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Dietary and Biochemical Profile of Congolese Athletes in Endurance Races during International Competition

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Abstract

Biochemical parameters are useful in the diagnosis of many health abnormalities in athletes. Some studies suggest training well and eating a balanced diet to improve performance. The modification of biochemical parameters during endurance races has not yet been studied in many African countries. Our objective was to evaluate the dietary profile and the effects of competition on the biochemical parameters of Congolese endurance athletes. The method used was the questionnaire for the food profile and blood samples were taken to measure the biochemical parameters of the athletes. A total of 64 athletes, *i.e.* 20 girls and 44 boys divided into two groups (group 1 or experimental group (EG), 32 endurance athletes and group 2 or control group (CG), 32 walkers who participated in a cross-sectional study in Brazzaville. The subjects were respectively 26.16 ± 2.79 years old for the EG and 27.44 ± 3.34 years old for the CG. The results indicated that quality foods were difficult to access. The main course was more consumed compared to the starter and dessert (60% of girls and 63.63 of boys). However, biochemical parameters showed a significantly lower serum creatinine concentration in EG subjects compared to CG subjects (0.86 ± 0.06 mg/dl vs 1.04 ± 0.16 mg/dl; $t = -5.95$; $p < 0.000$), the triglyceride level of EG subjects was slightly lower (0.91 ± 0.32 g/l vs 1.04 ±

0.41 g/l; t = −1.97; p > 0.05). Similarly, Total Cholesterol was significantly low (1.66 ± 0.34 g/l vs 2.09 ± 0.50 g/l; t = −3.99; p < 0.000). Cholesterol concentrations of EG subjects (HDL-C) were significantly elevated (0.98 ± 0.49 g/l vs 0.48 ± 0.18 g/l; t = 5.34; p < 0.000). In conclusion, the biochemical data were normal but the food profile of the runners was unfavorable, inadequate and unbalanced. This is considered to be a performance limiting factor.

Keywords

Food Profile, Biochemical Parameters, Congolese Athletes, Endurance Race, International Competition

1. Introduction

The functioning of the body in motion has been the subject of multiple reflections at various levels: anatomo-physiological [1] [2], nutritional [3] [4] psychological [5] and sociological [6]. Several studies have assessed psychosocial [7] [8], technical-tactical [9], physical [10], morphological [3], medical [8], and cognitive [11] factors. In addition, over the past ten years, many studies have looked into the evolution of sports performance and the training methods used to achieve performance. On the other hand, there is little data on the dietary habits of athletes and on the potential need to modify their nutritional intake [4]. It is well established that a balanced diet is essential for maintaining good health and even more important for athletes who have increased energy needs [4]. To avoid the occurrence of nutritional and biochemical disturbances, although complex, it is recommended to use a healthy and balanced diet [12]. However, athletes must benefit from a quantity of food to meet their needs in terms of energy, quality, macronutrients (carbohydrates, lipids, proteins), micronutrients (vitamins and mineral salts) and water. This would allow them to have a fairly interesting level of biochemical status and allow better clinical management [13]. In sport, biomarkers are key parameters to assess the impact of exercise on different systems, tissues and organs. They also allow the identification of risk situations, such as overtraining and nutrient deficiencies according to Gonzalo Palacios *et al.* [14]. It is in this perspective that studies have highlighted the link between diet and biochemical parameters [15]. The evolution of scientific data over the past ten years has made it possible to highlight the links between the evolution of dietary practices and lifestyles and health. INRAE [16] indicates that nutritional imbalances are indeed involved in the appearance and development of most chronic diseases such as obesity, cardiovascular disease, type 2 diabetes, hypercholesterolemia, osteoporosis, etc. Similarly, nutrient deficiency can be accompanied by biochemical abnormalities [17]. Indeed, it is quite obvious that the athlete has well-defined nutritional requirements and any deficit will have serious consequences not only on his performance but also on his body. Some more significant deficits can trigger real pathological disorders (anaemia, hypoglycemia, musculotendinous disorders) according to the study by Lino Tricoli [18]. However, the Republic of Congo is distinguished by a constant deterioration of living conditions, with a Human Development Index (HDI) equal to 0.234 in 2011 [19], which places it in 136th place in the world in relation to the Sustainable Development Goals. This has as its corollary the undernourishment of the general population [20] thus deteriorating the biochemical data of athletes who practice sports activities in competition [14]. Given the deterioration of living conditions in households, athletes who participated in the 11th African Games, organized in Brazzaville in September 2015 and recent competitions were characterized by poor performance and dropouts in endurance races [21]. During this period, the conditions for practicing competitive endurance racing, the biochemical requirements of which are increasingly being identified, remain little known. In the absence of precise knowledge of the effect of sustained physical exercise, for an elite athlete, whether he or a recreational sport, the approach to nutritional errors is seeing the rebirth of controversy [22]. Nutritional errors would be responsible for chronological disturbances inducing a drop in the level of performance of athletes [23]. This appears to be related to either food deprivation or a change in eating habits. However, few studies have addressed performance in the dietary dimension [24] [25] [26]. Notwithstanding these works, in Congo-Brazzaville, few studies have unsealed dietary practices and listed the variations of biochemical parameters within athletes [25] [27] [28]. However, to our knowledge, no study has focused on the evaluation of the dietary and biochemical profile of Congolese athletes in comparison with subjects practicing maintenance sports such as walking. Our study aims to evaluate the dietary profile and the effects of competition on biochemical parameters in Congolese endurance racing athletes. We hypothesized that the underperformance of Congolese athletes is explained by the poor dietary and biochemical profile.

