



PREPARATION EFFECTS OF THE HALF MARATHON ON THE CARDIOVASCULAR AND METABOLIC MORPHOLOGICAL ADAPTATION OF CONGLESE MIDDLE-DISTANCE RUNNERS

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ABSTRACT

This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document. (Abstract) The purpose of our study is to evaluate the morphological, cardiovascular and aerobic performance of middle-distance athletes of the Brazzaville's athletic league. This, during the preparation of the Brazzaville International Half Marathon, in French, *Semi-Marathon International de Brazzaville (SMIB)*. For this purpose, twelve (12) senior athletes ($= 25.58 \pm 2.50$) years old, with a height ($= 1.73 \pm 0.06$ m), including weights ($= 61.75 \pm 7.01$) kg and Body Mass Index (BMI) values of ($= 20.52 \pm 1.59$) kg m⁻² were selected. These were tested for body composition, arterial pressure, and aerobic fitness assessment (VAM EVAL). The averages were compared by using the *Student's test*. The results obtained showed the decrease in the fat index and the fat mass ($p < 0.001$) parallel to an increase in lean mass ($p < 0.001$). The athletes also underwent pre and post training tests. The post-endurance training, test reveals that the Heart Rate at rest (HR_0) after one minute (HR_1), after five minutes (HR_5) and after ten minutes in the post-training (HR_{10}), were significantly reduced compared to those recorded in pre-training test. Similar results were obtained regarding the Systolic Blood Pressure (SBP) of athletes. That at rest (SBP_0), after five minutes (SBP_5) and after ten minutes (SBP_{10}) after training were significantly less large / than their initial values. Also, the number of steps, the duration, the maximal aerobic volume (VMA and V_{O_2} max after endurance training-speed, were significantly higher than those recorded before training ($p < 0.001$). These results suggest that the training program for middle distance runners reoriented towards the preparation of the *SMIB* entails morphological and cardiovascular adaptations and improves the aerobic performance. However, an action should be oriented on the biomechanical action and the economy of the race.

I. INTRODUCTION

The racing events are varied. They do not require the same preparations or the same characteristics to the athletes. The physical preparation of a sprinter is essentially based on the strength and speed that generate power. But the physical preparation of the middle-distance and half race runners focused on pure endurance and speed endurance (Hottenrott, 2018). As a result, the morphological characteristic, linked to the economy of running, cardiorespiratory, metabolic and muscle of a sprinter are different from those of a runner of half race and long-distance race. A sporting performance is a fascinating event. It requires bioenergetics analysis. For example, Milanovic and al., (2015) have proposed an analytical model which middle distance race performance depends on three parameters. The first, VO_2 max is expressed in $ml.kg^{-1}.min^{-1}$. The second is the fraction of the VO_2 max, which can be sustained for the effort duration. The third is the energy cost. Indeed, the more the oxygen consumption (VO_2) is reduced during the race, the more the runner realizes his energy saving and his energy cost is low. In developed countries, the club's trainer, physical trainer, sports physician and physiotherapist of the club rely on physiological data. These allow us to understand the elements that influence the performance of the middle distance and half race runners. To do this, treadmill tests are carried out to check the data closer to the actual running situations. And, these tests require specific equipment and require time. To remedy these deficiencies, some field tests have been proposed such as the *20 m shuttle* test, the *VAMEVAL*, or the *yoyo* test (Léger and Gardoury, 1989; Carzola 1990; Bangsbo 2008). Thus, these tests are commonly used to assess the aerobic fitness of athletes. In the Republic of Congo, the monitoring of athletes is undertaken only on the eve of the international competition, including the *Semi-Marathon International de Brazzaville* (SMIB). This is paradoxical to the requirements of the *International Federation of Athletics and Association* (FIAA). This failure can be explained by the high costs of laboratory tests. However, the developed countries favour the monitoring of athletes by the tests of grounds. It is in this context that we have been concerned to evaluate the effects of training oriented towards the preparation of the SMIB on the morphological, cardiovascular and metabolic adaptations of the Brazzaville middle-distance runners. It is recognized that aerobic training is likely to induce physiological adaptations, new motor behaviors and improved performance of middle-distance runners and those of long-distance running. Indeed, the intense exercise results, at the hemodynamic level, important volumetric and barometric modifications. And it covers the Neuro-hormonal level with modifications of the autonomic nervous system, catecholergic and cortisol, etc. The genetic heritage has a major role which is largely explained by the inter-individual differences observed for the same level and type of training. Other factors influence, to a lower level, the characteristics of the adaptations such as the type of sport, gender, age, ethnic origin and ... Unfortunately doping according to (Carré, 2006, Bouchard, 2001). Indeed, the maximum oxygen consumption in the athlete is (+ 40 to 60%) compared to a sedentary. This is due firstly to peripheral adaptation with increased extraction of muscle oxygen and secondly to a maximum cardiac output of (35-40 l / min). On the other hand, it is (20-25 l / min) in the sedentary. This increase in cardiac output (4-6 bpm) is not due to an increase in maximum heart rate, but rather to a very high systolic ejection volume (110-130 ml) in the sedentary versus (150-180) in the athlete. This increase in the volume of systolic ejection is due to the of the blood volume, the dilation of the cardiac cavities and the good capacity of relaxation of myocardial contractions. "The heart of the athlete fills up better and empties better" (Carré, op.cit.). Also, at the myocardial level, coronary arterial vasodilatation is improved (Kalliokoski and al., 2002, p.2).

