2022, *Retos, 43,* 1073-1078
 ISSN: Edición impresa: 1579-1726. Edición Web: 1988-2041 (www.retos.org)

Most effective mean for lactate clearance in Olympic wrestling
Medio más eficaz en el aclaramiento de lactato en luchadores olímpicos

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Abstract. This research project determined the most effective training mean for lactate clearance using the subaerobic functional area in Olympic wrestling athletes of the freestyle modality. Eight Olympic wrestlers participated (age: 20.1±2.74 years), using a four-phase crossover study design, in which the athlete performed active recovery alternating each of the training means (Elliptical machine, treadmill, crank ergometer and stationary bicycle); lactate samples were taken 5 minutes after each bout and 15 minutes after finishing the active recovery. The elliptical machine presented the highest average efficiency, with 56.6%, followed by the treadmill with a 54.1% efficiency average; the repeated measures ANOVA F test evidenced differences among the means (p = .001). Likewise, differences were found when performing the post hoc comparisons of minimal significant difference, between the elliptical machine with respect to the crank ergometer (p = .001) and the stationary bicycle (p = .007), but they were not registered between the elliptical machine and the treadmill (p = .737). Of the means analyzed in this study, the highest efficiency in the process of blood lactate clearance during active recovery was evidenced by the elliptical machine and treadmill.
Keywords: Olympic wrestling, lactate, metabolic clearance rate.

Resumen. La presente investigación determinó el medio de entrenamiento más eficaz en el aclaramiento de lactato utilizando el área funcional subaeróbica en deportistas de lucha olímpica de la modalidad de libre. Participaron ocho luchadores olímpicos (edad: 20.1±2.74 años), utilizando un diseño de estudio cruzado de cuatro fases, en el que el deportista realizó la recuperación activa alternando cada uno de los medios de entrenamiento (Elíptica, banda trotadora, ergómetro de manivela y cicla estática); las muestras de lactato fueron tomadas a los 5 min finalizado cada combate y a los 15 min de terminar la recuperación activa. La elíptica presentó el mayor promedio de eficacia, con un 56.6%, seguido de la banda trotadora con un 54.1%; la prueba F de ANOVA de medidas repetidas evidenció diferencias entre los medios (p = .001). Asimismo, se encontraron diferencias al realizar las comparaciones post hoc de diferencia mínima significativa, entre la elíptica con respecto al ergómetro de manivela (p = .001) y la cicla estática (p = .007), pero no se registraron entre la elíptica y la banda trotadora (p = .737). De los medios analizados en este estudio, la mayor eficacia en el proceso de aclaramiento de lactato sanguíneo durante la recuperación activa, lo evidenciaron la elíptica y la banda trotadora.
Palabras clave: lucha olímpica, lactato, tasa de aclaramiento metabólica.

Introduction

Freestyle wrestling is a combat sport, of permanent contact and intermittent nature, which alternates sequences of high and moderate intensity effort (García-García & Blasco-Lafarga, 2010), combining various grappling and counterattacks techniques, with a high participation of force and its manifestations, with predominating strength, resistance and power (Kraemer, 2004), where isometric and auxotonic muscular actions interact in maneuvers such as knocks, throws, pushes and turns (Petrov, 1986; Wozniak, Kosmol, Lutoslawska & Bem, 2004).

Fecha recepción: 07-04-21. Fecha de aceptación: 30-09-21
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These actions show explosive efforts of the lower limbs when performing rapid movements, and isometric actions in the upper limbs (Kraemer, 2001), so that in the fight there is a great predominance of the power and the non-oxidative glycolytic capacity (Hasegawa et al., 2006; Vardar, Tezel, Öztürk & Kaya, 2007); that is to say, the anaerobic metabolism of glucose plays a fundamental role (Chaabene et al., 2016; Papassotiriou & Nifli, 2018), generating a large production of blood lactate, which ranges between 14.8 and 20 mmol/l (Karnincic, Tocilj, Uljevic & Erceg, 2009; Nilsson, Csergö, Gullstrand, Tveit, & Refsnes, 2002); this metabolite affects performance, requiring efficient clearance processes during recovery pauses between bouts, by means of training that use aerobic processes (Lopéz-Chicharro & Vicente-Campos, 2017).

