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Effect of Physical Training on Anthropometric Parameters and Cognitive Performance in Obese Adolescents.

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ABSTRACT: *Some studies have explored cognitive functions on obese persons. Thus, elevated body mass index (BMI) has been associated with reduced cognitive performance in community samples of older adults, middle-age adults, and young adults, specifically in the areas of memory and executive function, selective and sustained attention and problem-solving. Therefore, the aim of this research is to study the effect of a training program on anthropometric parameters and cognitive performance in obese adolescents. Twelve obese adolescents boys (mean age = 15.9 ± 1.4), voluntarily participated in this study, whose body mass index (BMI) was greater than 97th percentile. All subjects participated for an average of 12 weeks to a fitness program. Before the first and after the last training session, we compared anthropometric and cognitive performance (test of short-term memory and test of visual perception). Our results showed that obese lost 1.73 ± 0.7 kg, which corresponds to a decrease of 2.05% (p = 0.006). The fat loss was 2.38 ± 0.4 kg, which corresponds to a decrease of 6.01% (p <0.001). Thus a reduction in BMI (6.60% ; p <0.001) was observed at the end of the training program. On short-term memory, scores of MT and EMT increase of 20.77% respectively (p <0.001) and 33.56% (p <0.001) at the end of the training program. On visual perception, visual perception scores (PVT) increased significantly from 11.44% (p <0.05) at the end of the training program. In contrast, our results showed a reduction of 32.15% (p <0.05) at the level of visual perception errors (EPV) at the end of the training program. Thus, obesity is a risk factor for lower cognitive performance in young individuals. However, the results showed the beneficial effect of the training program on reducing BMI of obese and also improve cognitive performance. Therefore, the sport strengthens memory and allows for better concentration. Thus, we believe that many people could benefit from a training program similar to the one used in this study.*

Keywords: *Adolescents, BMI, cognitive performance, physical training, Obesity.*

I. INTRODUCTION

Overweight and obesity are a major public health issue. They have adverse effects on health and mortality [1]; [2]; [3]; [4]. An increasing proportion of the population is affected by these problems [5]; [6]; [3]. Factors of obesity and overweight are multiple [7]. They are largely correlated with inactivity and inadequate eating habits. This is the case during childhood and adolescence, when leisure time is largely devoted to television [8]; [7]; [9]; [10]; [11], and where eating habits are characterized by a higher energy intake to energy expenditure, and daily physical [8]; [12]; [10]; [11]. Many preventive measures are taken to combat or prevent obesity among children and adolescents [13]; [6]; [14]; [15]; [16]; [17]; [18]; [19]; [20]; [21]; [22]; [23]; [24]; [25].

Obesity is defined as overweight with excess body fat has adverse consequences for health. The measurement of body fat is difficult to achieve in clinical practice, estimates of overweight is used to define obesity: body mass index (BMI), which is equal to the weight (in kilograms) divided by height (in meters) squared.

According to the classification adopted by the World Health Organization [26]: underweight is defined as a BMI less than or equal to 18.5 ; normal is defined by a BMI greater than or equal to 18.5 but less than or equal to 24.9 ; overweight is defined as BMI greater than or equal to 25 but less than or equal to 29.9 ; obesity is defined as a BMI greater than or equal to 30.

Obesity itself is divided into three classes: class I or moderate obesity ($30 \leq BMI \leq 34.9$); class II or severe obesity ($35 \leq BMI \leq 39.9$); class III or morbid obesity ($BMI \geq 40$).

In children and adolescents (<18 years) [27]; [28], underweight is defined as BMI <3rd percentile; the normal weight is defined by the 3rd ≤ BMI <97th; overweight is defined as BMI ≥ 97th and obesity is defined by a threshold ≥ IOTF-30 [29].

Obesity has become a major health concern today affecting a large portion of the world population [30]. Obese children aged 5-17 years were 2.4 times more likely to have a high level of total cholesterol, 7.1 times more triglycerides and 12.6 times for fasting insulin compared to young normal weight [31]. Similarly, the risk of systolic hypertension in obese children of similar age is higher by a factor of 2.5 to 4.5 [32]; [33]; [34]. Le et al., [35] showed that the condition of blood vessels 75% of obese children aged 6-19 years could be similar to adults aged 45.

The psychosocial, children and adolescents who are obese are more likely to have low self-esteem and low skills in social and sporting activities [36]. The young severely obese have a related quality of life five times lower than that of young healthy and similar to that of young people with cancer [37]. In addition, obese children have more symptoms of depression and anxiety than youth of normal weight [38]; [39].

Elevated body mass index (BMI) has been associated with reduced cognitive performance in community samples of older adults, middle-age adults, and young adults, specifically in the areas of memory and executive function [40]; [41].

