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RESEARCH ARTICLE

Differences in **VO2** max Readings Between Treadmill and Cosmed K5 for Elite Boxers

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Abstract

Purpose of the study: The purpose of this study was to analyze the effectiveness of the accurate and best method for assessment of VO₂ max in both treadmill and Cosmed K5 data. **Method:** The subjects of this study included 20 competitive male senior boxers mean 22.81 (SD = 3.59) years, height 178.83 (SD = 8.56) cm, body mass 78.28 (SD = 12.54) kg, and body mass index BMI 24.43 (SD = 3.45) kg/m², with a range of 17.5 years and respective variances. Boxers have 5-10 years of competitive experience. Analyzing the data, descriptive statistical methods, descriptive statistical indicators, paired samples t-tests, independent samples t-tests analyses, and effect size calculations (Cohen's d) were used, with a significance level of p < 0.05. **Findings:** The results showed that there was a statistically significant increase of VO₂ max. from pre- to post-training measurement (p < 0.01), respectively, in both treadmill and Cosmed K5. The VO₂ max values with the treadmill were higher compared to those of the Cosmed K5 method; the absolute change value of 13.4% with K5 measurements was greater compared with the absolute change of 8% for the treadmill. **Conclusion:** The main findings of this study are that improvements of VO₂ max values with Treadmill in VO₂ max are slightly greater than those reported with the Cosmed K5 method. The results of this study are that applying a special training program, such as HIIT, these exercises can improve performance levels of aerobic capacity and oxygen uptake.

Keywords

Interval Training, VO2 max, Boxing

INTRODUCTION

Physical exercise is recognized as an important tool in increasing the energetic cost, which is estimated by measuring oxygen uptake (Vianna et al., 2011). Regular exercise is well known to improve health and reduce a number of risk factors for chronic disease (Myers et al., 2015). Boxing is a sports branch which requires dynamic and static features (Evrim et al., 2019), and as such it serves as a basic for biomechanical analysis and it is closely related to high levels of kinetic variables development, which is distinguished from other types of sporting activities. Implementation of the

sport of boxing takes several elements of main conditions, namely anaerobic endurance, strength, speed, accuracy, mental elements that include courage and tenacity (Akhmad et al., 2021), as well as the cardiovascular endurance, muscle strength, flexibility, power, balance, coordination and response time. Training status has recently been identified as an important factor for the development of strength during concurrent training, especially when resistance and aerobic training are performed within the same session (Petre et al., 2023).

Resistance training (RT) is a potent stimulus to the neuromuscular system, for muscle

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hypertrophy and strength gain (Ozaki et al., 2013), which is known to have positive effects on health (Paoli et al., 2017), High Intensity Interval Training (HIIT) is a sustainable and effective method for improving Cardiorespiratory Fitness (CRF), which is proven to produce equal or greater improvements in CRF when compared to other training exercises. (Martin-Smith et al., 2020). The training process should take advantage character loads pronounced aqnaerobik physiological during which prevailing energy processes anaerobic against those aerobic (process anaerobic alaktik, at 10%, anaerbik process lactic glikolitik, 60% and aerobic process, to the extent 30%), (Bushati, 2020). High-intensity interval training (HIIT) may be a feasible and efficacious strategy for improving health-related fitness in young people (Costigan et al., 2015).

The combination of exercise training modalities improves body composition and cardiovascular fitness (Ho et al., 2012; Shaw & Shaw, 2009). The VO_2 max in response to interval training (IT) or combined IT and continuous training (CT) is reported in many studies, and it is well accepted that the increases in VO₂ max with training are due to increases in cardiac output and peripheral oxygen extraction (Bacon et al., 2013). Cardiorespiratory endurance has long been recognized as one of the fundamental components of physical fitness (Kukeli & Skënderi, 2018). A study had suggested that a circuit -based wholebody aerobic resistance training program can elicit a greater cardiorespiratory response and similar muscular strength gains with less time commitment compared with a traditional resistance training program combined with aerobic exercise (Myers et al., 2015).

