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DISCONTINUOUS TRAINING METHODS AND THEIR INFLUENCE ON LACTIC AND CARDIAC BEHAVIOR IN HIGH PERFORMANCE 400M RUNNERS

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ABSTRACT
Introduction: High-intensity interval training is widely used to improve anaerobic and cardiovascular capacity in prolonged speed events, thereby increasing lactate tolerance and improving buffer and oxidation capacity, which delays muscle fatigue during maximum efforts.Objective: The aim of this study was to determine how discontinuous training methods influence the lactate and cardiac components of 400m runners from the

Ecuadorian national Paralympic team.Methodology: A pre-experimental study was conducted on a sample of seven high-performance athletes.Results: After applying for the t-Student test, a significance of < 0.05 was observed.Discussion: This demonstrates a positive impact on cardiac recovery and strengthening of the cardiovascular system, as well as significant lactate clearance due to appropriate adaptation to training. Conclusions: These findings confirm that discontinuous methods are effective for designing specific training programs for 400m athletes, especially in the special stage.

Keywords High performance; disability, heart rate; lactate; speed.

INTRODUCTION

Para Athletics is one of the largest adapted sports within the Paralympic movement, highlighted by its large number of Para athletes and countries. It is made up of athletes with physical, visual and intellectual disabilities, competing in track, field and marathon events, adjusting the regulations to their disability, to participate in Paralympic events the athlete must have an eligible disability and meet the World Para Athletics Minimum Disability Criteria. This manual details 10 eligible disabilities: 8 physical, 1 visual, and 1 intellectual (Reina et al., 2021). The classifying doctors assign a status to each athlete (N: new, C: confirmed, R: revision) after reviewing exams and reports, the professionals a fair and degenerative evaluation, to compete on equal terms (Paralympic.org, 2020).

The Paralympic Games is the event of the highest expression, they are held every 4 years, being the most important event for athletes with disabilities. To qualify for the Paris 2024 Paralympic Games, the classification marks in the discipline of Para Athletics, in the 400-meter event the marks were 0:48.61 sec for men and 0:59.60 sec for women, reflecting a highly competitive level close to that of able-bodied athletes. Coaches should adapt training methods to improve the performance of runners with intellectual disabilities (Paralympic.org, 2020).

Training is a structured process to achieve specific goals and improve sports skills, especially in high performance to compete among the best para-athletes in the world (Rodríguez, 2022). Para Athletics training for the 400m event should include physical, technical, tactical, strategic, psychological and physiological aspects, which, together with the coach and a team of doctors, physiotherapists, psychologists and nutritionists, work to optimize the performance of athletes in each phase of training (Bompa & Buzzichelli, 2018).

The Paralympic 400 meters T20 test is stipulated for athletes with intellectual disabilities, competing on a regulatory synthetic track of 400m, seeking to improve their performance with the use of different training methods, one of them being discontinuous training, so that they can manage the stress of training and competition in this way they can complete the 400m in the shortest possible time (Moposita, 2022). It is a difficult test due to the maintenance of the technical gesture of the race. Tactics are very important due to the distribution of energy throughout the competition. The anaerobic lactic energy system is of great predominance, the athlete must manage his energy reserves and have good lactic tolerance to complete the race (Gutiérrez, 2020).

This test requires multidimensional analysis and a personalized tactic per athlete. In the first 80 to 120 meters, they must maintain cadence and speed, moving towards speed resistance. Between 170 and 180 meters, the athlete accumulates lactic acid, completing almost 45% of the race. From 200 to 300 meters, it is crucial to maintain speed due to the high heart rate and lactate production. In the last 100 meters, the stride frequency changes, and psychological factors are key. In the last 40 m, the athlete must maintain the technique and the pressure of the effort until reaching the finish line (Claro Sports, 2024). It is here where ergogenesis, which refers to the distribution of energy systems according to their duration in relation to strength, endurance and speed training, is a test with the following energy system distribution: 12% anaerobic alactic, 58% anaerobic lactic and 30% aerobic (Rincón et al., 2022).

