Some Biochemical Variables and its Relation to Muscular Fatigue in 800 m Freestyle Swimmers

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Abstract:

The current research aims to identify the effects of 800 m freestyle swimming race on the concentration levels of lactic acid and other biochemical variables before and after performance. And variance rate and effect size of lactic acid on some biochemical variables before and after 800 m freestyle swimming race. The researchers used the descriptive approach. The researchers perpetually chose (14) 800 m freestyle swimmers representing their zone in all national championships and who were registered at the Egyptian Federation of Swimming (17-19 years). Results indicated that:

- *Concentrations of lactic acid and lactate dehydrogenase after 800 m freestyle swimming race increased by (87.28%) and (51.97%) respectively.*
- *Concentrations of calcium and phosphor after 800 m freestyle swimming race increased by (8.80%) and (33.26%) respectively.*
- *Effect size of lactic acid on some biochemical variables that induce fatigue in 800 m freestyle swimmers were between (0.149 – 0.729) before the race and (0.507 – 1.000) after the race.*
- *The increase of some biochemical variables leads to increases in muscular acidosis that in turn decreases the physiological abilities of muscles and induces fatigue.*

Keywords: *Internal Morphine – Muscular Fatigue – Lactic Acid – Pyruvic Acid*

I. Introduction:

Regular training and controlling training loads according to athletes' abilities are sufficient for inducing functional improvements in all body systems, including the nervous system, through chemical and functional reactions that improve body systems' functionality. It is probable to decrease the suppressive effect of Golgi Objects as a response to strength training. This allows athletes to produce more muscular power and improve power production (Wilmore &Costill 1993). One of the most important factors of daily monitoring is to

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distinguish between internal and external loads. Internal loads can be defined as all biological stressors (physiological and psychological) imposed on athletes. These include heart rate, oxygen consumption and rate of perceived exertion in addition to hormonal and enzyme responses as measured in blood, saliva, urine and other body vital fluids. It can be measured by resultant power, speed, acceleration, distance covered and weights lifted in addition to other requirements of physical performance (Gabbett et al. 2017). Physiological requirements of most sports activities during training are almost the same as in official competitions as intense training increases heart rate to the extent of activating fitness. At the same time, training induces perceived exertion indicators leading to significant increases in blood lactate (Hill-Hass et al. 2010).

Physical training under suitable conditions leads to adaptations that balance in the pituitary and adrenal glands through decreasing exertion hormones at rest (Fry et al. 1991; Kuipers& Keizer 1988). Intensive training overloads these glands leading finally to Overtraining Syndrome. Therefore, overtraining-induced disorder in the pituitary gland and hypothalamus lead to impaired balance between catabolic hormones (testosterone) and anabolic hormones (cortisol). This negatively affects recovery and prolongs its duration (Kuipers, H. 1998; Coutts et al. 2007).

Internal morphine appears and increases in blood as it transfers to pain location as a response to relief pain and fatigue (Lamb 1984). Lactate Dehydrogenase transfers hydrogen that turns lactic acid into pyruvic acid through oxidation at presence of NDA as a catalyst that works as hydrogen receptor. This process is called oxidation. Therefore, the enzyme that turns lactic acid into pyruvic acid is called "dehydrogenase" (McArdle et al. 1996).

Cortisol is one of the most important hormones that affect glucose and regulate glucose, carbohydrates and proteinmetabolism. It plays several vital functions including glycogen formation and increase of enzymes that turn amino-acids into glucose in the lever in addition to increasing glucose concentrations. It is very important to measure several biochemical variables that include cortisol, internal morphine, lactic acid, lactate dehydrogenase, calcium and phosphor due to its vital role in several vital processes, especially during athletic activity, and to determine the relationships among these variables and muscular fatigue in addition to its relative contribution in the digital record of 800 m freestyle swimming (Lamb 1984; Edward 1988).

