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Original Article

The Effect of Anaerobic Training Based on Critical Speed Indicator on Some Physiological Variables and Record Level of 800-Meter Junior Female Runners

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Abstract

The aim of this research is to investigate the effect of anaerobic training based on the critical speed indicator on some physiological variables and the performance level of junior 800-meter runners. The researchers used the experimental method with one experimental group, consisting of six 800-meter junior runners from the secondary sports school in Shebin El-Kom during the academic year (2024/2025). Anaerobic training based on the critical speed indicator was applied to the research sample as part of a training program for 12 weeks, with three training sessions per week and each session lasting 90 minutes. The results of the study showed that the training program, using anaerobic exercises based on the critical speed indicator, positively affected (heart rate, maximal oxygen consumption, blood pressure, vital capacity, and blood lactate concentration), as well as the performance level of the junior 800-meter runners. The researchers recommended using anaerobic training based on the critical speed indicator to improve the physiological variables and performance level of junior 800-meter runners

Keywords: ***Anaerobic training, Critical speed, Physiological variables***.

Introduction

Modern athletic training is a planned process based on sound scientific principles aimed at achieving optimal performance, contributing to athletes' attainment of comprehensive excellence in athletic execution. To achieve this goal, coaches must design integrated plans for the development of their athletes' physical, physiological, technical, tactical, and psychological capacities in a unified framework, particularly during competitions.

According to Mohamed Abdo and Diaa El-Din Motawa (2014), subjecting the body to various types of physical loads during athletic training induces physiological changes that enhance the athlete's efficiency, as a result of the development and adaptation of both aerobic and anaerobic capacities to meet the essential, functional, and physical demands of the practiced sport (Abdo & Motawa, 2014).

Blagrove et al. (2018) explained that middle-distance running performance results from the interaction of physical, physiological, mechanical, psychological, and tactical factors, and that significant differences in performance between competitors can be attributed to cardiovascular variables (Blagrove et al., 2018).

Gareth Sandford et al. (2019) suggested that the 800-meter race presents a unique challenge for middle-distance coaches due to the close interaction between aerobic and anaerobic functions (Sandford et al., 2019).

Fumiya Tange et al. (2018) and Marie Orysié et al. (2018) indicated that performance in the 800-meter race requires approximately 60% aerobic and 40% anaerobic energy expenditure. Therefore, both energy systems are necessary for enhancing performance (Tange et al., 2018; Orysié et al., 2018).

Abou El-Ala Abdel-Fattah (2012) clarified that anaerobic capacity training exercises are characterized by short performance durations ranging from 5 to 10 seconds, with maximum intensity and long rest intervals (2–3 minutes). These exercises typically do not deplete more than 50–60% of the muscle's phosphagen stores (Abdel-Fattah, 2012,).

Mark Kramer et al. (2020) reported a strong relationship between critical speed and other variables such as maximal oxygen consumption, thus supporting the use of critical speed as a strong performance indicator during competition (Kramer et al., 2020).

According to Amer Fakher (2010), critical speed is defined as the speed at which an athlete continues to perform without exhaustion or the sensation of fatigue

Determination of Critical Speed for 800-Meter Runners:

The aerobic speed is calculated from the recorded time of the 800-meter run using the following formula: Aerobic speed (m/s) = Distance (m) / Time (s)

Once the aerobic speed level of the runner is determined, the race is broken into shorter distances (less than the total race distance). The time to cover each of these distances is then calculated using the following equation: Performance time (s) = Target distance (m) / Aerobic speed (m/s)

This calculated time represents 100% of the aerobic speed for the 800-meter event and not 100% of the performance time for the shorter distance. This allows the athlete to maintain proper step rhythm and pace according to race conditions through interval training with varying intensities (high and low).

To determine the performance time at different intensity levels, the following formula is used:

Performance time = Time at 100% intensity × (100 / Desired intensity %)

Example: Determining Critical (Aerobic) Speed

Determine the average race speed:

Speed = Distance / Time = 800 m / 180 s = 4.44 m/s

This value (4.44 m/s) represents 100% of the race speed or aerobic speed.

If the athlete is to train at an intensity higher than their aerobic speed to develop anaerobic capacity, they should run a distance shorter than the full race at an intensity exceeding 100% of their standard race speed.

