

## Effects of Three Training Methods on the Physical Fitness in Adult Cameroonian Boxers

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**Abstract:** This study aimed to evaluate three training methods on the physical capacity of Cameroonians boxers in order to propose the best method for their preparation. Thus, thirty-six boxers aged twenty-three to twenty-six were recruited and divided into three groups of twelve boxers each. They were submitted to training session for eight weeks using the continuous method, the intermittent method and the mixed method for group one, two and three respectively. Anthropometric (weight, height and Body Mass Index (BMI)) and physiological (Maximal Oxygen Consumption (VO<sub>2</sub>max), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Blood Glucose Levels (BGL) and Blood Lactic Acid concentrations (BLA)) parameters were measured before and after the training session program. Results at the end of the program showed no significant variation of Blood Glucose Level of boxers between the three groups as well as inside the same group ( $p > 0.05$ ). On the other hand, significant differences ( $p < 0.05$ - $p < 0.001$ ) in weight, BMI, SBP, DBP, VO<sub>2</sub>max and Blood Lactic Acid concentrations were observed. Indeed, weight, BMI, SBP and DBP decreased significantly ( $p < 0.05$ - $p < 0.001$ ), while VO<sub>2</sub>max increased significantly in the three experimental groups ( $p < 0.05$ - $p < 0.001$ ). The analysis of these results reveals that the group having practiced the mixed training method showed the strongest rates of increase in VO<sub>2</sub>max ( $67.8 \pm 5.00$  ml/min/kg). In addition, their VO<sub>2</sub>max at the end of the experimentation is largely above the average value defined by literature (64.8 ml/min/kg). This can justify the choice of the mixed training method for the physical preparation of Cameroonian boxers.

**Keywords:** Training Method, Boxing, Physical Capacity.

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## 1. Introduction

Performance in sport is a permanent quest. Understanding the elements that surround training and performance means seeking to identify the elements that constitute them, determine their meaning, form, or cause them as they appear before our eyes. Training is defined as the controllable and controlled processes for the improvement of performance through physical exercise [1]. Sports training includes all the tasks that ensure good health, education, harmonious development, technical and tactical mastery and a high level of development of specific qualities [1]. Depending on the subject's physical capabilities and the requirements of the target performance, the goal of training is to bring the athlete to his or her best "state of fitness" during the most important competitive periods [2]. This requires adaptations of the organism for the production and continuation of efforts appropriate to the discipline practiced [3].

When we talk about sport, it refers to the search for performance. Thus, the specialists conducted the studies from different angles whether in the field or outside, as in the laboratories. Some have studied performance during matches and training sessions [4, 5]. Other studies have focused on the physiological demands of the game, for example by

taking physiological measurements before and after the game or at halftime [6]. With the evolution of practices following new training methods, science has been incorporated to a greater extent in the planning and execution of training [5]. This has led to an improvement in the physical preparation of athletes in general and that of boxers in particular.

Improving physical capacity and combating fatigue therefore becomes a permanent concern in boxer training. Fatigue is defined as an inability to produce or sustain physical or mental effort [7]. It can result from intense physical exercise (peripheral or physical fatigue), prolonged mental activity (central fatigue) or following a pathology [8]. Several physiological mechanisms have been developed to explain physical fatigue. In fact, during prolonged physical exertion, the continued use of carbohydrates creates muscle and hepatic glycogenic depletion, considerably reducing blood glucose levels, a direct cause of hypoglycaemia. It is believed that muscle glycogen stores are depleted after two to three hours of continuous exercise at an intensity of 60 to 80% of  $VO_2$  max [9]. When the blood glucose concentration drops below the physiological level and muscle glycogen is depleted, fatigue occurs [9]. In addition, incomplete oxidation of glucose produces lactic acid which builds up in the blood and muscle causing acute or chronic acidosis [10]. This metabolic imbalance is at the origin of muscle cramps and aches, ventilatory distress, hindrance to muscle contraction, inhibition of the enzymatic system and the onset of fatigue [11].

Boxing is an activity that involves both aerobic and anaerobic actions. The physiological demands placed on boxers during fights and training have been the subject of much research in recent decades [12]. Indeed, boxing is a sport with multiple requirements in which the qualities of speed, strength, flexibility, endurance, power, agility and rapid recovery are necessary. Thus, the average value of the maximum oxygen consumption in the boxer was estimated at 64.8 ml. mn<sup>-1</sup> kg<sup>-1</sup> [13, 14].

