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Study of obesity prevalence, body mass index, energy consumption measured by accelerometer and pollution related health effects in children attending primary school in Milan

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Abstract

Study of obesity prevalence, body mass index including energy consumption measured by accelerometer and pollution related health effects in children attending primary school in Milan

The purpose of our study is to evaluate the synergy between air pollution and obesity in causing damage to health.
We try to create a sort of guideline of conduct tending to modify the lifestyle. The goal is to improve health both directly by increasing the possibility of movement of children and indirectly by reducing air pollution.
It's been shown that obesity, reduced physical activity and air pollution are cofactors that can cause systemic diseases.
This is most evident in children because they are more susceptible, have immature metabolism, phenomena of bio-accumulation.
Children breathe proportionately more air volume than adults so they inhale a higher concentration of pollutants, also breathe more being lower near the ground.
A campaign was carried out to the families by providing adequate information on the aims of the study.
Since 2006 was undertaken a cross-sectional study about BMI in children attending primary school in the city of Milan (n= 54000).
2459 children from 9 different schools (every school representative of a district of the city) were analyzed.
This sample as representative of entire population of children was obtained as a result of a statistical inference.
There were 1212 (49%) girls and 1247 (51%) boys. Mean age was 8,34 +/- 1,52 years (range 6-11).
From these 2459 1782 (77,2%) were within the average range of BMI. According to criteria of Cole there were 416 overweight (16,9%) whereas obese children were 144 (5,9%) (overweight + obese 22,8%).
We analyzed the episodes of respiratory diseases and it was found that obese children had a higher number of episodes of asthma.
At this point we have selected two schools.
Daily levels of PM 10 and PM 2,5 were measured both outdoor and indoor.

Prior consent were therefore enrolled 376 children.
At first the children underwent skin prick test for allergens, analysis of fractional exhaled nitric oxide, spirometry, access hospital were evaluated and respiratory problems.
We evaluated anthropometric data and dietary habits.
It was assessed physical activity by accelerometer (Lifecorder Plus Kenz).
To the children was therefore indicated the need to change the dietary habits and carry at least 1 hour of physical activity daily, enough to keep the weight in balance.
At a distance of 1 year were reviewed body weight, timing, number and quantity of the meals, physical activity and rates of respiratory problems.
The data thus obtained revealed a higher percentage of accidents breathing in obese subjects compared to normal weight.
There were no significant changes in weight.
There was an increase in physical activity in the children and a lower percentage of asthma exacerbations despite PM concentrations were maintained throughout the year.
While accepting the fact that the samples are small and the period of observation is too limited we are convinced that this is a first step to show that pollution and obesity are capable of causing damage on susceptible individuals and changes of the lifestyle produce an increase of health.

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INTRODUCTION

Obesity is an emerging problem in public health for the increased morbidity and mortality related to this condition. (1)

The World Health Organization estimates that 400 million adults are obese and almost 20 million overweight children under 5 years of age. (2)

The prevalence of obesity in the last two decades has also increased steadily in the pediatric population (3).

It must follow closely the nutritional situation of the general population and especially children, primarily for the direct consequences of overweight and obesity on child health (4) but also for the fact that these conditions in children are a risk factor for the onset of disease in adulthood.

The survey Okkio (5), made in Italy by the Ministry of Labour, Health and Social Policy in 2008 of 45590 children attending the third grade of primary school at the nation level has identified a prevalence of 23,6% overweight and 12,3% of obesity and confirmed a higher prevalence in the south. The recognition and early treatment of over weight is crucial to combat obesity. An ideal approach to the treatment

of this condition provides for the modification of eating habits and encouraging the development of an active lifestyle, promoting sports planned and reduction sedentary lifestyle.

ESSENTIAL OBESITY

DEFINITION

Obesity can be defined as an excess of adipose tissue to induce a significant increase in health risks. The instrument currently used to evaluate the relationship between weight and stature in both children and adults is the Body Mass Index (BMI) which is calculated by dividing weight (in Kg) by height squared high (in meters):

$$BMI = \frac{\text{Weight (Kg)}}{\text{Height (m)}^2}$$

Because BMI in children increases with age and is influenced by pubertal status and sex, for the interpretation of this parameter in children the International Obesity Task Force (IOTF) recommends using reference curves of Cole (6) different in the two sexes.

