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Effect of time-of-day specific obese training on body composition and physical capacity

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***Abstract*:** *The best strategy for management of obese, outside pharmacological interventions, is physical exercise associated to diet. Recent research has discovered that the problem of obesity is largely due to a biological clock and that lipid oxidation is higher in the evening compared to the morning and at night compared to day. The purpose of this study is to investigate the effect of time-of-day specific obese training on body composition and physical capacity in obese following a low calorie diet. 20 sedentary pre-obese and obese with a mean BMI of 34.3 kg/m^2 aged 20 to 47 years subjects participated in a concurrent strength and specific endurance training for obese. Subjects were divided into two training groups: a Morning training Group (MG: n = 10) and an Evening training Group (EG: n=10). The specific training associated to lower caloric diet has increased physical capacity (17,7% for EG and 15,6% for MG), decreased body weight (7,3% for EG and 6% for MG) fat percentage (19,5% for EG and 11,3% for MG) and waist circumference (10,2% for EG and 8,2% for MG) in both groups. Afternoon training was more effective than morning training on fat loss (24.9% for EG versus 15.9% for MG) and on lean mass variation (+2.9% for EG versus -0.5% for MG).*
Keywords: *Obesity, Time of day Training, physical capacity, Body Composition*

I. Introduction

The global epidemic of overweight and obesity has become a major health, social and economical burden with 312 million people worldwide being obese [BMI (body mass index) ≥30 kg/m^2] and at least 1,1 billion people being overweight (BMI 25–29.9 kg/m^2) [1] [2]. The obesity treatment must be adapted to the disease evolutionary stage and the dominant complications [3] [4] [5] [6]. The treatment of obesity can associate several methods: diet, behavioral therapy, drug therapy, surgery and physical exercise [7]. In the literature it appears that the best strategy to manage overweight or obese subjects, outside pharmacological interventions, is the association of diet and physical exercise [8] [9] [10] [11]. Associating diet and physical exercise is the best form of treatment to induce weight loss in overweight or obese individuals in the first weeks, followed by physical exercise to maintain weight loss [12]. Physical exercise is included in most treatment programs for overweight patients or obese because its energy expenditure causes weight loss [13] [14] [15].

In addition to diet, physical activity has a significant effect on metabolism, it decreases the basal metabolic rate and increases resting metabolic rate permitting healthy weight loss by preserving lean mass [11]. This metabolic action includes reducing insulin resistance by improving the use of energy substrates by the muscle [16]. Otherwise, some of the metabolic and hormonal variables that affect fat oxidation are regulated by circadian rhythms [17]. A. Chwalibog et al. [18] indicated that during the day, carbohydrates are the major oxidative fuel, while during the night, changes in the energy status are accommodated by increasing fat oxidation. R.A Salata et al. [19] reported greater release of ACTH in the afternoon than in the morning.

Recent research has found that the problem of obesity is related to a biological clock and that lipid metabolism has a biological rhythm during the day through lipolysis and lipogenesis [20] [21]. In a recent study, H. Mohebbi et al. [17] revealed that time of day affects significantly the maximal fat oxidation (Fat max) in obese and normal-weight subjects. They found that the measured Fat max in the evening is higher than in the morning in obese and in normal-weight subjects.

Knowing one hand that greatest benefits of physical qualities training are achieved when it coincides at the acrophase of the correspondent qualities [22] and secondly that maximal fat oxidation in exercise is in the evening [17], we believe that training in the evening for the obese may be more effective than training in the morning. To our knowledge no study has been devoted to the effect of the time-of-day training on physical capacity, body weight and body composition in obese.

Therefore, the purpose of this study was to determinate the effect of time-of-day specific training on body composition and physical fitness in pre-obese and obese assigned to an energy restricted diet.