In addition, aerobic training requires adaptation mechanisms of the body to be able to withstand significant loads (intensity-duration) exercise. Della Ricca reported that low intensity activity (walking, gardening) helps maintain good health. And, it corresponds to 2 and 3 evaluation measures. To improve physical fitness, a sustained intensity level is required (5 to 6 METs). The middle-distance race and endurance race require energy in connection with the increase in maximum aerobic speed. The maximum oxygen uptake (VO_2 max) and effort management should also be considered (Lab, 1996, Lab and al., 2003). However, in the Congo, physiological field evaluation tests are not used to control the volume of training programs, followed by athletes from the departmental athletics leagues and Brazzaville leagues. This is to the detriment of the athletes, exposing them to the risks of overtraining and poor performance control. Thus, the absence of tests is a fundamental concern that leads us to ask ourselves the following question: - Does the training program for middle-distance runners oriented to the preparation of the international Brazzaville half-marathon improve morphological, cardiovascular and aerobic performance adaptations?

To answer our question, we have formulated the hypothesis that: "The training program for middle distance athletes of the Brazzaville athletics league oriented towards the preparation of the SMIB improves the morphological, cardiovascular and aerobic performance adaptations." The objective of this research is to evaluate the effects of the athlete training program.

This study aims not only to make the sports community aware of the positive impact of the training on physiological adaptations and the improvement of the aerobic performance of the athletes but also on the importance of the physiological evaluation test of the athletes to prevent the risk of overtraining.

II. METHODOLOGY

II.1 Scope of Investigation

This experimental study was conducted from 24th March to 07th July 2018 at the annex stage of Kintélé concord. This stadium is located in District 9, Djiri, in the Department of Brazzaville.

II.2-Population and Sampling

The study involved 28 semi-bottom athletes from the Brazzaville County Athletics League and the Congolese Athletic Federation. The selection of competitors was based on the following criteria:

- Be male;
- Be at most 29 years old;
- Be regular at practices and competitions;
- Have submitted to all tests.

The sample in this study was 12 middle distance athletes who voluntarily agreed to participate in the study and met the above criteria. Aged 23 to 29, these 12 middle distance athletes have been subjected to a regular endurance training program. They are committed to the preparation of the Brazzaville International Half Marathon. Taking into account the training specific to medium and long-distance races, the days of Saturday, 24th March and 7th July 2018 have been chosen for the VAMEVAL test for athletes in order to avoid disrupting the training. Indeed, a period of 15 weeks (between the first and the second tests) was long enough to obtain significant physiological improvements. In this regard, *Warren and al.* (2001) and *Thomas et al.* (2014) reported that it is already possible to achieve significant physical and physiological improvements from 6 weeks of training.

II. 3 - Data Collection Technique

This study focused on three (3) areas: anthropometric, cardiovascular, and aerobic fitness assessment.

II.3.1. Anthropometric measures

Each athlete was provided with an information sheet that included information on their age, weight, height and body mass index. Weight (Body Composition), height and Body Mass Index (BMI) were measured before the start and end of training.

– Measurement of the weight

The weight measurement determined the total body mass of the subject. It was made using a *SOKEI.SARL* electronic device. Before lifting the weight, the correct operation of the device has been checked by a technician. For the operation, the athlete, in sportswear, goes up on the apparatus, barefoot. He must stand upright, with his feet together, his arms along his body, and his gaze horizontal. The technician presses a button, the weight is displayed. When inserting the age of the athlete, display: the value of weight, lean mass, fat mass in kilograms (kg) and percent fat (%).

– Measurement of the Height

The size is the distance between the sole of the foot and the top of the head. It was measured using a *Sokei.Sarl. electronic device*. Before measuring the size, the efficiency of the device was checked. The athlete, dressed in sportswear, was standing barefoot and joined, with arms along the body and eyes fixed horizontally. When reading the results, the length of the waist was indicated in cm.

– Body Mass Index (BMI)

The Body Mass Index (BMI) is an index that can detect overweight subjects. It is calculated according to height and weight. This body mass index has been interpreted taking into account the thresholds of the *International Obesity Task Force (IOTF)*. It is calculated after unlocking and calibrating the weight and height parameters. In our study, the BMI was calculated according to the following formula: $BMI = \text{Weight (kg)} / \text{Height}^2 \text{ (in m}^2\text{)}$ (Pineau and al., 1991).