2. Methodology

2.1. Attendees

We are interested in the entire Congolese sporting population of male and female sexes practicing endurance races and walkers practicing recreational sport. The athletes were part of the national middle-distance running (MDR) team and participated in the national and international competitions of the 2012-2016 and 2017-2021 Olympiad. The non-random method and the reasoned-choice technique allowed us to retain a sample of 64 subjects including 32 long-distance running (LDR) and middle-distance running (MDR) athletes and 32 walkers. The subjects were divided into two groups: an experimental group(EG) made up of 32 trained athletes, *i.e.* 22 boys and 10 girls practicing endurance races (MDR and LDR) with an average age of 26.16 ± 2.79 years, a height average of 1.69 ± 0.07 m, and an average weight of 57.28 ± 4.49 kg, and a BMI of 19.73 ± 1.49 kg/ and a control group (CG) consisting of 32 walkers, *i.e.* 22 boys and 10 girls with a average age of 27.44 ± 3.34 years, average height 1.66 ± 0.04 m, average weight of 63.13 ± 4.03 kg and BMI of 22.49 ± 1.50 kg/m^2.

2.2. Ethics Committee

All participants signed a written informed consent after explaining the objectives and interest of the study. The study was presented and validated by the ethics committee (LNSP-ILP/0122/04-2020), in accordance with the Helsinki recommendations.

2.3. Experimental Protocol

The investigation took place within a week. The first two days were devoted to measuring the height, weight and collecting information related to the marital status of the athletes. Then we launched a questionnaire to the 32 athletes in their training places. The food survey containing various aspects related to food behavior was carried out using food survey sheets [29] which were filled out on site and collected by the interviewer.

Trained athletes and walkers practicing maintenance sports were received at the national laboratory for the blood sample which was taken in 4 days.

2.4. Biological Blood Tests

Blood samples in both groups (elite athlete's vs maintenance walking club) were taken by qualified personnel from the National Public Health Laboratory. All these analyses were carried out via an automatic process of the biochemistry laboratory of the National Public Health Laboratory.

2.5. Determination of Biochemical Parameters

Biomarker examinations such as fasting blood glucose, serum creatinine, triglycerides, total cholesterol, HDL-Cholesterol (HDL-C), LDL-cholesterol (LDL-C), and Complete Blood Count (NFS) were carried out in trained athletes constituting the experimental group (EG) and walkers constituting the control group (CG) at the National Public Health Laboratory of the Republic of Congo, precisely at the Directorate of Medical Biology in Brazzaville.

These samples were taken in the morning on an empty stomach with the "vacutainer system" in the subjects of two groups. Blood was collected in dry sterile evacuated tubes bearing the subject's name or number. The blood samples were centrifuged (3500 rpm, 15 minutes) and the collected sera were stored at −20˚C until the day of the analyses. These biochemical assessments should make it possible to diagnose some biochemical variations and suspect nutritional deficiencies [30].

2.6. Equipment Used

Biological material: Human blood;

Laboratory equipment: sterile single-use needles (21G) for blood sampling; micro infusion sets for blood sampling, tourniquets, 90˚ alcohol, sterile gloves (single use); absorbent cotton; hemolysis tubes; sticking plaster; indelible ink markers; a red blood cell counter (PENTRA ES 60), racks for transporting the tubes, adjustable micropipettes from 10 to 100 µl and from 500 to 1,000,100 µl, tips for the serum and for the reagents, a centrifuge, a refrigerator; a freezer; an HP computer; an HP printer; a spectrophotometer for the analysis of biochemical data (KENZA MAX BioChemisTry); and BIOCHEMISTRY ABALYSTER RX and racks for tube transport).