Significant associations between high BMI and low cognitive test performance have been reported. However, cross-sectional studies show contradictory results, where some indicate that higher BMI is associated with better cognitive function [42]; [43]; [44], whereas others have found that higher BMI is associated with lower cognitive function [45]; [46]. Taken together, findings based on cross-sectional studies do not convincingly demonstrate a significant association between BMI and cognitive function at younger ages. Two previous studies have reported neurocognitive deficits in overweight/obese children and adolescents. The first study found increased body weight was associated with decreased visuospatial organization in children/adolescents aged 8 –16 years [47]. The second study compared 12 overweight/obese adolescent boys (BMI 24 –30 kg/m^2) with their normal weight peers (BMI < 24 kg/m^2) and found no differences in memory, intelligence, or verbal fluency between the 2 groups; however, the overweight/ obese adolescent boys did show more deficits in mental flexibility compared with their normal weight peers [48]. However, Gunstad et al. [49] found no association between BMI and cognitive function in healthy children and adolescents, although underweight girls exhibited poorer memory performance than normal weight and obese girls [49]. However, obesity is a risk factor for lower cognitive performance in young individuals [50].

To date, few studies have focused on cognitive abilities in a sample of obese children seeking primary treatment of obesity through sports. Therefore, the aim of this research is to study the effect of a training program on anthropometric parameters and cognitive performance in obese adolescents.

II. METHODS

2.1. Subjects

Twelve obese adolescents boys aged from 14 to 17 years, enrolled in colleges and secondary schools in the public urban area of Mahdia, voluntarily participated in this study, whose body mass index (BMI) was greater than IOTF-30, as defined by French population curves [29]. None of the subjects were using drugs or other therapy for obesity, and none had prior histories of disease or injury that would prevent daily exercise. All of these students were enrolled in schools selected at random and did not receive at any time a special diet instruction.

Before enrolling in the study, subjects were informed of the experimental procedures, as well as the potential risks and benefits associated with the study; however, they were not informed of the study’s purpose. To be included in the study, each subject provided written consent in accordance with the Declaration of Helsinki. The study was approved by the research ethics committee of the University.

Table 1: Characteristics of study subjects.

	Obese
Age (Years)	15.9 ± 1.4
Body mass (kg)	84.45 ± 5.6
Height (m)	1.62 ± 0.06
Body mass index (kg/m^2)	32.40 ± 3.7
% body fat	39.6 ± 4.8
Tanner stage (%)	
Stage 1	0.0
Stage 2	0.0
Stage 3	3.2
Stage 4	8.4
Stage 5	88.4

2.2. Experimental procedures

The study was conducted during the 2009-2010 school year. All subjects participated for an average of 12 weeks to a fitness program. Before the first and after the last training session, we compared anthropometric and cognitive performance of a group of obese adolescents.

2.3. Pubertal assessment (Table 1)

Pubertal status was measured with a self-assessment questionnaire using gender-specific line drawings of the Tanner puberty stages [51]. Participants were asked to complete this alone and in private at home. All participants reported being either in puberty or completing puberty.

Pubertal stage was evaluated according to the Tanner classification [51] by a trained paediatrician:

• prepubertal children were those in Tanner stage I;
• pubertal children were in Tanner stages II–III;
• and post-pubertal children were in Tanner stages IV–V.

2.4. Anthropometry

All anthropometric measurements were performed once before the first session of the training program and again after the last session. Weight and height were measured among participants in an upright position, wearing light clothing and bare foot. The size of the subjects was measured using a stadiometer, to the nearest centimeter. Subjects were also weighed on scales Seca (alpha model 770), 100 grams. Overweight was defined as a body mass index (BMI [weight/height^2] ≥ 25). Obesity was defined from a BMI ≥ 30 according to international standards recently established [31]. The percentage of body fat was calculated using a measuring device such Harpenden Skinfold Caliper (Harpenden, UK) at four standardized sites (biceps, triceps, subscapula and suprailium). The four measures were then summed and converted to body fat percentage using the Durnin and Womersley table [52].

2.5. Cognitive tests

Two cognitive tests from Intelligence Scale for Adults (WAIS) Wechsler [53] were used, with a coefficient of test-retest stability that exceeds 0.88

2.5.1. Short-term memory tests

The tests of short-term memory [53] during which the subject must repeat a series of different items composed of digits set by the examiner. The scores are calculated:

- The total score of memory of numbers (MT) is the sum of scores in the two subtests [54]: memory in direct order (MD) and memory in reverse order (MI). Each is noted on 16 points.

MT (32 pts) = MD (16 pts) + MI (16 pts);

- The total score of the span in memory of numbers (EMT). The span corresponds to the mnemic amplitude, it is taken from the number of digits restored correctly in block into the last test in each subtest. The EMT is the sum of the scores obtained in the memory span in direct order (EMD, noted on nine points) and the memory span in reverse order (EMI, noted on eight points).