Table 1 System Classification, Duration, Capacity and Working Methods

Sistema de Energía	ANAEROBICO SIN PRESENCIA DE OXIGENO				AEROBICO CON PRESENCIA DE OXIGENO		
Modalidad	Potencia	Capacidad	Potencia	Capacidad	Potencia		Capacidad
Duración	1 – 6 seg	7 - 8 seg	9 – 20 seg	21- 60 seg	61 seg - 2 min	2 min - 8min	8 min +-120 min
Tipo de entrenamiento De fuerza que puede trabajar	Fuerza Máxima Potencia		Fuerza Máxima Potencia R. Potencia	Fmx, P, RP, RMC	FM, P, RP, RMM	FM, RP, RMM	FX (-80% de 1RM) RP, RML
Tiempo de recuperación en	Potencia 24 horas Capacidad 36 horas		Potencia 48 horas	Capacidad 72 horas	72 horas	48 horas	24 horas
Volúmenes de entrenamiento por sesiones de entrenamiento.	Distancia total de la sesión 600 metros		Distancia total de sesión 1200 metros	Distancia total de sesión 1500 metro Distancia total de la	Distancia total de sesión 4000	Largo	Largo
	Distancia total de serie 120 metros		Distancia total de serie 300 metros	serie 500 metros	Total de serie Largo		
Método sugerido Fraccionado Interválico			Interválico Muy Corto 8 seg - 15 seg / 3 - 4 Rep / Rec. 2 min - 3 min / macro 5 - 10 min / 6 - 8 series	Interválico Corto 8 seg - 20 seg / 60 seg / 3 - 4 Rep / Rec. 1 min - 2 min / macro 10 - 12 min / 3 - 4 series	Interválico Medio 1 min - 4 min / 12 - 15 Rep / Rec. 1 min - 3 min / 1 series	Interválico Largo 4 min - 15 min / 6 - 10 Rep / Rec. 2 min - 5 min	
Método sugerido Fraccionado Repeticiones				Repeticiones Cortas 20 seg - 30 seg / 6 - 10 Rep / Rec. 8 min - 10 min	Repeticiones Medias 40 seg - 70 seg / 4 - 6 Rep / Rec. 10 min - 12 min	Repeticiones largas 2 min - 3 min / 3 - 5 Rep / Rec. 10 min - 12 min	

Leyenda. RML = resistencia muscular de larga duración; RMMD = resistencia muscular de media duración; RMCD = resistencia muscular de corta duración; FM = fuerza máxima; P = potencia, y RP = resistencia de la potencia.

Note. Energy Systems and in relation to Training Methods. Taken and Adapted from (Gutiérrez, 2020; Valdés, 2019; Gastin, 2001).

MACRO STRUCTURE

The macrocycle covers a time interval of planning and can include the entire season or a fraction of it, according to the model used, the coach must take into account the control and fundamental competencies of the season (García, 2018; Martin et al., 2022). The Matveev periodization is ideal for training athletes with developmental intellectual disability and then the ATR model can be used to achieve a high level of performance. Periodization helps the trainer effectively manage volume, intensity, and breaks to achieve an optimal balance in workloads. The authors Masteferrer (2024), Camacho et al. (2019) and Coldeportes (2010) agree on the structure of (Matveev, 2001). Periodization which is composed of: Periods (preparatory, competitive and transitory), stages (general physical preparation, special, competitive and transitory physical preparation. Mesos: They constitute a coherent structure that is defined from the weeks of training, that is, the microcycles that cover from 1 to 6 weeks. Its objective is to promote the development of determining or conditioning capacities, and both the duration and the organization of the contents are aligned with the corresponding denomination or emphasis, these being: incoming, basic (developer and stabilizer), competitive modeling, competitive and re-establishment. Micros: The microcycle is characterized by scheduled training sessions per day, with the corresponding hours, there should be a progressive increase in both the volume and intensity of training. The duration of a microcycle can vary between 2 and 7 days and is integrated within the framework of the mesocycle, these being the following: (current, adjustment, shock, approach, competition and recovery) and Training sessions which can be distributed by quantifying kilometers, time or repetition, in the different low, medium, high and super high intensities.

TRAINING METHODS

Training methods are organized procedures that help athletes to improve conditional physical capacities such as endurance, speed, strength and technique, being distributed according to each period, stage, meso and micro cycle, within the training process, the development and work of coordination skills such as coordination, agility, balance and rhythmizing is also consolidated to optimize performance (Forteza de la Rosa, 2000).

DISCONTINUOUS METHODS

This methodological approach is mainly characterized by the segmentation of the workload and the associated rest time, emphasizing the alternation between effort and recovery (Forteza de la Rosa, 2000). The training volume is distributed according to the specific objectives of the training period; the trainer must calculate the percentage of Maximum Aerobic Speed (MAV) or VO2max. An active, passive or mixed recovery is determined according to the percentage of load. Recovery will depend on the intensity of the exercise and the athlete's experience. Fractionated methods significantly increase the size of the myocardium in the heart chambers. It is crucial for the athlete to distinguish between slow and fast rhythms (Moyano & Bolognese, 2024; ISAF, 2021).

INTERVALLIC DISCONTINUOUS METHOD

Interval training mixes intense and extensive loads with active rest of 120 to 130 bpm, adjusting intensity and volume. It improves aerobic and anaerobic capacity, optimizing performance over various distances. Interval methods are summarized, differentiating between extensive and intensive training (Lasso & Chalapud, 2024). A distinction is made between short, medium and long-term interval methods, which are related to power, lactic capacity and speed resistance, which are crucial in speed and medium-distance events. In the 400-meter test, the use of the short and medium-duration discontinuous method is beneficial for the development of the anaerobic threshold due to its duration of less than and more than 60 seconds (Morocho et al., 2021).