2.7. Statistical Analysis of Data

The statistical exploitation for the food practice questionnaire was carried out with the student test. The statistics were performed using the Statistical Package of Social Science for Windows (SPSS) version 22 software. The results were presented as mean and percentage.

For the biochemical parameters, the statistical treatment was carried out using a student test, the comparison test with two independent samples.

For the biochemical parameters we used a student t test for independent groups in order to compare the means.

3. Results

Table 1 shows the anthropometric data of the subjects.

Table 2 indicates that the food available is very expensive for 70% of girls and 81.82% of boys.

The results in **Table 3** show that 60% of girls and 63.64% of boys had consumed poor quality food; and 60% of girls and 54.55% of boys had consumed an insufficient amount of food. Similarly, our results indicate that the majority of athletes (70% of girls and 81.82% of boys) were dependent on their parents, while 30% of girls and 18.18% of boys were unsupported.

Table 4 indicates that the majority of athletes took only the main courses.

Recommended values for Girls and Boys: fasting blood sugar (0.70 to 1.10 g/l); creatinine or serum creatinine (0.7 to 1.36 mg/l); Triglycerides (0.40 to 1.60 g/l); total cholesterol (1.40 to 2.70 g/l); HDL-C (>0.35 g/l); LDL cholesterol (<1.60 g/l); LDL/HDL ratio (<3.22 g/l); TC/HDL ratio (<4.44 g/l) (**Table 5**).

Table 1. Anthropometric data of the subjects.

Variables	Experimental Group (G = 10; B = 22)	Control Group (G = 10; B = 22)	**t**	**Sig**
	$\bar{X} \pm \sigma$	$\bar{X} \pm \sigma$		
Age (years)	26.16 ± 2.79	27.44 ± 3.34	−1.66	NS
Weight (Kg)	57.28 ± 4.49	63.13 ± 4.03***	−5.47	<0.000
Height (m)	1.69 ± 0.07*	1.66 ± 0.04	2.05	<0.05
BMI (Kg/m^2)	19.73 ± 1.49	22.49 ± 1.50***	−7.37	<0.000

Legend: NS = not significant; *: significant; ***: highly significant.

Table 2. Food availability in athletes.

Answers	Girls (N = 10)		Boys (N = 22)	
	N	%	N	%
Food availability				
Available and less expensive	1	10	0	00
Available and very expensive	7	70	18	81.82
Unavailable	2	20	4	18.18

Legend: N = total number of subjects; n = number of subjects; % = percentage.

Table 3. Amount of food consumed and management of athletes.

Answers	Girls (N = 10)		Boys (N = 22)	
	N	%	N	%
Quantity of food consumed				
sufficient	1	10	8	36.36
Insufficient	6	60	12	54.55
Do not know	3	30	2	9.09
Athlete support				
Parents	7	70	18	81.82
oneself	3	30	4	18.18
Coach-Club-Federation	00	00	00	00

Legend: N = total number of subjects; n = number of subjects; % = percentage.

Table 4. Dishes taken by the athletes.

Service	Girls (N = 10)		Boys (N = 22)	
	n	%	n	%
Aperitif + Main dish + Dessert	1	10	-	-
Main dish + Dessert	2	20	6	27.27
Main dish	6	60	14	63.63
starter dish + Main dish + Dessert	1	10	2	9.09

The results of this Table 6 show that, overall, the difference between the sexes of the two groups of subjects is not significant concerning respectively blood sugar (F(3.60) = 0.72, NS) and triglycerides (F(3.60) = 2.01, NS).

Standard values for girls and boys: Blood sugar (g/l) = 0.70 to 1.10; Creatinemia (mg/l) = 7 to 13.6; Triglycerides (g/l) = 0.40 to 1.60; Total cholesterol (g/l) = 1.40 to 2.70; HDL-C (g/l) = 0.35; LDL cholesterol (g/l) ≤ 1.60; LDL/HDL ratio (<3.22 g/l); TC/HDL ratio (<4.44 g/l) (Table 7).

Table 5. Comparison of biochemical parameters according to the groups.