II. Materials and Methods

2-1 Subjects

20 sedentary subjects (12 men and 8 women) pre-obese and obese with a mean BMI of 34.3 kg/m^2 aged 20 to 47 years who have no heart, respiratory or orthopedic disease participated voluntarily in this study. We preferred to work only with obese, but the protocol constraints lead us to take two pre-obese subjects. This option was already selected in this kind of study to keep satisfactory number of participants. The subjects' chronotype determination was carried out by the self-assessment questionnaire of J.A. Horne and O. Östberg [23]. The subjects chosen for this study were neither of morning nor of evening. Participants were randomly assigned to one of two groups of 10 subjects (6 males and 4 females in each group): an (MG) group who had training in the morning between 07:00 h and 08:30 h and an (EG) group who had training in the evening between 17:00 h and 18:30 h.

Tab. 1: Characteristics of the study subjects

Parameters	Morning Group (N = 10)	Evening Group (N = 10)	[Min ; Max]
Age (years)	31,2 ± 8,1	28,4 ± 8	[20 ; 47]
Height (m)	1,68 ± 0,11	1,68 ± 0,11	[1,51 ; 1,87]
Weight (kg)	97,1 ± 15	96,7 ± 17,8	[65,9 ; 120,9]
BMI (kg/m^2)	34,3 ± 4,3	34,3 ± 5,6	[28,9 ; 48,5]

2.2. Diet

At the beginning of the study all subjects were invited to the endocrinology department of the university medical center Hédi Chaker of Sfax to complete one week recall questionnaire. The subjects' food intakes during the last week were recorded. Then their energy intakes were calculated using Bilnut 2.01 software package (SCDA Nutrisoft, Cerelles, France) and the food composition tables published by the Tunisian National Institute of Statistics in 1978. The diet prescribed for each participant was containing 30% calories less than previous caloric level calculated by the software. This low calorie diet prescribed was balanced with an average of 15% protein, 30-35% fat and 50-55% carbohydrates. Both groups had a similar dietary monitoring with an initial consultation in the beginning of the protocol, a second visit in the middle and a third one in last sessions of the protocol in the endocrinology service.

2.3. Training protocol

Eight weeks of one session concurrent strength and aerobic endurance training was recommended to the subjects by a frequency of three sessions a week. The aerobic endurance program consisted in 60 minutes of brisk walking at 65% of the heart rate reserve (HRR). The pace of walking increased during training to keep the same level of cardiac solicitation. The strength training follows the endurance training in every session. It includes three exercises: abdominal crunch, oblique crunch and back crunch Tab 2. Subjects were instructed to do 3 series of 10 repetitions (increased by 5 repetitions every 15 days) with a 30 seconds break between series. At the end of the session, stretching exercises for 5 min are done by the subjects.

Tab 2. The instructions of prescribed exercises for the participants

Exercises	Instructions
Abdominal crunches	Lie on the back on the exercise mat and keep your knees flexed. Then while your feet are hips width apart and are on the floor, lift your head, neck and shoulders off floor.
Oblique crunches	Lie on the back on the exercise mat and place the left knee on the right knee. Then while the hands are behind the head, rise the head and upper body of the mat and move toward to tour left.
Back crunches	Lie on your front on the exercise mat with your arms stretched out in front of you (fingers pointed) and your legs together (toes pointed). Then carefully lift your arms, chest and legs off the floor. Hold this position about one second before returning to the start position.

2.4. Body measurements

At the beginning of the study and after 8 weeks training, all subjects were evaluated by measuring their height, body weight, body composition and waist circumference. For height measurement, all subjects removed their shoes and stood erect with heels together, took a deep breath, and held it. Subjects stood with head level looking straight ahead. The height of subjects was then recorded in centimeters [24]. Total body weight and body composition (fat mass, lean mass and fat percentage) were measured using validated [25] body composition analyzer (Tanita TBF 300) with an accuracy of 0,1 Kg in body weight and 0,1% in fat percentage. Waist circumference (WC in cm), being used as a marker of central body fat [26], was measured with a non-deformable tape ruler between the lower rib margin and the iliac crest, at the end gentle-expiration (as recommended by international guidelines).

2.5. Fitness test

To assess the obese fitness, we were limited to the 6-minutes walk test which was validated in obese men and women to measure their physical ability seen its high correlation with VO_{2max} and quality of life [27] [28]. It was conducted according to the proposed protocol of the American Thoracic Society (ATS) [29].