In order to improve the boxer's physical qualities, three training methods have been developed. These are the interval method (intermittent), the continuous method and the mixed method. The rest time between rounds being short, the boxer is taken to restart the fight with a debt of oxygen [15]. It is established that the dominant sector in boxing is the anaerobic lactic sector, even if the others are also called upon. Primarily, the anaerobic lactic capacity is the most used by boxing. The anaerobic lactic acid

capacity training protocol indicates that the recovery time between two repetitions is 2 to 8 minutes [1]. However, according to the rules of the International Boxing Association [16], the break time between two rounds is 1 minute. This means that the boxer does not fully recover before the resumption of the next round. He resumed the fight with a debt of oxygen, therefore a significant accumulation of lactic acid. This state of affairs is a problem. To date, no research investigated the effect of boxing training program on general or specific physical fitness components among adult boxers in Cameroon. This situation leads us to seek which method (s) of training is/are indicated for optimum preparation to improve the physical capacity of boxers.

## 2. Methods

### 2.1. Participants

Study was conducted according to the Helsinki Declaration in 1964, which requires compliance with the ethical principles for medical research involving human subjects, including research on identifiable human material and data. Thirty-six boxers aged twenty-three to twenty-six were selected from Pro-Boxing Academy of the National Institute of Youth and Sports of Yaoundé (Cameroon). They were divided into three groups of twelve boxers each. Boxers were subjected to training session for eight weeks using the continuous method, the intermittent method and the mixed method for groupe one, two and three respectively. Measurements were performed at baseline (pre the training program interventions) and after eight weeks (post the training program interventions). Boxers were familiar with measurements procedures one week prior to the beginning of these measurements. All measurements were executed at the similar time of day to decrease the impact of diurnal differences on performance. Participants were informed not to receive any medications, caffeine, or implement any vigorous activity in the 24 hours prior to assessing measurements. They were knowledgeable about the study objectives, risks and benefits, that contribution was voluntary, as well as they possibly retreat from the study. Local institutional review board reviewed and approved the study.

### 2.2. Training Session Program

Groups were carried out three workouts per week, comprising of sum twenty-four workouts of ninety minutes each ( $\approx$ forty-eight hours). The training

sessions of the boxers included in addition to a classic warm-up and cool-down, three types of exercises (Shadowboxing-Jumping Rope-Heavy bag intervals). Group one was subjected to continuous training, group two to intermittent training and group three to mixed training. Intermittent method consists of repeated periods of high intensity exercise alternating with periods of lower intensity, whereas continuous method is characterized by constant submaximal workload without rest period in between sets. The mixed training method was carried out by alternating the continuous method and the intermittent method each week, starting the first week with the continuous method. Within training workouts, boxers were informed to keep the daily dietary as consistent as possible.

### 2.3. Anthropometric Measurements

Body weight and body height were recorded with participants dressed in light clothing, after overnight fasting, without shoes and having washed their feet with an alcoholic disinfectant. Body weight was measured with a bio-impedance meter scale Tanita BC-532 (Tanita Corp., Tokyo, Japon). Body height was measured using a precision stadiometer (Seca 220, Seca) to the nearest 0.1 cm. Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared ( $\text{kg}/\text{m}^2$ ).

### 2.4. Hemodynamic Parameters

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and resting heart rate (RHR) measurements have been taken from the left arm, after a fifteen min-period at sitting position, using an automatic oscillometric instrument (Omron HEM 742-E, Bannockburn, USA).

### 2.5. Measurement of maximum oxygen consumption (bleep test)

The test was administered in a sports hall (temperature 20-25°C) and involved running between two lines set twenty m apart at a pace dictated by a recording emitting tones at appropriate intervals. Velocity was eight-point five  $\text{km}\cdot\text{h}^{-1}$  for the first minute, which increased by half  $\text{km}\cdot\text{h}^{-1}$  every minute thereafter. The test score achieved by the subject was the number of twenty m shuttles completed before the subject either withdrew voluntarily from the test, or failed to be within 3 m of the end lines on two consecutive tones. Afterwards, the last level shuttle was scored on the performance recording sheet. The

maximum oxygen consumption ( $VO_2\max$ ) was estimated as per the regression equation developed by Leger *et al.*, [17].

## 2.6. Blood Glucose Levels (BGL)

Each participant's blood sugar was assessed using strips and a glucometer (Accu-CHEK® Active meter). Blood was sampled from finger-tip five minutes after the end of the bleep test. Each strip is provided with a reagent zone containing reagents. Applying blood to this reactive area will cause a chemical reaction resulting in a change in color of the test area. The Accu-CHEK® Active meter will detect this color change and use the group-specific information on the code chip to convert the result corresponding to the color obtained into a numerical value.