Variables	Experimental Group (G = 10; B = 22)	control Group (G = 10; B = 22)	t	Sig
	$\bar{X} \pm \sigma$	$\bar{X} \pm \sigma$		
Blood sugar (g/l)	0.81 ± 0.08	0.82 ± 0.20	−0.29	NS
Creatinemia (mg/l)	0.86 ± 0.06***	1.04 ± 0.16	−5.95	<0.000
Triglycerides (g/l)	0.91 ± 0.32	1.09 ± 0.41	−1.97	NS
Total cholesterol (g/l)	1.66 ± 0.34***	2.09 ± 0.50	−3.99	<0.000
HDL-C (g/l)	0.98 ± 0.49***	0.48 ± 0.18	5.34	<0.000
LDL cholesterol (g/l)	0.87 ± 0.33***	1.27 ± 0.48	−3.85	<0.000
LDL/HDL ratio (g/l)	1.08 ± 0.56***	2.96 ± 1.45	−6.82	<0.000
TC/HDL ratio (g/l)	2.06 ± 0.89***	4.73 ± 1.71	−7.82	<0.000

Legend: NS = not significant; *: significant; **: very significant; ***: highly significant.

Table 6. Comparison of biochemical parameters according to sex.

		sums of squares	ddl	medium square	F	Sig
Blood sugar	Inter groupe	0.05	3	0.02	0.72	NS
	Intra groupe	1.41	60	0.02		
Creatinemia	Inter groupe	0.55	3	0.18	11.57	<0.000
	Intra groupe	0.95	60	0.02		
Triglycerides	Inter groupe	0.82	3	0.27	2.01	NS
	Intra groupe	8.18	60	0.14		
Total cholesterol	Inter groupe	3.15	3	1.05	5.70	<0.000
	Intra groupe	11.06	60	0.18		
HDL Cholest.	Inter groupe	6.17	3	2.05	19.71	<0.000
	Intra groupe	6.26	60	0.10		
LDL Cholest.	Inter groupe	3.02	3	1.01	6.09	<0.000
	Intra groupe	9.93	60	0.17		
LDL/HDL ratio	Inter groupe	60.10	3	20.04	16.89	<0.000
	Intra groupe	71.15	60	1.19		
TC/HDL ratio	Inter groupe	123.29	3	41.09	23.44	<0.000
	Intra groupe	105.17	60	1.75		

Table 7. Multiple comparison of the biochemical state of the subjects according to gender.

Variables	BEG N = 22	BCG N = 22	GEG N = 10	GCG N = 10	Sig
Creatinemia (mg/l)	0.87 ± 0.07***	1.05 ± 0.19			<0.000
	0.87 ± 0.07***	/////	/////	1.04 ± 0.07	<0.01
	/////	1.05 ± 0.19	0.84 ± 0.06**	/////	<0.000
	/////	/////	0.84 ± 0.06**	1.04 ± 0.07	<0.01

Continued

Triglycerides (g/l)	0.87 ± 0.32**	/////	/////	1.21 ± 0.51	<0.02
Total cholesterol (g/l)	1.72 ± 0.38**	2.07 ± 0.48	/////	/////	<0.01
	1.72 ± 0.38**	/////	/////	2.11 ± 0.57	<0.02
	/////	2.07 ± 0.48	1.53 ± 0.21**	/////	<0.01
	/////	/////	1.53 ± 0.21**	2.11 ± 0.57	<0.01
HDL Cholesterol (g/l)	1.15 ± 0.48***	0.45 ± 0.13	/////	/////	<0.000
	1.15 ± 0.48***	/////	0.59 ± 0.23	/////	<0.000
	1.15 ± 0.48***	/////	/////	0.56 ± 0.26	<0.000
LDL Cholesterol (g/l)	0.95 ± 0.37**	1.31 ± 0.43	/////	/////	<0.01
	/////	1.31 ± 0.43	0.71 ± 0.14***	/////	<0.000
	/////	/////	0.71 ± 0.14**	1.17 ± 0.59	<0.01
LDL/HDL ratio (g/l)	0.94 ± 0.49***	3.14 ± 1.32	/////	/////	<0.000
	0.94 ± 0.49***	/////	/////	2.55 ± 1.70	<0.000
	////	////	1.39 ± 0.62**	2.55 ± 1.70	<0.02
	/////	3.14 ± 1.32	1.39 ± 0.62***	/////	<0.000
TC/HDL ratio (g/l)	1.71 ± 0.72***	4.84 ± 1.42	/////	/////	<0.000
	1.71 ± 0.72**	/////	2.84 ± 0.76	/////	<0.03
	1.71 ± 0.72***	/////	/////	4.48 ± 2,28	<0.000
	/////	4.84 ± 1.42	2.84 ± 0.76***	/////	<0.000
	/////	/////	2.84 ± 0.76**	4.48 ± 2.28	<0.01

Legend: BEG = boys in the experimental group; BCT = boys in the control group; GEG = Girls in the experimental group; GCT = Girls in the control group; TC = Total cholesterol; HDL = High density lipoprotein or good cholesterol; LDL = Low density lipoprotein or bad cholesterol.