II.3.2. Cardiovascular measurements

In order to determine the cardiovascular parameters of athletes, heart rate (a) and blood pressure (b) were collected.

a) Heart Rate (HR)

Heart rate refers to the number of beats per minute required by the heart to pump blood throughout the body. The calculation of the Heart rate at rest (HR_0) was done by taking a pulse on the large artery of the wrist (radial artery) 30 minutes after the arrival of the last athlete at the concord stage. To know the current heart rate, it is necessary to count the pulsations, over 15 seconds and multiply the number obtained by 4. During or after exercise, as early as (the fifth and tenth minutes), the heart rate measurement was taken using a GIMA electronic blood pressure monitor.

b) Blood Pressure (BP)

Blood pressure is the blood pressure in the arteries. It was measured using a GIMA brand electronic blood pressure monitor. Before taking the voltage, the correct operation of the device has been checked. This removal was done by placing the athlete with the back lying on the ground. The blood pressure figure was displayed in mm Hg. Sampling the systolic and diastolic blood pressure measurements began 30 minutes after the last athlete reached the concord stage.

II.3.3- Evaluation of aerobic performance

Aerobic performance was evaluated before and after training using the *VAMELVAL* test (Cazorla, 1990). This test determined the bearing that indicated the cap reached by the athlete. With the value of the step that is calculated the Maximum Aerobic Speed (MAS). The maximum Oxygen Consumption ($\dot{V}O_2 \text{ max}$) of each athlete was determined during an incremental test.

– Equipment

The completion of the test required the following equipment: a 400 m track, 20 javelins, a computer and amplifier and a *VAMEVAL* recording.

– Description of the Test

The test consists of following a set travel speed using a soundtrack. It beeps at regular intervals. With each beep, the athlete must be at one of the javelins placed on the track (every 20 meters). The speed increases by 0.5 km / h every minute. This corresponds to the crossing of a landing. The first landing starts at a pace of 8 km / h. The athlete will stop (or will be stopped by the judges), as soon as he has a delay of more than 3 m between 2 consecutive javelins. Indeed, the test is triangular (increasing intensity step-wise). It is not necessary to warm up because the test is progressive and starts at a moderate pace. The first few minutes are pretty easy. In addition, the athlete should stay as fresh as possible to complete the test to the end.

Calculation of MAS

$$\text{MAS} = \left(\frac{P}{2} + 8\right)$$

MAS in km. h⁻¹

Calculation of $\dot{V}O_2 \text{ max}$

$$\dot{V}O_2 \text{ max} = \left(\frac{7}{2} * \text{MAS}\right)$$

$\dot{V}O_2 \text{ max}$ in ml.kg⁻¹.min⁻¹

II.4. Data Analysis.

Data analysis was performed using SPSS version 22 (*Statistical Package for the Social Sciences*) (SPSS Inc., Chicago, IL, USA). The *Kolmogorov-Smirnov* test was used to verify, check the normal distribution. For the comparison of the quantitative variables of the half-bottom athletes, before and after the *VAMEVAL* test, the *parametric data* test was applied. The values are represented on average ± standard deviation. Differences were accepted as significant at the 5% level (P0.05).

III. RESULTS

III.1. Dynamics of anthropometric characteristics

The age, height, weight, Body Mass Index (BMI), Fat Percentage (FP), Body Fat (BF) and lean body mass (BM) are presented in Table 1 in the form of mean and standard deviation ($\bar{x} \pm \delta$).

Table 1: Age, height, weight, BMI, FP, BF and BM as mean \pm standard deviation ($\bar{x} \pm \delta$)

	Before test	After test	t	P
	(n=12)	(n=12)		
	$\bar{x} \pm \delta$	$\bar{x} \pm \delta$		
Age (ans)	25,58 \pm 2,50	25,58 \pm 2,50	-	-
Height (m)	1,73 \pm 0,06	1,73 \pm 0,06	-	-
Weight (kg)	61,75 \pm 7,01	61,88 \pm 7,18	0,28	NS
BMI (kg. m ⁻²)	20,52 \pm 1,59	20,56 \pm 1,66	0,25	NS
FP (%)	18,15 \pm 2,24	15,63 \pm 2,92***	3,94	<0,001
BF (kg)	11,73 \pm 2,55	9,47 \pm 2,14***	4,34	<0,001
BM (kg)	50,75 \pm 4,69	52,66 \pm 5,06***	4,78	<0,001

NS : Not significant Difference

** : Very Significant Difference ($p < 0,01$)

*** : Highly Significant Difference ($p < 0,001$)

The analysis of *Table 1* shows the equal ages and sizes of middle-distance runners in the Brazzaville Departmental League and the values in the pre- and post-endurance-speed race regarding weight and BMI substantially equal.

However, the post-training values of these middle-distance runners were significantly lower compared to their initial value; for GI, MG ($p < 0.001$). In contrast, the post training value was higher for these middle-distance runners compared to the initial value of the MM ($p < 0.001$).

III.2- Cardiovascular Adaptations to the Training

Table 2 shows: resting Heart Rate (HR_0), during exercise (HR_1), five minutes (HR_5), ten minutes (HR_{10}) after stopping and during maximum effort (HR_{max}). Also, it presents: resting systolic blood pressure (SBP_0), five (SBP_5) and ten (SBP_{10}) minutes after stopping, resting diastolic blood pressure (DBP_0), five (DBP_5) and ten (DBP_{10}) minutes after stopping the effort.