The calculation of the value of BMI at each clinical monitoring is recommended, in case of overweight or obesity, then, to better quantify the fat mass is possible to evaluate the body composition by anthropometric methods (measuring the circumferences of arm, waist and hips and fold cutaneous triceps, biceps, subscapular and suprailiac or methods such as impedance.

ETIOLOGY

Excess weight appears when caloric intake is higher than daily energy expenditure. The amount of energy we consume daily is divided into 3 components: resting metabolic rate, thermogenesis and physical activity. The basal metabolic rate represents the greatest share of the daily energy expenditure and in addition to age and sex is influenced by lean mass (muscles). The type of aerobic exercise daily allows the development of muscle mass, resulting in a high daily energy expenditure. The daily physical activity is indispensable and irreplaceable.

Environmental Factors

Several social-economic and environmental factors determine the quality of food consumption and the degree of inactivity. In the presence of a genetic predisposition these factors were able to determine a progressive increase in average adiposity of the children population. The malnutrition of the fetus during intrauterine development is associated with subsequent appearances of obesity as well as risk of hypertension and diabetes type 2, regardless of

familiarity or heredity (7). It's suggestive to think that the fetus adapts its development and its metabolism to the expectation of a reduced availability of nutrition in post-natal life. It is hypothesized that malnutrition induces metabolic and physiological responses in fetuses that help them survive. In later stages when the amount of food is more abundant the same adaptative response can lead to development of hypertension, cardiovascular disease and glucose intolerance.

The methods of feeding and weaning would be able to influence the development of obesity. According to some epidemiological studies breastfeeding is protective and an excess of protein however in the first 2 years would increase the risk of obesity (8-9).

Habits of life and eating of the family may influence greatly the children's habits (10).

In the family where was described a behavior of nursing mothers who respond to any manifestation of their child by providing food, could lead the child to seek solace in food later.

The habits of child's life.

Television induces and promotes food consumption and reduce energy expenditure by increasing physical inactivity. The time spent in the

company of the TV was significantly associated with the development of obesity in children.

Another aspect recently investigated, linked to the development of childhood obesity is the adiposity rebound.

The age at which it reaches the minimum value before the increase in BMI is called physiological adiposity rebound and average age is 5-6 years. An increase in BMI before age of 5 (early adiposity rebound) is recognized as an early indicator of risk for the development of obesity (8, 11).

Supply characteristics of obese child

- Excessive intake of food than consumption of calories (a sedentary lifestyle).
- Propensity to take food in the afternoon not in the morning and not during meals. Preference for liquid foods (fruit juices) or very creamy that do not require chewing (cakes, puddings, pastries).
- Poor intake of whole grains, legumes, fish, dietary fiber, vegetables and fruits season
- High sugar

CLINICAL FEATURES

The child with essential obesity has very specific characteristic:

- Normal psychomotor development
- Obesity is gradual in onset with peak incidence of school age and adolescence;
- Distribution of adipose tissue is consistent across the face, trunk, limbs;
- Height with high growth curve adjust: If investigated the maturation of bone is accelerate and is comparable to the stature age;
- Accelerated maturation of puberty tend;
- In cases of severe obesity can be found acanthosis nigricans, lesion characterized by hyperpigmented areas of skin, surface smooth, warthy, and an important sign of abnormal glucose metabolism and insulin;
- Valgus Knees and flat-feet are frequently found in obese child, coxa vara or epiphysiolysis of the femoral head;

COMPLICATION ON OBESITY

The obese child after a few years presents some metabolic disorders. First of all the alterations of glucose metabolism: insulin resistance, impaired glucose tolerance, diabetes mellitus type 2 .

NUTRITIONAL EDUCATION

Normocaloric diet, associated with enhanced physical activity, aims to achieve reduction of overweight using weight maintenance. In relation of the habits of the child, the most significant change that aims are:

- Avoid consumption of food outside the recommended 4-5 meals
- Promotion and enhancement of the breakfast
- Snacks of fruit, yogurt, bread preferably integral type
- Avoid prolonged periods of fasting
- Increased satiety favouring foods with low glycemic index sugar limitation of high glycemic index. The latter fact do not give fullness and are responsible for high levels of blood glucose.