Endurance exercise is classically performed against a relatively low load over a long duration, whereas strength exercise is performed against a relatively high load for a short duration (Hughes et al., 2018). Endurance training leads to adaptations in both the cardiovascular and musculoskeletal system that supports an overall increase in exercise capacity and performance (Brooks, 2012). There are two types of endurance. Aerobic endurance is one of the basic physical skills in terms of sports performance as well as health in athletes. In aerobic endurance the athlete always performs the activity in the presence of oxygen. In anaerobic endurance the activity is fast, dynamic and of short duration, so it is more specific to team sports and martial arts, while the aerobic endurance is more specific to

long-duration sports. Most athletes need a good aerobic base before focusing on anaerobic endurance, typical for their sport (Bompa & Carrera, 2015). Exercise with intensity close to maximal oxygen consumption (VO₂ max) represents the best stimulus to develop aerobic capacity (Delextrat & Martinez, 2014). Circuit training is a more effective option for improving aerobic endurance in Bina Darma futsal players. Choosing the right type of sport can increase the aerobic endurance (Satria et al., 2024).

The level of endurance depends on the effectiveness of the cardiorespiratory system, the indicator of which is expressed as the maximal oxygen intake (VO₂ max), or maximal aerobic capacity, which is the maximum capacity of an individual's body to transport through circulatory system and use of oxygen in motor muscles (Habibi et al., 2014). The aerobic capacity is measured through direct and indirect methods. Direct methods include using treadmill, ergometer and Cosmed K5 which are more accurate and expensive, whilst the indirect method include the formulas and heart rate (HR) variable. VO₂ max is the body's ability to consume oxygen maximally during activity and training and it is calculated in ml/kg/min using specific laboratory tests (Ridho et al., 2020). Increasing VO₂ max will improve player performance in matches (Russell et al., 2016), and they who have large VO₂ max have the supply and creation of energy to move without limits, have a recovery period that is very fast so that athletes can work long hours without experiencing significant fatigue, and high VO₂ max and skills are needed to complete at the international level (Ridho et al., 2020).

Some authors concluded that the general metabolism is mainly aerobic (average of 85%), emphasizing the importance and considering the level of aerobic fitness in boxing as a determinant of performance, and although Olympic boxing is a full contact combat sport, the results of these studies were important and represented a first step that should be reinforced by future studies (Arseneau, et al., 2011; Thomson et al., 2020). In order to obtain the most accurate measurements, foreign authors have measured oxygen consumption in the conditions of a boxing match, although it remains difficult to perform due to the presence of the mask which must be worn on the face during the match. In these studies the authors attempted to challenge this problem by directly measuring oxygen

consumption during a semi-contact boxing match. The aim of this study is to analyse the effectiveness of the accurate and best method for measurement of VO_2 max in both treadmill and Cosmed K5, performed with Interval training method.

MATERIALS AND METHODS

Participants

The subjects of this study included 20 competitive male senior boxers mean 22.81 (SD= 3.59) years, height 178.83 (SD = 8.56) cm; body mass 78.28 (SD = 12.54) kg and body mass index BMI 24.43 (SD = 3.45) kg/m², with a range of 17.5 years and respective variances, as shown in table 1. Boxers have from 5-10 years competitive experience. All participants were amateur boxers competing according to the standards of the Association Internationale de Boxe Amateur (AIBA) and they were among the best of their categories in the competition analyzed. From the category of seniors, the bronze medalist in the world, 2 Balkan championships and the national championship were included.

Ethics statement

This research has met ethical rules. Research ethical approval was obtained from the UST Ethics Committee for Scientific Research with project number 978/2, approved date 14/05/2024. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of Declaration prioritizing the of Helsinki, participant's rights and well-being in design, procedures, and confidentiality measures.

