World Journal of Sport Sciences 3 (S): 912-920, 2010
ISSN 2078-4724

Effect of Maximal Training Load on Minerals and Choline Esterase Concentrations as Indicators to Peripheral Fatigue in Wrestlers

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Abstract: Minerals play a major role in performance level. This research aims at identifying the effect of maximal training load on concentrations of some minerals (calcium, sodium and potassium) and Colin Esterase as indicators of fatigue in wrestlers. The researchers used the quasi-experimental approach with one group (pre-/post- measurement). Sample was chosen purposefully from junior wrestlers of Al-Shoban Al-Muslimin sports club in Ismailia, registered in the Egyptian wrestling federation under 15 years (8 wrestlers). Results showed that there was an effect of maximal training load on the concentrations of calcium, sodium and potassium and an increase of Colin Esterase as an indicator of peripheral fatigue in wrestlers.

Key words: Calcium · Sodium and potassium · Colin Esterase · Peripheral fatigue

INTRODUCTION

Wrestling competition needs continuous struggle until the end of the match which, in turn, needs maximal efforts to face competitive aspects represented in fatigue due to the opponent's resistance, body weight challenges and performing technical skills. This leads the wrestler to spend power to the limit that allows him/her to face all such resistances and keep up with high functional efficiency.

Minerals play a major role in performance level as they are part of body cells structure and some hormones and enzymes that help regulating heart beats and controlling muscle contraction and blood clotting [1].

Fatigue is one of the physiological processes that happen to athletes when performing maximal training loads. It is manifested in the form of temporary decrease in the ability of continuing to perform the needed work. There are several theories about reasons of fatigue. Most of these theories concentrate on the role of central nervous system and the muscle itself in inducing fatigue. But most of these reasons can be connected to chemical reactions related to metabolism of energy production. One of these reactions is disorder of physiological state of the cell due to differences in sodium and potassium ions [2].

Peripheral Fatigue can be identified through CHE as researchers can identify the causes happening inside the muscle from the transmission of the nervous pulse from the motor –emolliate until it penetrates into the muscle, calcium disorder inside the sarcoplasmic net, energy depletion and other factors related to metabolism for energy production and muscle contraction [3].

Minerals are very important as calcium helps in muscle contraction and potassium and sodium affect osmotic pressure and help in Ph balance to preserve plasma volume. Sodium and potassium also play three major roles:

- Fixing sodium and potassium through plasma membranes in cells. This is an important balance for muscular and nervous cells in producing electric showers that help them function well.
- Help organizing cell volume by controlling the soluble substance concentration in cells and decreasing the osmotic effect that leads to cell swelling or shrinking.
- The energy used in sodium / potassium pumping succession can be used as a direct source of energy to transfer glucose and amino acids through kidney cells [4].

One of the causes of fatigue is the lack of Adenosine Tri Phosphate in motor nerves. This leads to irregularity of nervous pulses reaching the muscle and necessary to

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muscle contraction, along with lack of production of Acetyl Colin. This lack affects negatively nervous pluses transfer into the muscle [5].

Choline Esterase removes Acetyl Choline formed inside the muscle-nervous cavity rapidly and turns it into choline and acetate. There are two types of Choline Esterase in blood. The first is Acetyl Choline Esterase, found basically in red blood cells and it is the same type found in nervous contacts. The second type is found in the lever and blood serum and is called Plasma Choline Esterase [6, 7].

Fatigue is a temporary decrease in the ability to continue performance and it has several factors, psychological, chemical or even muscular. But the mechanism of fatigue is due to the muscle needs of minerals during sodium metabolism for energy. Sodium is exerted in sweating or during pumping calcium that helps in combining actin with Miocene [8].

Calcium has a very important role during physical activity as its concentration in blood regulates heart, muscles and nerves functions. It also helps in insulin secretion due to its presence in pancreas solutions. This has a positive effect on glucose concentrations in blood during physical activity. It is also important in blood clotting and fluid transfer through cell membranes, beside its effects on muscle nerves function [9].

