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Mixed Sports Evaluation of the Variation between the Main Biomarkers Induced by Different Forms of Exercise

Avaliação Esportiva Mista da Variação Entre os Principais Biomarcadores Induzidos por Diferentes Formas de Exercício

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Abstract

Sportomics studies are essential to understand the impact on metabolism exerted by each training method and sport. To observe the impact on biomarkers induced by four exercises: CrossCombat™, Jiu-Jitsu, Parajiu-Jitsu, and a spirometric treadmill test. 41 adult male, 12 Jiu-Jitsu, 03 ParaJiu-Jitsu, 16 Mixed Martial Arts, and ten running athletes. The percentage variation of 772% (Lactate) in the Parajiu Jitsu is noteworthy. An increase in creatininemia was only in Jiu-Jitsu. The percentage variations in the Anion Gap had a positive behavior, but with different amplitudes, so that the treadmill running test caused a variation of 187.1%, followed by Parajiu Jitsu 157.9%, 64.3% for the HIFT, even with 40 minutes of duration and only 42.8% for the Jiu-Jitsu. More significant stress to the acid-base balance caused by ParaJiu Jitsu to lactate, sodium, potassium, and bicarbonate, leading to an anion gap change close to the running test. It is noteworthy that even the CCombat using fighting movements combined with running and jumping generated smaller percentage variations in hematocrit, lactate, glucose, potassium, bicarbonate, and anion gap, putting it as a safe method from a metabolic point of view, even with a total duration much longer than the other sports studied.

Keywords: Sportomics. High-Intensity. Metabolism. Sports.

Resumo

Os estudos da esportômica são essenciais para entender o impacto no metabolismo exercido por cada método de treinamento e esporte. Observar o impacto nos biomarcadores induzidos por quatro exercícios: CrossCombat™, Jiu-Jitsu, Parajiu-Jitsu e teste espirométrico em esteira. 41 adultos do sexo masculino, 12 de Jiu-Jitsu, 03 de ParaJiu-Jitsu, 16 de Mixed Martial Arts e dez atletas de corrida. Destaca-se a variação percentual de 772% (Lactato) no Parajiu Jitsu. O aumento da creatininemia foi apenas no Jiu-Jitsu. As variações percentuais no Anion Gap tiveram um comportamento positivo, mas com amplitudes diferentes, de modo que o teste de corrida em esteira causou uma variação de 187,1%, seguido do Parajiu Jitsu 157,9%, 64,3% para o HIFT, mesmo com 40 minutos de duração e apenas 42,8% para o Jiu-Jitsu. Estresse mais significativo no equilíbrio ácido-base causado pelo ParaJiu Jitsu ao lactato, sódio, potássio e bicarbonato, levando a uma alteração do gap aniônico próximo ao teste de corrida. Vale ressaltar que mesmo o CCombat utilizando movimentos de luta combinados com corrida e salto gerou menores variações percentuais de hematócrito, lactato, glicose, potássio, bicarbonato e anion gap, colocando-o como um método seguro do ponto de vista metabólico, mesmo com uma duração total muito maior do que os outros esportes estudados.

Palavras-chave: *Sportomica. Treinamento de Alta Intensidade. Metabolismo. Esporte.*

1 Introduction

Studies involving sports science have long been part of the projects of scientists around the world[1,2]. For an extended period, the main objective was to observe the performance and physical conditioning variables, proposing different methods and forms of assessment[3,4].

In recent decades, the influence of this practice on health and longevity parameters has received greater attention, with studies involving the impact of exercise programs on different diseases and quality of life[5,6].

On the other hand, the application of exercises and indirect tests in the field or the laboratory may not impact biomarkers, similar to what occurs in the sport to be evaluated, which often makes analysis and comparison with field practice difficult[7,8].

In this sense, the so-called sports science emerged, aiming to assess the influence of different sports and exercise methods on metabolic and immunological biomarkers in the natural field of practice, taking mobile laboratories to different environments common to each sport[9,10].

The main objective of the present study was to observe and correlate the impact on different biomarkers induced by four different forms of stress: a class of the high-intensity functional training method (HIFT) or CrossCombat™, a Jiu-Jitsu fight, a fight of Parajiu-Jitsu in amputees and a spirometric treadmill test in middle-distance runners. All in high-level athletes, indicating the correlations between these types of exercise and the percentage variations generated.