Instrument

The study was performed in Physiologi Laboratory of Sports University of Tirana and all data were recorded in its licensed equipment's. Theo main apparatuses utilized for studying endurance performance were: a physician beam scale, Height body was measured using "Health o Meter" Professional, Model 500KL-BT;ISO 13485:2016; Pelstar, LLC, USA. Aparatur Tanita Body Compositon Monitor BF511. Aparatur Treadmill T200M COSMED aparatur Cosmed K5. The standard Treadmill & Cosmed K5 testing protocol were used to collect the data and the spss program was used.

Procedure Treadmill

Initially the boxers will warm up in the gym normally like any training session for 30-35 min then they will go to the laboratory and start testing on the Treadmill track, in the first 3 minutes they will walk at 8 km \cdot h⁻¹ and incline 0%. Thereafter, speed will increase by 2.5% in ascent km \cdot h⁻¹ every 2 minutes until exhaustion (Vianna et al., 2011). The objective is to determine VO₂ max, HRmax, of boxers. The temperature and relative humidity of the environment in the laboratory where the test will take place will be around 21°C, the same as in the first test carried out in the gym. After completing both phases of testing at the beginning of the study and at the end of the study, a comparison of the results will be made between the $\dot{V}O_2$ max test performed through simulated boxing 3 x 3 min performed in the gym under competition conditions with the Fitmat Pro device and the test of $\dot{V}O_2$ max performed in laboratories with Treadmill equipment according to Astrand's protocol.

Cosmed K5

Both study groups will undergo testing and it will be carried out in two phases at the beginning of the study and at the end of the study. The tests will be done on different days where the VO2 max will be measured first through the Cosmed K5 device. The testing will be carried out during a training session where the athletes will first start with the warm-up that they do every day in training for about 30-35 min. Then the mask will be placed which is connected to the fitmate pro device and the test will begin with 3 rounds of 3 minutes each with a 1 minute break between rounds, the same as in match conditions. Upon giving the command, the boxer will start the semi-contact simulated boxing, working with the commands given by the trainer by holding the paddles, at rest, the boxer will sit the same way as during a boxing match. The temperature and relative humidity of the environment in the gym where you want to take place the test will be around 18-23°C.

Training First test

The training programs lasted 12 weeks and involved 3 weekly RT sessions. After all testing procedures were completed, subjects were randomly assigned to two groups: control group (n = 10) exercised with only with TRT exercises and experimental group (n = 10) with only HIRT program, as shown in Table 1. The procedure in this study consisted of three phases: the first phase, initial. Both groups training period involved three workout days/or session per week. In this phase, the pretest data of biomechanical variables for both groups experimental and control group were collected, with the hypotheses that the pretest data of the two groups data didn't have a significant difference on average values.

Training Methods

The experimental group implements the Continuous Method where the physical-motor action is applied non-stop, in long periods of time and at a relatively low speed. This method was developed through running in several ways, depending on the discipline of boxing:

Slow running mode; where the training unit lasted 45-50 min and pulse/min at 145-150.

Mode with medium pace; where the training unit lasted 30-40 min and heart rate/min at 155-160.

Fast-paced mode; where the training unit lasts 20-30 min and pulse/min at 160-165.

The Fartlek method was implemented with running segments, with variable distances and speeds, according to the boxer's condition and desire. It was organized mainly in two ways, according to boxing requirements:

With great extension; from 50-60 min; with pulse 140-150 rr/min

With mese extension; from 30-40 min., with a pulse of 160-170 rr/min

Mountain training; it was organized as a specific process of preparation for endurance in certain deadlines and in special environments, at high altitudes above sea level. Experience has shown that this training method promotes the "hypoxia" process, which is associated with the increase of red blood cells and blood hemoglobin and, therefore, improves the metabolic and functional aerobic activity of the boxer's organism. The control group performed treadmill exercise.

Past –Test

Following two distinct training approaches (HIRT program group experimental and TRT exercises group control), the data post-test for both groups was gathered and subjected to spss statistical techniques.