The 6-MWT consists on browsing the greatest distance possible in 6 min, by making round trips on 30 m distance, while keeping a walking speed as regular as possible (without running). Patients are encouraged every minute using standardized sentences, and at the same time we announce the elapsed time. A familiarization test is performed 10 minutes before the test run of 6 minutes.

The 6-minute walk test took place always at the same hour, between 07 h and 8.30 h for MG and between 17 h and 18.30 h for EG, before and after the training program. A heart rate monitor (Polar T61) permitted to record the measured heart rate of the test subjects before and during the 6-MWT.

2.6. Statistics

All statistical analysis was performed using STATISTICA analysis software (Version 6.1, StatSoft, France). Data is reported as the mean ± SD (standard deviation) within the text and table, and displayed as the mean ± SE (standard error) in the figure. The Shapiro-Wilk W-test of normality revealed that data was normally distributed. A paired Student's t-test was used to determine the significance of differences between pre- and post-training. The mean percent change from baseline [100 * (T1 –T0)/T0] are calculated. Differences between groups after training were analyzed using analysis of covariance, with baseline values used as covariates and the group used as the independent variable. A p value of less than 0.05 was considered statistically significant.

III. Results

3. 1: Effect of time of day training on the physical capacity

The effect of time of day training on the physical capacity in MG and EG is reported in fig. 1. Both groups increased significantly ($p < .001$) the distance traveled in the 6 MWT by 15.6% and 17.7% respectively in MG and EG.

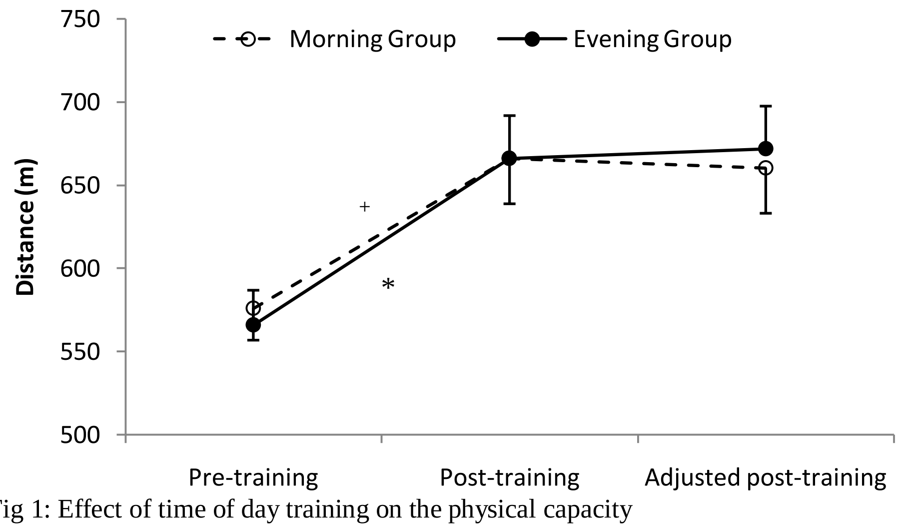

Fig 1: Effect of time of day training on the physical capacity
+ Significantly different from pre-training at $p < .001$ for the morning group
* Significantly different from pre-training at $p < .001$ for the evening group

3.2: Effect of time of day training on body mass and BMI

The effect of time of day training on the body mass and BMI in MG and EG is reported in fig. 2. Body mass for both groups decreased significantly ($p<.001$) by 6% and 7.3% respectively for MG and EG. Similarly, BMI for the two groups decreased significantly ($p<.001$) by 5.8% and 7.1% in MG and EG respectively.

