Original article

Biochemical changes in Popular Runners after a marathon (Stress Test)

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Summary

The study we conducted with a group of veteran runners, but with a long career in the popular sport, is to analyze the changes that occur in biochemical profiles of a group of fifteen amateur runners who run a marathon. This maximum effort we have called "stress tests".
Our goals are aimed at evaluating the results of the changes in biochemical parameters in simple popular runners to reference them with those occurring in professional athletes, is a prevalence study without previous variables or random assignment.
The method employed: previous blood sampling (baseline or reference conditions) and another immediately after.
The results: increased blood glucose concentration of 3.25% increased 95% urea and creatinine of 45.3 while on cholesterol has no effect on triglycerides and the increase was 3%.
We discuss our results against the results published on the professionals, with the intent to see the differences in the changes of biochemical values in the pros versus popular riders, amateurs and veterans. We found studies professionals from other disciplines, such as triathletes, cyclists, skiers etc.
The conclusion is that the benefits and harms of intense physical exercise are as beneficial or detrimental to both groups. But the differences in biochemical values are used to compare the professional and amateur sport.

Key words:
Sports stress.
Glucose & marathon.
Urea-creatinine & carathon.
Cholesterol-triglycerides & marathon.

Cambios bioquímicos en corredores populares tras correr una maratón (test de estrés)

Resumen

El estudio que hemos llevado a cabo con un grupo de corredores veteranos, pero con una larga trayectoria en el deporte popular, consiste en analizar los cambios que se producen en los perfiles bioquímicos de un grupo de quince corredores populares que corren una maratón. A este esfuerzo máximo lo hemos denominado "Test de Estrés".
Nuestros objetivos se encaminan a evaluar los resultados de los cambios producidos en los parámetros bioquímicos simples en corredores populares para referenciarlos con los que se producen en los atletas profesionales, es un estudio de prevalencia, sin variables previas ni asignación aleatoria.
El método empleado: toma de muestra sanguínea previa (condiciones basales ó de referencia) y otra inmediatamente posterior.
Los resultados obtenidos: incremento de la concentración de glucemia en sangre del 3,25% incremento de la urea del 95% y de la creatinina del 45,3 mientras sobre el colesterol no tiene repercusión y sobre los triglicéridos el incremento esta en 3%.
Discutimos nuestros resultados comparándolos con los resultados publicados sobre los profesionales, con la intención de ver las diferencias en los cambios de los valores bioquímicos en los profesionales frente a los corredores populares, aficionados y veteranos. Hemos encontrado estudios sobre profesionales de otras disciplinas, tales como triatletas, ciclistas, esquiadores etc.
La conclusión es que los beneficios y perjuicios de ejercicio físico intenso son tan beneficiosos o perjudiciales para ambos grupos. Pero las diferencias encontradas en los valores bioquímicos sirven para comparar el deporte profesional y aficionado.

Palabras clave:
Estrés deportivo.
Glucemia & maratón.
Urea-creatinina & maratón.
Colesterol-triglicéridos & maratón.

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Introduction

Humans are surprisingly good distance runners; in the entire animal kingdom there are very few mammals that can keep up a constant pace when running 10 Km or more (a marathon comprises 42,195m). Many animals are better sprinters than humans over short distances, such as leopards, but only very few land mammals and humans are capable of making long journeys at a jogging pace, and considering that humans only have two legs, they compete surprisingly well, weight for weight.

A surprising fact is that no primates are able to perform a resistance run. This distinct human capacity was the subject of an article in the Nature magazine on 18th November 2004 Bramble DM, *et al*.[1,2].

Therefore, anthropologically and medically speaking it is interesting to obtain as much information as possible regarding the physiology of the exertion as there are biochemical indicators regarding the efficiency of the physical exercise performed by people that partake in this physical expenditure in the prevention or correction of possible excesses, Nuviala-Mateo RJ, *et al*.[3,4]. There are many studies about marathon runners or athletes that undergo great exertion over long periods of time; but almost all of them refer to professional athletes Moreno-Lemos SM[5].