2 Material and Methods

This is an observational and cross-sectional cohort study from the subgroup of studies in special populations. This type of study, in a previously defined population, measures exposure and its effects.

The study included 41 adult male individuals, 12 high-level Jiu-Jitsu athletes, 03 high-level ParaJiu-Jitsu athletes, category A - CLASS A/ Lower limb amputee[11,12], 16 high-level Mixed Martial Arts athletes using Crosscombat™ in their preparation, and ten high-level mid-distance running athletes in a treadmill ergospirometry test.

The investigation met the requirement for research with human beings (Conselho Nacional de Saúde, 2012) approved by the Ethics and Research Committee, number 2,230,073 of the Federal University of Mato Grosso (UFMT), registered in clinictrials.gov (NCT 03522883). All volunteers gave written consent after being informed about the nature and procedures of the study.

The Jiu-Jitsu and ParaJiu-jitsu match followed a six-minute protocol, with the opponent changing at the end of the third minute, aiming to keep the stimulus intensity high, a protocol already used before[9,12].

The class on the new High-Intensity Functional Training method (Crosscombat) lasted 40 minutes, with the protocol for advanced level athletes, held in the structure of the largest MMA team in Rio de Janeiro and with the management of the physical trainer responsible for the method.

The running test was performed on a treadmill based on an increasing ramp protocol with spirometry.

2.1 Statistical analysis

Spearman's test was used to find the correlation coefficients and P values between the data, and the sigmaplot™ version 12.0 software was used to make the graphics and heatmap.

The T-test was applied to compare the data between pre and post-times, adopting a significance level of 5%, $P<0.05$.

First, a test was adopted to verify normality in data distribution. As the sample was smaller than 30 individuals, the Shapiro-Wilk test was applied, which may result in two possibilities:

1. If the value obtained was $p\leq0.05$, the Mann-Whitney non-parametric test would be ap-plied.
2. If the value obtained was $p>0.05$, the Equal Variance Test would be applied, and if this test failed ($p<0.050$), the Mann-Whitney Test would be applied, but if this test passed ($p>0.050$), the Test Paired tee would be applied.

2.2 Blood or serum measurements

The hematocrit was measured by centrifugation using microhematocrit tubes. Lactate and bicarbonate (SHCO3-) were measured using a CG4+ cartridge on I-STAT (Abbot -Abbott Point of Care Inc., NJ, USA). Creatinine, glucose; urea; sodium; chloride, and potassium were measured using CHEM8+ cartridge and I-STAT.

2.3 Calculations

To calculate the percentage variation between pre and post exercise times, the formula was used:

$\Delta\%$ = ((Final Concentration – initial Concentration) x 100) / Initial Concentration))

To calculate the anion gap, the formula (all in mmol/L):

AG = ((Sodium – (Bicarbonate + Chloride))

To calculate Cohen d, the formula:

$AVG_1 – AVG_2 / [\sqrt{(SD_1 + SD_2)/2}]$

*AVG – Average; SD - Standard Deviation.

#small (d = 0.2 – 0.3)
Medium (d = 0.4 – 0.7)
Large (d > 0.7).

To calculate Cohen effect size, the formula:

$r = d / \sqrt{D^2 + 4}$

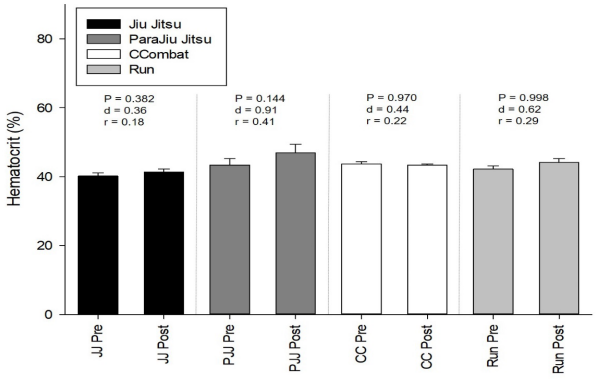
*D - D Value (standardized mean Difference) of Cohen.