For many researchers, studying biochemical variables that accompany all types of athletic activity is a major field of interest. These changes are either temporary or permanent. They help in selecting cadet players and develop training methods in addition to improving the performance level of players in general, and especially their digital records with clear identification of their training status as most vital systems are affected by practicing athletic activities through modifying their functions and adapting to training loads. One of the most significant obstacles on the way to elite levels is fatigue resulting from lack of oxygen and other energy resources in addition to metabolic wastes in muscles and blood. According to review of the available related literature, the researchers noticed that many studies dealt with fatigue and its effects on the muscular performance level and its relation to some biochemical variables that may cause or even contribute to it. But none of these studies dealt with 800 m freestyle swimming. Therefore, the researchers decided to try to identify the most important cause of fatigue and the changes in some biochemical variables due to effort exerted in 800 m freestyle swimming, so that swimming coaches and instructors can identify and avoid causes of fatigue to increase the swimmer's ability to endure fatigue and to establish training programs for best results.

Aims:

The current research aims to identify:

1. The effects of 800 m freestyle swimming race on the concentration levels of lactic acid and other biochemical variables before and after performance.
2. Variance rate and effect size of lactic acid on some biochemical variables before and after 800 m freestyle swimming race.

Hypotheses:

1. There are statistically significant differences between pre- and post-measurements of lactic acid concentrations and other biochemical variables in 800 m freestyle swimmers in favor of post-measurements.
2. There are variance rates between pre- and post-measurements of lactic acid concentrations and other biochemical variables in 800 m freestyle swimmers.
3. There are statistically significant differences in effect size of lactic acid on some biochemical variables before and after performance in 800 m freestyle swimmers.

II. Methods:

<u>Approach:</u>

The researchers used the descriptive approach.

<u>Participants:</u>

The researchers perpetually chose (14) 800 m freestyle swimmers representing their zone in all national championships and who were registered at the Egyptian Federation of Swimming (17-19 years). Table (1) shows results of homogeneity at growth factors for all participants.

Table (1): Mean, SD and Squewness for all participants on Growth Factors (n=14)

Variables	Measurement	Mean	SD±	Minimum	Maximum	Median	Squewness
Age	Day/year	18.54	0.38	18.00	19.00	18.54	-0.224
Height	Cm	169.79	2.94	167.00	175.00	169.79	0.923
Weight	Kg	67.57	4.26	62.00	73.00	67.57	-0.044
Training experience	Year	5.86	1.03	4.00	7.00	5.86	-0.172

Table (1) indicated that Squewness values ranged from (-0.224) to (0.923). This means that all values are between (±3) indicating homogeneity of sample.

Statistical Treatment:

The researchers used SPSS software to calculate the following: mean – SD – squewness – (t) test for difference significance – one-way ANOVA – η^2 – effect size

III. Results:

Table (2): Difference Significance among means of biochemical variables before and after 800 m freestyle swimming (n=14)

Variables	Measurement	Before performance (pre-)		After performance (post-)		(t)	P	Variance rate (%)
		Mean	SD±	Mean	SD±			
Cortisol	**Microgram / dcl**	10.95	1.11	20.01	1.51	-19.450	0.000**	45.28
Lactate Dehydrogenase	**U/L**	43.05	3.64	89.64	4.77	-33.352	0.000**	51.97
Lactic Acid	**Mmol/L**	1.21	0.33	5.57	1.00	-17.277	0.000**	78.28
Internal Morphine	**Picogram/L**	26.88	4.87	43.19	3.82	-8.555	0.000**	37.76
Calcium	**MlG/DCL**	8.91	0.50	9.77	0.45	-4.288	0.001**	8.80
Phosphate	**MlG/DCL**	2.91	0.26	4.36	0.18	-21.276	0.000**	33.26

P ≤0.05 for significance of both parties

Table (2) indicated statistically significant differences between pre- and post-measurements, in favor of post-measurements (after 800 m freestyle swimming). Variance rates ranged from (8.80%) to (78.28%).