The marathon has special characteristics within the concept of the run: it is a running trial measuring 42,195 metres in a circuit not in a stadium, meaning it takes on the concepts of both a popular run and an athletic event. The completion time for professionals is less than 2 hrs 30 mins, whilst our study group times ranged between 3hrs 30 mins and 4 hrs 30 mins.

In order to complete the run in those times, the dedication of each participant is different: whilst professional athletes undergo scientific preparation, supervised by trainers, doctors, nutritionists and exertion physiologists, the only activity our group performed was to maintain a jogging pace, which they had been practising for over 10 years, with the only exception being that 60-90 days before the competition, they increased their dedication time, in which they increased their average of 60-90 minutes for 5 or 6 days a week, to 120 to 160 minutes five days a week, plus 1 day which was over 180 minutes.

It would appear that publishing our results would be interesting, considering that this is a group of male veteran runners of working age and who are not professionals, rather they participate in running races as a hobby.

The importance of using biochemical measurements as a way of monitoring the effect of training on individuals that partake in this sport is studied and published in scientific literature, as revealed in studies such as those by Moreno-Lemos SM, *et al*.[5,6].

With regards to the biochemical parameters studied, we only found discrepancies in terms of the behaviour of the blood glucose after strenuous exertion. Authors such as Bluche PF, *et al*.[7] propose an increase in blood glucose after the exertion. On the other hand, some authors, such as Minuk HL, *et al*.[8], propose that exertion brings about a drop in blood glucose immediately after the exertion.

We suggest the need to see the results obtained from our study group, in order to be able to compare them with results published about professional or semi professional athletes, and to confirm or oppose the results published. Studies about strenuous sports such as Triathlons have been published by authors such as Long D, *et al*.[9-11] and the results are similar to those collected in this study.

Material and methods

General protocol

A short time before the stress test (marathon), blood samples were taken from the group participants to establish the parameters that we were going to study after a 10-hour fasting period; and immediately after the run another blood sample was taken for the same purpose. The samples were identified, coded and kept chilled for transporting to the laboratory to determine the haematological parameters that are described in the study.

Once the results were collected in the laboratory, they were tabulated and studied with the aim of achieving statistical data that would allow us to produce graphs, informing us about the trend or behaviours of the blood parameters of the study subjects.

Material

The materials needed for the research were the essential tools for extraction (tourniquet, 10 cc syringes and 25/8 needles and the tubes where the samples would be deposited and identified. They were transported in a chilled environment (±4 º) until they reached the biochemical analysers. Later, once the results were gathered, we applied the data to register the information and then proceeded to tabulate it and produce graphs.

The sources of information (bibliographic references) that we used in this study were those gathered from different databases.

The group of people ("Los Chiribitos") had the following characteristics:

- A group of fifteen amateur runners that formed the Los Chiribitos running club. All 15 are males, with an average age of 50.4 years (±9.6-7.6).
- Anthropometric profile: average weight 76 ± 8 kg, an average height of 173± 8 cm, and a BMI of 2.5 ± 04.
- The time spent in preparatory training: over 90 days with road running training sessions lasting 1 to 1.5 hours six days a week.
- Average time as an amateur runner that can be considered to be an adaptation period: over 10 years.
- Time taken running (marathon): between 3 hrs 30 mins and 4 hrs 30 mins.
- Nutrition: the normal, local diet, no special diet.
- Medicines and supplements: Not mentioned (¿).
- Lifestyle: healthy (none smokers, moderate alcohol consumption, no drugs).
- Antecedents: no illnesses, various accidents or injuries, no lasting effects.
- Employment: varied.

Method

First, the participants underwent a health examination (including ECG to check their health and to reject unfit individuals). They received a talk beforehand in which the study was explained to them, and once they understood they gave consent for the study and for the data obtained to be published, whilst remaining anonymous, in the event that is should be of interest to the scientific community.