Such aerobic processes promote clearance, since

most of it is directly oxidized in type I fibers (H»50% at rest and 75-80% during sustained exercise) and only 25% by gluconeogenesis (Åstrand, Rodahl, Dahl & Strømme, 2010; Brooks, 2020), is in other words, aerobic endurance exercises directly accelerate the lactate oxidation process by between 75% and 90% (athletes with low and high levels of training, respectively) (López-Chicharro & Fernández-Vaquero, 2017).

In this way, when performing an active recovery between bouts, the lactate clearance processes are accelerated (Papassotiriou & Nifli, 2018), but the training mean used will affect according to the number of muscle groups involved; that is, if a training mean that activates a greater number of muscle groups will involve greater blood flow, it will facilitate the oxidation of lactate in type I fibers (Gladden, 2004), thus promoting effective recovery in a sport where not only upper limbs participate, but also the core and lower limbs (Kraemer et al., 2001).

Scientific evidence has shown that active recovery accelerates the processes of blood lactate clearance between bouts in the same session, dealing with them effectively (Lopéz-Chicharro & Vicente-Campos, 2017); in addition, an optimal zone of intensity of clearance speed is established (Greenwood, Moses, Bernardino, Gaesser & Weltman, 2008; López-Chicharro & Fernández-Vaquero, 2017; Lopéz-Chicharro & Vicente-Campos, 2017; Menzies et al., 2010); but there is no research comparing different training means to accelerate clearance, they are only limited to comparing the difference between active recovery and passive recovery and identifying the intensity zone.

Precisely, in the study carried out with 17 high-performance judokas, the active recovery and passive recovery were compared, observing how the group that performed the active recovery presented higher lactate clearance speed than the group that performed the passive recovery (Franchini, Yuri, Yuzo, Ayumi, & Kiss, 2003). Likewise, in another population of judokas, the active recovery on the treadmill at 70% of the lactic threshold (4 mmol/l) was compared with the passive recovery, finding the same results of the previous investigation, in addition to appreciating how the group that performed the active recovery presented a probability ten times greater to be successful in future matches with respect to those who performed a passive recovery (Franchini, de Moraes Bertuzzi, Takito & Kiss, 2009).

Furthermore, in two investigations, one carried out with eight judokas and another with kickboxing athletes, the effects of active recovery and passive recovery on lactate clearance levels were determined, finding statistically significant differences between the active recovery and passive recovery protocols in kickboxers (Ouergui, Hammouda, Chtourou, Gmada, & Franchini, 2014), but not so in judokas (Touguinha et al., 2011).

Now, in studies that analyzed the optimal intensity zone for lactate clearance, various exercise intensities were compared, finding that active recovery intensity values from 80% to 100% of the lactate threshold presented a greater clearance rate than those performed at 30%, 60% and 70% of the lactate threshold (Hermansen & Stensvold, 1972; Menzies et al., 2010).

In wrestling athletes, the study carried out on eight high-performance wrestlers stands out, where different areas of exercise intensity were compared during the 20 minute active recovery on a cycle ergometer, showing how the intensity of fatmax presented greater efficacy in lactate clearance (Ghorbani, Mohebbi, Safarimosavi & Ghasemikaram, 2015). Similarly, in another study, differences in recovery between heart rate and blood lactate were determined, identifying at three, 15 and 30 minutes after the efforts, how heart rate values decreased faster than blood lactate, in addition to finding a higher clearance rate at 15 minutes (K1vrak & Pepe, 2019).

According to what has been discussed priorly the aim of this research project was to determine the most effective training mean for lactate clearance using the subaerobic functional area in wrestling athletes.