From what is mentioned, it is clear that minerals are very important to the body as losing those affects the physical and technical performance negatively. The researchers think that the problem of this research concentrates on that wrestlers, during training periods, are under high physical loads for prolonged periods as the training unit for wrestling is not less than 90 minutes and may reach 120 minutes. The predominant nature of performance during most of the training unit time is anaerobic, as wrestlers perform high intensity exercises leading to increasing body temperature and losing much of the fluids and minerals as well.

The researchers assure that most wrestlers, especially juniors, feel tired and exhausted before the end of the training unit and in its main part, representing technical skills and competitive wrestling, especially when using maximal load during competitions. This study is trying to identify the effect of maximal training load on minerals (calcium – sodium – potassium) and choline esterase concentrations as indicators of peripheral fatigue in wrestlers.

The researchers used the following key terms for the research purposes:

- Maximal physical load is a load that the wrestler can not continue performing after reaching it. (procedural term).
- Choline esterase forms in the perepheral motor nerves at the end of nervous cells via transforming the acetyl group from acetyl co-enzyme into choline and choline may be reused from acetyl choline freed in the nervous net [10].

The current research aimed at:

- Identifying the effect of maximal training load on the concentrations of some minerals (calcium, sodium and potassium) in wrestlers.
- Indentifying the effect of maximal training load on the concentrations of Colin Esterase concentrations as an indicator of fatigue in wrestlers.

The researchers hypothesized that:

- There are statistically significant differences between pre- and post- measurements in the effect of maximal training load on the concentration of some minerals (calcium, sodium and potassium) and in wrestlers in favor of the post-measurement.
- There are statistically significant differences between pre- and post- measurements in the effect of maximal training load on the concentration of Colin Esterase as indicators of fatigue in wrestlers in favor of post-measurement.

A related stud aimed at identifying the effects of marathon race on minerals concentration in blood and blood serum [11].Another study aimed at identifying the effect or rowing on some minerals and rare substances in blood, urine and sweat.4 A third study identified the concentrations of some minerals in blood and its relation to VO2max after match load for soccer beginners and he noted a positive direct relation between minerals concentration and VO2max [9]. Another study identified the effect of a nutrition component on the concentrations of MAO and CHE enzymes in short-distance runners and concluded that peripheral fatigue is a qualitative fatigue linked to maximal physical loads [5]. Finally, a study aimed at identifying the effects of various training loads (moderate – high – intense) on some hydration balance variables for judo performers less than 16 years [12].

MATERIALS AND METHODS

Approach: The researchers used the quasi-experimental approach with one group (pre- and post- measurement).
Sample:

The research sample was chosen purposefully from junior wrestlers of Al-Shoban Al-Muslimin sports club in Ismailia, registered in the Egyptian wrestling federation under 15 years (8 wrestlers chosen form the whole community that was 12 wrestlers). All members are punctual in training and involving in zone and Egypt's championships. The following table shows the sample variables (age – height – weight).

Data Collection Tools: According to the literature review and the sample of study, the researchers used the following tools and equipments:

- Basic variables: age height and weight.
- Minerals: calcium, sodium and potassium.
- Perepheral fatigue: Colin Esterase enzyme (Appendix 1).

Equipments: Medical balance – restameter for heights – syringes – plastic tubes – medical cotton – alcohol – medical bandages – ice tank with ground ice – centrifuge for separating blood components.

Main Study: The researchers performed the main study from 2-8-2009 to 2-9-2009as follows:

Table 1: Means and Standard Deviation of age, height and weight for the sample (n=8)

	Variables	Measurement	Means	SD ±
1-	Age	Year/Month	14.35	0.72
2-	Height	Cm	156.82	3.76
3-	Weight	Kg	60.41	10.23

Pre-Tests: Blood samples were taken by specialists before the beginning of the training unit.

Program Application: The program was applied to identify the effect of maximal training load on minerals and choline esterase as indicators to peripheral fatigue in wrestlers. The program continued for 4 weeks (appendix 2). These 4 weeks were the competition season with maximal physical loads. This period is enough to identify the effect of using maximal loads in body systems as noted in a previous study [13].

Content and formation of the training loads applied to the experimental group are shown in Appendix 3; some specific exercises for physical preparation of wrestlers are shown in Appendix 4.Fig.1 shows training intensity during the program.

Post-Tests: Blood samples were taken by specialists immediately after the training unit. The training unit was 120 min.