Results

Once the results obtained in our study were processed on the computer, they were transferred to graphs and were tabulated. These results were structured according to the different parameters studied, assessed before and after the "stress test", observing and studying the concentrations of blood glucose, urea, creatinine, total cholesterol and triglycerides.

Blood glucose

Starting with an average pre-test value of 80.00 mg/dl, the average value obtained after the test is 82.60 mg/dl, revealing an increase of the average values of 2.60 units, in absolute value, meaning the increase percentage is 3.25%.

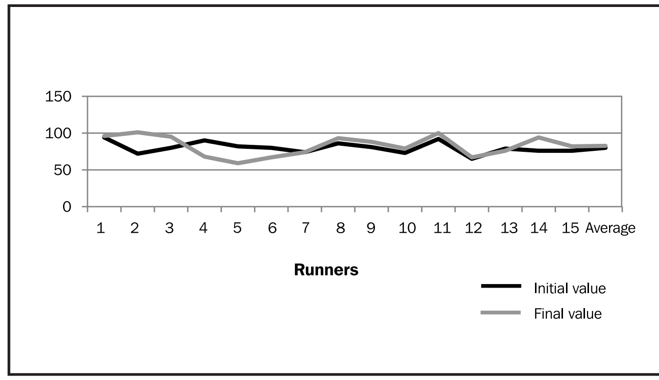
The pre-test blood glucose concentration values are all within the normal range, and regarding the average value, they oscillate between ±7-14. In the values obtained after the test, only two are over 100 mg/dl, but they are all within the normal ranges and oscillate between ± 18.4 -23.6. Therefore it can be observed that the dispersion of the values obtained after the test are framed within a wider range - yet within normality - than the dispersion obtained in the pre-test study values (Table 1, Figure 1).

Table 1. Blood glucose levels in mg/dl.

I.D.	Prior	Post
1	94	96
2	72	101
3	80	95
4	90	68
5	82	59
6	80	67
7	74	74
8	86	93
9	81	88
10	73	79
11	92	100
12	65	67
13	79	76
14	76	94
15	76	82
Average	8000	82.60

I.D: Subjects. Prior: initial values.
Post: final values. Average: arithmetic average.

Figure 1. Blood glucose levels.



Urea

Starting with an average value of 32.8 mg/dl in the pre-test measurements, after the test an average value is achieved of 64.20 mg/dl, meaning that the values increase by 31.34 units, which as a percentage reaches 95.54%.

Both the values of urea concentration in the blood in the pre and post test measurements have values below 100 mg/dl, and limited with the average values, it can be seen that the pre-test values are in a dispersion window in a range of ± 4.2-5.8 whilst dispersion in the post-test measurements ranges at ± 15.5-18.8. This leads us to observe that the dispersion of the values obtained before and after the test move in quite similar ranges and the only outstanding aspect is the huge increase shown in the post-test measurements (Table 2, Figure 2).

Table 2. Uremia levels in mg/dl.

I.D.	Prior	Post
1	33	46
2	37	50
3	37	62
4	37	60
5	35	75
6	26	60
7	27	75
8	32	56
9	38	73
10	37	60
11	27	62
12	26	64
13	33	75
14	37	65
15	30	80
Average	32.80	64.20

I.D: Subjects. Prior: initial values.
Post: final values. Average: arithmetic average.

Figure 2. Uremia levels.