Tableau 2: HR_0 , HR_1 , HR_5 , HR_{10} , HR_{max} , SBP_0 , SBP_5 , SBP_{10} and DBP_0 , DBP_5 and DBP_{10} as an average \pm écart-type ($\bar{x} \pm \delta$)

	Before test	After test	t	P
	(n=12)	(n=12)		
	$\bar{x} \pm \delta$	$\bar{x} \pm \delta$		
HR_0 (bpm)	57,50 \pm 1,78	54,80 \pm 1,91**	3,58	<0,01
HR_1 (bpm)	159,00 \pm 19,08	115,50 \pm 16,76***	7,79	<0,001
HR_{max} (bpm)	194,42 \pm 2,50	194,42 \pm 2,50	-	-
HR_5 (bpm)	96,08 \pm 13,44	83,50 \pm 15,65**	3,33	<0,01
HR_{10} (bpm)	85,33 \pm 11,58	74,58 \pm 11,86***	4,89	<0,001
SBP_0 (mm Hg)	122,00 \pm 4,55	111,75 \pm 3,79***	6	<0,001
SBP_5 (mm Hg)	116,67 \pm 4,75	111,08 \pm 0,29***	4,07	<0,001
SBP_{10} (mm Hg)	113,17 \pm 4,41	110,25 \pm 0,45*	2,28	<0,05
DBP_0 (mm Hg)	83,75 \pm 0,45	83,66 \pm 0,49	0,47	NS
DBP_5 (mm Hg)	80,25 \pm 0,62	79,75 \pm 0,97	1,50	NS

DBP ₁₀ (mm Hg)	79,67 ±0,89	79,42 ±0,51	0,84	NS
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NS : Not significant Difference ; * : Significant Difference (p<0,05) ; ** : Very Significant Difference : (p<0,01) ; *** : Highly Significant Difference (p < 0,001).

Table 2 shows that post-workout heart rate endurance values at rest, after one minute, five, and ten minutes (HR₀, HR₁, HR₅, and HR₁₀) were significantly reduced compared to those recorded in the pre-test of this training in middle-distance runners (p <0.01, p <0.001, p <0.01 and p <0.001, respectively). However, the maximum heart rates (HR_{max}) pre and post endurance training-speed of these athletes were identical. These results also indicated resting systolic blood pressure values, five and ten minutes (SBP₀, SBP₅ and SBP₁₀), post significantly lower training of middle-distance runners than their baseline values (p <0.001, p <0.001) and p <0.01). However, these middle-distance athletes showed similar values of resting diastolic blood pressure after five and ten minutes of effort (DBP₀, DBP₅ and DBP₁₀).

III.3- Aerobic performance

The number of steps, the duration, the Maximum Aerobic Speed (MAS) and the maximum oxygen consumption (VO₂max) are given in table3 as mean and standard deviation ($\bar{x} \pm \delta$).

Table 3: Bearings, duration, MAS and VO₂max as mean and standard deviation ($\bar{x} \pm \delta$)

Table 3: Ranges, duration, VMA and VO₂max as mean and standard deviation ($\bar{x} \pm \delta$).

	Before test	After test	t	P
	(n=12)	(n=12)		
	$\bar{x} \pm \delta$	$\bar{x} \pm \delta$		
Stages	19,75 ±0,45	25,25 ±0,97***	17,82	<0,001
Duration (min)	20,83 ±1,03	23,67 ±0,49***	8,63	<0,001
MAS (km.h ⁻¹)	17,88 ±0,23	20,63 ±0,48***	17,90	<0,001
VO ₂ max (ml.kg ⁻¹ .min ⁻¹)	62,56 ±0,79	72,19 ±1,69***	17,88	<0,001

NS : Not significant difference ; ** : Very Significant Difference (p<0,01); *** : Highly Significant Difference (p < 0,001)

The reading in Table 3 shows the number of levels, the duration, the MAS and a VO₂max post endurance-speed training significantly higher than those recorded before the training (p <0.001) of the athletes.

IV. DISCUSSION

IV.1- Dynamics of Anthropometric Characteristics

The size of the selected runners of middle distance is between (1.73 ± 0.06) m. Their weights and weight before training were (61.75 ± 7.01) kg. The results obtained show that these middle-distance runners of the Departmental Athletics League of Brazzaville have a weight-loss problem according to the scale of Carzola and al., (1998). This problem can be attributed to previous drive load, environmental conditions, and poor power. Indeed, after intense training in a hot and humid environment, athletes without rehydration, recover slowly. A varied and balanced diet after exercise is responsible for changing body composition (Ewamela and al., 2006). These results indicate statistically identical pre- and post-training values for age, height, weight and BMI of middle-distance runners (Table 1). It should be noted that these middle-distance runners are morphologically normal according to the scale of appreciation of international experts. The training leads to an increase in the number of muscle fiber calibres (by hypertrophy and hyperplasia). Nutritional / morphological status depends on whether or not lean mass is increased during training. A nutritional contribution makes it possible to compensate the losses caused by the training, in particular, that of the fat mass (McArdle and al., 2001). However, the post-training values of these runners were significantly lower compared to their pre-training value with respect to the IG (18.15 ± 2.24% Vs 15.63 ± 2.92%. <0.001), MG (11.73 ± 2.55 kg Vs 9.47 ± 2.14 kg, p <0.001): (Table 1). This decrease in their values is caused by an endurance training that has an effect on the body composition. Kasmi and Mokrani (2013) report that after sixteen (16) endurance training sessions, there is a decrease in body weight. And, this weight loss varies according to the frequency of training. If people train once a week: (total loss of 0.9 kg, corresponding to 1.07% of body weight) and more than three weeks of training:

(decrease of 3.3 kg, equivalent to 4.62%. This weight loss is associated with the enormous demand for energy reserves, particularly lipids (Billat, 2003: 34). The difference in weight loss between the group of people training one time and the one doing it more than three times a week is explained by the reduction of fat for the overweight person (Darmon and Darmon, 2009, p.80). The high solicitation of energy reserves is linked to the muscular demand for O₂ and nutrients that mobilize the chain of respiratory functions. The cardiorespiratory, circulatory and muscular activities are the most requested (Grappe, 2009, p.56). These activities are maintained by a good mind that drives them optimally to act and to exploit all the energy potential that the body needs. In sum, the results show that an intense training program is beneficial for the athlete who obtains the lean mass needed while maintaining the vital percentage of fat as reported by Kraemer et al., (1999). The achievement of lean mass is parallel to the decrease in the percentage of fat and fat mass runners' middle distance of the league departmental Brazzaville. This balance helps to normalize the physical abilities of an athlete. The reserve of lean mass is the necessary mass of energy that allows the high-level athlete to achieve aerobic performance (Cometti, 1993).

IV.2- Cardiovascular adaptation to training

At the end of the training, the resting heart rate (HR₀) of middle-distance runners of the departmental league of Brazzaville is considerably reduced compared to that of these runners before the training (54.80 ± 1.91 bpm Vs 57.50 ± 1.70 bpm $P < 0.01$): (Table 2). These results reflect the slowdown in HR₀ that results from activation of the parasympathetic system during training. Also, the decrease in HR₀ is due to the reduction of the sinus node frequency associated with Autonomic Nervous System (ANS) influences (Ewamela, 2005). In fact, stabilizing one's resting pulse helps to increase one's chances of living longer (Jouven, 2006). However, the stabilization of the pulse during training is hardly possible. Having a heart rate at rest as low as possible is a necessary asset. And, the heart rate recorded one minute after training, endurance-speed was lower than that recorded before the training middle distance runners of the league departmental Brazzaville (115.50 ± 16.76 bpm Vs $159, 00 \pm 19.08$ bpm, $p < 0.001$) (Table 2). This decrease is associated with prolonged endurance training taking into account short sprints (150 to 400m) and long-distance sprints (500 to 800m). The reduction of heart rate during exercise, during training, in long and medium distance runs is associated with aerobic and anaerobic efforts (ranging from sub-maximal intensity to maximum intensity), (Garcon 1992, p.1). In this study, there was a slight decrease in heart rate one minute after training (HR₁): a decrease of 2.44% on average. This confirms the results of a study by David and al (2009, p. 468). These authors have shown that a period of aerobic training can slightly reduce the heart rate during exercise (Kasmi and Mokrani, 2013, p.110). This fluctuation of the heart rate during exercise is linked to the oxygenation phenomenon. Indeed, Boisseau and al. (2009) have demonstrated the existence of a natural mechanism adaptation, both respiratory and cardiovascular, which allows the muscles to absorb oxygen and to contract by saving energy. The maximum heart rate (HR_{max}) is slightly lower in high performance athletes than in sedentary athletes. It decreases with age. Hence the famous rule of Astrand and Ruthming (FC_{max} = 220 - Age). However, recovery is not limited to the time of cessation of physical effort. Recovery may be related to the short-term adaptation of the athlete's body and the work load. It manifests itself in rapid physiological and biochemical changes before, during, and after exercise. Long-term adaptation is the result of the accumulation of adaptations in the short and medium term (Marquet et al., 2002). The results obtained from (Table 2) indicate that the heart rate, five minutes after training (FC₅), is (83.50 ± 15.65 bpm Vs 96.08 ± 13.44 bpm, whereas that of ten minutes after training (HR₁₀) are (74.58 ± 11.86 bpm Vs 85.33 ± 11.58 , $p < 0.01$): These results reveal the decrease in heart rate during cardiac recovery whose index is interesting to verify the adaptation between the differences in cardiac load and the athlete's response (Gacon, 1992; p.1) showing the cardiovascular impact. This mechanism does not depend on the age and intensity of the exercise (Imai et al., 1994). The parasympathetic system slows the heart rate. After exercise, there is a gradual decrease in heart rate. Perini and al, 1989), (Pedro Leal and Autonne, 2017, p.1). The cardiac recovery explain by the reduction of the post-exercise heart rate is also related to the capacity of performance. Cross-sectional studies show that cardiac recovery is faster for trained people than for untrained and healthy people (Daanen, 2012). Most longitudinal studies conclude that the capacity of cardiac recovery is significantly different between a healthy, trained and untrained individual. These longitudinal studies observed a corresponding increase between cardiac recovery and power output (Daanen, 2012). In fact, preparing not only for the departmental championships but also for the national championships, these athletes committed themselves to training during certain sessions until tiredness. This commitment has allowed these middle-distance runners from the departmental league of Brazzaville to improve their maximum aerobic power by exceeding the fatigue threshold, responsible for improving cardiac recovery, post-exercise during training. Indeed, when states of fatigue or extreme fatigue are excluded, cardiac recovery improves with a better state of fitness. It remains unchanged if the conditioning state does not change and decreases with a decrease in the training stage (Daanen, 2012). With respect to the above, cardiac recovery may be an indicator of