EMT (17pts) = EMD (9 pts) + EMI (8 pts)

2.5.2. Symbol test

The test assessed visual perception, that is to say the capacity and processing speed of the visual information [53]; [55]; [56]. The test takes place in 120 seconds during which the subject observes a series of 60 different items each consisting of a series of five symbols and must decide each time, as soon as possible, if one of the two target symbols is present or not in series.

Two scores are recorded for each subject:

- the total score of visual perception (PVT) is the number of items correctly completed;

- the score of the mistakes of visual perception (EPV) is calculated based on the number of mistakes during the selection of items correct.

2.6. Training program

The physical training program consists of running, walking, physical strengthening and stretching muscles, with 2 sessions a week. Each session lasts about 50 minutes. We determined the subject's heart rate at rest, for this reason, we left about 10 minutes rest in the supine position (lying on the back). Heart rate was measured using a Polar heart rate monitor (Polar, Finland).

The training program is divided into three periods:

- Period 1: from week 1 until the end of Week 3:

We proposed an aerobic endurance program fractionated upon 3 repetitions of 10 minutes. The subject recovers completely after every 10 minutes of racing. Work intensity during each repetition is equal to 50% of the maximum heart rate of the subject.

$HR_{max} = 191.5 – 0.007 \times age^2$ [57]

As the subject is informed about the intensity of work before the start of training, must follow his heart rate on the display of heart rate to keep it in the meantime. At the end of a 10 minutes run, the subject walk until the heart rate returns to its resting value, which marks the beginning of the second repetition. At the end of each session, subjects performed muscular strengthening exercises (abs, dorsal and squats). These exercises consist of 3 sets of 10 repetitions with 30 seconds recovery between repetitions. Each session ends with stretching muscular exercises.

- Period 2: from week 4 until the end of Week 7:

The work is divided into 2 repetitions of 15 minutes per session at an intensity equivalent to 60% of the maximum heart rate of the subject. In addition to the race, the subjects performed 3 sets of 20 repetitions (abs, dorsal and squats) with a recovery of 30 seconds between repetitions. The session ends with stretching muscular exercises.

- Period 3: week 8 until the end of week 12:

70% of the maximum heart rate of the subject is the intensity of work during this period. At each session, the subject performs two fifteen-minute races separated by a complete recovery. Then, the subjects performed 3 sets of 30 reps (abs, dorsal and squats) with a recovery of 30 seconds between repetitions. The session ends with stretching muscular exercises.

2.7. Statistical analyses

All statistical tests were processed using STATISTICA Software (StatSoft, France). All data are expressed as mean ± SD.

Differences in anthropometric parameters and cognitive performance in obese subjects before and after training were analyzed using paired Student's t test.

Statistical significance was set at $p < 0.05$.

III. RESULTS

Regarding anthropometric parameters, the physical exercise program allowed us to get significant changes in body composition in obese subjects. Thus, the obese lost 1.73 ± 0.7 kg, which corresponds to a decrease of 2.05% ($p = 0.006$). The fat loss was 2.38 ± 0.4 kg, which corresponds to a decrease of 6.01% ($p <0.001$). Thus a reduction in BMI (6.60% ; $p <0.001$) was observed at the end of the training program.

Concerning the short-term memory, data analyzed by the Student's t-test paired sample on the variation of scores of on memory numbers (MT) and the memory span of digits (EMT) show a significant effect of training ($p <0.001$). Indeed, compared to the reference period, scores of MT and EMT increases of 20.77% respectively ($p <0.001$) and 33.56% ($p <0.001$) at the end of the training program.

On visual perception, the Student's t-test showed a significant effect of training ($p <0.05$). Indeed, the scores of visual perception (PVT) increased significantly from 11.44% ($p <0.05$) at the end of the training program. In contrast, our results showed a reduction of 32.15% ($p <0.05$) at the level of visual perception errors (EPV) at the end of the training program.

Table 2: Effect of physical training on anthropometric and cognitive parameters (mean± SD).

	Obese	
	Pre	Post
Body mass (kg)	84.45 ± 5.6	82.72 ± 5.1**
BMI (kg/m²)	32.40 ± 3.7	30.26 ± 3.6***
% body fat	39.6 ± 4.8	37.3 ± 4.5***
MT	16.42 ± 0.51	19.83 ± 1.40***
EMT	8.67 ± 1.50	11.58 ± 1.68***
PVT	46.59 ± 3.53	51.92 ± 4.19*
EPV	6.75 ± 3.05	4.58 ± 1.83*

***: Significant difference compared to pre training at $p < 0.05$; ** $p < 0.01$; *** $P<0.001$**

IV. DISCUSSION

The aim of this research is to study the effect of a training program on anthropometric parameters and cognitive performance in obese adolescents.