## 2.7. Blood Lactic Acid concentrations

Blood lactate concentration was measured with the portable lactate analyser Lactate Scout™ (SensLab GmbH, Germany) using the enzymatic amperometric method. Blood was sampled from finger-tip five minutes after the end of the bleep test.

## 2.8. Data Analysis

Data were expressed as mean  $\pm$  standard deviation and were analysed using the SPSS statistical package version 21. Consequently, paired t-tests were utilized to evaluate the differentiations between the two sets of observations (pre and post) within groups. ANOVA followed by the Tukey-Kramer post-test were utilized to conclude statistical differences between groups. P value was set at 5% for all statistical analyses.

## 3. Results

Table 1 shows age and body height of the different groups of boxers. No statistically significant difference between the groups in ages and body heights was observed ( $p > 0.05$ ).

Figure 1 shows body weight of different group of boxers. No statistically significant difference between the groups in body weight was observed ( $p > 0.05$ ). However, intra-group comparisons showed significant reductions in boxer's body weight who practiced interval and mixed training ( $p < 0.05$ - $p < 0.01$ ). Indeed, their respective weights went from  $69.25 \pm 2.63$ kg and  $71.00 \pm 2.94$ kg at the start of the experiment to  $66.98 \pm 2.41$ kg and  $67.25 \pm 1.70$  kg at

the end. This represents a weight loss of approximately 3.28-5.41% from the initial weight.

Boxers' Body Mass Index (BMI) of different groups are presented in Figure 2. Data analysis showed no significant difference in boxers' BMI between the groups at both the start and the end of the study ( $p > 0.05$ ). However, the intragroup comparison showed a significant decrease in BMI at the start and at the end of the experiment for the continuous method group ( $p < 0.05$ ). The BMI value in this group fell from  $24.31 \pm 1.56$  kg/m<sup>2</sup> at the start to  $23.07 \pm 1.34$  kg/m<sup>2</sup> at the end. This represents a drop of 5.10% from the initial value.

Figure 3 shows the maximum oxygen consumption of the different group of boxers. It emerges that the comparison between the three groups did not show any significant differences in  $VO_2\max$  either at the start or at the end of the experiment ( $p > 0.05$ ). On the other hand, the intragroup comparisons showed a significant increase in  $VO_2\max$  at the start and at the end for the three groups of boxers ( $p < 0.05$ - $p < 0.001$ ). The values at the start were  $46.63 \pm 5.85$  ml/min/kg;  $47.37 \pm 4.41$  ml/min/kg and  $46.65 \pm 5.35$  ml/min/kg and those at the end of  $64.87 \pm 2.83$  ml/min/kg;  $62.67 \pm 3.78$  ml/min/kg and  $67.8 \pm 5.00$  ml/min/kg respectively for the continuous method group, interval method group and mixed method group. The greatest increase in  $VO_2\max$  was recorded in the mixed method group with 40.34% increase.

The results of the SBP and the DPB of the boxers of the three groups were shown in Table 2. No significant difference between the groups was observed. However, intra-group comparisons showed significant reductions in SBP in the continuous method group and in DBP in the mixed method group ( $p < 0.05$ ). SBP went from  $138.5 \pm 10.41$ mmHg to  $124.75 \pm 8.54$  mmHg, while DBP went from  $82 \pm 3.92$  mmHg to  $75 \pm 2.94$  mmHg.

The results of the blood sugar and the lactatemia of the boxers of the different groups are presented in Table 3. No significant difference in blood sugar levels and lactatemia between the different groups at the start and at the end of the experiment ( $p > 0.05$ ) was observed. Likewise, intragroup comparisons showed no significant difference between baseline and end glucose values ( $p < 0.05$ ). However, the intragroup comparison showed a significant decrease in lactatemia at the start and at the end of the experiment for the mixed method group ( $p < 0.05$ ).