#Ignored ($0 \leq ES < 0.2$)
Small ($0.2 \leq ES < 0.5$)
Moderate ($0.5 \leq ES < 0.8$)
Large ($0.8 \leq ES < 1.3$)
Very large ($ES > 1.3$).

3 Results and Discussion

The fact that there was no significant change in hematocrit confirms the hypothesis that the changes observed in biomarkers were induced by exercise methods and not by changes in volemia (Figure 1).

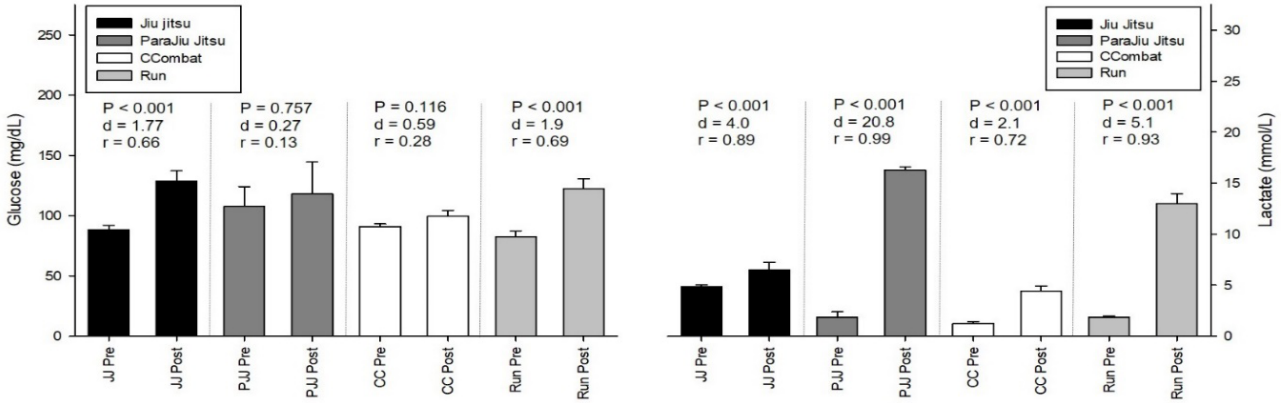
Figure 1 - Volemia did not change in response to exercise



Source: resource data.

In a superficial analysis of the impact of the methods on carbohydrate metabolism, blood glucose showed a significant increase only in the Jiu-Jitsu group. Concerning lactatemia, only the HIFT method showed no difference. The percentage variation of 772% in the Parajiu-Jitsu group is noteworthy (Figure 2).

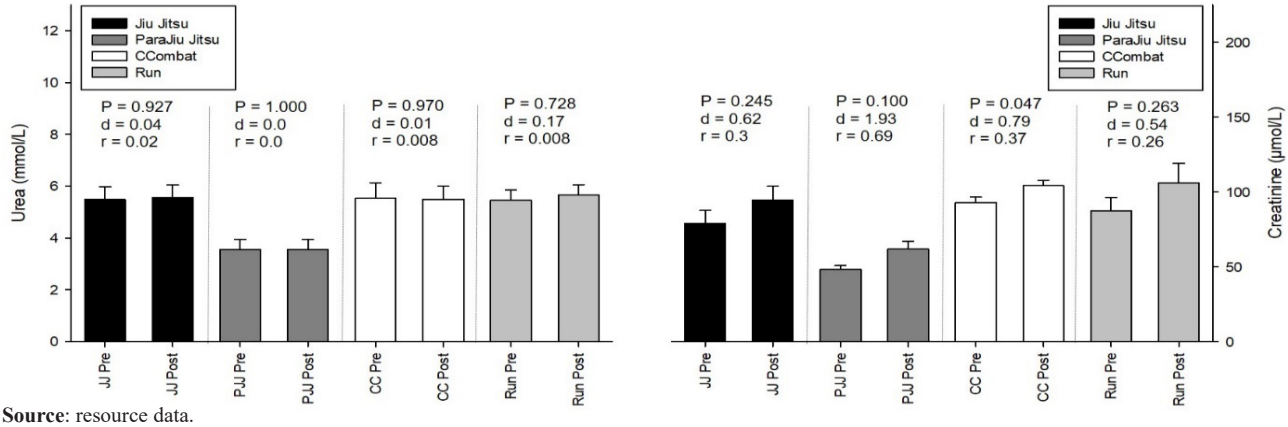
Figure 2 - Overview of a precursor (glucose) and product (lactate) of cellular metabolism induced by forms of exercise



Source: resource data.