In addition to the well recognized adverse health effects of obesity [58], emerging evidence points to the fact that cognitive function is also compromised in the presence of obesity [59]. Specifically, many studies demonstrate an increased risk of cognitive dysfunction or dementia in obese individuals [60]; [61]. Other studies have found no changes in cognitive performance [41]; [62]; [63].

The intelligence test score used in the present study has been evaluated against the WAIS, which is an individual intelligence test widely used and approved in psychological research [64]. Working memory assessed in this study mobilizes the restoring mechanism of short-term auditory memory, through attention and concentration, while the Symbol test assesses the ability of the processing speed of visual information, the control and fluidity attentive cognitive mobilizes a high concentration [53].

As expected, our results are consistent with the work of Gunstad et al. [41] and Whitmer et al. [65] suggest that obese people get poor results on a number of cognitive tests. In addition, obese often report great difficulties in terms of capacity and speed of processing visual information [66]. Moreover, Jennifer et al. [67] have shown that obese people have a higher risk (approximately fourfold) to have a reduced cognitive performance compared to non-obese subjects. By cons, there is no difference between overweight people and people who have a normal weight [68].

While the reasons underlying the association between obesity and cognitive dysfunction remain unclear, we can advance the following explanation. First, it is possible that since a larger body mass requires more blood flow for optimal functioning, the brain is deprived of blood flow that it normally receives under circumstances when the body is not as large. In turn, this lack of essential blood flow could be a contributing factor to poor cognitive performance in individuals with a larger body mass index. Alternatively, adipocytes, once thought only to store fat, are now known to secrete proteins (e.g., cytokines, leptin) that may alter cognitive functioning when present in abnormal levels [69]; [25].

However, the results showed the beneficial effect of the training program on reducing BMI of obese [36] and also improve cognitive performance. These results are consistent with the study of Carroll et al. [70] who suggest that sport strengthens memory and allows for better concentration. A study by Nigam et al. [71] conducted six participants overweight or obese with a BMI between 28 and 31 have made sport sessions for four months in alternating sessions of 30 seconds then sprint for 30 seconds slower activity, such as walking or jogging. Before this study, participants underwent a battery of cognitive tests, to measure biological and physiological performance. Cognitive tests include a memory pairs of numbers and symbols. Participants in this study lost fat in the abdomen and saw their waist down. The results showed that the sports program has significantly improved the cognitive performance of participants, parallel to their improved insulin sensitivity and level of oxygenation. Thus, Lambert et al. [72] have shown the benefits of a sports program on insulin resistance, that is to say, the loss of ability of cells to use sugar. The improvement of insulin resistance may explain the beneficial effects of exercise on the waist and brain function. Insulin resistance leads to a decrease in the storage and use of glucose in muscle, whereas in the liver, there is a stimulation of the synthesis of glucose from fat. This contributes to increase blood glucose and eventually lead to diabetes and cerebral malfunction.

Another study by Meyer et al. [73] has shown that the analysis of brain oxygenation during exercise phases showed that participants' cognitive functions were significantly improved through training. In addition, tests on memorizing numbers and symbols have proved much better at the end of the training program. Indeed, the sport would improve the performance of the grey matter [73]. However, muscular exercise increases cerebral blood flow and improving cognitive functions and psycho-sensory seems correlated with circulatory phenomenon [74]. Thus, it is reassuring to know that the sport helps obese to improve cognition and reduce body weight and body fat percentage. In addition, reduce anxiety and increase self-esteem of obese [36].

V. CONCLUSION

Our study shows the importance of physical activities in obese adolescents to reduce their BMI as well as for the improvement of cognitive performance (short-term memory and visual perception).

This study has several limitations, including the absence of information on past history of traumatic brain injury [75] and other psychiatric [76] or depressive conditions [77] that may affect cognitive functioning. In conclusion, this study showed, first, an association between obesity and reduced cognitive performance. Then we showed the beneficial role of sport in reducing body weight and improving cognitive performance. The results highlight the importance of cognitive function assessment and the need to investigate the health effects of obesity beyond traditional disease end points but in intermediate states such as decreasing cognitive function.

Independently or in addition to the effects of prevention programs on the reduction of body mass index (BMI), which is one of the most used to diagnose overweight and obesity and its evolution [78]; [79]; [80] the success of interventions is largely related to certain psychosocial variables [81]; [82]; [83]; [84]; [85]; [86]. There is, for example, that the success of prevention programs is related to increased satisfaction and self-image of the body as well as improving the athletic skills of perception, affect and identity children and adolescents [5]; [82]; [87]; [13]; [88]; [19]; [20]. The involvement of subjects in prevention programs is also dependent on the active participation of their social environment near or far [86]. Thus, we believe that many people could benefit from a training program similar to the one used in this study.

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