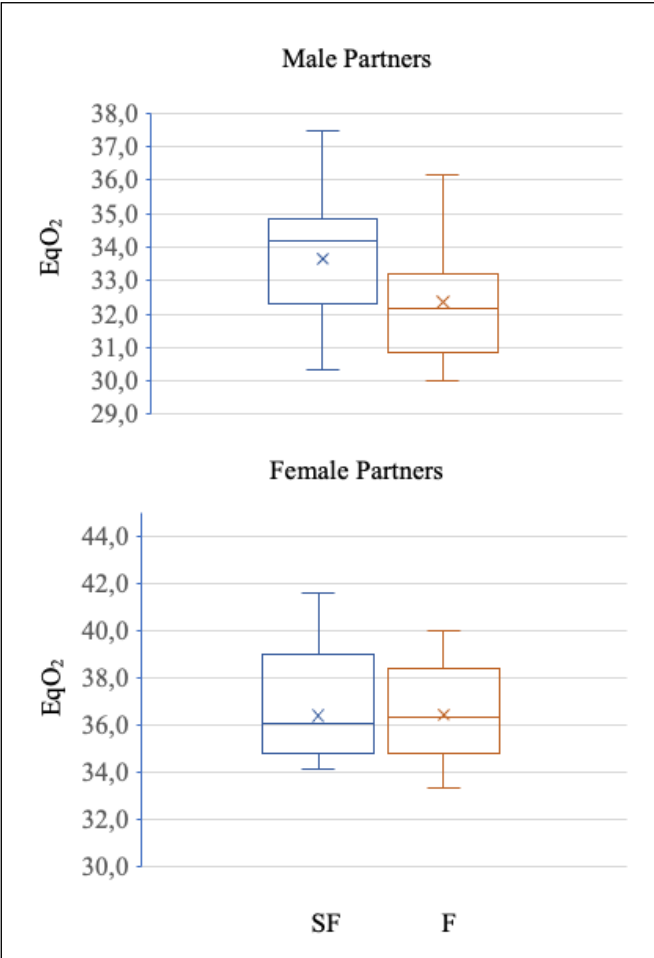


Fig. 4. Statistical characteristics of pulmonary ventilation for oxygen consumption
Picture taken by the authors

assessment of dance performance. In practice, dancers “artificially” regulate breathing functions, which reflects the specifics of adaptation processes. This is especially evident in the degree of increase in the pulmonary ventilation response in the final part of the competition. This

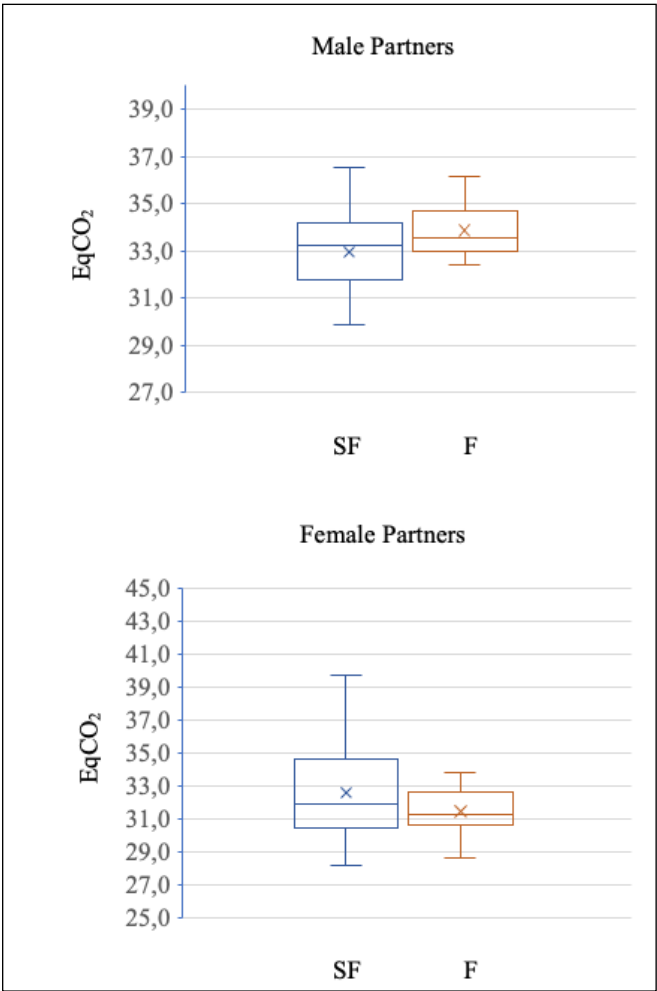


Fig. 5. Statistical characteristics of pulmonary ventilation to remove carbon dioxide
Picture taken by the authors

is certainly a debatable issue and requires more detailed study based on identifying different types of responses to increased physiological stress of load. Monitoring of pulmonary ventilation indicators in real time made it possible to make assumptions about the higher significance of the stability of the respiratory response than its power.

At the same time, the presented research results indicate certain patterns that accompany the correlation of the processes of pulmonary ventilation, oxygen consumption and glycolytic reactions. The increase in the peak values of pulmonary ventilation in the final is consistent with an increase in aerobic power and glycolytic capacity. The increased response of pulmonary ventilation to increased metabolism that accompanies higher VCO₂ (EqCO₂) is interpreted as an increased response of respiratory compensation of metabolic acidosis, the decrease of EqO₂ indicators in F shows reduction of ventilation load per unit of oxygen consumption. This factor becomes especially important in the final part of competitive activity.

CONCLUSIONS

In the final of the standard European program, in most dancers, an increase in aerobic metabolism was found in male partners and glycolytic capacity in female partners. The structure of energy supply is influenced by the reactive properties of the

cardiorespiratory system. The reactive properties of cardiorespiratory system are reflected in the efficiency of oxygen consumption per unit of pulmonary ventilation (EqO_2) and the stability of the respiratory compensation response to metabolic acidosis (EqCO_2).

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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