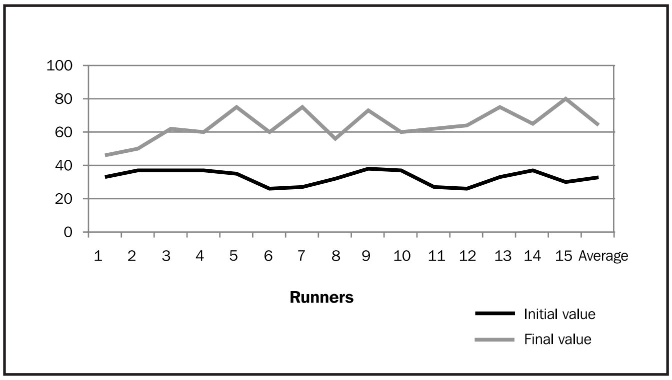
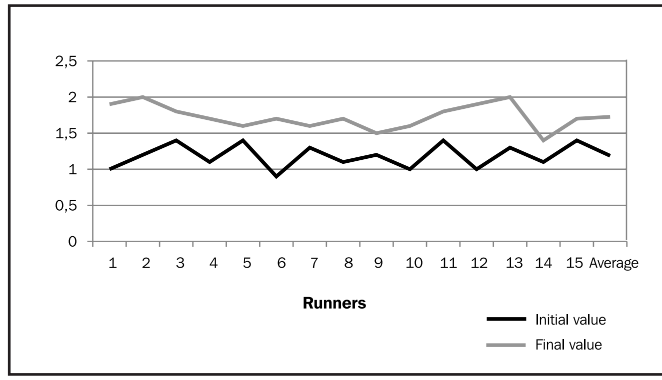


Figure 3. Creatinine levels.



Creatinine

Starting with an average value of 1.19 mg/dl in the pre-test measurements, in the post-test the average value reaches 1.73 mg/dl, revealing an increase of 0.54 units in the average value, giving a percentage of 45.37%.

The values established in the pre-test measurements fall within the normal range (>1.3), which means that 26.6% are above the average. Whilst in the post-test measurements, 100% are above the normal range.

The dispersion window of the pre-test values is within the range of ± 021-0.29 whilst the dispersion of the values found in the post-test measurements falls within a range of ± 0.27-0.33. Thus by observing the previous data, it can be seen that the behaviour of the creatinine is quite similar to that of urea in the test: the difference lies in the percentage increases and in the dispersion ranges (Table 3, Figure 3).

Total cholesterol

The average value of the pre-test measurements is 175.40 mg/dl, and after the test the average value of the measurements reaches a figure of 174.47 mg/dl, revealing a decrease of 0.93 units, which is a percentage of 0.53%.

Both the pre and post test values are within the normal range for this kind of demographic (<200). The pre-test values fall within a range of ± 16.6-25.4, whilst the values obtained after the test fall within the range of ± 16.53-14.47 (Table 4, Figure 4).

Triglycerides

The data obtained reflects a behaviour very similar to the total Cholesterol, i.e. we start with a pre-test average value of 80.33 mg/dl

Table 3. Creatinine levels in mg/dl.

I.D.	Prior	Post
1	1	1.9
2	1.2	2
3	1.4	1.8
4	1.1	1.7
5	1.4	1.6
6	0.9	1.7
7	1.3	1.6
8	1.1	1.7
9	1.2	1.5
10	1	1.6
11	1.4	1.8
12	1	1.9
13	1.3	2
14	1.1	1.4
15	1.4	1.7
Average	1.19	1.73

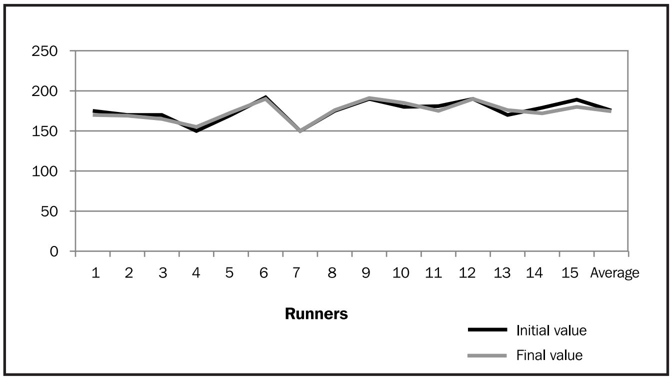
I.D: Subjects. Prior: initial values.
Post: final values. Average: arithmetic average.

Table 4. Cholesterol levels in mg/dl.