Statistical Analysis

Sample characteristics were analyzed applying descriptive statistics to the data using the IBM SPSS Statistics version 29.0.2.0. Analyzing the data descriptive statistical methods, descriptive statistical indicators, paired samples t-test and

independent samples t-tests analyses were used. Mean values and their respective standard deviations were calculated for numerical variables. The data analysis techniques include: the normality Kolmogorov-Smirnov test, to determine whether the data has a normal distribution, and the Levenie's test for the homogeneity of variation. Shapiro Wilks test was used to test the normality of distributions for the measured variables, which corresponded to a normal distribution (p > 0.05). The distribution of data variance between the two post-test in both measurements methods was found homogenous, based on the Levenie's test result, which showed a significance value of p > 0.05. Paired samples t-test was conducted to determine whether there was a variable difference between VO2 max in the data taken in each method from pre-test and post-test measurements, whilst the independent samples ttest was used to compare the difference of the VO₂ max variable between two post-test measurements in treadmill and Cosmed K5 for the same boxers. Effect size calculations (Cohen's d) were used to determine the meaningful of the observed differences, with a significance level of 5% (p < 0.05).

RESULTS

The study was completed on 20 male elite boxers of Albanian national team. Table 1 gives the descriptive statistics of the results which have been reported in pre and post mean values \pm SD. Mean values for their physical characteristics were: age: 22.81 \pm 5.59 years; height 178.83 \pm 8.56 cm; weight 78.28 \pm 12.54 kg; and body mass index (BMI): 24.43 \pm 3.41 kg/m².

The results show that there was a statistical significance increase of VO₂ max. from pre- to posttraining measurement (p < 0.01) respectively, in both treadmill and Cosmed K5. The aim of this study was to analyse the effectiveness of the accurate and best method for assessment of VO₂ max in both treadmill and Cosmed K5 in the data taken from pre-test and post-test measurements. Table 1 shows the anthropometric and VO₂ max variable statistics, range and variances of all variables. It is noticed that there are variances in mean for both groups. As it is noticed by the results, the mean values VO₂ max are lower for the Cosmed K5 compared with the treadmill measurements.

Variable	Range	Min. value	Max. value	Mean value	Mean SD	SD value	Variance
Age (years)	17.50	18.00	35.50	22.8133	1.44347	5.59054	31.254
Height (cm)	22.0	170.00	192.00	178.831	2.1542	8.5693	14.782
Weight (kg)	39.50	62.50	102.00	78.2867	3.23980	12.54767	157.44
BMI	11.40	19.70	31.10	24.4333	.89302	3.45867	11.962
VO2.T1	18.90	42.50	61.40	54.9667	1.42300	5.51124	30.374
VO2.T2	22.30	51.70	74.00	59.7467	1.36235	5.27634	27.840
VO2.Cos.1	22.60	30.80	53.40	47.1600	1.58195	6.12685	37.538
VO2.Cos.2	11.30	49.00	60.30	54.5133	.99608	3.85781	14.883

Table 1. Descriptive statistics of anthropometric and VO₂max variable

Table 2 gives the descriptive statistics of both methods, in terms of mean values, including min and max values, as well as the mean difference between pre-test and post-test measurements. The difference of VO₂ max in both tests, treadmill and Cosmed K5 is increased after interval training method. The measures of Treadmill showed a difference of 4.78 mlmol/kg/min, between pre-test and post-test mean, while the value of VO₂ max in

Cosmed K5 measurements was increased more compared to those of treadmill, with a value of 7.35 mlmol/kg/min for the pre-test and post-test mean difference. The post-test mean difference between two methods of measurements gives a value of 5.23 mil/mol. The interval training method that was used by the experimental group and the routine training that was developed by the control group.