The Intervallic Method uses incomplete breaks in training, controlling recovery from 60% to 80% depending on the season, duration and intensity. Some studies quantify interval training by distance and pause (1/1, 1/2, 1/3, 1/4). Recovery can be doubled or tripled depending on the intensity and pulse. Some physiologists and trainers see 120-130 ppm as ideal for cardiac recovery in the interval method. This methodology causes myocardial hypertrophy due to greater peripheral resistance and improved performance in breaks (Yang et al., 2023) The interval method combines work and short breaks that do not allow full recovery, adjusting to the level of the athlete. Moyano and Bolognese (2002) and Weineck (2005) propose distinguishing between intensive and extensive interval work in adult athletes. This information is key to visualizing distances, repetitions and pauses, as well as to quantify the load related to power, lactic capacity and resistance to speed.

INDICATORS WITHIN SPORTS PERFORMANCE

In sports performance it is a sum of indicators that allow effectiveness in competition, several indicators stand out, such as biomechanical, psychological, technical-tactical, functional biological, biochemical, anthropometric and physiological. These reflect the effect of effort on high competition. Physiological indicators, especially heart rate and lactate production, are key to measuring effort and determining training load (Comas, 2023; Unisport, 2023).

HEART RATE

The heart rate is defined as the number of contractions that the heart makes in one minute, expressed in beats per minute ppm, the heart rate can be monitored with an electronic sensor such as the heart rate monitor or manually by the method of cardiometry by the manual measurement in the carotid vein, this indicator manifests its elevation in action to the effort of the person's activity, one of the recommendations is to have resting values, before the activity, at the end of the activity, at 60˝, 3´ and 5´ in this way a curve can be established and this behavior can be evaluated according to the training period (Hincapié et al., 2024; Escobar, 2018).

MAXIMUM HEART RATE

The maximum heart rate can be estimated through indirect algorithms, which are a valuable tool for coaches, as it allows them to consider the percentage of the effort made, according to Tapia (2023) and Chinome et al. (2016) propose five standardized formulas that have been validated through scientific evidence and that have facilitated the estimation of cardiac effort, which are described below:

- ACSM: HR max=220–age
- Tanaka: Maximum oxygen consumption (HR max) = 208 - (0.7 × age)
- English: HRmax = 214 – (0.65 × age)
- Men's Whaley: Maximum HR = 214 - (0.79 × age)
- Whaley Women: Freg=209 – (0.72 × age)

LACTATE

Lactate is a byproduct generated during exercise, whether aerobic or anaerobic in nature (Vargas et al., 2023). Lactate includes the following chemical formula ($C_3H_5O_3^-$) and a hydrogen ion (H^+) when in an environment with a slightly acidic pH, such as that of muscles during intense exercise. Although it is produced as lactic acid during anaerobic glycolysis, the term "lactic acid" actually refers to the acidic form that is generated, but in most tissues, lactic acid is found in its lactate form (Vélez et al., 2021). However, it is important to note that this metabolite can also be used as an energy source through recycling in the Cori cycle, where it is transformed into ATP and CO2. Its production originates in the mitochondria of muscle cells (Pesántez & Chica, 2024; García, 2018).

Sprinters, when running at high speeds, rely primarily on the anaerobic system to generate energy. This means that due to the high demand for energy in a short period of time, lactate is produced as a byproduct of anaerobic glycolysis. This process is efficient at generating energy quickly, but it also results in the accumulation of lactate in the muscles. Although lactate is not primarily responsible for fatigue, the accumulation of hydrogen ions, which accompany lactate, can lower the pH in the muscles, creating an acidic environment. The lactate threshold is the point at which lactate production in the muscles exceeds the body's ability to eliminate it (Olbrecht, 2024).

Trained sprinters typically have a higher lactate threshold, which means they can maintain a high level of intensity without accumulating lactate as quickly. This allows them to sustain a fast speed for longer. Lactate can be transported to the heart, muscles, and brain, where it is converted back into energy. This process is known as the Cori cycle, and it is essential to maintain anaerobic efforts during intense activities. Speed workouts help improve the body's ability to remove and recycle lactate more efficiently. Trained sprinters are able to use lactate more efficiently than less trained athletes (López, 2024; Díaz et al., 2012).