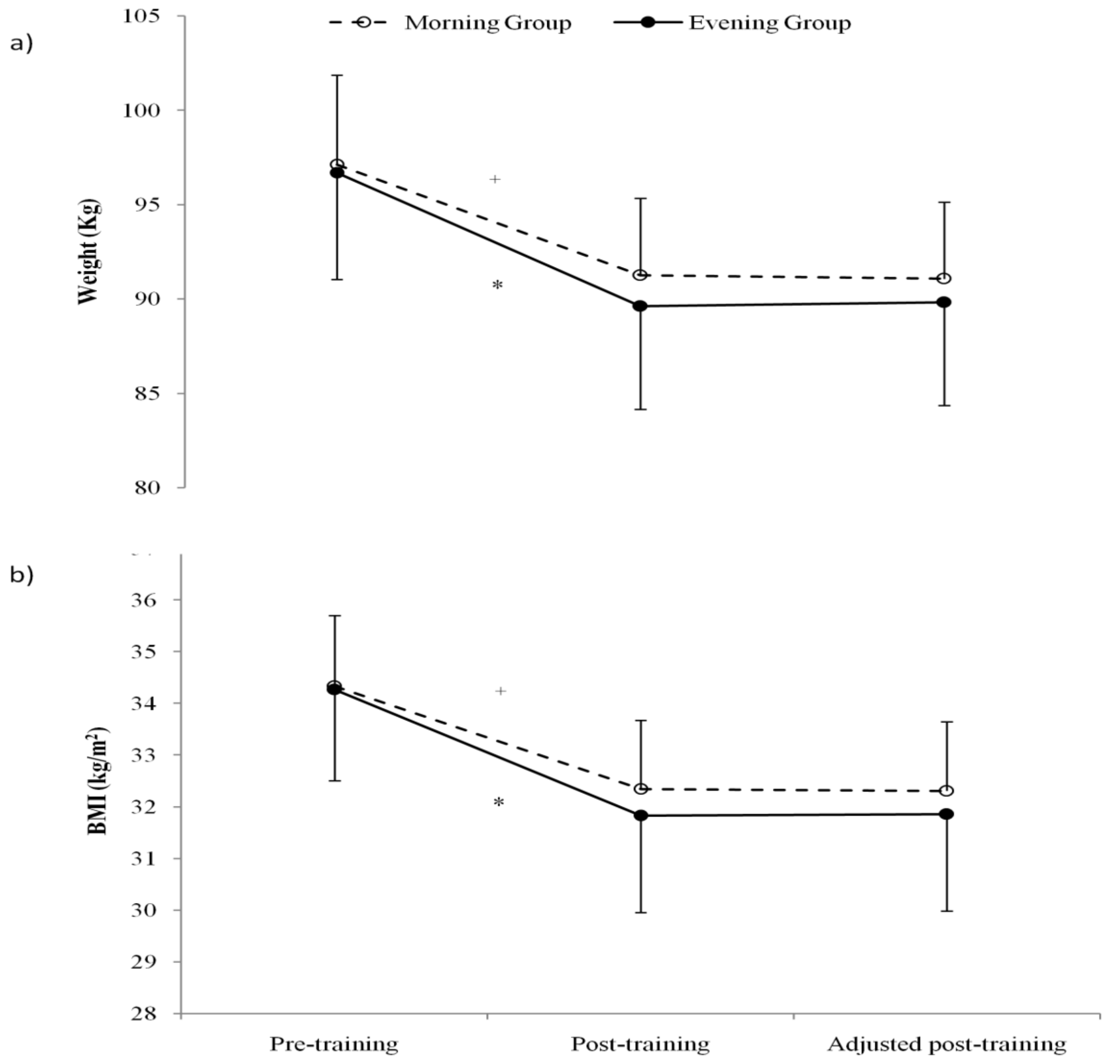

Fig 2: Effect of time of day training on body mass (a) and BMI (b)
+ Significantly different from pre-training at $p < .001$ for the morning group
* Significantly different from pre-training at $p < .001$ for the evening group

3. 3: Effect of time of day training on fat mass and percentage of fat

The effect of time of day training on fat mass and percentage of fat is reported in fig. 3. Fat mass for the both groups decreased significantly ($p < .001$) by 15.9% and 24.9% respectively for MG and EG. Similarly, percentage of fat for the two groups decreased significantly by 11.3% and 19.5% for MG and EG respectively. ANCOVA showed greater decrease of fat mass ($p = .026$) and percentage of fat ($p = 0.008$) in EG compared with MG.