physical fitness and is closely related to $VO_2\text{max}$ as an index of cardiac function. These tests allow a better use of the aerobic profile of each athlete favoring individualization of work (El Ouirghioui and al., 2018, p.37). This is related to the training situation in a population, but less looking for high performance athletes (Daanen, 2012). The heart rate is a means of control, simple and effective aerobic effort and recoveries. The goal is to use heart rate to estimate the intensity of effort in a range of 50 to 100% of the maximum aerobic power (MAP). It is essential to know beforehand the resting heart rate, the maximum frequency obtained by a maximum aerobic power (MAP) field test and also the heart rate of recoveries of the repetitions performed. These results indicate a decrease in the systolic blood pressure at training which is related to the proliferation of peripheral capillaries favorable to blood redistribution. Billat (2012) reported that training induces a numerical, dimensional and vasomotor increase in the peripheral capillaries, thus promoting blood redistribution and the reduction of Systolic Blood Pressure (SBP). Post-workout SBP_5 and SBP_{10} are significantly reduced from baseline (111.08 ± 0.29 mm Hg vs 116.67 ± 4.75 mm Hg, $p < 0.001$ and 110.25 ± 0.45 mm Hg Vs $113, 17 \pm 4.41$ mm Hg, $p < 0.05$) (Table.2). These results reinforce the hypothesis of the reduction of arterial pressure, depending on aerobic training (Monod and Flandrois, 2000). These authors also obtained revealing results of the reduction of blood pressure below the pre-training value. The results reported by these authors are similar to those of this study because the postoperative SBP_5 is significantly lower than and SBP_{10} and the SBP_o (110.25 ± 0.45 mmHg Vs 111.08 ± 0.29 mmHg and $111, 75 \pm 3.79$ mm Hg, $p < 0.01$). This reduction in SAP to recovery is due to dynamic exercises that eliminate metabolic waste and improve peripheral circulation. The results obtained indicate post-training values for middle distance runners in the departmental Brazzaville league significantly higher than those recorded at home before training with regard to the number of stages (25.25 ± 0.97 Vs 19.75 ± 0.45 , $p < 0.001$), the duration (23.67 ± 0.49 min Vs 20.83 ± 1.03 min, $p < 0.001$) and the AMS (20.63 ± 0.48 km.h⁻¹ Vs 17.88 ± 0.23 km.h⁻¹, $p < 0.001$) (Table 3). These results show an improvement in aerobic performance that is dependent on training. The values of the aerobic maximum speed (AMS) of middle-distance runners of the departmental league of Brazzaville are higher than those reported by Le Gall (De Saltin, 1969, p 50). This author has indeed noted that the juniors operating in the Fernand Sastre National Technical Center presented average values of the aerobic maximum speed of 15, 46 km.h⁻¹ and 17. 5km.h⁻¹ respectively before and after training. It continues to grow significantly to equal 17.5 km.h⁻¹ and even exceed 17. 71km.h⁻¹ at the end of the eighth week the average (17.5km / h) reported by the Gall 2005 at French footballers of the same age. The improvement of the aerobic maximum speed is a reflection of the intrinsic motivation that can be explained by the preparation much more for the semi-marathon which constitutes the paid competition in Athletics. Indeed, during the sports season, these runners participated in the circuit meeting *globe d'or* (composed of 4 competitions) without a single reward while at the semi-marathon the first 50 are remunerated (50,000 FCFA for the last and 2,000,000 FCFA for the first). The intrinsic motivation is no doubt responsible for the aerobic maximum speed of the Brazzaville Departmental League half-bottom runners during the preparation of the semi-marathon. The maximum aerobic speed is the highest speed attained during the prolonged and moderate effort which is systematically accompanied by an elevation a $VO_2\text{max}$. This $VO_2\text{max}$ is associated with the maximum aerobic speed determines the running speed of each subject during treadmill tests (Reiss and Prévost, 2013, p.120). The results obtained reveal a post-workout value of $VO_2\text{max}$ significantly greater than that of before training (72.19 ± 1.69 ml.kg⁻¹.min⁻¹ Vs $62, 56 \pm 0.79$ ml.kg⁻¹.min⁻¹; $p < 0.001$) (Table 3). These results reflect a significant increase in $VO_2\text{max}$ in training. This increase in $VO_2\text{max}$ is one of the most representative markers of physical performance that represents cardio-respiratory endurance. Indeed, it improves the training in relation to the contribution of several functions and increases with the intensity of the exercise until reaching a peak. Thus, aerobic training allows to develop its intracellular mechanisms to optimize the oxidative work of the cell. Recent studies show that the reality is different and that muscle building could even have a positive effect on endurance. It is established that force development does not alter the development of $VO_2\text{max}$ and under certain conditions may induce an improvement in aerobic submaximum performance (Marcinick and al., 1991; Le Gallet and Millet, 2007). The $VO_2\text{max}$ improves in training with the increase of the arteriovenous difference in O₂. In fact, endurance training leads to an increase in the number and size of muscles, chondriomas, enzyme activity and the importance of O₂ in aerobic metabolism (Billat, 2000; Monod and Flandrois, 2000; McARDLE and al. 2001). This increase in $VO_2\text{max}$ in athletes may also be related to submaximum intensity and volume of work. The improvement of the $VO_2\text{max}$ in middle distance athletes of the departmental league of Brazzaville is related to the increased training load of the race reoriented towards the SMIB. Indeed, these athletes were subjected to the intermittent program characterized by movements of different nature and work of varying intensity according to the principle of overload.