Statistical Treatment: The researchers used (SPSS) software for social sciences in calculating the difference significance between the pre- and post- tests. Wilcoxon test and Spearman test were used to identify the relations among the study variables.

Appendix 1: Registration and biochemical measurements form

Name: ………………………… Age: …………………………
Weight: ………………………… Height: …………………………

Years of experience: …………………………………..

Calcium …………………………………….

Sodium ………………………………………

Potassium ……………………………………..

Colin Esterase ……………………………………..

Appendix 2: General Plan of Training

Plan components	2-16/8/2009	17-23/8/2009	24/8 – 2/9/2009
Training styles	Aerobic endurance training – weight training – acrobats – various bridging exercises – rope jumps – training on various velocities	Mixed endurance training – attack / defense techniques exercises – rope jumps to enhance cardio-respiratory endurance Lactic	Training on various velocities – lactic exercises – tactic training for enhancing tactical aspects of wrestling from top and ground positions.
Training method	High and low interval training	lactic endurance training - circle training	Lactic endurance training – high intensity interval training
Training goals	Enhancing cardio-respiratory effectiveness and developing flexibility and balance	Enhancing aerobic / anaerobic endurance	Training techniques under different changing circumstances
Number of units	6	8 (training should be divided into 2 phases)	8 (training should be divided into 2 phases)
Load intensity	80-90%	90-100%	80-100%
Expected heart rate	130-150 h/m	150-180 h/m	150-180 h/m
Load direction	Mixed	Mixed - anaerobic	Anaerobic

Unit duration: less than moderate intensity = 80 min – moderate intensity = 90 min – sub-maximal intensity = 110 min – maximal intensity = 120 min

Load intensity: less than moderate = 50-70% - moderate = 70-80% - sub-maximal = 80-90% - maximal = 90-100%

Appendix 3: Content and formation of the training loads applied to the experimental group during the first week, Training load intensity during the week: Sunday 80% - Tuesday 90% - Wednesday 100% - Thursday 90%

Unit parts	Content		Load formation Intensity	Sets	Repetitions	Rest intervals	Heart beat	Load direction	Duration
Preliminary	Warm up	Running on various velocities to prepare muscles + acrobats	50%	-	-	-	120-130 h/m	Aerobic	10 min
	Physical preparation	Some exercises from appendix 4: 1,5,8,13,9,16,18,21,22,23,24	70%	5	4-5	50 sec	150 h/m	Mixed	15 min
Basic	Skills training	Enhancing some attack and ounter-attack aspects from high and ground positions	80%	2	4	60 sec	150 h/m	Anaerobic	25 min
		Training on how to get on the opponent from ground position (rotations and getting rid of holds)		2	4		150 h/m	Anaerobic	
	Competitive wrestling	Practicing attacks and counter-attacks with wrestlers of different weights on 3 or 4 phases	100%	3	4	3 min	180 h/m	Anaerobic	20 min
Conclusion		Cool down (swings-walks-shakes)	50%	-	-	-	120-130 h/m	Aerobic	5 min

Content and formation of the training loads applied to the experimental group during the second week

Training load intensity during the week: Sunday 80% - Tuesday 100% - Wednesday 90% - Thursday 100%

Unit parts	Content		Load formation Intensity	Sets	Repetitions	Rest intervals	Heart beat	Load direction	Duration
Preliminary	Warm up	Fast running + tug-war to elevate body temperature and activate blood circulation	50%	-	-	-	120-130 h/m	Aerobic	10 min
	Physical preparation	Some exercises from appendix 4: 6,8,11,12,19,20,22,23,24	80%	6	4-5	45 sec	150 h/m	Mixed	15 min
Basic	Skills training	Using advantages revealed during matches to perform specific wrestling moves	80%	2	3	90 sec	180h/m	Anaerobic	30 min
		Training on maneuvers (footwork-trunk position change-sudden moves)		2	4		180 h/m	Anaerobic	
	Competitive wrestling	Practicing attacks and counter-attacks with wrestlers of different weights on 3 or 4 phases	100%	3	4	3 min	180 h/m	Anaerobic	25min
Conclusion		Cool down (swings – shakes)	50%	-	-	-	120-130 h/m	Aerobic	5 min