  If the family is cooperating, this approach has a good acceptance since it involves mostly qualitative changes without excessive restrictions, allows for the gradual reduction of overweight and

lasting, and the acquisition by the child and the entire family of proper nutritional education (12, 13).

MEASUREMENT METHODS

The assessment of body composition compartments can be done with several methods that differ in precision, accuracy, reproducibility, cost and invasiveness.

The Q*uetelet index or BMI (Body Mass Index)*, obtained by dividing body weight in Kilograms and square of Height in meters (kg/m^2) is considered to have the best validity as an indicator of obesity. The BMI is associated positively with total fat mass, but only explains the variability in the extent of 60-80% and therefore represent an indicator also of the other body compartments: lean mass. Because BMI in children increases with age and is influenced by pubertal status and sex, for the interpretation of this parameter in children, the International Obesity Task Force (IOTF) recommends using reference curves of Cole, different in the two sexes, that allow to establish the limits of overweight and obesity at different ages. (6)

The BMI has a good correlation with fat mass and the simplicity of measurement in the best tool to perform population studies, but has several limitations: first, does not provide information on the

distribution of body fat, increases lean body mass or stands, muscle or bone, which explains why, especially in subjects with high muscle mass, can give false positives.

PHYSICAL ACTIVITY

The combination of poor nutrition and inadequate physical activity was reported as the second leading cause of death in the United States in 2000. Several studies have shown that levels of physical activity are reduced in obese children and this helps to maintain a vicious circle. Treatment protocols including an exercise program were more effective than protocols that had none.

EVALUATION OF PHYSICAL ACTIVITY

It is not easy to determine what the calorie cost of various physical activities, especially in children. The intensity of physical activity may be expressed as the equivalent of metabolic thermogenesis or MET (international unit of energy expenditure), which represents a ratio of energy expenditure for a particular type of physical activity and energy expenditure at rest (14).

The improvement of the detection technologies of physical activity daily has been with the advent of portable instruments with motion sensors such as Pedometers and Accelerometers that allowed to quantify physical activity in condition of real life. These tools detect

objectively the activities, are simple to use, small, do not involve an impediment to physical activity.

Pedometer. The pedometer does not accurately reflects the totality of usual activities. The instrument can also record in fact passive movements of the body to the prevailing vertical component, does not discriminate the intensity of the movement recorded and does not measure activities carried out by stationary or low vertical component (15).

Accelerometer. The monitoring of physical activity by accelerometer, measures the acceleration due to body movements. It is an instrument by means of a piezoelectric transducer measures the acceleration of a given body segment. When it moves, its acceleration causes a bending of the transducer that produces a current proportional to the force exerted on it.

New instruments are smaller, are equipped with memory functions for storing data for extended periods of time. The use of these devices has been recognized as a valid tool for evaluation of intensity and energy expenditure of physical activity (16).

In the guidelines established by the National association for sport and Physical Education in 1993 (17) is recommended for children who

attend elementary school physical activity lasting at least 30-60 minutes a day.

The UK Health Education Authority recommends that all young people accumulate at least 1 hour of physical activity per day of at least moderate intensity (18-19).

The 2002 report of Institute of Medicine (National Science Academy – Washington DC) is recommended for adults and children at least 1 hour of physical activity if your goal is weight maintenance.

WHAT ACTIVITY FOR CHILDREN?

Tips for physical activity.
Funny, adequate for the age
Appropriate to the child's motor skills
Aimed to involve the large muscle
Frequency, intensity and duration increasing
Associated with nutrition education and reduction of sedentary

The observations discussed above focus attention on the importance of making continuous and intense physical activity to maintain a healthy eating behaviors to prevent weight gain.

PURPOSE OF THESIS

The purpose of our study was to evaluate the synergy between ai pollution and obesity in health damages and then create a sort of guideline of conduct tending to modify the lifestyle and thereby improve health.

Assess the physical activity of children quantified by portable accelerometer and explore possible correlation with body composition.

PATIENTS AND METHODS

Our research was structured as follows.

Since 2006 we conducted a cross-sectional study about BMI in children attending primary school in the city of Milan.