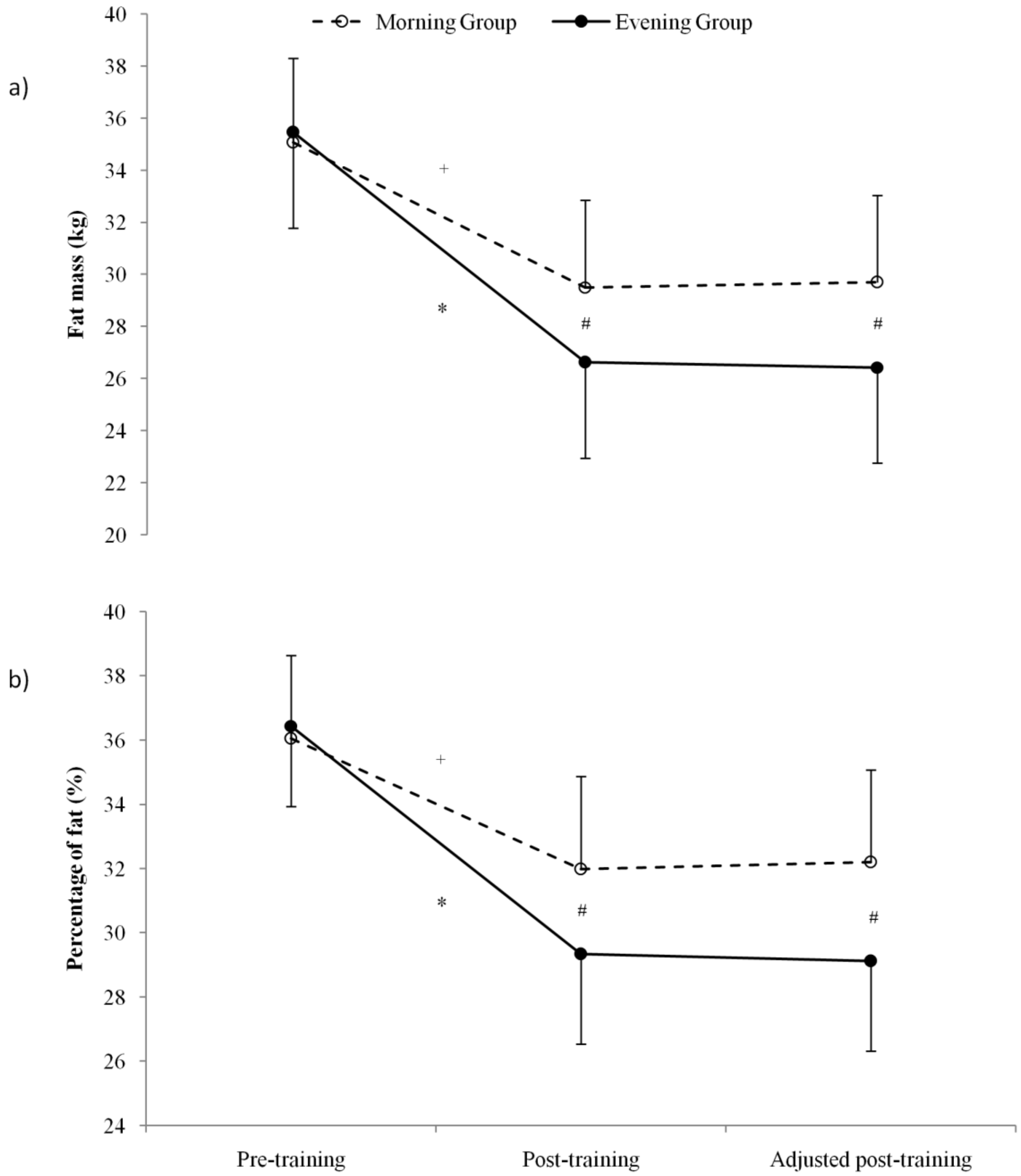

Fig 3: Effect of time of day training on fat mass (a) and percentage of fat (b)
+ Significantly different from pre-training at p < .001 for the morning group
* Significantly different from pre-training at p < .001 for the evening group
# Significantly different from the morning group at p <0.05

3. 4: The effect of time of day training on the lean body mass

The effect of time of day training on the lean body mass of MG and EG is reported in fig. 4. The lean body mass for MG decrease insignificantly (p = .75) by 0.5%, however it increase significantly (p < .001) by 2.9% for EG. ANCOVA showed a significant difference (p = .033) of lean fat mass with adjusted post-training in EG compared with MG.