Content and formation of the training loads applied to the experimental group during the third week

Training load intensity during the week: Sunday 80% - Tuesday 100% - Wednesday 100% - Thursday 90%

Unit parts	Content		Load formation Intensity	Sets	Repetitions	Rest intervals	Heart beat	Load direction	Duration
Preliminary	Warm up	Fast runs and hurdle gymnastics to prepare muscles and activate blood circulation	50%	-	-	-	120-130 h/m	Aerobic	10 min
	Physical preparation	Some exercises from appendix 4: 3,5,10,14,17,15,18,19,22,23,24	80%	6	5-6	40 sec	150 h/m	Mixed	15 min
Basic	Skills training	Training some major techniques from different positions	80%	2	4	60 sec	150 h/m	Anaerobic	25 min
		How to enhance specific thinking of tactics of the wrestler		2	4		150 h/m	Anaerobic	
	Competitive wrestling	Practicing attacks and counter-attacks with wrestlers of different weights according to match rules	100%	3	3	3 min	180 h/m	Anaerobic	20 min
Conclusion		Cool down exercises + massage	50%	-	-	-	120-130 h/m	Aerobic	5 min

Content and formation of the training loads applied to the experimental group during the fourth week

Training load intensity during the week: Sunday 90% - Tuesday 100% - Wednesday 100% - Thursday 80%

Unit parts	Content		Load formation Intensity	Sets	Repetitions	Rest intervals	Heart beat	Load direction	Duration
Preliminary	Warm up	Fast runs – rope jumps – acrobats to elevate body temperature and activate blood circulation	50%	-	-	-	120-130 h/m	Aerobic	10 min
	Physical preparation	Some exercises from appendix 4: 2,3,7,9,10,18,19,20,21,22,24	90%	6-7	5-6	40 sec	150 h/m	Mixed	15 min
Basic	Skills training	Training on maneuvers to enhance tactics (making basic moves look like maneuvers-fake hold-seducing the opponent with initiative)	100%	2	4	2 min			
						3 min	180h/m	Anaerobic	25 min
		How to use the opponent's mistakes		2	3		180h/m	Anaerobic	
	Competitive wrestling	Practicing attacks and counter-attacks with wrestlers of different weights on 3 or 4 phases	100%	3	4	3 min	180 h/m	Anaerobic	35 min
Conclusion		Cool down (relaxation + sauna)	50%	-	-	-	120-130 h/m	Aerobic	5 min