Out of a population of about 54000 students using statistical inference was extracted a representative sample of 2459 children attending 9 primary schools (one from each district where the city was divided).

Of these 2459 1212 were female (49%) and 1247 were male (51%).

The average age was of 8,34 +/- 1,52 years (range 6-11).

According to the tables of Cole 1782 of these 2459 were considered normal weight, overweight the remaining 416 (16,9%) and obese 144 (5,9%) (overweight + obese 16,9 + 5,9%).

Daily levels of PM 10 and PM 2,5 were measured both outdoor and indoor.

We evaluated episodes of respiratory diseases and it was found that obese children had a higher number of episodes of asthma with statistical significance of 0,05.

With the consent of the parents, explaining the aims of the study, 360 children were enrolled.

The children were between 6 and 11 years of age (average age 8 years SD 1,4).

AGE	FREQUENCY	PERCENTAGE
6 years	60	16,66
7 years	86	23,89
8 years	54	15
9 years	90	25
10 years	50	13,89
11 years	20	5,56
Total	360	100,0

Each student received an informational letter for the collection of written consent to participate by their parents.

Only children with consent were included in the study.

The percentage of adhesion to participate in the study was 87,4% (360 of 412 school children, including both children for whom consent was not given both absent).

To each child was assigned a code to ensure anonymity.

During the month s of April- May 2009 and in 2010 qualified medical staff collected the following data using portable instrumentation:

- Anthropometric data:

1. Height in meters (to two decimal places) using mobile stadiometer SECA 214®
2. Weight in Kilograms (with 1 decimal place), using impedance scale Tanita BC 420 MA®,

Children were measured without shoes and socks in their underwear, heels together in position of Frankfurt. The rounding of weight and height were : height to the nearest 0.5 cm and weight to the nearest 0.1 Kg.

The interpretation of BMI was made using reference curves of Cole (7).

The physical activity of children has been quantified by a portable accelerometer (Lifecorder PLUS, KENZ) to wear for at least 3 days, two weekdays and one holidays, for at least 8 hours a day (48).

The accelerometer provides data concerning the average daily number of steps , minutes of physical activity of moderate to vigorous intensity, and calculates an approximation of calories expended during the minutes of non-light.

Lifecorder Plus (KENZ) has dimensions 7.0 x 4.0 x 2.5 cm; is positioned at the belt at the waist. It uses a technology that measures the uniaxial vertical accelerations of the hip.

The accelerometer detects the 32 Hz and detects values between 0,06 and 1,94 g. The signal is filtered and digitized.

In addition the Lifecorder detects the number of cycles in the acceleration signal and expresses this value as a measure of total activity (eg walking distance).

LC was programmed setting the date and start time of the measurements, height, weight, age and gender of the child and the data were downloaded according to manufactoring instruction using the Physical Activity Analysis Software (Version 1.1, SuzukenCo. Ltd, Nagoya, Japan).

For the quantification of physical activity data we considered were the average number of steps and average daily minutes of physical activity daily minimum intensity of 3 METs, moderate intensity and therefore stronger.

With regard to levels of physical activity were taken as reference values of the American College of Sports Medicine that divided the pediatric population aged between 6 and 12 years in descriptive categories based on scientific evidence of the benefits health (52).

Number of steps per day		
GIRLS 6-12 years	**BOYS 6-12 years**	**CATEGORY**
>15.000	>17.500	VERY ACTIVE
12.000-14.999	15.000-17.499	ACTIVE
9.500-11.999	12.500-14.499	QUIET ACTIVE
7.000-9.499	10.000-12.499	LITTLE ACTIVE
<7.000	<10.000	SEDENTARY

STATISTICAL ANALYSIS

The data processing were performed using SPSS 17.0 per Windows (SPSS Inc., Chicago, IL, USA).