A significant increase in creatinine was observed only in the Jiu-Jitsu group, with the most remarkable percentage change in the ParaJiu-Jitsu group, even with the decrease in body mass caused by amputation (Figure 3).

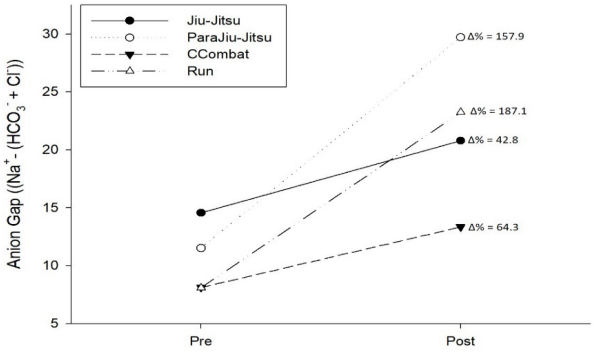
Figure 3 - A significant increase in creatinine was observed only in the Jiu-Jitsu group, with the greatest percentage change in the ParaJiu-Jitsu group



Source: resource data.

The percentage variations in the Anion Gap had a positive behavior, but with different amplitudes, so that the treadmill running test caused a variation in the order of 187.1%, followed by Parajiu-Jitsu with 157.9%, 64.3% for the HIFT method, even with 40 minutes of duration and only 42.8% for the Jiu-Jitsu fight (Figure 4). The singular values and their variations for sodium, potassium, bicarbonate, and chloride were presented in supplementary Figure 1.

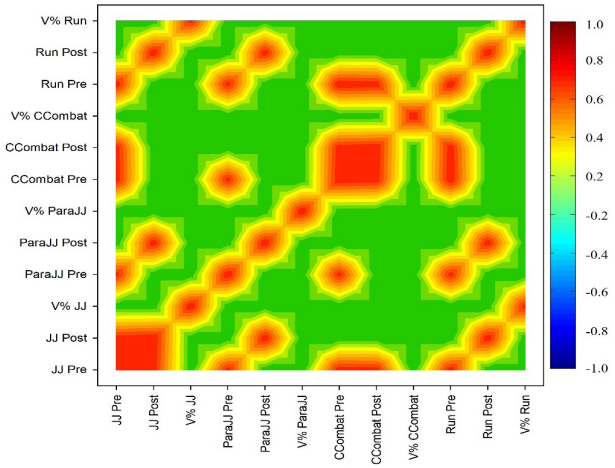
Figure 4 - Treadmill running event caused the highest (Δ%) of the Anion Gap.



Source: resource data.

A correplot (Figure 5) was made with the correlation coefficients obtained from the Spearman test (Table 1) for the set of all variables for each time and modality, seeking modifications in these biomarkers with significant correlation (>0.95).

Figure 5 - Correplot indicated a similar behavior between CCombat and jiu-jitsu



Source: resource data.

Table 1 - Correlation coefficients between modalities and times for the sum of variables

	JJ Pre	JJ Post	Δ% JJ	PJJ Pre	PJJ Post	Δ% PJJ	CC Pre	CC Post	Δ% CC	R Pre	R Post	Δ% R
JJ Pre	1	0.964	0.0303	0.952	0.927	0.0424	0.976	0.964	0.0909	0.976	0.939	-0.115
JJ Post	0.964	1	0.236	0.939	0.988	0.261	0.915	0.927	0.285	0.915	0.988	0.0909
Δ% JJ	0.0303	0.236	1	-0.0060	0.321	0.867	-0.0788	0.0303	0.794	-0.0788	0.273	0.952
PJJ Pre	0.952	0.939	-0.0060	1	0.891	-0.0303	0.952	0.915	-0.0060	0.952	0.927	-0.2
PJJ Post	0.927	0.988	0.321	0.891	1	0.37	0.867	0.891	0.394	0.867	0.976	0.2
Δ% PJJ	0.0424	0.261	0.867	-0.0303	0.37	1	-0.0424	0.103	0.927	-0.0424	0.309	0.939
CC Pre	0.976	0.915	-0.0788	0.952	0.867	-0.0424	1	0.976	0.0060	1	0.903	-0.224
CC Post	0.964	0.927	0.0303	0.915	0.891	0.103	0.976	1	0.139	0.976	0.939	-0.0909
Δ% CC	0.0909	0.285	0.794	-0.0060	0.394	0.927	0.00606	0.139	1	0.00606	0.321	0.867
R Pre	0.976	0.915	-0.0788	0.952	0.867	-0.0424	1	0.976	0.0060	1	0.903	-0.224
R Post	0.939	0.988	0.273	0.927	0.976	0.309	0.903	0.939	0.321	0.903	1	0.127
Δ% R	-0.115	0.0909	0.952	-0.2	0.2	0.939	-0.224	-0.0909	0.867	-0.224	0.127	1