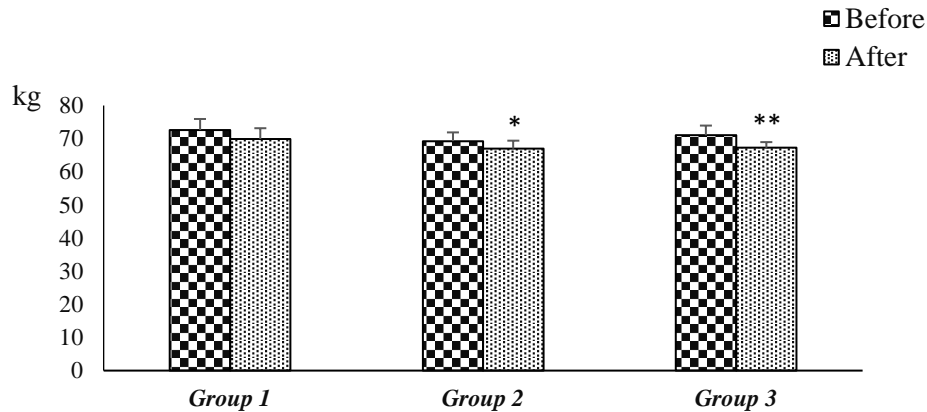
The lactate value in this group decreased from 5.52±2.60 mmol/l at the start to 3.05±1.36 mmol/l at

the end. This represents a decrease of 44, 80% of the initial value.

**Table 1.** age and body height of the different groups of boxers

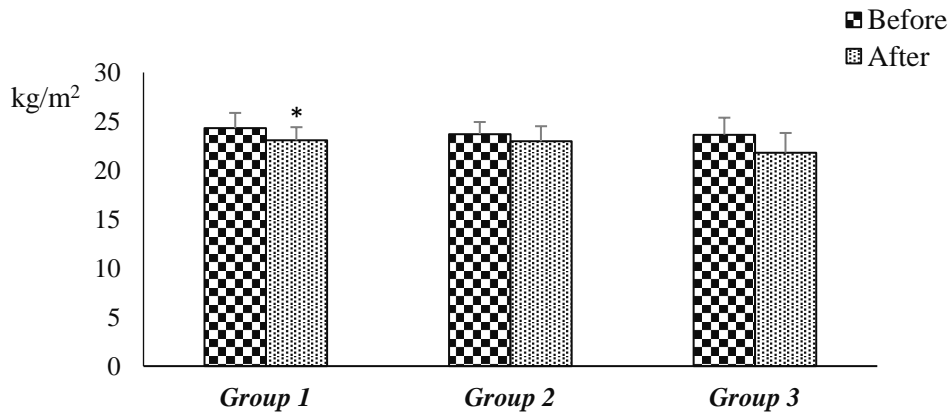
Parameters	Group 1 (n=12)	Group 2 (n=12)	Group 3 (n=12)
Age (years)	26.00±2.51	25.25±3.11	25.40±2.83
body height (m)	1.73±0.11	1.71±0.14	1.73±0.10

Each value represents the mean ± SEM. Group 1= continuous training method, Group 2= intermittent training method and Group 3= mixed training method.



**Figure 1.** body weight of different groups of boxers

Data are presented as mean ± SEM. Group 1= continuous training metho, Group 2= intermittent training method and Group 3= mixed training method. \**P* < 0.05 and \*\**P* < 0.01.



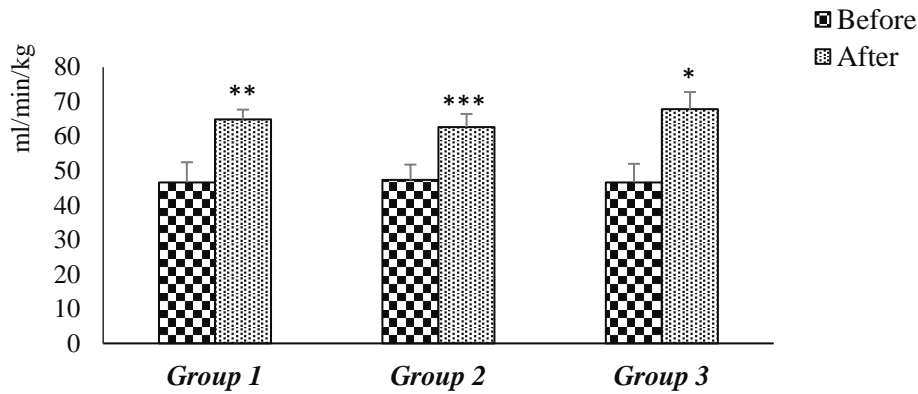
**Figure 2.** boxers' Body Mass Indes (BMI) of different groups

Data are presented as mean ± SEM. Group 1= continuous training method, Group 2= intermittent training method and Group 3= mixed training method. \**P* < 0.05.