Material and Methods

Participants

In this research, five male and three female wrestlers from the «Valle de Colombia» freestyle modality team participated (age: 20.1±2.74 years; body weight: 67.5±8.41 kg; height: 1.71±0.06 m and with experience in fighting practice of 6.75±2.31 years). Previously, the athletes, parents and coaches were informed about the blood lactate measurement protocol. After accepting and signing the consent and assent, the athletes underwent a preliminary medical examination, where anthropometric and electrocardiographic evaluations were performed, finding normal results and absence of cardiovascular, pulmonary and orthopedic diseases. The study was approved by the ethics committee of the «Universidad Unidad Central del Valle del Cauca» and was carried out in accordance with the guidelines of the Declaration of Helsinki.

Design

A four-phase crossover study design was used, where the most effective training mean in lactate clearance was determined in wrestling athletes, considering four sessions of three bouts each, separated by washout periods of 72 hours. Initially, the sequence of training means for lactate clearance was developed for each athlete, through the design of a tree diagram, followed by the choice of combat partners to finally randomize the sequences of mentioned means.

During the two weeks of intervention in the four training means, a standardized nutritional protocol was proposed and adapted to the energy requirements of each athlete, designing a basic menu of three meals (breakfast, lunch and dinner) and three snacks between meals, as well as good hydration during combat days.

Methodology

The athletes performed an adaptation process of two microcycles for the use of the training means, in this case the *Ergoselect 400* crank ergometer (Ergoline ltd., Bitz, Germany), *EVO 8600 – BS03 0030* exercise bike (Sport fitness, Medellín, Colombia), *TRM 833* treadmill and *EFX 885* elliptical (Precor ltd, Woodinville, Washington, United States).

Consequently, the variables of effort intensity were determined for each one of the training means, identifying the subaerobic functional area (80% to 100% of the lactate threshold) by means of blood lactate levels, with reference to values that fluctuated between 3.4 and 5.2 mmol/l which are close to the values found in other researches (Lopéz-Chicharro & Vicente Campos, 2017), being associated with the effort heart rate, controlled with a Garmin Forerunner 735XT (Garmin ltd., Olathe, Kansas, United States), and to the scale of subjective perception of effort (SPE)(6-20) (Borg, 1998), using a range between six and 10 of that stated scale.

Moreover, watts were used on the crank ergometer, Garmin (Garmin ltd., Olathe, Kansas, United States) cadence sensors were used on the exercise bike and the elliptical machine, while the running speed was controlled on the treadmill in km/h, all of them associated with the intensity variables above mentioned.

In the following two weeks, four sessions of combats were carried out in the fighting arena with 72-hour rest intervals; and in each of them the equipment, instruments and procedures described below were used.

Before starting each session, a 10-minute warm-up program of general cardiovascular activation was carried out, followed by 15 minutes of joint and muscle activation with gymnastic exercises and sport-specific technical actions; afterwards, a protocol similar to a day of competitions was carried out (three bouts, each of two rounds of three minutes, with a rest period between rounds of 30 seconds and 20 minutes between bouts), within which lactate intakes were made blood pressure and the active recovery process, using the following procedure:

Blood lactate measurements were performed five minutes after the end of each bout, applying all biosafety standards, such as the use of gloves, gown, and mask by the evaluators, and local asepsis with alcohol and soap with neutral pH in athletes in the ball of the index finger, where it was punctured with an automatic trigger lancet (Accu-chek) to obtain a blood sample from the second drop with 20 µl capillaries, then hemolyzed in 1 ml test microtubes and was subjected to analysis using enzymatic amperometry with the Biosen S-Line Sport (EKF-Diagnostik GmbH, Magdeburg, Germany).

Now, regarding the active recovery protocol after taking lactate, the wrestlers carried out the clearance process for 15 minutes by applying the training method established for the session, after finishing each bout, each one of them within the subaerobic functional area (80% to 100% of the lactate threshold), controlling maximum heart rate, subjective perception of effort, watts, running and pedaling speeds.

Finally, the blood lactate values at the end of the 15 minutes of active recovery were identified, extracting in the same area, the second drop of blood, which was subjected to the analysis in the Biosen S-Line Sport (EKF-Diagnostik GmbH, Magdeburg, Germany); this procedure was carried out three times during each session, that is, after each bout, emphasizing that each fighter carried out their active recovery processes in the four training means, one for each session.