Table 2 Lactate Concentrations in the Differences Distances

Distance Traveled at Maximum Possible Speed	Blood Lactate Concentration in Mmol/l
100 m	12,5
400 m	20,1
800 m	21,9
1500 m	20,8

Note. Retrieved from (Garcia Verdugo, 2018, pág. 82)

METHOD

Discontinuous methods are those that can be fragmented and used harmoniously with units of time or distance, with adequate complete and incomplete rest according to the demand of the load, for this purpose a quantitative approach research was used, with an experimental design, of a pre-experimental type (Díaz & Romero, 2022) with a pre-test and post-test to evaluate the indicators of the 400m test such as heart rate, lactate and final execution time, in this way to analyze the effects of the application of the discontinuous training method, in a sample of n=7 high-performance athletes with intellectual disabilities of the national Paralympic team of Ecuador and in their vast majority are registered among the top 12 of the world ranking, these being 4 women and 3 men, with a non-probabilistic sampling for convenience (Hernández, 2021), since they are the best for national athletes who register in the country, theoretical methods such as synthetic analytical were also used to describe all the arguments of the research and empirical methods such as observation and measurement to be able to record and quantify the results of the indicators that support the research, as for the statistical method used, descriptive analysis was through the SPSS v.25 program, which allowed quantifying the means of the final times, heart rate and lactate described in tables, and graphs to be able to analyze the curves of rest, production, recovery and lactic clearance at the beginning and at the end of the research.

POPULATION AND SAMPLE

To comply with the effects of studies, a sample of athletes from the national Paralympic team of Ecuador was considered, it is a sample of great relevance since at the national level the para-athletes have an IPC license and are the best in the country and constantly participate in national and international events, being sprinters of the 400 m test, with the following characteristics.

Table 3 Sample Characterization

Indicator	Disability (%)		Age (years)		Weight (Kg)		Height (cm)		IMC		Fat Percentage		Masa Corporal (Kg)	
	M	DS±	M	DS±	M	DS±	M	DS±	M	DS±	M	DS±	M	DS±
Women (n=4 – 42,86%)	46,62	14,07	23	3,51	54,09	0,98	1,63	0,06	20,35	1,31	9,95	0,82	50,59	1,5
Males (n=3 – 57,14%)	49,99	11,59	21	1,53	63,02	3,65	1,70	0,02	20,16	1,12	9,93	1,0	51,82	3,42
Total (n=7 – 100%)	48,01	12,08	22	2,81	59,7	3,1	1,66	0,05	20,27	1,13	9,94	0,82	51,11	2,35

Note. Anthropometric Analysis; Mean (M) and Standard Deviation (SD±).

As can be seen in the table above, the data are segmented by women and men, of the total analyzed by the percentage of intellectual disability was 48.01 ± 12.08%, as for age a mean of 22 ± 2.81 years is recorded, the weight recorded was 59.7 ± 3.1 kg, height was 1.66 ± 0.05 meters, BMI was 20.27 ± 1.13 and body mass was 51.11 ±. 2.35, characteristics that are closely linked to 400-meter runners with intellectual disability that is in a range of mild to moderate.

DATA COLLECTION TOOL

For the purposes of the evaluation, the 400-meter flat test was used on an approved track, being the same distance of the competition, it is correctly validated by (Orgaz, 2024; Aguilar et al., 2022; Páez et al., 2021;) For the recording of the indicators, the final time, heart rate and lactate were taken into account, within the protocol of taking were those at rest, at arrival, at one minute, at 3 minutes and at 5 minutes, in order to be able to establish curvatures and analyze the significant differences after the application of the training based on the discontinuous method. for the recording of the heart rate, the Garmin 920XT watch with the chest strap was used, recording the heart rate in real time, as for the recording of lactate, the StatStrip Xpress device with test strips with a response time of 13 seconds was used, a recorder, a heart rate evaluator, a lactate evaluator and another for taking times.

PROPOSAL FOR DISCONTINUOUS TRAINING

Below is a summary of the types of discontinuous training methods used within a specific period, with a duration of 3 months, being 12 weeks with a frequency of 2 to 3 times a week, in accordance with the performance of each athlete.

VERY SHORT INTENSIVE INTERVAL METHOD

This method involves short, powerful stimuli of 8 to 15 seconds, with 3 to 4 repetitions and 6 to 8 sets, and recoveries of 2 to 3 minutes between repetitions and 5 to 10 minutes between sets. It improves lactic anaerobic power, increases ATP and PC, and improves coordination and fast fibers. Examples of work are: 3 x (4 x 10 sec R6 / 2min R0) / 10 min R0, 3 x (3 x 15 sec R6 / 3min R0) / 5 min R0 and 5 x (4 x 8 sec R6 / 3min R0) / 10 min R0 (Fuentes et al., 2024; Pallares, 2015; Peinado, 2012).

SHORT INTENSIVE INTERVAL METHOD

This method uses stimuli of 20 to 60 seconds with 3 to 4 repetitions and sets, with recoveries of 1 to 2 minutes between repetitions and 10 to 12 minutes between sets, in R3 and R4 intensity efforts (100-120%). It improves VO2 max, reduces %VT2, increases lactic acid tolerance and raises PC and glycogen stores. Typical exercises include: 3 x (3 x 1 min R3 / 1 min R0) / 10 min R0, 4 x (3 x 30 sec R4 / 2 min R0) / 10 min R0, and 2 x (4 x 45 sec R3 / 1 min R0) / 10 min R0 (Fuentes et al., 2024; Pallares, 2015; Peinado, 2012).