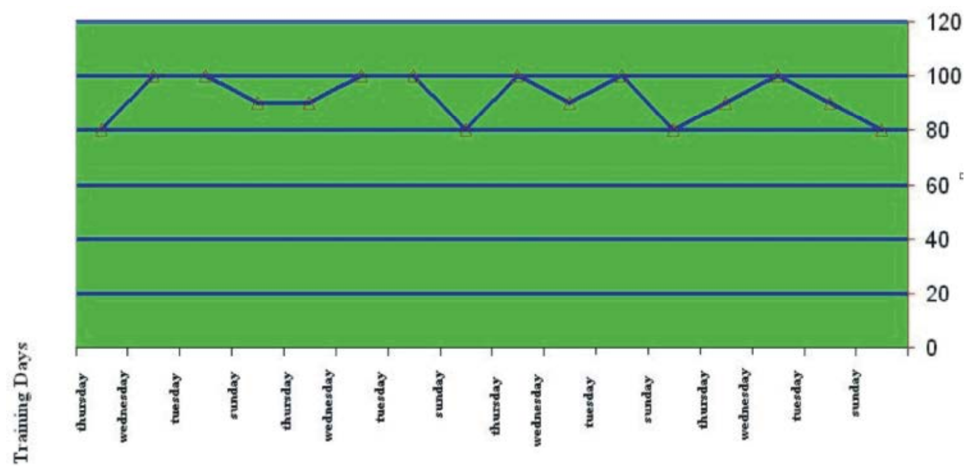

Fig. 1: Training intensity During the Program

Appendix 4: Some specific exercises for physical preparation of wrestlers

1-	Standing – bending trunk forwards and downwards – chest tuck under.
2-	Standing face to face with a partner – hands interlocked and pulling the partner.
3-	Inclined prostration facing partner and partner pushes wrestler until tired with shoulders.
4-	Bridge (holding feet with hands) and pushing the body alternatively forwards and backwards.
5-	Standing – getting up and down a 20:30cm box for 2 minutes.
6-	The same previous exercise for 3 minutes.
7-	Standing – jumping with alternating knee bending to chest and holding with hands.
8-	Standing – in-place-jump with touching feet with opposite arms.
9-	Standing – back to a wall and arching backwards and walking the wall.
10-	Standing – getting up and down a 30:40 cm chair.
11-	Pulling trunk upwards from prostration.
12-	Sitting from prostration.
13-	Squatting face to face with a partner and trying to knock him out of balance.
14-	Standing face to face with a partner – arms interlocked behind partner's neck and pulling.
15-	Bridging (holding weights on chest) and swinging arms forwards and backwards.
16-	Bridge (holding feet with hands) and pushing the pelvis upwards.
17-	A partner kneels horizontally and the wrestler sits on his back and arches backwards.
18-	Face to face prostration with hands interlocked and each partner tries to pull to his direction.
19-	Standing open – trunk bent backwards and trying to touch heels with fingers.
20-	A partner kneels horizontally and the wrestler sits on his back and arches backwards.
21-	Face to face inclined prostration and trying to hold the partner's arms or neck to knock him out of balance.
22-	Inclined prostration facing partner and each partner pushes his mate until tired with shoulders.
23-	Face to face squatting and trying to knock the partner out of balance.
24-	Climbing a 5m rope up and down several times.

RESULTSAND DISCUSSION

From Table 2, it is clear that Wilcoxon test values for the difference s between pre- and post- measurement for all variables were significant as calculated Y values were less than it table values on p≤o.o5. This shows statistically significant differences between the pre- and post- tests in favor of the post-test.

From Table 3 it is clear that variance percentage for the minerals and Colin Esterase were (6.52%, 27.98%, 61.83% and 38.99%) while the difference between means was 0.64, 6.42, 5.33 and 18.19.

From Table 4 it is clear that there are 6 correlation coefficients as follows: 3 significant correlations for calcium, 2 significant correlations for sodium and 1 negative insignificant correlation for potassium.

Table 2: Difference significance between the pre- and post- measurements for minerals (calcium, sodium and potassium) and peripheral fatigue for the sample (n=8)

		Number		Total order		Means order			
	Variables	-	+	-	+	-	+	Y values	Significance
1-	Calcium	1	7	1.5	34.5	1.5	4.93	-2.31	Significant
2-	Sodium	0	8	0	36	0	4.5	-2.52	Significant
3-	Potassium	0	8	0	36	0	4.5	-2.52	Significant
4-	Colin Esterase	0	8	0	36	0	4.5	-2.52	Significant

Y values on p ≤ 0.05 = 5

Table 3: Variance percentage of minerals (calcium, sodium and potassium) and peripheral fatigue for the sample (n=8)

		Pre-test		Post-test			
	Variables	M	SD ±	M	SD ±	Difference between means	Variance%
1-	Calcium	9.81	0.30	10.54	0.41	0.64	6.52%
2-	Sodium	21.56	1.10	27.98	0.53	6.42	27.98%
3-	Potassium	8.62	0.28	13.95	0.44	5.33	61.83%
4-	Colin Esterase	43.65	0.45	61.84	1.30	18.19	38.99%

Table 4: correlation matrix of minerals (calcium, sodium and potassium) and peripheral fatigue for the sample (n=8)

	Variables	Calcium	Sodium	Potassium	Colin Esterase
1-	Calcium	-------	0.71*	0.86*	0.72*
2-	Sodium		-------	0.71*	0.92**
3-	Potassium			-------	-0.66
4-	Colin Esterase				-------

Y values on $p \leq 0.05 = 0.707$

DISCUSSION

Table 2 indicates a statistically significant difference in all variables in favor of the post-measurement,while Table 3 indicates an increase in variance percentage for all variables.