Source: resource data.

The fact that the hematocrit values (Figure 1) did not show changes after the exercise gives robustness to the data since there was no hemoconcentration or hemodilution and that the values presented for the other biomarkers reflect the stress generated by the meth-od.

Stress primarily generates an alteration in the intracellular acid-base balance, which in response to this phenomenon, adapts intra and extracellularly to maintain balance[13]. In the case of exercise, stress at the muscular level first induces the consumption of adenosine triphosphate (ATP), which is already available and quickly resynthesized by the ATP-CP system or the phosphagen system, using creatine phosphate, lasting only a few seconds[14-18].

After these initial seconds, glycolysis and glycogenolysis are activated with increased formation of ATP. However, during exercise, an enzyme called myokinase uses two adenosine diphosphate (ADP), forming ATP again and releasing an adenosine monophosphate (AMP), which will suffer deamination by the enzyme AMP deaminase, releasing inosine monophosphate (IMP) and ammonia[19-21].

The IMP will be sent to the xanthine/purine pathway, forming urate, which will be sent to renal filtration and elimination through urine, and the ammonia formed will be sent through the blood to the liver, which from the urea cycle will receive the ionized form, which will receive the same end as urate[9,22,23].

Each ATP hydrolyzed during exercise, aimed at releasing energy, will release a pro-ton (H+) which will reduce the pH of the medium. This phenomenon signals that pyruvate, an intermediary of glycolysis, receives two protons and forms lactate that will be released into the blood. This lactate will be converted back into glucose by the liver, which will return to the blood to be used again by a metabolic cycle known as the Cori cycle[24-26].

In the present study, the behavior of glucose and lactate (Figure 2) indicated, for glucose, greater percentage variations for running and Jiu-Jitsu. Lactate had a greater percent-age variation in the ParaJiu-Jitsu group.

Wrongly thought of as a consequence of the lack of oxygen in skeletal muscle contraction, lactate fulfills at least three purposes: an essential source of energy for mitochondrial respiration, primary gluconeogenic precursor, and as a signaling molecule[27], including modulating the immune system[28,29].

Another parameter used in the interpretation of acid-base balance, the anion gap, is the difference between measured cations (positively charged ions like Na + and K +) and measured anions (negatively charged ions like Cl- and HCO3-). The most common application of the anion gap is classifying cases of metabolic acidosis[30].

Regarding the Anion gap (Figure 4), the present study found the highest percentage variations for running (Δ% = 187.1), followed by ParaJiu-Jitsu (Δ% = 157.9). Analyzing each ion involved in the equation individually (Table2), ParaJiu-Jitsu showed the greatest variations for Sodium (Δ% = 5.39), Potassium (Δ%=-14.3) and Bicarbonate (Δ%=-50.7), followed closely by running with Sodium (Δ% = 1.92), Potassium (Δ% = -12.4) and Bicarbonate (Δ% =-48.7), which indicates these modalities as the ones that caused the greatest electrolyte imbalance, but without solvent change (Figure 1).

One more possible action of lactate was recently proposed to modulate the anion gap. However, some researchers confuse this relationship by trying to attribute acidosis to lactate[31], when it has long been known that lactate is a consequence of acidosis and not the cause of this phenomenon[32], and that not even acidosis conditions cause muscle fatigue, but that intracellular acidosis increases muscle excitability during contraction[33].