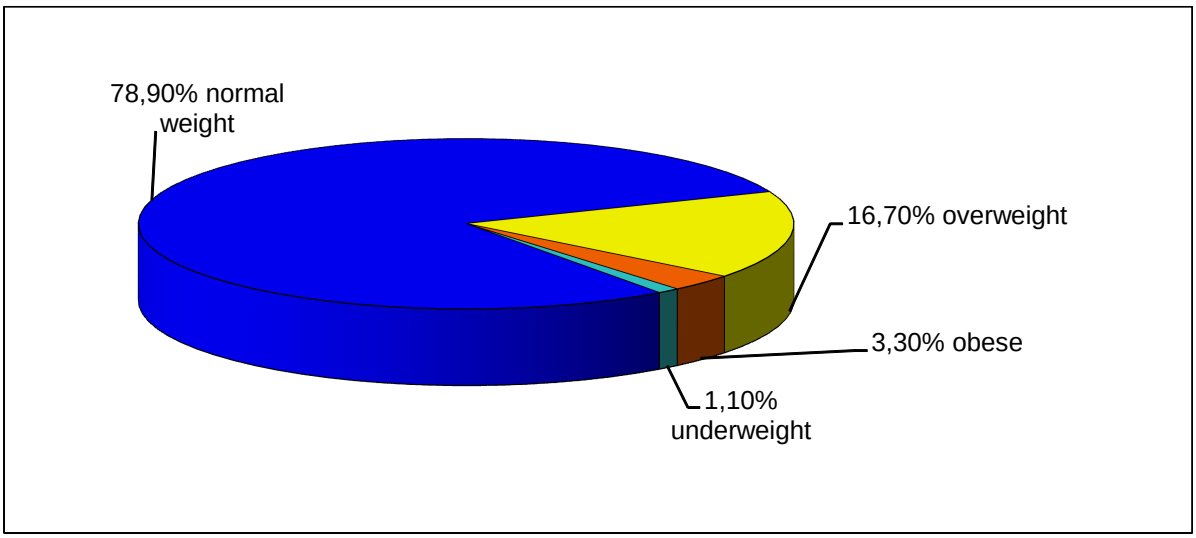
The significance was set at $p<0,05$ (two-tailed test).

Correlation were used to test nonparametric of Pearson and for comparison between groups treated Chi-square test and Fisher's test when appropriate.

RESULTS

The average BMI values in our group of children was 18,3 Kg/m^2, (minimum 12,8, maximum 24, SD 2,04).

According to Cole's reference curves for the interpretation of body mass index (7,37) in the population studied 4 children bambini (1,1%) were underweight, 284 (78,9%) normal weight , 60 (16,7%) overweight and 12 children obese (3,3%) (graph. 1).



Graph. 1: distribution of the population examined for BMI

The distribution of BMI in the studied population by age and gender shows no statistically significant differences in the two sexes.

The analysis of data on physical activity using accelerometers obtained showed an average of 11985 (median 11431, minimum 6667, maximum 20343, SD 2764).

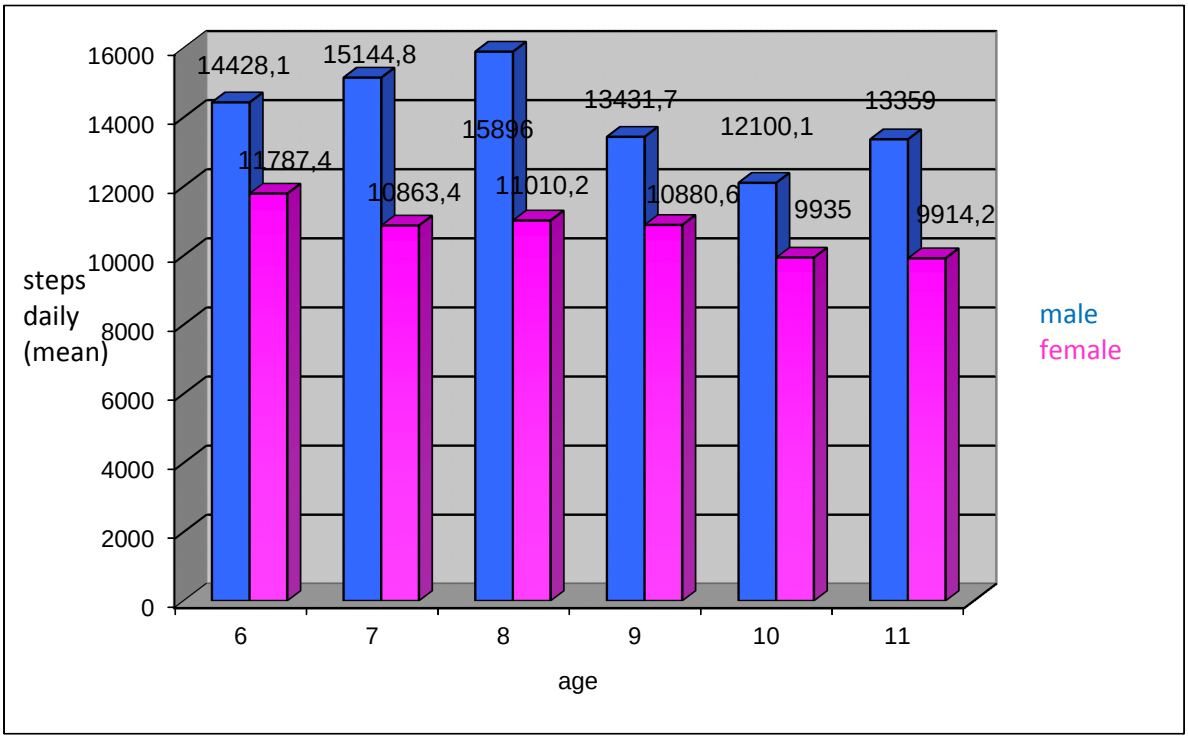
Analysis of the data shows that the average number of steps per day decreased significantly with increasing age (p= 0,02), univariate analysis of that trend shows a statistically significant difference between the average number of daily steps to age of 6-7 years and 10 years (p=0,04).