The volume of work is also a characteristic of the effort that influences the improvement of $VO_2\text{max}$. Indeed, these middle-distance athletes from the departmental league of Brazzaville were subjected to a training program realized in fifteen (15) weeks at the rate of five (5) sessions of 3 hours per week. This volume is greater than the work of Hickson and Rosenkoher (1981) (three weeks),

which resulted in a 5 to 75% improvement in $VO_2\max$ during an endurance training program. According to the same authors after three (3) weeks of training, the improvement in aerobic capacity is significant. In sum, the training of middle distance runners according to a program developed by the technical direction of the departmental league of Brazzaville reoriented towards the preparation of the international half-marathon of the said city induced a modification of the body composition including adipose tissue, hemodynamic functions, cardiac recovery on exertion and aerobic performance improvement.

CONCLUSION

The purpose of this study was to evaluate the morphological, cardiovascular and aerobic fitness adjustments of middle-distance athletes in the Departmental Athletics League during a training program reoriented towards the preparation of the Half Marathon. The initial hypothesis was that the endurance-speed training program for middle distance athletes of the Brazzaville Departmental Athletics League based on the very high volume and intensity could induce cardio-respiratory adaptations favorable to the improvement of aerobic performance. The results obtained in this study showed that the middle-distance athletes of the departmental league of Brazzaville presented significantly lower values of fat percentage (FP), body fat (BF) at post-training compared to their initial values. On the other hand, their post-training value is significantly higher compared to the initial value for the body mass (BM). Moreover, at the end of this training, the resting Heart Rate (HR_0), the heart rate after one minute (HR_1), the HR_5 and the HR_{10} were significantly reduced compared to those recorded before the said training in these subjects. Similar results were also obtained in these athletes who the resting systolic blood pressure (SBP_0), systolic blood pressure, after five minutes (SBP_5) and post-workout SBP_{10} values were significantly less than those presented before this training. In addition, the number of steps, duration, aerobic maximum speed, and $VO_2\max$ post-endurance-speed training was significantly higher than those recorded in these subjects prior to training. In view of the above, the hypothesis of our study has been verified. These results suggest that the endurance-speed training program induces morphological, cardio-respiratory adaptations favorable to the improvement of the aerobic performance. The results obtained lead us to formulate the suggestions with regard to the Congolese federation of athletics in French Fédération Congolaise d' Athlétisme (FCOATH). Indeed, it is a question for this federation to evaluate by laboratory and field tests the level of training load of the athletes, according to the program set up by the National Technical Direction which must be adapted by the departmental leagues and sports clubs.