4. Discussion

The present study aimed to evaluate the dietary profile and the effects of competition on biochemical parameters in Congolese athletes in endurance races versus the group of walkers practicing recreational and/or maintenance sports. The main results of our study showed a decrease in serum creatinine, triglyceride levels and Total Cholesterol. However, the EG subjects' cholesterol (HDL-C) concentrations were significantly elevated. These changes are favorable for the elite athletes and hence the middle distance and long distance athletes surveyed. The results of the biochemical data obtained were compared with European standards [31] [32], with those described elsewhere in Africa [33] [34] and with universal WHO recommendations [35].

The results obtained showed that the two groups (EG and CG) did not differ in age. However, the control group (CG) consisting of untrained subjects differed significantly from the experimental group (EG) consisting of athletes, in weight and BMI, respectively (63.13 ± 4.03 vs 57.28 ± 4.49 kg and 22.49 ± 1.50

vs. 19.73 ± 1.49 Kg/m^2). There is also a significant difference in height in favor of the experimental group (1.69 ± 0.07 vs 1.66 ± 0.04 m) (**Table 1**).

This good development of height in the subjects of the experimental group compared to those of the control group, of almost similar ages (26.16 ± 2.79 years vs 27.44 ± 3.34 years; $t = -1.66$; $p > 0.05$), was probably due to the fact that the practice of endurance for a long time had stimulated bone growth as indicated by Ratel (2014) [13].

4.1. Food Data Found

Regarding the availability of food, as well as its accessibility on the Congolese market, it is important to note that the accessibility of food on the market was difficult [36]. Similarly, our results indicate that quality foods were available but were very expensive on the market (70% of girls and 81.82% of boys) (**Table 2**).

These results agree with those of Bouhika *et al.* [36] which stipulate that the low local agro-pastoral and halieutic production, insufficient income, the absence of a culture of preservation, processing and storage of food and the seasonality of the supply of products would be associated with the unavailability of food in the Congo. It is clear that the availability of quality food, sold at reasonable prices, remains a very worrying situation in Congo. This would lead to resorting to inappropriate eating habits [37]. In the same perspective, the WHO/FAO [38] indicates that access to healthy food is almost reserved for wealthy populations. Regarding the quantity of food served, the results show an insufficiency in 60% of girls and 54.55% of boys (**Table 3**).

From a quantitative point of view, to provide enough energy and ensure muscle glycogen reserves, a quantitative intake is necessary. In this perspective, the results of previous work report that feeding with a sufficient quantity of food is a necessity for man in order to obtain energy permanently, whether for movements, vital functions (breathing, circulation, digestion) but also for the functioning of the brain [39]. Indeed, it is estimated that more than 840 million people around the world are chronically hungry, despite record per capita food availability in most countries and globally as indicated by the WHO [40].

In our study, the deficit in food quantity could be explained by the fact that these athletes lived in the households of the parents (70% of the girls and 18.82% of the boys) without being supported by the federation. These parents certainly had unfavorable socioeconomic conditions [36] [41]. This seems to agree with what Folaranni reported [42]. Indeed, this author reported that while living under the parental roof, the consumption of the quality and quantity of food was linked to the monthly income of the parents or the head of the household.

Thus, 60% of female athletes and 63.6% of male athletes reported consuming the main course. In addition, 20% of girls and 27.27% of boys had eaten the main course plus dessert. However, very few subjects had been able to consume a starter dish, a main course accompanied by dessert respectively (10% of girls and 9.09% of boys). This was probably due to the fact that these athletes came from families with a somewhat high socio-economic level (**Table 4**). However, according to Fréderic Maton [43], a balanced diet must be sufficient from an energy point of view, as diversified as possible. But also guarantee a good distribution between proteins, lipids, carbohydrates and a good complementary supply of vitamins, minerals and fibers. The main food was corn porridge with donuts, rice pudding with donuts, spaghetti and CAO (legumes) plus buttered bread and a cup of milk plus peanut paste bread in breakfast and salted fish, beans, foufou, gnetum, peanut paste, palm nuts, eggplants, cassava, game meat, vegetables, pork, rice, chicken wing, chicken thigh, sorrel, smoked fish, pigeon peas, saka-saka and pork tail for lunch, and had consumed more smoked fish, gnetum, foufou, bread, spaghetti, cup of milk, bread with butter, meat from pork, beans, rice, turkey wing and cassava for dinner. This way of eating is inappropriate and does not cover the athlete's energy needs. However, a substantial nutritional intake provides the energy to run the body. A bit like a heat engine, the muscles transform a large part of the energy consumed into heat. To regulate the resulting water losses, water inputs must therefore be taken into account with the same care as energy inputs; this, both to prevent dehydration accidents and to maintain an optimum level of performance.