For example, if a runner completes the 800 meters in 3 minutes (180 seconds), their aerobic speed is 4.44 m/s. To train at this speed, we want the athlete to run 4 repetitions of 400 meters each. The required time for each 400-meter repetition at 100% intensity is calculated as follows:

400 m / 4.44 m/s = ~90 seconds (or 1.5 minutes)

If the desired intensity is e.g., 120%, then

Performance time = 90 s × (100 / 120) ≈ 75 seconds (1.25 minutes)

This approach enables structured and precise training based on the athlete's physiological capacity

The researchers observed a decline in the performance level of secondary preparatory school female students in Shebin El-Kom in the 800-meter race, compared to the recorded times in the national school sports championship. This prompted the researchers to design a training program using anaerobic exercises based on the critical speed index, aiming to examine its effect on certain physiological variables and the performance level of young female 800-meter runners.

This research aims to design a training program using anaerobic exercises based on the critical speed index, and to examine its effect on certain physiological variables and the performance level of young female 800-meter runners.

Study Hypotheses

1. There are statistically significant differences between the pre- and post-measurement means in the physiological variables of young female 800-meter runners in favor of the post-measurements.
2. There are statistically significant differences between the pre- and post-measurement means in the performance level of young female 800-meter runners in favor of the post-measurements.

Materials and Method

The researchers adopted the experimental method using a one-group pre-post design, which is appropriate for the nature of this study.

Participants

The research population was selected from the female athletes of the Secondary Preparatory Sports School in Shebin El-Kom.

The research sample was purposefully selected from the track and field athletes specializing in the 800-meter event at the Secondary Preparatory Sports School in Shebin El-Kom for the academic year 2024/2025. The total number of participants was six (6) female runners, aged between 14 and 16 years.

Homogeneity of the participants groups:

The homogeneity of the research sample was calculated with respect to growth-related variables and physical variables.

Table 1. Homogeneity of the Research Sample in Growth and Physical Variables for the 800-Meter Event (n = 6)

	Variables	Unit of Measurement	Mean	Median	Standard Deviation	Skewness Coefficient	Minimum Value	Maximum Value
Growth variables	Height	cm	157.50	157.50	5.36	-0.19	150.00	164.00
	Weight	kg	52.17	51.50	3.06	0.71	49.00	57.00
	age	year	15.67	15.65	0.31	0.04	15:30	16.00
	experince age	year	4.17	4.00	0.75	-0.31	3.00	5.00
physical variables	50-Meter Sprint	m/s	7.22	7.18	0.24	0.15	6.89	7.50
	120-Meter Sprint	m/s	18.53	18:45	0.42	0.28	18.00	19.05
	Standing Long Jump	cm	209.33	209.00	6.56	-0.07	200.00	218.00
	Cooper 12-Minute Continuous Run	meters	1922.5	1935.0	81.72	-0.17	1800.0	2040.0
	Trunk Flexion (Forward Bend)	cm	9.17	9.50	1.47	-0.42	7.00	11.00

The results presented in Table (1) indicate that the skewness coefficients for the growth and physical variables of the research sample fall within the range of ±3, which reflects the homogeneity of the sample

Table 3. Homogeneity of the research groups (exploratory - experimental) in skill test battery for the harmonic capabilities as variables of the reactive Quickness (n =20)

Variables for reactive kinetic velocity	Units	arithmetic mean	The median	standard deviation	Skewness	Kurtosis
Arm Quickness response speed test	Th	0.33	0.31	0.12	0.50	-0.185
Muscle kinesthetic ability test for punch strength	Kg	2.30	2.10	1.26	0.48	-1.447
Coordinative performance linking ability test	Nr	29.00	28.00	2.41	1.24	-0.546
Muscle-kinesthetic ability test for distance movement	Cm	4.10	3.50	1.17	1.54	-0.147

As shown in Table (3), the skewness and kurtosis coefficients of the experimental research sample in the skill test battery for coordination abilities—used as variables for reactive quickness—ranged between (0.48 to 1.54) and (–1.447 to –0.147), respectively. These values fall within the acceptable statistical range of (±3), indicating homogeneity among the sample participants in these tests.

Main Study

Pre-measurements

The researchers conducted the pre-test measurements for the research sample on September 9, 2024. The proposed training program was then implemented from October 1, 2024 to December 22, 2024, over a period of 12 weeks, with 3 training sessions per week.

Training Program

The researchers designed the proposed training program using anaerobic exercises based on the critical speed index, in accordance with the scientific principles of program design and taking into account the characteristics and capabilities of young female 800-meter runners.

Steps of Training Program Development

- Identifying the specific physical capacities required for the 800-meter race.
- Selecting training days (Sunday – Tuesday – Thursday) for implementing the program.
- Structuring the training load intensity according to each athlete's individual capacity.
- Executing the program over 12 weeks (36 training sessions) at a rate of three sessions per week.