 Table 2. Descriptive statistics of VO2
 treadmill & cosmed K5 measurements

Variable	Data		Trea	ıdmill	Pre-test-post-test	Post-test mean	
	-	Min.	Max.	Mean	SD	mean difference	difference
	Pre-test	42.50	61.40	54.9667	5.51		
VO_2 max.	Post-test	51.70	74.00	59.7467	5.27	4.78	
(mlmol/kg/min)			COSM	IED K5			5.23
	Pre-test	30.80	53.40	47.1600	6.12	7.35	
	Post-test	49.00	60.30	54.5133	3.85		

The paired samples t-test and independent samples t-test are analysed for tests. The paired samples t-test in the table 3 has identified the **Table 3.** Paired samples t-test for pre-test & post-test f

differences in pre-test and post-test data, showing that p-value (p < 0.001) is related with a significant difference between them.

Table 3. Paired samples t-test for pre-test &	post-test for treadmill & cosmed K5 measurements
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			P			Sig. 2-			
Pairs of Variable	Pre-test-	Mean	SD	Std. error	95% Confidence		t-value	df	tailed
VO2	Post-test			mean	Lower	Upper	-		p-value
Pair1	Treadmil	-4.78000	3.03508	.78365	-6.46077	-3.09923	-6.100	18	<.001
VO2.T1-VO2.T2	1								
Pair1	Cosmed	-7.35333	3.75516	.96958	-9.43287	-5.27379	-7.584	18	<.001
VO2.Cos.1-	K5								
VO2.Cos.2									

Table 4 gives the paired Samples effects size, which is estimated using the denominator and

expressed in terms of Cohen's d coefficient with the Hedges' correction.

Fable 4. Paired	l samples	effect	sizes
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Paired Samples Effect Sizes										
Pair of variables	Coefficients		Point	95% Confidence Interval						
		Standardizer ^a	Estimate	Lower	Upper					
Pair 1:	Cohen's d	3.03508	-1.575	-2.331	795					
VO2.T1 - VO2.T2	Hedges' correction	3.21075	-1.489	-2.203	751					
Pair 2:	Cohen's d	3.75516	-1.958	-2.825	-1.068					
VO2.Cos.1 - VO2.Cos.2	Hedges' correction	3.97251	-1.851	-2.670	-1.010					

Table 5 gives the independent samples t-test for the post-test data for both VO_2 max treadmill and K5 measurements. The results show that there is

a significant difference between the post-test data of the experimental group and control group.

		Leve	ene's	t-test for Equality of Means							
		Test for								95% Co	onfidence
Variable		Equal Varia	ity of ances	t- value	df	p-v	alue	Mean Differe	Std. Error		
								nce	differe	Lower	Upper
		F	Sig.						nce		
	Equal variances	.256	.617	3.101	18	.002	.004	5.2333	1.6876	1.7763	8.6903
VO_2	assumed										
Max.	Equal			3.101	25.641	.002	.005	5.2333	1.6876	1.7619	8.7047
	variances										
	not										
	assumed										

Table 5. Independent samples t-test for the post-test data of the treadmill and cosmed K5 measurements

Table 6 gives the Independent Samples effects sizes, which is estimated using the

denominator and expressed in terms of Cohen's d coefficient with the Heges' and Glass's corrections.

Table 6. Independent samples t-test effect sizes for the post-test data of the treadmill and cosmed K5 measurements

Independent Samples Effect Sizes										
Variable	Coefficients			95% Confide	nce Interval					
		Standardizer ^a	Point Estimate	Lower	Upper					
	Cohen's d	4.62182	1.132	.349	1.898					
VO_2 max.	Hedges' correction	4.75041	1.102	.340	1.846					
	Glass's delta	3.85781	1.357	.469	2.212					

The difference of VO_2 max after training program between Treadmill and Cosmed K5 measurement was a value of 5.23 mil/mol, which shows that training program was proven to increase the physiological variable of VO_2 max in this study.