Table (3): Effect size of lactic acid on some biochemical variables and fatigue before and after 800 m freestyle swimming (n=14)

Variables	Before performance (pre-)					After performance (post-)				
	Sum of	Freedom	F	P	Effect	Sum of	Freedom	F	P	Effect

			squares	**degree**			**size**	**squares**	**degree**			**size**
Lactic Acid	**Cortisol**	**Inter-group**	9.24	5	2.14	0.162	0.572	27.97	7	13.06	0.003^{**}	0.938
		Intra-group	6.91	8				1.84	6			
		Total	16.15	13				29.80	13			
	Lactate dehydrogenase	**Inter-group**	125.41	5	4.31	0.034^{**}	0.729	295.71	7	77591.58	0.000^{**}	1.000
		Intra-group	46.56	8				0.00	6			
		Total	171.98	13				295.71	13			
	Internal morphine	**Inter-group**	53.25	5	0.33	0.879	0.173	96.33	7	0.88	0.570	0.507
		Intra-group	255.38	8				93.69	6			
		Total	308.63	13				190.02	13			

	Calcium	**Inter-group**	0.88	5				1.77	7			
		Intra-group	2.39	8	0.59	0.708	0.270	0.89	6	1.71	0.265	0.666
		Total	3.27	13				2.65	13			
	Phosphates	**Inter-group**	0.13	5				0.40	7			
		Intra-group	0.74	8	0.28	0.912	0.149	0.03	6	12.89	0.003**	0.938
		Total	0.87	13				0.43	13			

P ≤0.05 for significance of both parties

Table (3) indicated that the effect size of lactic acid on some biochemical variables of fatigue before 800 m freestyle swimming ranged from (0.149) to (0.729) while the effect size ranged from (0.507) to (1.000) after performance on P ≤0.05 for Cortisol, Lactate Dehydrogenase and Phosphate. This indicates that the effect size after performance was higher than its value before performance. This means that lactic acid had a highly significant effect size on other biochemical variables.

IV. Discussion:

Table (2) indicated statistically significant differences between pre- and post-measurements with noticeable variance in concentration levels of lactic acid and other biochemical variables with variance rate ranging from (8.80%) to (78.28%). The researchers think that the significant increase in concentration levels of Cortisol and Internal Morphine are due to the fact that internal morphine is secreted at the same time with ACTH under stress conditions. Duration of physical effort also affects the secretion of internal morphine and ACTH. This increase in internal morphine after 800 m freestyle swimming race is to help bearing pain resulting from physical effort. In addition, the exerted physical effort from working muscles during the race induces high percentage of variance in physical effort variables under investigation. This is consistent with the results of Fox and Bowers (1988), Fox et al. (1993) and Adebero et al. (2019).

Adebero et al. (2019) indicated that cortisol concentration increased in saliva and blood for both groups in post-training measurements, compared with pre-training values. They also indicated significant increases of testosterone in men but not in boys, both in saliva and blood in pre-measurements. Cortisol levels were higher in blood than in saliva and testosterone levels decreased significantly in men after training.

Results also indicated increased level of lactic acid (87.28%) and lactate dehydrogenase (51.97%) after 800 m freestyle swimming race. These increases are due to the high-intensity effort and decreased levels of oxygen concentrations in muscles that turns pyruvic acid into lactic acid by lactate dehydrogenase. Lactic acid increases muscle acidity leading to decreased physiological abilities and inducing fatigue. These differences are clearly due to high-intensity exercises practiced by the swimmer through relating together high requirements, major movement, extreme effort and repeated starts for longer distances. This is consistent with Anderson et al. (1993), Cadegiani et al. (2019), Romano et al. (2019) and Martorelli et al. (2020). McArdle et al. (1996) indicated that lactate dehydrogenase transfers hydrogen to facilitate the oxidation of lactic acid into pyruvic acid in presence of NAD (hydrogen receptor). Oxidation means that each oxygen atom gives up one electron to a hydrogen atom. This is who the enzyme responsible for turning pyruvic acid into lactic acid is called "dehydrogenase". Cadegiani et al. (2019) indicated that high-intensity functional training decreased lactate and increased testosterone in addition to increasing body metabolism, fats oxidation and improving hydration. On the other hand, 90% of functional training advantages disappear once the player suffers over training syndrome.