Axes			Time period
Duration of the training program			**12 weeks**
Number of training sessions per week			**3 training units**
Total number of training sessions during the program			**36 training units**
Duration of each training session			**90 minutes**
Breakdown of session duration:	**warm-up**		**20 minutes**
	Main part	Skill component	**20 min.**
		Physical component	**40 minutes**
	Cool-down		**10 minutes**
Total training time per week			**270 minutes**
Total training time during the program			**sessions × 90 min = 3,240min (equivalent to 54 h)**
Total time allocated to physical training			**sessions × 40 min = 1,440min (equivalent to 24 h)**
Total time allocated to skill component			**sessions × 20 min = 720 min (equivalent to 12 h)**

Table 3. Distribution of training load intensity and time distribution of the program

month		1				2				3				Total
		July				August				September				3
intensity distribution	max									*				
	High					*								
	middle	*												
Severity level		95%				105%				115%				105%
Weeks		1	2	3	4	5	6	7	8	9	10	11	12	12
intensity distribution	maximum 115%:135%							*				*		
	High 105%114%			*			*				*		*	
	middle 90%:104%	*	*		*	*			*	*				
Severity level		90%	95%	105%	90%	100%	105%	115%	100%	97%	114%	135%	114%	105%
Time of the week		270	270	270	270	270	270	270	270	270	270	270	270	3240 min

Post measurements

The post-test measurements for the research sample were conducted between December 22 and December 23, 2024.

Tools and devices

– Restmate devicer (RESTAMETER) To measure the total body length to the nearest (cm).

- Electronic scale to measure weight to the nearest kilogram.
- A stopwatch for measuring time in seconds.
- Polar heart rate monitor (HRM).
- A video camera to record the friendly matches of the research sample.
- Laptop with my program (Filmora9) (MV2 player) to display Matches at speeds Different
- Punching bags (heavy, medium, light).
- Trainer Pads (Training Gloves) Swedish seats, Ajump rope.
- Gloves, wall pillows Hanging and free, indicator, dancing ball, speed ball.

Statistical Analysis

The researchers used **SPSS version 21** for statistical analysis of the data. The following statistical treatments were applied:

- Arithmetic mean
- Standard deviation
- Skewness coefficient
- Z-test to determine the significance of differences
- Percentage change calculation

Results

Table (4) illustrates the rate of change between the pre- and post-test measurements for the research sample in the physiological variables. The results indicate improvements in all measured variables.

Table 4. Rates of Change Between Pre- and Post-Measurements in Physiological Variables (n = 6)

Variables for reactive kinetic velocity	Pre-measurement		Post measurement		Rate of Change
	mean	St.Dv	mean	St.Dv	
Lactic Acid at Rest	1.87	0.29	1.60	0.22	16.88%
Lactic Acid Post-Exercise	5.12	0.71	4.68	0.58	9.40%
Vital Capacity	3.20	0.43	3.55	0.46	10.94%
Heart Rate Before Exercise	76.50	2.88	73.67	1.51	3.84%
Heart Rate After Exercise	163.00	3.03	159.33	2.66	2.30%
VO_2max	37.98	7.18	41.82	6.99	10.11%
Systolic Blood Pressure	99.17	8.01	109.17	6.65	10.08%
Diastolic Blood Pressure	64.17	4.92	71.67	6.06	11.69%

Table 6. significant differences between the pre- and post-test measurements in the physiological variables

Variables	The sign	number	Mean Rank	Sum of Ranks	Z Value	significance
Lactic Acid at Rest	-	6	3.50	21.00	-2.214	0.027
	+	0	0.00	0.00		
	=	0				
	total	6				
Lactic Acid Post-Exercise	-	6	3.50	21.00	-2.226	0.026
	+	0	0.00	0.00		
	=	0				
	total	6				
Vital Capacity	-	0	0.00	0.00	-2.214	0.027
	+	6	3.50	21.00		
	=	0				
	total	6				
Heart Rate Before Exercise	-	6	3.50	21.00	-2.214	0.027
	+	0	0.00	0.00		
	=	0				
	total	6				
Heart Rate After Exercise	-	6	3.50	21.00	-2.232	0.026
	+	0	0.00	0.00		
	=	0				
	total	6				
VO_2max	-	0	0.00	0.00	-2.232	0.026
	+	6	3.50	21.00		
	=	0				
	total	6				
Systolic Blood Pressure	-	0	0.00	0.00	-2.032	0.042
	+	5	3.00	15.00		
	=	1				
	total	6				
Diastolic Blood Pressure	-	0	0.00	0.00	-2.041	0.041
	+	5	3.00	15.00		
	=	1				
	total	6				

*The tabulated Z value at a significance level of 0.05 ranges between -2.032 and -2.232.