DISCUSSION

The present study was undertaken to analyse the effectiveness of the best and correct method for assessment of VO2 max in both treadmill and Cosmed K5, performed with interval method training program, for improving Vo2 max in elite female boxers. The t-test SPSS analysis was used to compare the pre-test – post-test data statistically for changes from initial to final tests for each method applied for the estimation of VO₂ max variable. Based on the results of this study, the value of VO₂ max in methods (treadmill and Cosmed K5) was statistically increased after a 12 week HIIT program. After this training program VO₂ max variable for treadmill measurements was increased respectively by a value of 4.78 mlmol/kg/min. Meanwhile the VO₂ value for the Cosmed K5 measurements was increased by a value of 7.35 mlmol/kg/min. The difference in mean values for VO₂ values from the post-test data of the two methods showed a significant value of VO₂ by 5.23 mlmol/kg/min.

The paired samples t-test for pre-test & posttest for treadmill point out these results: t(38) = -6.100; p <.001, statistically significant and for the Cosmed K5 measurements the results are respectively: t(38) = -7.584; p <.001, statistically significant. For the paired Samples t-test, the effects size is a measure of how large this effect was and it standardizes the mean difference. It was estimated using the denominator and expressed in terms of Cohen's d coefficient. The results of the pre- to post-test measurements for the treadmill, gives the Cohen's d value, which uses the sample standard deviation of the mean difference, whilst the Hedges' correction uses the sample standard deviation of the mean difference -1.489, and a correction factor of 3.21075. The Cohen's d = -1.575, shows that that the difference was really big

and this effect is very strong, While the results of the pre- to post-test measurements for the Cosmed K5, gives the Cohen's d = -1.958 and the Hedges' correction of 3.97251 and a correction factor of -1.851. In the second case, the Cohen's value of d =-1.958 shows that this effect was extremely strong. and as a consequence more powerful that in the treadmill measurements. This conlusion can be supported by expressing the changes of the mean differences as a percentage. So, the increased value of 4.78 mlmol/kg/min for pre to post-test mesurements for treadmill was about 8%, while the increased value of 7.35 mlmol/kg/min for pre to post-test measurements for Cosmed K5 was 13.4%, with an additional difference of 5.4% more compared to treadmill.

The results taken from the Levene's test: p = 0.617 > 0.05 shows that it is not significant, which means that the equal variances assumed for both two tests in Treadmill and Cosmed measurements. The results reported from the Independent samples t-test for the post-test data of the treadmill and Cosmed K5 measurements, showed that the mean value of the VO₂ max of treadmill measurements was 59.74 (SD = 5.51) and that of Cosmed K5 measurements was 54.51 (SD = 3.85). This difference was statistically significant, t(38) = 3.101; p < 0.05.

The effect size for the independent simples ttest for the post-test data for both methods is estimated using the denominator, but in this test, The Cohen's d coefficient uses the pooled standard deviation. The Hedges correction uses the pooled standart deviation of 1.102, and a correction factor of 4.75041, whilst the Glass's delta uses the sample standard deviation of the control with a value of 1.357, which means the second group. The Cohen's d = 1.132, shows that that the difference was really big and this effect is very strong. This result can be confirmed by the post-test mean difference between two methods of measurements with a value of 5.23 mlmol/kg/min, which can be expressed as 8.75 %.

The main findings of this study is that improvements of VO₂ max values with Treadmill in VO₂ max are slightly greater than those reported with the Cosmed K5 method. Even though the VO₂ max values with Treadmill are higher compared to those of the Cosmed K5 method, the absolute change value of 13.4 % with K5 measurements is greater compared with the absolute change of 8% for treadmill. This change is a consequence of the effect of training on the cardiovascular responses to maximal exercises, in which the changes that are induced by physical training, are specific to the muscles involved in that in terval method training.

The results of this study are in a line with another study which demonstrated that the average oxygen uptaken for international athletes ranges from 55-68 ml/kg/min (Slimani, et al., 2019). good maximal consumption of oxygen, clearly illustrates that a person's level of physical fitness also has a VO₂ max and good physical fitness in an athlete, can prevent or minimize the possibility of injury, and using effective training methods has a difference compared to conventional training program in improving VO₂ max (Ridho et al., 2020). Although the aerobic capacity varies at different workloads, there are several methods to evaluate and estimate work intensity (Habibi et al., 2014). Previous studies have reported after applying special training programs with moderate interval intensity can improve the VO₂ max and aerobic performance levels (Kukeli & Skënderi, 2018). A meta -analysis study has suggested that endurance exercise training studies frequently show modest changes in VO₂ max with training and very limited responses at some subjects, and longer intervals combined with high intensity continuous training can generate marked increases of VO₂ max in almost all relatively young adult (Bacon et al., 2013).