References

- [1] Boisseau, N., Duclos, M et Guinot, M. (2009). La femme sportive: Spécificités physiologiques et physiopathologiques, Paris, De Boeck, p. 43.
- [2] Billa, V. (2000). Physiologie et méthodologie de l'entraînement: de la théorie à la pratique du sport, De Boeck Université, Bruxelles, 396p.
- [3] Billat, V. (2003). Physiologie et méthodologie de l'entraînement: De la théorie à la pratique, Paris, De Boeck, p. 34.
- [4] Billat, V. (2012). Physiologie et méthodologie de l'entraînement de la théorie à la pratique 3^e édition. Groupe Boeck. Page 9.
- [5] Bouchard, C et Rankin, T. (2001). Individual differences in response to regular physical activity. *Med Sci Sports Exerc*; 33: 446-451.
- [6] Carre, F. (2006). Qu'est-ce qu'un cœur d'athlète? *Arch Mal Cœur Vaiss* 2006; 99: 951-4.
- [7] Cazorla G., Housseaux, P., Millet, G., Château, P., Dreano, P et Pages, B. (1998). Fédération Tri athlète: Evaluation du jeune tri athlète; batterie tri-éval, test et barèmes.
- [8] Cometti G. Football et Musculation. Paris- Action, 1993.
- [9] Daanen, H. A., Lamberts, R. P., Kallen, V. L., Jin, A et Van Meeteren, N. L. (2012). A systematic review on heart-rate recovery to monitor changes in training status in athletes. *International journal of sports physiology and performance*, 7(3), 251-260.
- [10] Daanen, H. A., Lamberts, R. P., Kallen, V. L., Jin, A et Van Meeteren, N. L. (2012). A systematic review on heart-rate recovery to monitor changes in training status in athletes. *International journal of sports physiology and performance*, 7(3), 251-260.
- [11] Darmon, N et Darmon, M. (2009). L'équilibre nutritionnel, concepts de base et nouveaux indicateurs, Paris, Tec et Doc Lavoisier, p. 80.
- [12] David, L., Costil, L., Jack H., Wilmore, W et Kenney, L. (2009). Physiologie du sport et de l'exercice physique, Paris, De Boeck.
- [13] El ouirghioui, A., Van Frachem, J., Boulahoual, A et Mesfioui, A. (2018). Impact de l'entraînement physique intégré en football sur les capacités cardiovasculaires $VO_2\max$ et fréquence cardiaque de récupération. Volume 5, PP 35-55.
- [14] Ewamela, A. (2005). L'enseignement de l'E.P.S. en ambiance chaude et humide: perturbations physiologiques et modèles de rémédiation. Université Marien Ngouabi.
- [15] Ewamela, A., Empilo, M.-S., Ndebani, F., Mankoko, L. et Bongbele, J. (2000). Composition corporelle au cours d'un cross scolaire en ambiance chaude et humide. *Cahiers africains de recherche en éducation*. n° 5. pp.123-132.
- [16] Gacon, G. (1992). Signification et rôle de la fréquence cardiaque dans l'entraînement aérobie. *CardiSport* Dijon.
- [17] Gestin, J. (2017). Lien entre le renforcement musculaire de forte intensité et l'évolution du $VO_2\max$. Institut De Formation En Masso Kinésithérapie De Rennes.
- [18] Grappe, F. (2009). Cyclisme et optimisation de la performance, Paris, De Boeck, p. 56.
- [19] Hickson, R.C et Rosenkoher M.A. (1981). Reduced training frequencies and maintenance of aérobie power, *Med. Sci. Sports Exercise*; 13, 13-19.

- [20] Hottenrott, K et Neumann, G. (2008). Methodik des Ausdauertrainings. Hofmann-Verlag, Schorndorf, p. 107-109.
- [21] Imai, K., Sato, H., Hori, M., Kusuoka, H., Ozaki, H., Yokoyama, H et Kamada, T. (1994). Vagally mediated heart rate recovery after exercise is accelerated in athletes but blunted in patients with chronic heart failure. *Journal of the American College of Cardiology*, 24(6), 1529-1535.
- [22] Jouven, X. (2006). Réussir à ralentir son rythme cardiaque, Paris, INSERM, Paris.
- [23] Kalliokoski, K., Nuutila, Laine, H et coll. (2002). Myocardial perfusion and perfusion reserve in endurance-trained men. *Med Sci Sports Exerc*; 34: 948-53.
- [24] Kasmi, A., Mokrani, F. (2013). Effet de l'entraînement d'endurance sur la fréquence cardiaque, le poids corporel et les habitudes alimentaires. *Sciences Humaines*, n°39 pp 107- 116.
- [25] Kraemer, R.R., Kraemer, G.R., Acevedo, E.O., Hebert, E.P., Temple, E., Bates, M, et coll. (1999). Effects of aerobic exercise on serum leptin levels in obese women. *Eur J Appl Physiol*; 80:154-8.
- [26] Marci nick, E., Potts, J., Schlabach, G., Will, S., Dawson, P. and Hurley, B. (1991) 'Effects of Strength training on lactate threshold and endurance performance. *Medicine and sciencesportexercise*, pp. 739-743.
- [27] Marquet, D., Hildes, J. et Schaefer, O. (1981). Le climat et la santé. In la santé et environnement: l'encyclopédie pour mieux vivre. OMS; 4: 168-183.
- [28] McArdle, W.D., Katch, F.I and Katch, V.L. (2001). Exercise physiology energy, nutrition, and human performance. Lippincott Williams & Wilkins. USA. 5e édition.
- [29] McArdle, Katch et Katch. (2001). Physiologie de l'activité physique: Energie, Nutrition, Performance. Vigot, Paris; 558p.
- [30] Milanovic, Z., Sporiš, G. and Weston, M. (2015) 'Effectiveness of High-Intensity Interval Training (HIT) and Continuous Endurance Training for VO2max Improvements: A Systematic Review and Meta-Analysis of Controlled Trials.', *Sport. Med.*, 45, pp. 1469-1481
- [31] Monod, H et Flandrois, R. (2000). Physiologie du sport, Masson, Paris; 378p.
- [32] Pedro Leal et Autonne. (2017). Stage Exploration Fonctionnelle. Master En Sciences Du Sport. Université de Lausanne.
- [33] Perini, R., Orizio, C., Comandè, A., Castellano, M., Beschi, M et Veicsteinas, A. (1989). Plasma norepinephrine and heart rate dynamics during recovery from sub maximal exercise in man. *European journal of applied physiology and occupational physiology*, 58(8), 879-883.
- [34] Reiss, D et Prévost, P. (2013). La bible de la préparation physique. Paris: Amphora.