The researchers think that the increase in calcium concentrations is due to intense physical effort, predominant in most parts of the training unit for wrestlers and to the increase of vitamin D activity and Para-thyroid enzyme due to intense physical effort, as intense physical effort increases the activity of vitamin D that increases Para-thyroid activity which in turn increases calcium and phosphor restitution from kidney to blood stream [14].

This is in agreement with some previous studies in that Para-thyroid increases kidney cells activity which in turn leads to increasing calcium and phosphor restitution and increase in blood [15, 16].

The researchers think that the increase in sodium and potassium is due to the amount of lost sweat during physical effort in training unit, characterized, in most parts of the training unit, by high and maximal intensity. This is in agreement with previous studies indicating that sweat is less in amount and contains less electrolytes (sodium and potassium) compared to blood. They also indicated that this is linked to a very interesting piece of information as sodium and potassium concentrations in blood serum increase in a far more way compared to its decrease during vital processes leading to sweating. These studies concluded that food salt amounts consumed heavily lead to health risks with efforts [4, 10, 17, 18].

The researchers think that the increase in sodium and potassium is due to that wrestling coaches do not care for administering fluids during training and exerting physical effort. Related studies indicated that not having fluids continually during long term training for prolonged periods leads to increasing sodium in blood serum and osmotic reaches high levels depending on the lost amount of fluids. The increase of osmotic decreases by having more fluids and this amount decreases when the amount of consumed fluids is nearly equal to the lost amount of fluids [19, 20].

The researchers think that potassium increase in blood serum is due to that potassium amount in urine and sweat was not large besides the decrease of aldostiron secretion. Some studies indicated that calibrated training loads lead to decreasing potassium in blood due to the secretion of aldostiron that leads to potassium secretion in blood and urine [21-24].

One study indicated that the decrease in pulse during training and the increase of effort leads to an increase in secreted fluids and the amount of lost sweat. This leads to potassium imbalance due to the increase of sweating [25]. This proves the first hypothesis that is "There are statistically significant differences between pre- and post-measurements in the effect of maximal training load on the concentration of some minerals (calcium, sodium and potassium) and in wrestlers in favor of the post-measurement".

Correlation matrix indicates a relation between sodium, potassium, calcium and Colin Esterase. The researchers think that this relation is due to the important role of calcium in regulating heart functions, muscles and nerves as it helps in secreting insulin. The researchers think that this relation is due to the amount of sweating and not having fluids during high intensity training load during the training unit.

The relation between calcium and Colin Esterase is due to that the increase in calcium concentrations is due to the increase of calcium restitution in cells and surrounding fluids, including blood. Some studies indicated that calcium concentration in blood is due to the increase of blood acidity because of physical effort leading to the increase of calcium restitution inside cells [9].

The researchers also think that this relation is due to calcium accumulation or absence leading to ATP de-breakdown. So, enough energy for exerting needed physical effort is not generated. The researchers think that anaerobic training loads, predominant in wrestling, prevent Colin Esterase from its regulation role. This makes the nerve free more Acetyl Colin to cope with the enzyme effect if the nervous signal is activating muscle fibers.

Acetyl Colin Esterase does this task by chemical breakdown of the compound and turning it into other compound and eliminating it from the nervous connection. This is in agreement with several previous studies [26-29].

The researchers think that the increase in Colin Esterase in wrestlers after the high intensity training unit is due to the Acetyl Colin breakdown as the continuous muscle contraction leads to increasing Colin Esterase with prolonged high intensity performance. This leads to increasing peripheral fatigue in athletes and is in agreement with previous studies [5, 30, 31].

This proves the second hypothesis indicating that there are statistically significant differences between pre- and post- measurements in the effect of maximal training load on the concentration of Colin Esterase as indicators of fatigue in wrestlers in favor of post-measurement.

CONCLUSION

- The increase of calcium, sodium and potassium.
- The increase of Colin Esterase.
- There is a relationship between the concentration levels of calcium, sodium and potassium and Colin Esterase.

RECOMMENDATION

- Paying attention to measuring minerals levels and other fatigue indicators in blood for wrestlers.
- Indicating the importance of having fluids during training.
- Using Colin Esterase as an indicator of fatigue in wrestlers.
- Making more research on peripheral fatigue in wrestlers.
- Using Colin Esterase as an indicator for choosing wrestlers.

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