The results of this study are also consistent with those of other investigations, which have shown that high intensity training in the form of special soccer games can increase aerobic capacity $(VO_2 max)$, (Seeger, 2016). The results of the present study show that HIIT program were effective in increasing VO₂ max.at the national elite boxers. Based on the data obtained, we believe that VO2max was substantially lower in Cosmed K5 than in treadmill method. Considering previous studies, that also indicated lower 'VO2 values in BBB at high intensities and a superior validity of the K5 in DMC mode (Winkert et al., 2021), the authors conclude that the Cosmed K5 is the accurate and the best mode to measure VO2max in athletes, and it should be selected.

Discation

The results of the present study suggest that, the HIIT composed by functional training, have the most benefit form improving maximal oxygen uptake. Based on the results of this study, and their statistical significance, it was found that the value of VO₂ max in methods (treadmill and Cosmed K5) was statistically increased after a 12 week HIIT program. The estimated mean change in the Vo max data, showed an increased value of 4.78 mlmol/kg/min for pre to post-test mesurements for treadmill was about 8%, compared to the increased value of 7.35 mlmol/kg/min for pre to post-test measurements for Cosmed K5 was 13.4%, with an additional difference of 5.4% more compared to treadmill.

The main findings of this study is that improvements of VO2 max values with Treadmill in VO₂ max are slightly greater than those reported with the Cosmed K5 method. Even though the VO₂ max values with Treadmill are higher compared to those of the Cosmed K5 method, the absolute change value of 13.4 % with K5 measurements is greater compared with the absolute change of 8% for treadmill. The results have verified that the Cosmed K5 is very effective and it is highly recommended to use widely for the other interests group or sports disciplines that not involve maintaining stable body position, but sports that require a verygood coordination, agility and flexibility. As a conclusion, the results taken from the VO₂ max measurements from treadmill and Cosmed K5 methods revealed that is the accurate and the best mode to measure VO2max at athletes. and it should be selected. We hope and believe that this study will help other researches to prove and to apply Cosmed K5 as the accurate method of VO₂ max. measurement. In summary, this study indicates there are differences between two methods of measuring VO₂ max at elite boxers. These findings suggest that the Cosmed K5 method is adequate for estimation of VO₂ max.

Impact of the Study

The results of this study serve to change the concept that applying a special training program, such as HIIT, these exercises can improve performance levels of aerobic capacity and oxygen uptake. More studies are needed to investigate the validity of this method, which include other samples also in different disciplines as well as active or no active subjects. It is also it is important to involve other interests' groups as comparative groups and to evaluate this effect using regimes which allow generating the most possible physiological adaptions, so that the effectiveness of VO₂ max with Cosmed K5 can be confirmed.

Study Limitations

However, there are some limitations, which need to be validated for the future researches. These

limitations include: the size of the sample used, so it is necessary to involve a wider sample size, including subjects of different ages and weights, in order to see the results over a longer period of time and to reduce comparisons between them.

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Funding Statement

This research was unfunded. No author has any financial interest or received any financial benefit from this research.

Conflict of interest

We declare that the article we have written is not involved in any conflict of interest.

Ethics Statement

This research has met ethical rules. Research ethical approval was obtained from the UST Ethics Committee for Scientific Research with project number 978/2, approved date 14/05/2024.

Author Contributions

Study design, MB and AB; Data collection, MB and SB; Statistical analysis, AB and OK; Data interpretation, MB, AB and SB. Literature search, MB, SB and OK. All authors have read and approved the published version of the manuscript.

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