The average number of daily steps of the female population in our sample is significantly lower than that of the male population (14262,9 vs 10874,5 p<0,05).

The tables and graphs below show the results obtained by accelerometer divided by age and gender.

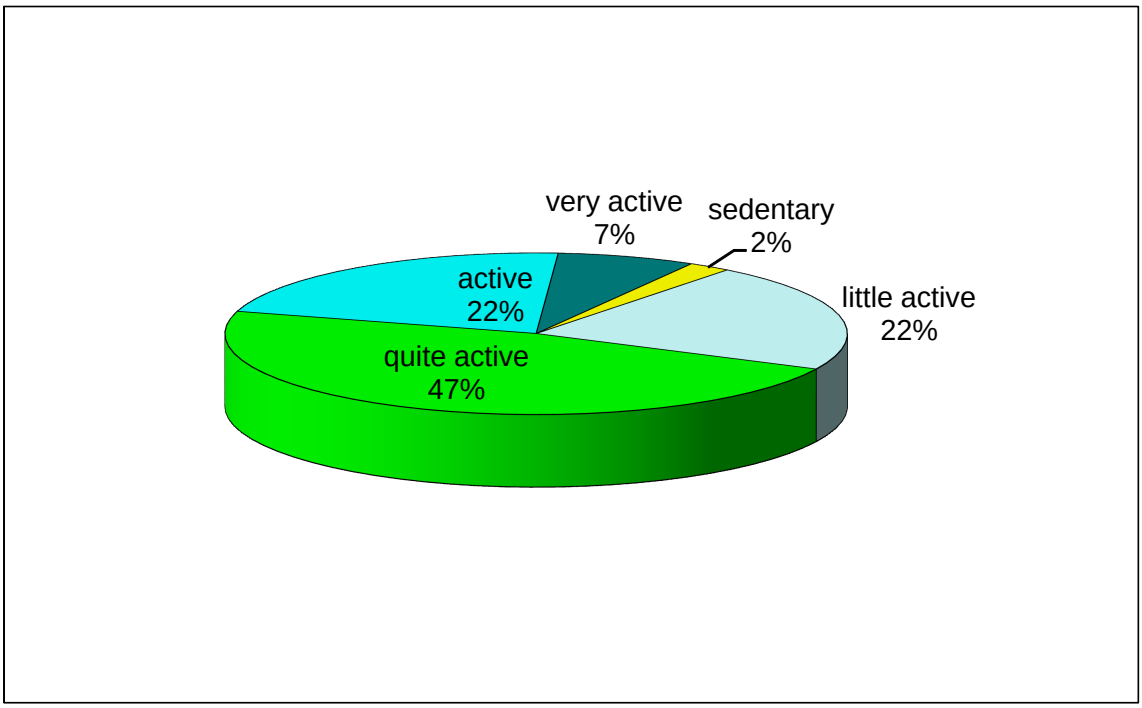
AGE	N	Number of steps per day (average)	Median	Range
6	60	12667,6	11658	8557-20343
7	86	12556	11946	6667-20325
8	54	12457,9	11450	7197-19227
9	90	11504,2	11172	6714-17992
10	50	10541,2	10080	7675-15882
11	20	11981,1	11270	9116-18562