The results presented in Table (5) show statistically significant differences between the pre- and post-test measurements in the physiological variables, favoring the post-test measurements. This is because the calculated Z value is greater than the tabulated Z value.

Table 6. Rates of Change Between Pre- and Post-Test Measurements in Performance Level

Variables	Unit of measurement	Pre-Test		Post-Test		Rate of Change
		Mean	St.Dv	Mean	St.Dv	
Performance Level (800m)	m/s	3.51	0.42	3.27	0.34	7.34%

Table (6) illustrates the rate of change between the pre- and post-test measurements for the research sample in the performance level. The rate of change in the performance level is 7.34%.

Discussion

Table (3) indicates the improvement rates between the pre- and post-tests in physiological variables, with the improvement rates as follows: lactic acid after effort 9.40%, lactic acid at rest 16.88%, vital capacity 10.94%, pulse before effort 3.84%, pulse after effort 2.30%, maximum oxygen consumption 10.11%, systolic blood pressure 10.08%, and diastolic blood pressure 11.69%.

The researchers attribute this improvement to the effectiveness of anaerobic training using the critical speed index, which included a variety of exercises and the proper adjustment of training loads according to the level of the research sample. Furthermore, Table (4) shows statistically significant differences between the pre- and post-tests in the physiological variables in favor of the post-test.

The researchers believe that anaerobic training using the critical speed index had a positive impact on improving physiological variables, as these exercises directly contribute to improving physiological variables through adaptations in the body's systems, which, with continuous training, lead to improved physiological performance.

Abdo & Motaweh (2014) argue that subjecting the body to various physical loads during training leads to physiological changes that improve the trainee's efficiency, particularly in the development of both anaerobic and aerobic capacities, and adaptation to meet the functional and physical demands of the sport efficiently, while conserving energy (Abdo & Motaweh, 2014).

Blagrove et al. (2018) highlight that middle-distance running results from a complex interaction of physical, physiological, mechanical, psychological, and tactical factors. While cardiovascular-related variables linked to aerobic energy production can explain a large portion of the performance differences among runners, anaerobic energy can better explain the variations in physiological markers for middle-distance runners (Blagrove et al., 2018).

The results of this study align with previous studies such as Khaleed Badawy (2023) (Badawy, 2023), Rami Hasson (2022) (Hasson, 2022), and Hamdi El Nawassari (2021) (El Nawassari, 2021), which demonstrated the effectiveness of anaerobic training in improving some physiological variables for 800-meter runners.

Thus, the first hypothesis, which states that there are statistically significant differences between the pre- and post-test means in favor of the post-test in the physiological variables of 800-meter runners, is confirmed.

Table (5) shows the improvement rate between the pre- and post-tests in the performance level, with an improvement rate of 7.34%. Table (6) also reveals statistically significant differences between the pre- and post-tests in the performance level of the 800-meter runners, favoring the post-test.

Sarai (2019) points out that track and field competitions rely heavily on high physical fitness, which athletes use to achieve their goals, and the complexity of these events is further amplified by the variety and interaction of the physical capacities required for each event (Sarai, 2019).

Abu Al-Ala Abdel Fattah (2012) emphasizes the importance of coaches familiarizing themselves with the latest training methods to help athletes enhance their physical abilities and performance levels (Abu Al-Ala Abdel Fattah, 2012).

The results of this study are consistent with studies by Ahmed Sharshar (2019) (Sharshar, 2019), Khaleed Badawy (2023) (Badawy, 2023), and Mohammed Riyad (2023) (Riyad, 2023), all of which showed that anaerobic training using the critical speed index positively affected the performance level of 800-meter runners.

Thus, the second hypothesis, which states that there are statistically significant differences between the pre- and post-test means in performance level in favor of the post-test for 800-meter runners, is confirmed.

Conclusion

Based on the research problem, objectives, and the results obtained, the researchers concluded the following:

1. The proposed training program positively affects some physiological variables for 800-meter runners.
2. The proposed training program positively affects the performance level of 800-meter runners.

Recommendations

Based on the research problem, objectives, and the results obtained, the researchers recommend the following:

1. The use of anaerobic training based on the critical speed index to improve the specific physiological variables for 800-meter runners, especially for students in sports schools.
2. The use of anaerobic training based on the critical speed index to improve the performance level of 800-meter runners, especially for students in sports schools.

Organizing workshops and training courses for sports school coaches to familiarize them with these training programs due to their significant impact on improving athletic performance.

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