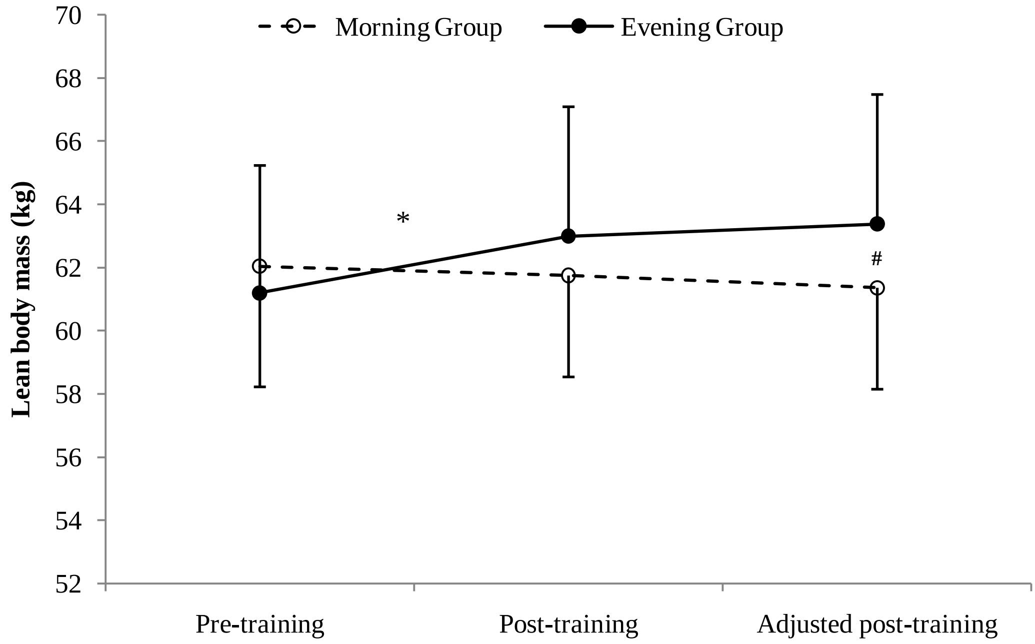

Fig 4: The effect of time of day training on the lean body mass
* Significantly different from pre-training at $p < .001$ for the evening group
# Significantly different from the morning group at $p <0.05$

3.5: Effect of time of day training on the waist circumference

The effect of time of day training on the waist circumference of MG and EG is reported in fig. 5. Waist circumference of both groups decreased significantly ($p < .001$) by 8.2% and 10.2% respectively in MG and EG.