Statistical analysis

A general linear model was used with two factors, both of repeated measures. The first, the measurement of blood lactate concentrations at five minutes (peak lactate) and at 15 minutes (after active recovery); and the second, as the main factor, the training means in the efficacy of lactate clearance as a response variable, evaluating the effect through said model in each of the three bouts developed and generally consolidating all bouts with their averages.

At first, the Mauchly W sphericity test was carried out in the three bouts and in the general average of the same, allowing to establish that the factors satisfied the

hypothesis of sphericity ($p > .05$) but there was no compliance in their interaction ($p < .05$), so the tests with assumed sphericity were used for the main effects of the two factors and the Greenhouse-Geisser correction test for the interaction effect.

Afterwards, the repeated measures ANOVA test were performed, which determined the existence of statistically significant differences between the training means; now, to identify differences between each training mean; post hoc comparisons were used, using the minimal significant difference, establishing a level of statistical significance of $p < .05$. All statistical analyzes were processed using SPSS 24, software for Windows (SPSS Inc., Chicago, IL, USA) and Office Excel 2016 (Microsoft Corporation, Redmond, WA, USA).

Results

The results indicated that the elliptical machine is the training mean that generates the highest lactate clearance, presenting an efficiency of 54.2% after active recovery in the first bout, 53.7% in the second bout and 61.4% in the third bout; obtaining a general average of 56.6% of efficacy. Now, regarding the active recovery in the treadmill, an average efficiency of 54.1% was observed, which indicates that the elliptical and the treadmill presented higher levels of efficiency in the clearance processes with respect to the active recovery performed in the cycle ergometer (M = 43.5%) and on the crank ergometer (M = 34.8%) (Table 1).

The repeated measures ANOVA F test results in the three bouts and their average, showed differences in the training means (Bout one $p = .012$; bout two $p = .005$) except for the third bout ($p = .316$), but when performing the general average of lactate clearance, a difference was observed ($p = .001$). Furthermore, when comparing the lactate clearance values after 15 minutes of active recovery with respect to the peak lactate value 5 minutes after the end of the bouts, differences in the general average of the time factor were appreciated ($p = .000$).

In the case of minimal significant difference post hoc comparisons for the training mean factor in the three bouts and their average, it was found that there were no statistically significant differences between the treadmill and elliptical machine; while highly significant differences were observed between the averages of the three bouts of the elliptical regarding the crank ergometer and the stationary bicycle (Table 2).

Table 1.
Performance of average lactate clearance in the three bouts.

Training means	Time (min)	Mean (mmol/l)	Standard error	Average difference	Efficiency	Effect size
Treadmill	5	11.117	1.010	6.013	54.1%	2.482
	15	5.104	.486			
Elliptical Machine	5	10.888	1.157	6.163	56.6%	2.671
	15	4.725	.465			
Stationary Bicycle	5	13.088	1.430	5.692	43.5%	1.307
	15	7.396	.428			
Crank Ergometer	5	12.771	.944	4.442	34.8%	1.939
	15	8.329	1.043			

Table 2.
Post hoc test of minimal significant difference for the training mean factor in the three bouts and their average.

Training means		*p* valor			
		Bout 1	Bout 2	Bout 3	Bout Average
Treadmill	Stationary Bicycle	.182	.061	.037*	.029*
	Crank Ergometer	.018*	.023*	.246	.022*
Elliptical Machine	Treadmill	.444	.902	.591	.737
	Stationary Bicycle	.011*	.015*	.099	.007**
Stationary Bicycle	Treadmill	.182	.061	.037*	.029*
	Crank Ergometer	.437	.996	.942	.598
Crank Ergometer	Treadmill	.018*	.023*	.246	.022*
	Elliptical Machine	.018*	.001**	.299	.001**

***** Statistically significant ** Statistically highly significant

Discussion

Of the four means of active recovery training used in this research, those that presented the highest efficacy in lactate clearance in Olympic wrestling athletes in the freestyle modality were those performed on the elliptical machine and treadmill, compared to the stationary bicycle and the crank ergometer.