4.2. Biochemical Parameters

Regarding biochemical parameters, it should be noted that physical exercise plays a very important role in their regulation. Indeed, physical exercise under the effect of neurobiochemical substances such as norepinephrine and adrenaline, increases glycemia in athletes by inducing hyperglycemia and hyperinsulinemia. One would expect that high blood sugar would not be seen frequently in athletes and low blood sugar would be more of a concern due to increased energy expenditure. Our results do not reveal any significant differences between the groups of subjects on the one hand (0.81 ± 0.08 vs 0.82 ± 0.20; $t = -0.29$; $p > 0.05$) (**Table 5**) and the sexes of the subjects on the other hand (Sum of the squares = 0.05; dof = 3; $F = 0.72$; $p > 0.05$). The reference value being 0.70 g/l to 1.10 g/l in the mixed subjects, their results were within the norms (**Table 5**). The study conducted by Thomas *et al.* [44] had shown that the only athlete who had worked out with a blood sugar level below 4.0 mmol/L, had a calorie intake considerably reduced compared to the recommended intakes.

In the field of sports medicine, serum creatinine is generally used to assess the health status of athletes, particularly in activities where hydroelectric balance is crucial. Serum creatinine is not influenced by training and competition, although a 20% increase has been reported during endurance and ultra-endurance activities [45]. It is a very stable variable in the athlete, but its concentration can vary on the one hand between the athlete and the sedentary and on the other hand between the types of activities. The reference value being 0.7 mg/dl to 1.36 mg/dl in mixed subjects, our results reveal that EG subjects had a significantly lower serum creatinine concentration compared to CG subjects (0.86 ± 0.06

mg/dl vs 1.04 ± 0.16 mg/dl; $t = -5.95$; $p < 0.000$) (**Table 5**). Our results are in agreement with the work of Lippi *et al.* (2004) and Lippi *et al.* (2006) [46] [47] who obtained significantly low concentrations in skiers and cyclists compared to sedentary subjects.

In the same athletes, the concentration of serum creatinine can vary according to the different stages of competition in a sports season. However, lean mass is not a good index to assess this concentration. According to Banfi and Del Fabbro (2006) [48], cyclists, characterized by a very low percentage of fat mass, had a very low serum creatinine concentration compared to rugby players who had a very high fat mass.

Our results on the comparison of biochemical parameters according to sex show that the parameters of the subjects differ significantly concerning serum creatinine ($F(3.60) = 11.57$; $p < 0.000$), total cholesterol ($F(3.60) = 5.70$; $p < 0.000$), HDL Cholesterol ($F(3.60) = 19.71$; $p < 0.000$), LDL cholesterol ($F(3.60) = 6.09$; $p < 0.000$), the LDL/HDL ratio ($F(3.60) = 16.89$; $p < 0.000$) and the total cholesterol/HDL ratio ($F(3.60) = 23.44$; $p < 0.000$). This means that the means of these five parameters differ significantly according to sex. The use of the Post Hoc LSD (or two-by-two means test) for the multiple comparison then makes it possible to detect these differences (**Table 6**). Similarly, our results show that CG subjects, with a significantly elevated BMI, had significantly elevated serum creatinine concentrations compared to boys (0.87 ± 0.07 mg/dl vs 1.05 ± 0.19 mg/dl; $p < 0.000$) and girls (0.84 ± 0.06 mg/dl vs 1.04 ± 0.07 mg/dl; $p < 0.01$) of the EG (**Table 7**). This could be related to the lack of intensive physical activity in their maintenance program. Today, it is proven that physical activity leads to biochemical changes [23]. Triglyceride (TG) metabolism in adipose tissue and its regulation have been studied in detail for many years. It has been shown that muscle TGs are consumed during submaximal exercise as an important substrate for contracting muscle and that, this intramuscular contribution is 7%, 26% and 8% during exercise performed at 25%, 65% and 85% of VO2max respectively [49].