Results also indicated and increase of (8.80%) in calcium and (33.26%) in phosphor after 800 m freestyle swimming race. This is an indicator of muscular fatigue. This is consistent with Wagner et al. (1992) who indicated that the increase of calcium and phosphor induce muscular fatigue. This is because of the decreased sensitivity of contraction proteins to calcium including troponin, actin and myosin. This clearly means muscle contraction disorder.

Robergs& Roberts (1997) indicated that the higher the training intensity with shorter performance period the higher the peripheral and internal contributors of muscles in inducing muscular fatigue. There are several factors that severely affect fatigue process like muscle acidosis, the central nervous system effect, increased concentrations of calcium and phosphor, increased ammonia, increased ADP, decreased ATP and other electro-chemical factors.

Table (3) indicated that effect size of lactic acid on biochemical variables that increase fatigue in 800 m freestyle swimmers after performance ranged from (0.149) to (0.729) before performance with $P \leq 0.05$. Lactate dehydrogenase value was (0.034) with effect size between (0.507) and (1.000) while the value of cortisol with lactate dehydrogenase was (0.000) to (0.003) after performance. This indicates high effect size of lactic acid on biochemical variables under investigation. McArdle et al. (1996) indicated that lactate dehydrogenase work on transferring hydrogen that helps lactic acid oxidation into pyruvic acid in presence of NAD as hydrogen receptor. This is called oxidation and this is who the enzyme responsible for it is called dehydrogenase.

The ability of maximum performance during repetitive exercises are affected by the nature of exercise itself and recovery periods. It is well-documented that high-intensity exercises that last for a few seconds require anaerobic glucose to provide energy with directly proportionate relation with lactic acid and H+ that may affect performance negatively (Baldari et al. 2004). Physiological and morphological adaptations enable swimmers to improve their technical performance through delaying fatigue and muscular stress as seen clearly through monitoring swimming training loads and its consistency with improvements in technical performance (Barbosa et al. 2019).

Internal functional effects of swimmer's muscles can contribute in developing training programs and increasing its efficiency through controlling training loads that are considered the major tool for affecting the swimmer. It can also improve the functional ability of body vital systems through evaluating the functional status of swimmers in the face of muscular activity and physical effort race requirements. This helps swimmers continue exerting physical effort with increased endurance for hard work. This also helps improving the efficiency of chemical processes of energy production required by the body during the race.

V. Conclusions:

According to this research aims, hypotheses, methods and results, the researchers concluded the following:

1. Concentrations of lactic acid and lactate dehydrogenase after 800 m freestyle swimming race increased by (87.28%) and (51.97%) respectively.

2. Concentrations of calcium and phosphor after 800 m freestyle swimming race increased by (8.80%) and (33.26%) respectively.

3. Effect size of lactic acid on some biochemical variables that induce fatigue in 800 m freestyle swimmers were between (0.149 – 0.729) before the race and (0.507 – 1.000) after the race.

4. The increase of some biochemical variables leads to increases in muscular acidosis that in turn decreases the physiological abilities of muscles and induces fatigue.

VI. Recommendations:

According to these conclusions, the researchers recommend the following:

- Referring to concentration percentage of lactic acid and biochemical variables under investigation when calibrating training loads of 800 m freestyle swimmers.

- Using methods of recovery, rest intervals and sauna to decrease the effect size of lactic acid and in turn delay fatigue.

- Performing more studies on the physiological variables and lactic acid of swimmers' muscles on different age groups.

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