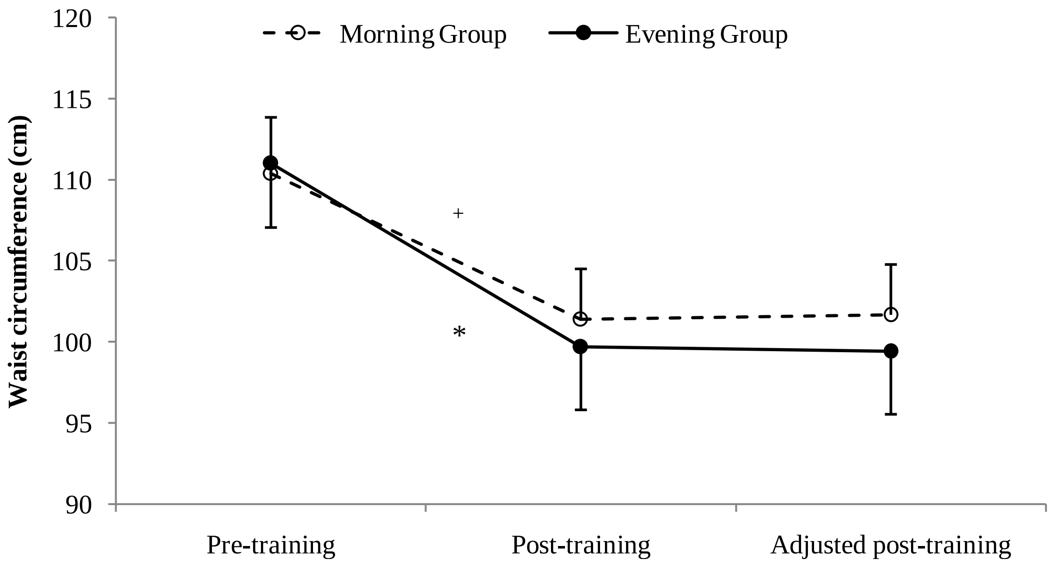

Fig 5: Effect of time of day training on the waist circumference
+Significantly different from pre-training at $p < .001$ for the morning group
*Significantly different from pre-training at $p < .001$ for the evening group

IV. Discussion

The main purpose of this study was to explore the effect of time of day specific training in obese. The results showed that evening specific training is more effective than morning specific training in body composition. Fat mass decreased more significantly in EG (24,9%) than in MG (15,9%). A significant improvement in lean body mass in EG by 2,9% was observed versus a stabilization and a trend towards a reduction in MG. Both groups had similar lean body mass in the beginning of the study but after training EG had significant more lean body mass than MG.

In this study, we have chosen to associate physical exercise to a restricted calorie diet to optimize the effect of the training program. This restrictive diet of 30% is the most prescribed diet in association with physical activity [30] [31] [32] [33] [34]. It permits more weight loss than more restrictive diet that can be quickly abandoned [35]. As a means of reducing total body-fat mass, it is generally accepted that a dietary regimen is easier and more effective than exercise alone [36] However, it has been reported that dietary treatment also reduces skeletal muscle mass [37] and is less effective in improving insulin resistance than exercise [38]. After a Meta-analyzes of literature, B. Schaar et al [12] concluded that physical exercise had beneficial effects in overweight and obese subjects. However, when it comes to inducing weight loss, physical exercise combined with changes in diet is the most effective form of treatment. Now, it is established that appropriate diet and physical activity are the most significant modalities with minimum complications in the prevention and treatment of obesity [39].

Concerning the training program, we opted to one session concurrent aerobic endurance and strength training. This choice is based on the recommendations of the American College of Sports Medicine [40] and the World Health Organization [41] which provide that both endurance training and strength training should be a part of obese and pre-obese management. For endurance training we chose aerobic endurance training at 65% of HRR during 60 minutes [42] as a moderate intensity exercise. The intensities used for obese endurance training in literature go from low intensities selected by obese themselves [43] [44] to 80-90% of HR_{max} [45].

Although high-intensity exercise results in a lower percentage of fat oxidation during the exercise sessions, it is important to highlight that it is the total amount of fat oxidized that determines weight loss. In line with this, isocaloric training programs at 45 and 85% of VO_{2max} caused the same reductions in body fat and weight despite more fat (in percentage) being oxidized in the low-intensity group during the exercise sessions [46]. This is explained by the continued fat oxidation during the restitution phase; the higher the intensity of the exercise, the higher the fat oxidation post-exercise [47] [48]. With moderate intensity exercise during 60 minutes, we consider that the most amount of energy expenditure occurs during exercise and few amount later at resting. The strength training proposed to obese might leads to increase of lean body mass, muscle strength and power in one hand and decrease of body fat percentage, waist circumference, visceral and subcutaneous abdominal and thigh fat thickness on the other hand [49] [50] [51] [52]. Interestingly, it has also been found that the resting metabolism is higher after strength training than endurance training with low or moderate intensity [41] .This mean that strength training that we combined with moderate endurance training will increase the low amount of fat oxidation post exercise due to the moderate endurance training.