**Table 2.** SBP and the DPB of the boxers

Hemodynamic Parameters	Group 1 (n=12)		Group 2 (n=12)		Group 3 (n=12)	
	Before	After	Before	After	Before	After
SPB (mmHg)	138.50±10.41	124.75±8.54*	130.50±7.55	117.50±10.64	126.75±11.04	120.25±9.32
DBP (mmHg)	86.75±2.47	78.25±3.12	84.00±2.81	77.25±3.01	82.00±3.92	75.00±2.94*

Each value represents the mean ± SEM. Group 1= continuous training method, Group 2= intermittent training method and Group 3= mixed training method. \**P* < 0.05



**Figure 3.** maximum oxygen consumption of the different groups of boxers  
Data are presented as mean ± SEM. Group 1= continuous training method, Group 2= intermittent training method and Group 3= mixed training method. \**P* < 0.05, \*\**P* < 0.01, and \*\*\**P* < 0.001.

**Table 3.** Blood Glucose Levels (BGL) and Blood Lactic Acid concentrations of the boxers

Biochemical Parameters	Group 1 (n=12)		Group 2 (n=12)		Group 3 (n=12)	
	Before	After	Before	After	Before	After
<b>Blood Glucose (mg/dl)</b>	82.25±5.31	84.25±4.03	83.50±3.42	81.00±2.91	83.25±4.36	85.25±3.97
<b>Blood Lactic Acid (mmol/l)</b>	6.57±1.77	5.41±3.33	5.22±1.96	4.45±2.41	5.52±2.60	3.05±1.36*

Each value represents the mean ± SEM. Group 1= continuous training method, Group 2= intermittent training method and Group 3= mixed training method. \**P* < 0.05

#### 4. Discussion

Fitness refers to a set of attributes such as aerobic capacity, strength, speed, and flexibility that collectively determine the ability of a given person to perform physical activity, including activities of life [18]. Fitness is generally measured as the results of normalized motor tasks requiring speed, agility, balance, flexibility, explosive strength, local muscle endurance, and static muscle strength [19]. In the boxer, the development of these qualities essential to achieving performance requires good physical capacity, work in hypoxia and good resistance to lactic acid. The objective of this work was to make an evaluation of the three training methods in order to adopt the one adapted to the training of boxers. These are in particular the continuous or duration or distance method, the interval method and finally the mixed method which combines the first two.

The results obtained showed that the age, height and blood sugar of the boxers did not undergo any significant variation during the experiment, both between the three groups and within the same group

(*p*>0.05). On the other hand, intragroup comparisons showed significant differences in weight, BMI, SBP, DBP, VO<sub>2</sub>max and lactatemia at the start and at the end of the experiment in certain groups (*p*<0.05-*p*<0.001). These results are in agreement with those obtained by other researchers who have worked on these methods of boxing training [1, 20, 21].

Weight decreased significantly in boxers who performed interval and mixed training (*p*<0.05-*p*<0.01). In fact, their respective weights went from 69.25±2.63 kg and 71.00± 2.94 kg at the start of the experiment to 65.50±3.41 kg and 67.25±1.70 kg at the start of the experiment. This represents a weight loss of approximately 5.28 to 5.41% from the initial weight. Concomitantly with weight, a significant decrease in BMI at the beginning and at the end of the experiment for the continuous method group was observed (*p*<0.05). The BMI value in this group fell from 24.31±1.56 kg/m<sup>2</sup> at the start to 23.07±1.34 kg/m<sup>2</sup> at the end. This represents a drop of 5.10% from the initial value. These results are similar to those obtained by Smith [22]. Indeed, the weight is the most determining anthropometric constant in this sporting discipline. Top boxers have an ideal of thinness which

is associated with the idea of strength, speed, endurance and agility. It seems that maximum strength is reached when the boxer is at the upper limit of his weight class. This is the reason why most boxers have a few pounds above the upper limit of their usual category and have to lose grams or even pounds through various processes a few hours before the weighing. This is how the knowledge of body composition, the calculation of lean mass, offers us fundamental elements to appreciate the adaptation of a subject to a weight category. Our results therefore suggest that boxers with a weight problem should preferentially work with the interval method or the mixed method.