MEAN INTERVAL METHOD

This method uses medium-duration (60" to 4') and medium-capacity stimuli (1-3 repetitions, 1 set) with recoveries of 1 to 3 minutes, in an effort of R3 intensity (85%-105% VAM and HR < 90%). Improves VO2 max, reduces %VT2, and optimizes stroke volume, lactate tolerance, and glycolytic and oxidative enzymes. Typical exercises include: 12 x 2 min R3 / 2 min R0, 14 x 3 min R3 / 3 min R0 and 4 x 4 min R3 / 3 min R0 (Fuentes et al., 2024; Pallares, 2015; Peinado, 2012).

LONG INTERVAL METHOD

This method uses long-duration stimuli (4-15 min) and high load (6-10 repetitions, 1 set), with recoveries of 2-5 min and efforts at 61%-88% of the VAM (R2-R3, Fc 80-92%). Its effects include anaerobic threshold shift, improvement in peripheral irrigation, increased glycogen and myocardial hypertrophy. Examples include 6 x 10 min R2/2 min R0 and 3 x 15 min R2/3 min R0 (Fuentes et al., 2024; Pallares, 2015; Peinado, 2012).

RESULTS

Once the pre-test and post-test had been applied to athletes with intellectual disabilities in the 400m event, the indicators of heart rate, lactate and final time were recorded, in order to be able to tabulate and analyze descriptively by gender and in total of the sample, using graphs to expand the understanding and to be able to analyze the behavior of these indicators during the established shots. under the condition that if the sample is less than 30, it will be validated by the Shapiro Wilk test, where it was verified that the data comply with a normality and the significance was evidenced over p>0.05, in this way it was tabulated with T-Student parametric test.

ANALYSIS OF THE LACTATE BEHAVIOR CURVE

Lactate is a product of metabolism where pyruvate is elevated due to the effects of exertion and when there is decompensation with oxygen intake (Matus et al., 2020). The objective of athletes was to produce, master and tolerate lactate so that in response to competition it can be more effective, the results are shown in Table 4.

Table 4 Lactate Intake Registration Pre Test and Post Test

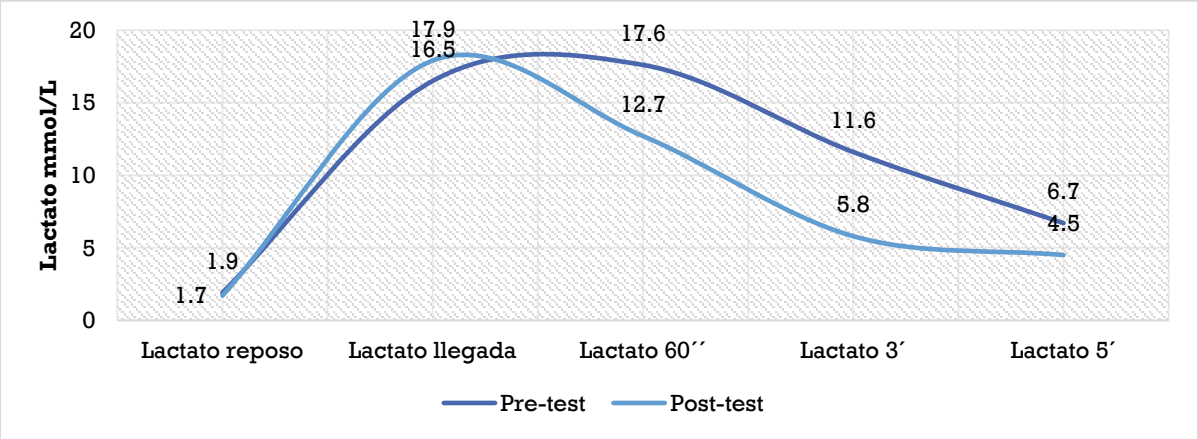
		Pre-test			Post-test			T-Student
Gender	Indicator	Min	Max	M (DS)	Min	Max	M (DS)	p-value
Women n=4	Lactate rest	1,5	2,3	1,9 ± (0,4)	0,9	1,7	1,3 ± (0,4)	0,09
	Lactate arrival	15,6	17,8	16,5 ± (1,0)	16,8	19,5	18,3 ± (1,1)	0,03
	- Lactate 60´´	16,8	19,4	17,9 ± (1,2)	11,5	14,2	12,9 ± (1,2)	0,02
	Lactate 3´	10,5	14,2	12,7 ± (1,6)	4,6	6,9	5,8 ± (1,0)	0,00
	Lactate 5´	5,8	8,3	6,7 ± (1,1)	3,5	5,9	4,6 ± (1,0)	0,00
Males n=3	Lactate rest	1,1	2,2	1,5 ± (0,6)	1,9	2,5	2,1 ± (2,1)	0,42
	Lactate arrival	14,8	18,9	16,3 ± (2,1)	16,5	18,5	17,2 ± (1,1)	0,67
	- Lactate 60´´	16,4	17,6	17,0 ± (1,0)	10,5	13,6	12,9 ± (1,6)	0,05
	Lactate 3´	8,8	11,3	9,8 ± (1,3)	4,9	6,2	5,5 ± (0,7)	0,02
	Lactate 5´	5,6	7,2	6,3 ± (0,8)	3,9	4,7	4,1 ± (0,5)	0,04