I.D.	Prior	Post
1	175	170
2	170	169
3	170	165
4	150	155
5	170	173
6	192	190
7	150	150
8	175	176
9	190	191
10	180	185
11	181	175
12	190	190
13	170	176
14	179	172
15	189	180
Average	175.40	174.47

I.D: Subjects. Prior: initial values.
Post: final values. Average: arithmetic average.

Figure 4. Cholesterol levels.



and the post-test average value is 82.67 mg/dl, producing an increase of 2.34 units, which is a percentage of 2.91%.

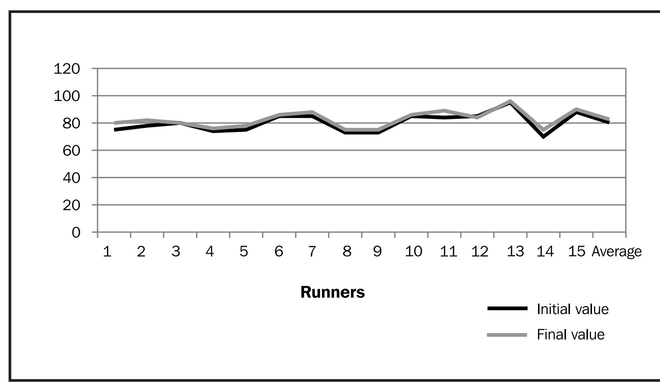
If we consider normal blood Triglyceride values to be lower than 150 mg/dl, we can see that all the measurements, both pre and post test, produce values that are lower than 100 mg/dl, i.e. within normal range, and we can also observe that the range of distribution in the pre-test measurements falls within ± 14.67-10.33 whilst in the post-test this range is in ± 13.33-7.67 (Table 5, Figure 5).

Table 5. Triglyceride levels in mg/dl.

I.D.	Prior	Post
1	75	80
2	78	82
3	80	80
4	74	76
5	75	78
6	85	86
7	85	88
8	73	75
9	73	75
10	85	86
11	84	89
12	85	84
13	95	96
14	70	75
15	88	90
Average	80.33	82.67

I.D: Subjects. Prior: initial values.
Post: final values. Average: arithmetic average.

Figure 5. Triglyceride levels.



Discussion

Once the results of our study are obtained and processed on the computer, we obtain some tables and graphs to compare them with those obtained by other authors.

By limiting the values obtained in our study with those obtained by other authors, we should consider the diversity of the study groups, as the studies we have found in literature refer to professional athletes, and despite the dedication of our study group to the sport being high, they cannot be considered to be professional athletes.

With regards to the behaviour of blood glucose under strenuous exertion, some suggest an increase after exertion, Bluche PF, *et al.*[7], whilst others propose a reduction with the same exertion Minuk HL, *et al.*[8]. According to our data, an increase of 3.25% occurs in the average values.

We consider this increase to be down to two independent yet related factors: on the one hand, dehydration must be considered when strenuous exertion is performed; and on the other hand, the release of catecholamines and neurotransmitters should be taken into account, which cause the stress of the exertion and this in itself causes hyperglycaemia. Therefore we align with Bluche PF, *et al.*[7] and with those that describe hyperglycaemia with exertion Bluche PF, *et al*[7,9,10].

Other authors study the effects of the marathon on people with diabetes, and make recommendations regarding when they should participate and when they should refrain, as well as recommendations for controlling diabetes during a marathon Graveling AJ, *et al.*[11-13].

When observing the behaviour of urea in marathon runners, we agree with Zapico, *et al.*[13-15] who found important increases in urea levels after strenuous exercise Murillo S, *et al.*[14-15]. Our data - raised average values of 95.5% - do not coincide in magnitude with data from these studies, but the trend is the same, which we justify with the fact they are not homogeneous groups or similar sports. Our explanation of this 95.5% increase of the average values is not unique. We believe that it is due to dehydration, a product of exertion, and that the participants do not correctly replenish these liquids during the exertion period. On the other hand, we put this considerable increase down to the metabolism of the tissues, fundamentally the striated muscle, which occurs with extreme exercise.