As regards to the means of training in post-combat active recovery, there is no scientific evidence where different methods have been compared in the Olympic fight, most studies are limited to comparing the levels of lactate clearance between active recovery and passive recovery after a session of bouts (Franchini et al., 2003; Franchini et al., 2009; Ouergui et al., 2014; Touguinha et al., 2011;), which confirms the effectiveness of the active recovery processes in lactate clearance compared to passive recovery (López-Chicharro & Fernández-Vaquero, 2017; Lopéz-Chicharro & Vicente-Campos, 2017; Papassotiriou & Nifli, 2018).

Likewise, current scientific evidence considers that the optimal training zone for lactate clearance is between 80% and 100% of the lactate threshold (4 mmol/l) (Greenwood et al., 2008), (López-Chicharro & Fernández-Vaquero, 2017; Lopéz-Chicharro & Vicente-Campos, 2017; Menzies et al., 2010) which was the training zone used in this research when the intensity level in each of the training mean was previously determined, being assessed from blood lactate samples in the individual wrestlers, having as a reference value a concentration of 4 mmol/l.

According to the previous analysis, the theoretical gap focused on identifying which training means effectively facilitates this physiological process after each

bout, which is precisely the problem that was elucidated in this research, when verifying that there are no studies that have analyzed the incidence of the training mean on the efficacy of lactate clearance.

When finding in the results of this research that the elliptical machine and the treadmill had a greater efficiency in the clearance of lactate when performing active recovery after fighting, it can be deduced that there is a high incidence of muscle groups involved in the clearance of lactate (Gladden, 2004), given that these training means largely activate the upper and lower limbs; even appreciating how the elliptical was more effective than the treadmill as it involved the upper limbs to a greater extent, despite the fact that there was no statistically significant difference between these two training means.

Now, in regards to the active recovery performed on the crank ergometer, the lowest level of efficiency in lactate clearance was found, despite being a training mean that emphasizes upper limb muscle groups, which are subjected to intense isometric and auxotonic actions during fighting, manifested in constant grips and grasps (Petrov, 1986), which increases blood lactate levels, showing how this sporting modality has a great predominance of the fast-glycolytic pathway (Chaabene et al., 2016; Hasegawa et al., 2006; Papassotiriou & Nifli, 2018; Vardar et al., 2007). The low efficiency of the hand crank ergometer in the clearance process indicates that despite the involvement of the upper limbs during the matches, wrestling presents a high demand not only on these, but also on the lower limbs and the central muscles (nucleus) (Kraemer et al., 2001).

Determining the most effective mean of training in the lactate clearance process, after each wrestling match allows athletes to perform extensive sessions of competition, characterized by executing several matches (elimination and classification phases), in order to access the finals. This is precisely reflected when, at a physiological level, the training mean used in active recovery accelerates the clearance process promoting the direct oxidation of lactate by type I fibers and the gluconeogenesis process; thus, benefiting the preservation of liver and muscle glycogen reserves that are necessary to face the different high intensity muscular efforts that occur in Olympic wrestling, especially in the last bouts during a day of competition.

The elliptical as a training mean, stands as a pedagogical alternative in active recovery processes, which facilitates lactate clearance by involving both lower and upper limbs in the biomechanics of movement, being a highly effective option for the sports community and trainers of this combat modality, besides of not causing any type of impact, unlike the treadmill. Despite the low impact of the treadmill in active recovery workouts, this training mean is also effective in the lactate clearance process, considering that jogging is one of the most performed general actions by wrestlers during different stages of a macro-cycle of training, for which the athletes present an adaptation towards this motor gesture.

Conclusions

Of the means analyzed in this study, the highest efficiency in the process of blood lactate during active recovery was evidenced was evidenced by the elliptical machine and treadmill, showing statistically significant differences when comparing with the results found in the stationary bicycle and the crank ergometer. Therefore, the elliptical machine was found to set up as the most effective active recovery in the process of clearance.

Explanatory note

The authors of this article declare that they have no conflicts of relevant interest to the content of this manuscript.

Acknowledgements

The authors thank the coaches and athletes of the Morgan and Gladiator Olympic wrestling clubs for their participation and support to the research process.

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