About training effect, the physical capacity of EG and MG has increased after training. The distance travelled in the 6 MWT has increased by 95 m for the MG and 100 m for the EG. This increase is much higher than the 56 m of increase reported by S. Ghroubi et al [53] after similar training combined with diet. Relative lower intensity and advancing subject age of S. Ghroubi et al [53] study can explain a part of differences. Time of day training has no effect on physical capacity measured by the 6 MWT.

Body mass decreased with similar proportions in both groups. The decrease of body mass measured in this study is 5,8 Kg for MG and 7,3 for EG. This decrease in body mass is reflected on subjects' BMI which decreased by 2 Kg/m^2 (5,8%) in MG and 2,4 Kg/m^2 (7,1%) in EG. No significant effect of time of day training was observed on body mass and BMI. The magnitude of body mass and BMI decrease is is widely acceptable when compared to other studies. Indeed, there is a great variation in the loss of body mass in comparable studies: 1,4 Kg, 4 Kg, 6,2 Kg, 6,7 Kg with a maximum of 7,5 Kg body mass loss respectively in M. Roussel et al [42], C.M. Beard et al [54], S. Ghroubi et al [53], S. Ghroubi et al (2009) [55] et R. Ross et al [56]. This dispersion is due to the variation in characteristics of studies' subjects, duration, intensity and shape of training program.

In general, 75% of weight loss after training program is fat mass loss independently from race, ethnic and age of subjects [57]. In this study, fat mass loss of both groups after training was greater than 75% of weight loss. In the MG, body fat mass loss (5,6 Kg, 15,9%) was quite equal to whole mass loss (5,8 Kg, 6%). In the EG, body fat mass loss (8,8 Kg, 24,9%) was even greater than whole mass loss (7,1 Kg, 7,3%). This means that in EG, the lean body mass increased. These amounts of fat loss in both groups are very important when compared with results of other studies. N. Mezghanni et al [58] measured a loss of 9,5% and 14,4% in fat mass respectively for a 50% of HRR and 75% of HRR intensity training for three months in obese. N. Mezghanni et al [58] training program has no strength training. The more fat mass loss we measured can due to strength training.

The EG fat mass loss was significantly greater than MG. The time of day training has an effect on fat mass loss. Training in the evening is more efficient than training in the morning for fat loss. The combined strength and aerobic endurance training we proposed permits fat oxidation during exercise and post exercise as we explained before. So, when we have training in the evening, fat oxidation periods coincides with best periods to fat oxidation which are: evening [17] and night [21]. This concomitance should give more efficiency to the evening training facing morning training [22].

Strength training is introduced in obese management essentially to preserve muscle mass against eventual atrophy caused by restrictive caloric diet [55]. Our results show that morning training permits to preserve lean mass whereas evening training permit a significant development of body lean mass (2,8%). These results could be easily explained by the acrophase of strength development which occur in the evening [22]. Results concerning fat mass and body lean mass variation show that time of day training has a benefic effects on body composition in obese. The increase in lean body mass due to an essential increase in muscle mass didn't permit better results in 6 MWT for the EG. This reality can be justified since muscles groups trained in this study aren't directly used in the 6 MWT.

Waist circumference of both groups decreased significantly by 9 cm (8,2%) in MG and by 11,3 cm (10,2%) in EG. This decrease show an important abdominal fat decrease when compared to results reported by K.J Melanson et al (5,3 cm) [59] and R. Ross et al (6,5 cm) [56]. And it can be considered as normal variation when compared to results reported by S. Ghroubi et al (8,8 cm) [53] and S. Ghroubi et al (10,3 cm) [55] in their combined strength and endurance training associated with diet in obese.

In conclusion, the time of day specific obese training on body composition and physical capacity showed that morning training is more efficient in changing body composition with increasing fat loss and body lean mass. Physical capacity has increased and body mass decreased similarly in both groups training. In this study we opted to a short term study of eight weeks, a long term study should better separate effects of time of day training in obese.

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