From observing the data regarding creatinine, similar behaviour can be observed to that of urea in terms of the trend in the post-exertion test. This is described by authors such as Zapico AG, *et al.*[13-15]. The only difference in the behaviour of the urea and the creatinine is the magnitude of the increase, which for the urea is 95.5%, whilst for the creatinine it is 45.3%. We give this relative value, as in order for it to be significantly important there should have been a series of samples taken over a period of time afterwards, whilst our study merely reflects a "photo finish" after the marathon. The explanation behind the increase is the same that we offer to explain the increase in the urea.

The studies by Mydlik M, *et al.*[16,17] compare the conditions of the urine excretory tract with its behaviour within the symptoms of kidney failure.

The behaviour of total cholesterol and the triglycerides after the exertion - in this case a marathon - proves to be irrelevant in the findings of our study. We discovered a 0.53% increase in the average values for cholesterol, which reveals practically no variation, and 2.91% for the triglycerides, which is also minimal.

All of our data has been compared with that from various authors that have studied the same issue - Warburton DER, *et al.*[18-20] - and we all reach the same assumptions.

The results obtained from our study were compared with those from different authors that have assessed similar parameters and published in various media - Coggan A, *et al.*[21-23] - and with those previously mentioned in this work. We were able to reach a conclusion from the results in our research and express them.

We observed the behaviour of the biochemical parameters studied both before and after the study group underwent the maximum exertion.

As mentioned previously, the study group is a homogeneous group of adult males of working age (average age 50.4 years with a deviation of ±7.6-9.6), that have been participating in significant physical activity for a considerable amount of time, meaning that the conditioning phase has been exceeded.

Therefore, after the discussion phase and comparing data published by other researchers, we believe that this is interesting data regarding the changes in the biochemical parameters analysed after executing a maximum exertion, stress test.

Conclusions

After the explanatory phase of the results obtained in our study, to see the agreement or discrepancy with those obtained by other authors, we conclude that:

- Blood glucose rises after the stress test by 3.25% and we deduce that this is due to a double mechanism: dehydration caused by the exertion along with the failure to replenish lost liquids and nutrients correctly.
- The other cause, for us, behind the raised blood glucose, is the significant release of catecholamines that act as hyperglucemiants.
- We consider that both the urea and the creatinine have a similar behavioural profile, which is a considerable increase after the stress test; this increase is 95.5% for the urea and 45.3% for the creatinine. We explain this increase with dehydration and the excessive increase of tissue metabolism, caused by the exertion, especially the large amount of striated muscle tissue that is used in the exertion.
- We have observed that the behaviour of the total cholesterol and triglycerides retains a similar profile and the only point we can gather is that the variations are so minimal that we can conclude they are not significant.