	Lactate rest	1,1	2,3	1,9 ± (0,4)	0,9	2,5	1,7 ± (0,6)	0,43
	Lactate arrival	14,8	18,9	16,5 ± (1,4)	16,5	19,5	17,9 ± (1,2)	0,08
Total n=7	- Lactate 60´´	16,4	19,4	17,6 ± (1,0)	10,5	14,3	12,7 ± (1,3)	0,00
	Lactate 3´	8,8	14,2	11,6 ± (2,1)	4,6	6,9	5,8 ± (0,8)	0,00
	Lactate 5´	5,6	8,3	6,7 ± (0,9)	3,5	5,9	4,5 ± (0,8)	0,00

Note. Lactate Samples and Mean Analysis: Minimum (Min), Maximum (Max), Mean (M) and Standard Deviation (SD).

After the collection of pre-test and post-test data, it was evident that the effects on resting and arrival were not significant, while in the 60´´, 3´ and 5´ shots there was evidence of a significant decrease and in verification of the parametric T-Student test it was verified that no significant changes were shown at rest. while at the finish it rises due to the effects of an improvement in time, at 3´ and 5´ there is evidence of significant improvement in recovery and clearance, then training through the discontinuous method managed to improve this lactic tolerance benefiting their competitive condition.

Figure 1 Lactate Behavior Curve



Note. Analysis of the Lactate Behavior Curve.

After the analysis of the data table, the graph of the pre-test and post-test of the lactate intakes is presented, it was possible to evidence significant differences in the means of lactate at rest in the pre-test of 1.9 ± 0.4 mmol/L and in the post-test 1.7 ± 0.6 mmol/L, in the arrival in the pre-test 16.5 ± 1.4 mmol/L and in the post-test 17.9 ± 1.2 mmol/L. at 60 seconds in the pre-test 17.6 ± 1.0 mmol/L and in the post-test 12.7 ± 1.3 mmol/L, at 3 minutes in the pre-test 11.6 ± 2.1 mmol/L and in the post-test 5.08 ± 0.8 mmol/L and at 5 minutes in the pre-test 6.7 ± 0.9 mmol/L and in the post-test 4.5 ± 0.8 mmol/L, It was clearly noted that in the post-test the lactic clearance process was improved.

HEART RATE BEHAVIOR ANALYSIS

Heart rate is a physiological indicator that is closely linked to effort, i.e. the greater the effort, the greater the increase in this indicator (Muñoz & Tlahuetl, 2023). In the same way, the pre-test and post-test evaluations were taken into account, recording with the same protocol at rest, on arrival, at 60 seconds, 3 minutes and 5 minutes as shown in the following table.

Table 5 Recording of Pre Test and Post Test Heart Rate Measurements

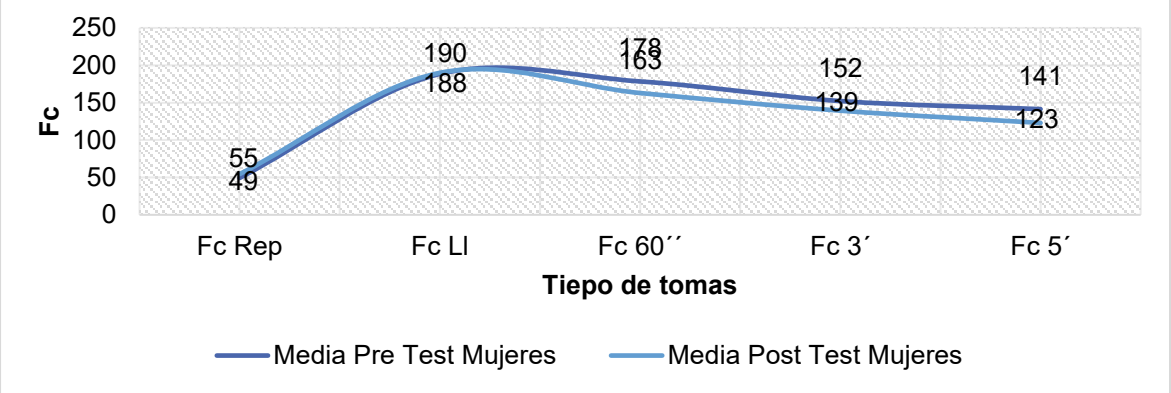
		Pre-test			Post-test			T-Student
Gender	Indicator	Min	Max	M (DS)	Min	Max	M (DS)	p-value
Women n=4	Resting HR	48	62	55 ± (5,9)	42	54	48 ± (5,3)	0,00
	Fc arrival	182	194	188 ± (5,5)	186	194	189 ± (3,7)	0,60