According to numerous studies, regular participation in endurance exercise and training is associated with lower concentrations of blood TGs [50]. Our results reveal that, compared to CG, the amount of TG in EG subjects is slightly low (0.91 ± 0.32 g/l vs 1.04 ± 0.41 g/l; $t = -1.97$; $p > 0.05$) (**Table 5**). These results are similar to those reported by Rahanama *et al.* [51] who state that highly trained athletes seem to use more of their intracellular TG stores. So this decrease in TG observed in our subjects of the EG is justified by the fact that the intensity of the activity had caused a consumption of intramuscular TG. This intensity of activity was higher between boys in EG and girls in CG. This is justified by a significant drop in TG in these boys (0.87 ± 0.32 g/l vs 1.21 ± 0.51 g/l; $p < 0.01$) (**Table 7**).

Results of previous work had demonstrated a clear relationship between levels of cardiovascular disease (CVD) and total cholesterol (TC) [52] [53]. According to the study by Kelley *et al.* [54], aerobic exercise reduced TC and TG levels in men over 18 years of age. The reference values being 1.40 g/l to 2.70 g/l in mixed subjects, our results indicate that, compared to CG, the Total cholesterol(TC) of EG subjects is significantly low (1.66 ± 0.34 g/l vs 2.09 ± 0.50 g/l; t = −3.99; $p < 0.000$) (**Table 5**). This high intensity had also induced a decrease in TC in girls and boys in the EG compared to girls and boys in the CG (2.07 ± 0.48 g/l vs 1.72 ± 0.38 g/l; $p < 0.01$) in boys and 2.11 ± 0.57 g/l vs 1.53 ± 0.21 g/l; $p < 0.01$ in girls) (**Table 7**). Like TC, LDL/HDL, TC/HDL, LDL-Cholesterol (LDL-C) is a major predictor of coronary heart disease. An increase in their levels has been shown to lead to an increase in the formation of atherosclerotic plaques [55]. Indeed, it is generally accepted that the values of TC, LDL/HDL ratio, TC/HDL ratio, and LDL-C are high in sedentary subjects compared to trained subjects. Our results show that, compared to EG, the CG presents LDL-C results and LDL/HDL and CT/HDL ratios, which are significantly elevated respectively (1.27 ± 0.48 g/l vs 0.87 ± 0.33 g/l; t = −3.85; $p < 0.000$; 2.96 ± 1.45 g/l vs 1.08 ± 0.56 g/l; t = −6.82; $p < 0.000$ and 4.73 ± 1.71 g/l vs 2.06 ± 0.89 g/l; t = −7.82; $p < 0.000$) (**Table 5**). The increase in LDL-C values was observed in both CG and EG boys, but showed no significant differences. However, compared to EG boys, CG boys have significantly elevated LDL-C, LDL/HDL and CT/HDL values, respectively (0.95 ± 0.37 g/l vs 1.31 ± 0.43 g/l; $p < 0.01$; 0.94 ± 0.49 g/l vs 3.14 ± 1.32 g/l; $p < 0.000$ and 1.71 ± 0.72 g/l vs 4.84 ± 1.42 g/l; $p < 0.000$). Similarly, compared to the girls in the EG, the girls in the CG showed significantly elevated C-LDL, LDL/HDL and CT/HDL values (0.71 ± 0.14 g/l vs 1.17 ± 0.59 g/l; $p < 0.01$; 1.39 ± 0.62 g/l vs 2.55 ± 1.70 g/l; $p < 0.05$ and 2.84 ± 0.76 g/l vs 4, 48 ± 2.28 g/l; $p < 0.01$) (**Table 7**). Indeed, biomarkers are associated with a diagnostic value to identify a physiopathological process or a disease (acute coronary syndrome or acute pulmonary edema for example) or prognostic value, in the short or medium term, to evaluate the effectiveness of the therapies undertaken or to allow the orientation of the patient in the structure of care most adapted to his condition. In our study, we checked Blood Glucose, Creatinemia, Triglycerides, Total Cholesterol, HDL-Cholesterol, LDL-Cholesterol, LDL/HDL and CT/HDL ratio to determine the health status of athletes.