Boxing is a complex and demanding sport which cannot be done without serious preparation [23]. Endurance corresponds to continuous, long and sustained work, the intensity of which tends towards maximum aerobic power. In amateur boxing (boxing which is practiced by most of our boxers), the duration of the fight is three times of three minutes (3 x 3 minutes) with one minute of recovery between rounds [16]. Indeed, the efforts produced in the ring by their intensity and pace are akin to resistance work. However, the duration of the fight also requires qualities of endurance. The results of this study showed significant increases in baseline and end  $VO_2max$  for all three groups of boxers ( $p < 0.05$ - $p < 0.001$ ). Analysis of these results reveals that the group that performed the mixed method exhibited the highest rates of increase, which was 40.34% for  $VO_2max$ . Furthermore, their  $VO_2max$  value ( $67.80 \pm 5.00$  ml/min/kg) at the end of the experiment is above the mean value defined by Fraisse *et al.*, (1990) [13] which is 64.80 ml/min/kg in the boxer. This increase of the  $VO_2max$  value may have happened because of the mixed method used by this group and can justify the choice of this method for the physical preparation of Cameroonian boxers. Our results are in the same direction as those of Berthoin *et al.*, [24] and Tuimil *et al.*, [25]. Indeed, these authors have shown that at the same volume, an intermittent training program (100 to 120% of maximal aerobic speed) allowed a significant increase (+ 5%) of the Maximum Aerobic Speed (MAS), compared to a continuous training program. (80 to 90% of MAS), and a mixed training program allowed to obtain better results.

Participating in endurance sports such as boxing can lower blood pressure values. Studies have shown that regular participation in endurance sport lowers 5 to 25 millimeters of mercury for systolic blood

pressure and 3 to 15 millimetres of mercury for resting diastolic [26-29]. The results of this study showed significant reductions in SBP in the continuous method group and in DBP in the mixed method group ( $p < 0.05$ ). The SBP increased from  $138.50 \pm 10.41$  mmHg to  $124.75 \pm 8.54$  mmHg, while the DBP increased from  $82.00 \pm 3.92$  mmHg to  $75.00 \pm 2.94$  mmHg. This situation is beneficial to boxers who are often victims of a state of dehydration which can lead to headaches.

In boxing, endurance allows you to sustain a higher rate of combat, while delaying reaching the zone of oxygen starvation that would lead to excessive production of lactic acid. It allows for quick recovery between rounds, it also allows for faster recovery from combat fatigue, which can also prove invaluable in a tournament. Lactic acid is a metabolite that results from the anaerobic breakdown of glucose. Its accumulation in the blood and muscles is a good indicator of the degree of fatigue during high intensity and short exercise [30, 31]. There is a very good correlation between lactate at peak exercise and peak oxygen uptake [32]. The results of this study showed a significant drop in lactatemia at the start and end of the experiment for the Mixed method group ( $p < 0.05$ ). The lactate value represents a decrease of 44.80% of the initial value. These results are in agreement with those obtained by Bonen *et al.*, [33]. Indeed, for these authors, endurance training increases the muscle density of the "lactate" transporters as well as those of the  $Na^+/H^+$  transporter. Therefore, the subject trained by the Mixed Method quickly compensates for the release of excess  $H^+$  by an improved system of its membrane transporters [34].

## 5. Conclusion

The objective of our work was to evaluate three training methods in order to offer one suitable for the physical preparation of Cameroonian boxers in general and those of the INJS Pro-Boxing Academy in particular. The results obtained showed that the age, size and blood sugar of the boxers did not undergo any significant variation during the experiment, both between the three groups and within the same group. On the other hand, the intra-group comparisons showed significant differences in weight, BMI, SBP, DBP,  $VO_2max$  and lactatemia at the start and at the end of the experiment in certain groups. Analysis of these results reveals that the group that performed the mixed method exhibited the highest rates of increase in  $VO_2max$ . This can justify the choice of this method for the physical preparation of Cameroonian boxers.

However, it would be important in future work to carry out serum haematological and biochemical studies in order to determine the exact mechanisms by which these different methods improve the physical capacity of boxers.

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### Ethics Approval

The Study was conducted according to the principles of the Helsinki Convention (1974) and approved by the Cameroun National Ethics committee (Reg. No FWAIRB00001954).

### Informed Consent

Informed consent was obtained from all subjects involved in the study.

**Author's contribution & Statement**

Conceptualization, methodology and writing original draft preparation were made by Dr Bonoy Lamou, Pr Taiwe Sotoing Germain and Mr Djofang Hugues. Formal analysis was made by Dr Mbame Jean-Pierre and Mr Djomo Ngnoko Evariste Edmondo. Writing and editing were made by Dr Bonoy Lamou. Dr Mibo'o Pascale and Dr Ebal Minye Edmond have been involved in Data collection and curation. All authors have read and agreed to the published version of the manuscript.

**Conflict of interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Does this article screened for similarity?**

Yes

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