	Fc 60´´	172	184	178 ± (5,0)	158	168	162 ± (4,2)	0,00
	Fc 3´	144	162	152 ± (8,1)	132	146	139 ± (6,0)	0,04
	Fc 5´	138	148	141 ± (4,4)	110	132	122 ± (9,6)	0,04
Males n=3	Resting HR	47	66	54 ± (9,6)	46	52	48 ± (3,1)	0,01
	Fc arrival	188	192	189 ± (2,3)	176	186	179 ± (5,3)	0,00
	Fc 60´´	174	184	179 ± (5,3)	150	158	153 ± (4,2)	0,00
	Fc 3´	138	168	153 ± (15,1)	126	148	136 ± (11,0)	0,00
	Fc 5´	136	148	143 ± (6,4)	114	136	125 ± (11,0)	0,00
Total n=7	Resting HR	47	66	55 ± (6,9)	42	54	49 ± (4,1)	0,00
	Fc arrival	182	194	190 ± (4,1)	176	194	188 ± (6,4)	0,02
	Fc 60´´	172	184	178 ± (4,7)	150	168	163 ± (6,4)	0,00
	Fc 3´	138	168	152 ± (10,4)	126	148	139 ± (7,7)	0,00
	Fc 5´	136	148	141 ± (5,0)	110	136	123 ± (9,3)	0,00

Note. Heart Rate Samples and Mean Analysis: Minimum (Min), Maximum (Max), Mean (M) and Standard Deviation (SD).

As shown in Table 5, the effects of heart rate, after the application of short and medium discontinuous training, it was possible to improve cardiac values, in the rest intake there is a minimal decrease, in the arrival take there were only 2 beats that shows a slight improvement in their cardiorespiratory condition, while in the 60´´, 3´ and 5´ shots a significant decrease is shown, and when relating the results to the T-Student test the significance was < 0.05, evidencing that the discontinuous method significantly improves the cardiorespiratory response.

Figure 2 Heart Rate Behavior Curve



Note. Analysis of the Heart Rate (HR) Behavior Curve.

Figure 2 shows the values collected from the means where the resting Hr in the pre-test was found at 55 ppm and in the post-test at 49 ppm, at arrival in the pre-test it was found at 190 ppm and in the post-test at 188 ppm, at 60 seconds in the pre-test it was found at 178 ppm and in the post-test at 163 ppm. at 3 minutes in the pre-test it was found at 152 ppm and in the post-test at 139 ppm and at 5 minutes in the pre-test it was at 141 ppm and in the post-test at 123 ppm, an elevation is observed at the finish due to the lactic effort of the 400m test and from this moment on the curve expresses a downward trend, This is due to the training adaptation process given by the benefits of the discontinuous method, this allows the heart to adapt to the effort and improve its recovery capacity.

HALF TIME ANALYSIS 400M PRE AND POST

Within the performance of this test undoubtedly execute it in the shortest possible time, that is to say that the lower the time the better the performance will be, although there are external factors that are immersed such as track conditions, weather, wind, public among others, the results are shown below.

Table 6 Runtime Analysis 400m Test Before and After the Intervention

Time	N	My	Max	M	DS	T Student p-value
Women's 400m Pre test	4	62,9	64,01	63,25	0,51	0,00
Women's 400m Post test	4	58,1	62,79	60,45	2,07	0,00
Men's 400m Pre test	3	50,14	52,16	51,22	1,02	0,00
Men's 400m Post test	3	48,24	54,60	50,70	3,33	0,00
Total Time Pre test	7	50,14	64,01	57,47	6,46	0,00
Total Time Post test	7	48,24	62,79	55,84	5,70	0,00

Note. Times by Gender and Total Times and Mean Analysis: Minimum (Min), Maximum (Max), Mean (M) and Standard Deviation (SD).

Table 6 shows the times made before and after the intervention, where the average of the pre-test was 57.47 ± 6.46 and in the post-test it is 55.84 ± 5.70, that is, they improve the time with other words, the discontinuous method positively influences the final time, this will allow them to be among the top 10 in the world and have great options to qualify for the Paris 2024 Paralympic Games.

DISCUSSION

COMPARISON WITH PREVIOUS STUDIES

The findings of this study underscore the efficacy of discontinuous training methods in modulating lactate levels and cardiovascular responses in 400-meter intellectual runners of the national Paralympic team of Ecuador. These results are consistent with previous research indicating that discontinuous workouts through high-intensity intervals may contribute to improved lactate tolerance and cardiovascular recovery capacity (Fuentes et al., 2024). In particular, it is evident that the implementation of active breaks and the control of intensities optimize metabolic adaptations, which is essential in a test as demanding as the 400 meters, in which anaerobic metabolism predominates (Díaz et al., 2012).