References

1. Bramble DM, Lieberman DE. Endurance running and the evolution of homo; *Nature* 2004;432(7015):345-52.
2. Zimmer C. Human Evolution. Faster Than a Hyena? Running May Make Humans Special, *Science.* 2004; 306(5700):1283-19.
3. Nuviala-Mateo RJ, Lapieza-Laínez MG. The intake of proteins and essential amino acids in top-competing women athletes. *Nutr Hosp.* 1997;12(2):85-91.
4. Galvis JC. Importancia del laboratorio en la evaluación del deportista. *Laboratorio Actual.* 2000;17(33):9-11.
5. Moreno-Lemos SM. Importancia de las valoraciones bioquímicas como medio de control del entrenamiento del deportista de alto rendimiento. http//www.compumedicina.com 2008 Diciembre; 149 (IX).
6. Ortega FB, Artero EG, Ruiz JR, Vicente-Rodriguez G, Bergman P, Hagströmer M, *et al.* Reliability of health-related physical fitness tests in European adolescents. The HELENA Study. *Int J Obes.* 2008;32(Suppl 5):S49-57.
7. Bluche PF, Callis A, Pages T, Ibáñez J. Analysis of some blood parameters in the arrival of a Class Triathlon (Carcassonne 1989). *Apunts Medicina de l' Esport*. 1990;23:97-102.
8. Minuk HL, Hanna AK, Marliss EB, Vranic M, Zinman B. Metabolic response to moderate exercise in obese man during prolonged fasting. *Am J Physiol.* 1980;238(4):322-9.
9. Long D, Blake M, Mc Maughton L, Angle B. Hematological and Biochemical changes during a short triathlon competition in novice triathletes. *Eur J Appl Physiol.* 1990;61:93-9.
10. Farber HW, Arbetter J, Schaefer E, Hill S, Dallal G, Grimaldi R, Acute metabolic effects of an endurance triathlon. *Ann Sport Medicine*. 1987;3(2):131-8.
11. Graveling AJ, Frier BM. Risks of marathon running and hypoglycaemia in Type 1 diabetes. *Diabet Med.* 2010;27(5):585-8.
12. Boehncke S, Poettgen K, Maser-Gluth C, Reusch J, Boehncke WH, Badenhoop K. Endurance capabilities of triathlon competitors with type 1 diabetes mellitus. *Dtsch Med Wochenschr.* 2009;134(14):677-82.
13. Zapico AG, Calderón FJ, Benito PJ, González CB, Parisi A, Pigozzi F. Evolution of physiological and haematological parameters with training load in elite male road cyclists: a longitudinal study. *J Sports Med Phys Fitness.* 2007;47(2):91-6.
14. Murillo S, Brugnara L, Novials A. One year follow-up in a group of half-marathon runners with type-1 diabetes treated with insulin analogues. *J Sports Med Phys Fitness.* 2010;50(4):506-10.
15. Clemente, V, Navarro, F, Gonzalez JM. Changes in biochemical parameters after a 20 hour ultra-endurance kayak and cycling event. *I Sport Med J.* 2011;12(1):1-6.
16. Mydlík M, Derzsiová K, Bohus B. Renal function abnormalities after marathon run and 16-kilometre long-distance run. *Przegl Lek*. 2012;69(1):1-4.
17. McCullough PA, Chinnaiyan KM, Gallagher MJ, Colar JM Geddes, T, Oro JM. Changes in renal markers and acute kidney injury after marathon running. *JE. Nephrology (Carlton)*. 2011;16(2):194-9.
18. Warburton DER, Welsh RC, Haykowsky MJ, Taylor DA, Humen DP. Biochemical changes as a result of prolonged strenuous exercise. *Br J Sports Med.* 2002;36(4):301-3.
19. Vaisberg M, Bachi AL, Latrilha C, Dioguardi GS, Bydlowski SP, Maranhão RC. Lipid Transfer to HDL is Higher in Marathon Runners than in Sedentary Subjects, but is Acutely Inhibited During the Run. *Lipids.* 2012;47(7):679-86.
20. Sánchez-González J, Rivera-Cisneros A, Tovar-Luz J. Association of physiologic responses to metabolic changes in exhaustive physical exercise. *Cir.* 2003;71(3):217-25.
21. Coggan A, Raguso C, Gastaldelli, Sidossis LS, Yeckel CW. Fat metabolism during high-intensity exercise in endurance-trained and untrained men. *Metabolism.* 2000;49(1): 122-8.
22. Kratz A, Lewandrowski KB, Siegel AJ, Chun KY, Flood JG, Van Cott EM, *et al.* Effect of Marathon Running on Hematologic and Biochemical Laboratory Parameters, Including Cardiac Markers. *Am J Clin Pathol.* 2002;118(6):856-63.
23. Smith JE, Garbutt G, Lopes P, Pedoe DT. Effects of prolonged strenuous exercise (marathon running) on biochemical and haematological markers used in the investigation on of patients in the emergency department. *Br J Sports Med*. 2004;38(3):292-4.