Observing the low variations in chloride about other ions (Figure 3), it could be seen that the proposed training methods induced no metabolic acidosis, this behavior has al-ready been seen previously[34], and even that the system buffer made by bicarbonate was more requested in the ParaJiu-Jitsu modality, which may have been more stressful to the acid-base balance (Table 2). This fact is corroborated by the more significant percentage variation for lactate (Figure 2).

Table 2 - Variation in electrolyte concentrations induced by the methods (all in mmol/L)

Method	Sodium			Potassium			Chloride			HCO_3		
	Pre	Post	Δ%	Pre	Post	Δ%	Pre	Post	Δ%	Pre	Post	Δ%
Jiu-Jitsu	141.0	140.9	0.08	4.7	3.8	-13.7	106.9	107.2	0.3	19.6	12.9	-34.2
ParaJiu Jitsu	142.0	149.7	5.39	3.7	3.3	-14.3	103.8	106.8	2.8	26.6	13.1	-50.7
CCombat	138.4	139.4	0.72	3.9	3.7	-4.1	102.8	103.5	0.7	27.5	22.6	-17.9
Run	141.8	144.5	1.92	3.9	3.4	-12.4	102.7	105.4	2.6	31.0	15.0	-48.7

Source: resource data.

As there was no significant change in the levels of sodium and potassium, it indicates that its regulators, the sodium/potassium ATPase pumps and the renal filtration took care of the control, as it is known that the accumulation of extracellular potassium hinders the excitability of cells, in this case in myocytes[35].

Based on the correplot (Figure 5) and the table with the correlation coefficients (Table 1), a similar behavior was found between the total set of Jiu-Jitsu biomarkers and the HIFT CCombat method, probably because this method uses many Jiu-Jitsu moves in his classes, as indicated by the method's creator, who is a Jiu-Jitsu black belt. Running also showed a high correlation with the HIFT method, as this method mainly combines fighting movements with running and jumping.

Data on the so-called CROSS modalities that form the group of HIIT (High-Intensity Interval Training) and HIFT (High-Intensity Functional Training) are still scarce, especially without conflict of interest[36].

In many studies in the area of immunometabolism, the large number of variables, biomarkers of collection times, makes a broader and more coherent analysis difficult, reducing the chances of innovations and great findings to parts of large databases.

Many high quality studies emerged from public databases, such as Epidemiology Surveillance, National Health and Nutrition Examination Survey (NHANES), The Cancer Genome Atlas (TCGA) and Medical Information Mart for Intensive Care (MIMIC) among many others[37].

Data mining technology (data-mining) has been an exceptional tool in medical research, as it demonstrates excellent performance in the assessment of patient risks and the behavior of health variables in different conditions, assisting in clinical decision-making and in building of disease prediction models[37].

This technology can seek potentially valuable knowledge from a large amount of data[38]. However, interpreting and integrating information from data mining models can be challenging[39].

Thus, We propose for the first time an integrated and holistic analysis of data[40]. And in the present study we present for the first time, in a metabolomic, sport and multisport study, data mining by the Spearman test strategy and data presentation by heat map.

4 Conclusions

Sportomics studies are essential to understand the impact on metabolism exerted by each training method and sport. Monitoring of hematocrit is still essential for assessing blood volume, and correction values should be applied to all data if there is any change in this biomarker.

In the present study, greater stress to the acid-base balance caused by ParaJiu-Jitsu in amputees was observed by lactate, sodium, potassium, and bicarbonate, leading to an an-ion gap change close to that of the running test.

The high correlations found between the whole set of biomarkers for the CCombat method and Jiu-Jitsu and running are easily understood because this HIFT method com-bines fighting movements with running and jumping.

It is noteworthy that even the CCombat method using fighting movements such as Jiu-Jitsu and ParaJiu-Jitsu combined with running and jumping, this method generated smaller percentage variations in hematocrit, lactate, glucose, potassium, bicarbonate, and anion gap, putting it as a safe method from a metabolic point of view, even with a total duration (40 minutes) much longer than the other sports studied (6 minutes for Jiu-Jitsu and ParaJiu-Jitsu and approximately 13 minutes for the running test).

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