LACTIC RESPONSE

The analysis of lactate behavior with the use of discontinuous methods facilitates an efficient management of lactate peaks that occur during maximal efforts (Matus et al., 2019). This indicates that this type of training promotes enzymatic and metabolic adaptations that enhance the capacity for lactate tolerance and clearance, which is essential to prevent the onset of premature fatigue (Vélez et al., 2021). Likewise, a reduction in lactate accumulation was identified with repeated high-intensity efforts, which could be attributed to an improvement in runners' ability to use lactate as an energy source through oxidation processes (Celdran & Sola, 2023).

The evidence of the study shows significant differences in the mean lactate at rest in the pre-test of 1.9 ± 0.4 mmol/L and in the post-test 1.7 ± 0.6 mmol/L, in the arrival in the pre-test 16.5 ± 1.4 mmol/L and in the post-test 17.9 ± 1.2 mmol/L, at 60 seconds in the pre-test 17.6 ± 1.0 mmol/L and in the post-test 12.7 ± 1.3 mmol/L. at 3 minutes in the pre-test 11.6 ± 2.1 mmol/L and in the post-test 5.08 ± 0.8 mmol/L and at 5 minutes in the pre-test 6.7 ± 0.9 mmol/L and in the post-test 4.5 ± 0.8 mmol/L, at rest and arrival no differences are shown, but at minutes, 3 minutes and 5 minutes a notable decrease is visualized, In this way, discontinuous training with the short and medium interval method managed to improve the lactic capacity, tolerance and recovery of intellectual Para athletes of 400 meters.

CARDIAC RESPONSE

With regard to cardiac response, discontinuous methods have been shown to be effective in optimizing heart rate control during the recovery period between intervals (Billat, 2002). This indicates that the cardiovascular system adjusts not only to face greater anaerobic demands, but also to optimize recovery, a crucial element in performance in events that integrate explosiveness and endurance, such as the 400 meters (Moposita, 2022). In contrast to continuous training methods, discontinuous training approaches seem to have a more significant influence on heart rate variability, which is considered an indicator of good cardiovascular health and ability to adapt to training (Boullosa et al., 2020).

Within the study, resting Fc in the pre-test was found at 55 ppm and in the post-test at 49 ppm, at arrival in the pre-test it was found at 190 ppm and in the post-test at 188 ppm, at 60 seconds in the pre-test it was found at 178 ppm and in the post-test at 163 ppm. at 3 minutes in the pre-test it was found at 152 ppm and in the post-test at 139 ppm and at 5 minutes in the pre-test it was at 141 ppm and in the post-test at 123 ppm, it is observed that HR improved considerably, this method through its complete and incomplete recovery allows to develop and stimulate the cardiorespiratory system to better tolerate anaerobic efforts.

FINAL TIME

The final time allows us to establish a comparative analysis on the improvement of the marks in this type of lactic tests, in the case of the intellectual athletes of the national team of the 400-meter test the initial average was 57.47 ± 6.46 and the final average was 55.84 ± 5.70, that is, 1.37 seconds improved in a period of 12 weeks. It should be noted that the athletes completed approximately 11 sessions per week, and the discontinuous method was used 2 to 3 times a week.

PRACTICAL APPLICATIONS

From a practical approach, the results of this research support the application of discontinuous methods as a fundamental tool for coaches and athletes in optimizing performance in 400-meter events. Structured sessions with specific intervals facilitate the simulation of the energetic and physiological demands associated with the event, thus optimizing the transfer to competition performance. In addition, the attention paid to strategic breaks provides flexibility to adapt the training load according to the level and specific needs of each athlete, which contributes to reducing the risk of injury and overtraining.

CONCLUSIONS

The findings of this research demonstrate that discontinuous training methods are significantly effective in improving the lactic and cardiovascular performance of Paralympic 400-meter athletes. These methods facilitate an improvement in lactate tolerance and optimize metabolic responses, leading to a greater ability to sustain high-intensity efforts and achieve more effective recovery between intervals. Similarly, the identified modifications in the cardiac response indicate a strengthening of the cardiovascular system, which leads to advantages in heart rate regulation and in the ability to recover after maximal efforts. From a practical perspective, the inclusion of discontinuous training in high-performance training programs represents a versatile and specific tool that adjusts to the energy demands inherent in the 400-meter event. In addition, the ability to adapt intensity and breaks to the particular needs of athletes facilitates performance optimization, while minimizing the risk of fatigue and injury. However, this research also emphasizes the importance of conducting additional studies that deepen the understanding of the impact of discontinuous methods in the long term and in various contexts. Research using larger sample sizes and exhibiting diversity in participant characteristics could provide more robust and generalizable data. In conclusion, the results obtained underline the relevance of adopting a scientific and evidence-based approach in training planning, especially in high-performance athletic disciplines, such as the 400 meters.

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