Physical training (endurance and strength) is generally associated with the elimination of risk factors for cardiovascular disease by improving the lipid profile. Results obtained from previous studies have shown that endurance training causes effective changes in the lipid profile. Indeed, endurance training increases the body's potential to mobilize and oxidize fatty acids. This adaptation may also influence the plasma concentration of lipids and lipoproteins [56]. According to Mazloom *et al.* [57], well-trained men have a lower level of total Tg, VLDL, LDL and a high level of HDL.

These results are similar to those found in our study. Indeed, compared to the CG subjects, the EG subjects had significantly elevated HDL concentrations (0.98 ± 0.49 g/l vs 0.48 ± 0.18 g/l; t = 5.34; $p < 0.000$) (**Table 5**). Looking at the HDL according to the sexes of the subjects, it appears that, compared to the boys of the CG and the girls of the experimental and control groups, the boys of the EG presented significantly elevated HDL concentrations respectively (1.15 ± 0.48 g/l vs 0.45 ± 0.13 g/l; $p < 0.000$; 1.15 ± 0.48 g/l vs 0.59 ± 0.23 g/l; $p < 0.000$ and 1.15 ± 0.48 g/l vs. 0.56 ± 0.26 g/l; $p < 0.000$) (**Table 7**). These results agree with those found by Mirghani *et al.* [58] and Thaveeratitham *et al.* [59]. Indeed, these authors had proven that low levels of TC and LDL-C as well as a high concentration of HDL-C lead to a lower risk of CVD. This is due on the one hand to the fact that exercise leads to an increase in the activity of enzymes in adipose tissue and in skeletal muscle. On the other hand, because the levels of HDL-C exhibit antioxidant properties and prevent the accumulation of LDL-C in the walls of the veins. However, compared to CG girls, the HDL-C concentrations found in EG girls show a high trend, but do not show significant differences (0.59 ± 0.23 vs 0.56 ± 0.26; $p > 0.05$). These results are probably justified by the regular participation in endurance activities and that the girls in the CG were probably more active than the boys (0.45 ± 0.13 vs 0.56 ± 0.26; $p > 0.05$) (**Table 7**). Although the link between physical activity and cardiovascular health has not been verified in our study, it is recognized that regular physical activity and exercise induce a myriad of physiological adaptations that directly or indirectly benefit the human cardiovascular health. Many of these benefits appear to be seen in traditional CVD risk factors, such as blood lipid and glucose levels, obesity and high blood pressure. Regular exercise induces antiatherogenic adaptations in vascular structure and function, independent of traditional cardiovascular disease risk factors. It improves cardiac parasympathetic regulation, thereby conferring protection against malignant arrhythmias, and it also provides protection to the heart against ischemia-reperfusion damage. Myokines produced and released by muscles are responsible for many of the beneficial effects of exercise, including supporting a healthy anti-inflammatory milieu.

4.3. Limitations of the Study

Random errors are limited by the small size of the sample, but the unique realization of the questionnaire does not escape the variability of the parameters studied. The non-sampling of athletes' blood after the African Games competition period for the purpose of comparing biochemical data between the two periods was a limiting aspect of our research.

5. Conclusions

The results of this study show that inappropriate dietary practices were associated with biochemical variations in some endurance runners compared to untrained subjects. Recorded data suggests that endurance running causes increased energy expenditure. However, an unbalanced food profile had been noted as linked to the deficit in food quantity, the difficulty of accessing food on the market, and the lack of food diversification. However, the results of parameters such as: blood sugar, HDL values, TG quantity, TC, LDL-C and LDL/HDL and TC/HDL ratios were within the norms. The comparison of these parameters had shown that no difference existed in the subjects of the two groups concerning glycaemia and triglycerides.

However, athletes in the experimental group had significant decreases in serum creatinine, total cholesterol and LDL cholesterol, LDL/HDL cholesterol and total cholesterol/HDL ratios compared to those in the control group. While the subjects of the CG presented the values of LDL-C, LDL/HDL and TC/HDL significantly elevated, which does not meet the health recommendations.

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Authors' Contributions

BEJ designed and conducted the study and wrote the manuscript. BAM, MKPR, NF, MSI, MBC, LDS and BPRA participated in data acquisition, performed statistical analyses, and reviewed the manuscript. The study protocol and the revision of the manuscript were carried out by IOYS, EM and MF.

Ethical Considerations

This research work received authorization for blood sampling and analysis from the Medical Biology Department of the National Public Health Laboratory of the Republic of Congo, precisely on March 04, 2020 (LNSP-ILP/0122/04-2020 Similarly, the informed consent of each athlete and walker was required.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this article.

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