Table 1: number of steps per day (mean, median and range) divided by age (p = 0,02)



Graph. 2: average number of daily steps in the two sexes ($p<0,05$)

The categorization of physical activity according to the average number of steps per day has shown that 8 children (2,2%) were sedentary, 78 (21,7%) little active, 170 (47,2,%) quite active, 78 (21,7%) active, 26 (7,2%) very active according to the classes reference proposed by Tudor Lock.



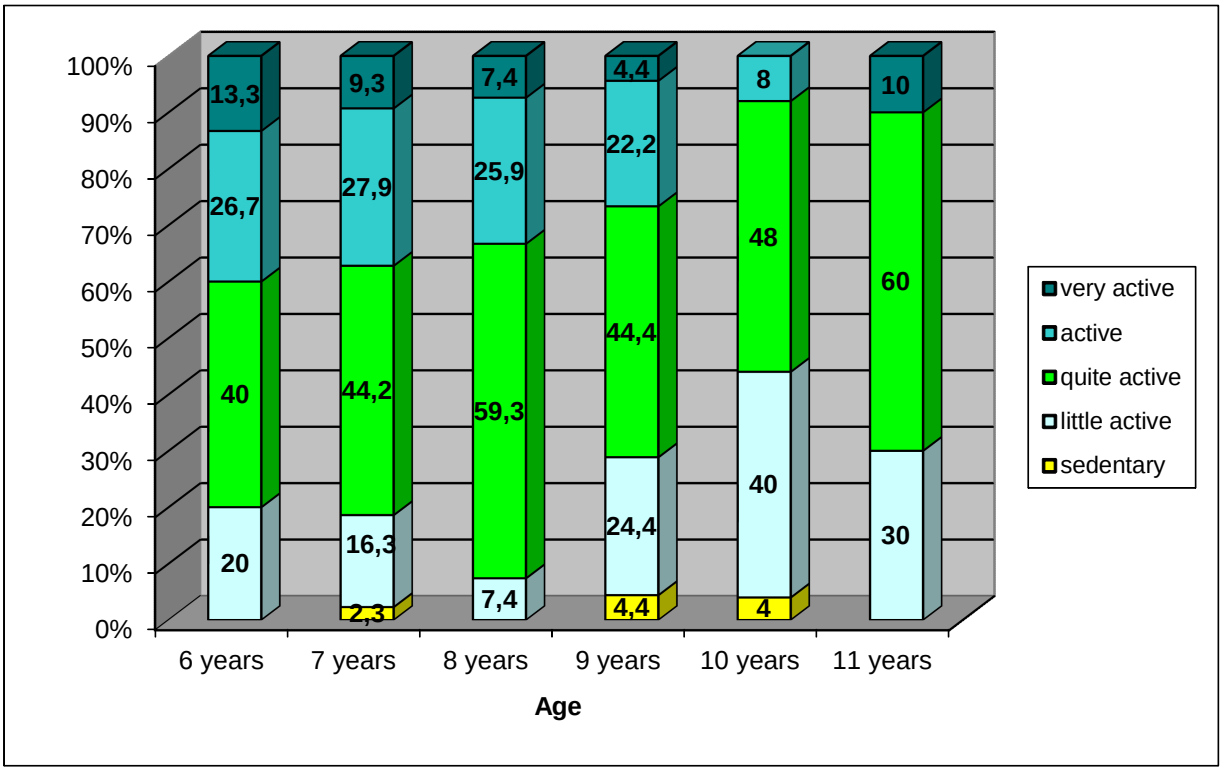
Graph 3: population distribution by category of physical activity

The distribution of the population by age shows that in all age groups most of the subjects were placed in the category of "quite activity" and the most active are the children of 6 and 7 years.

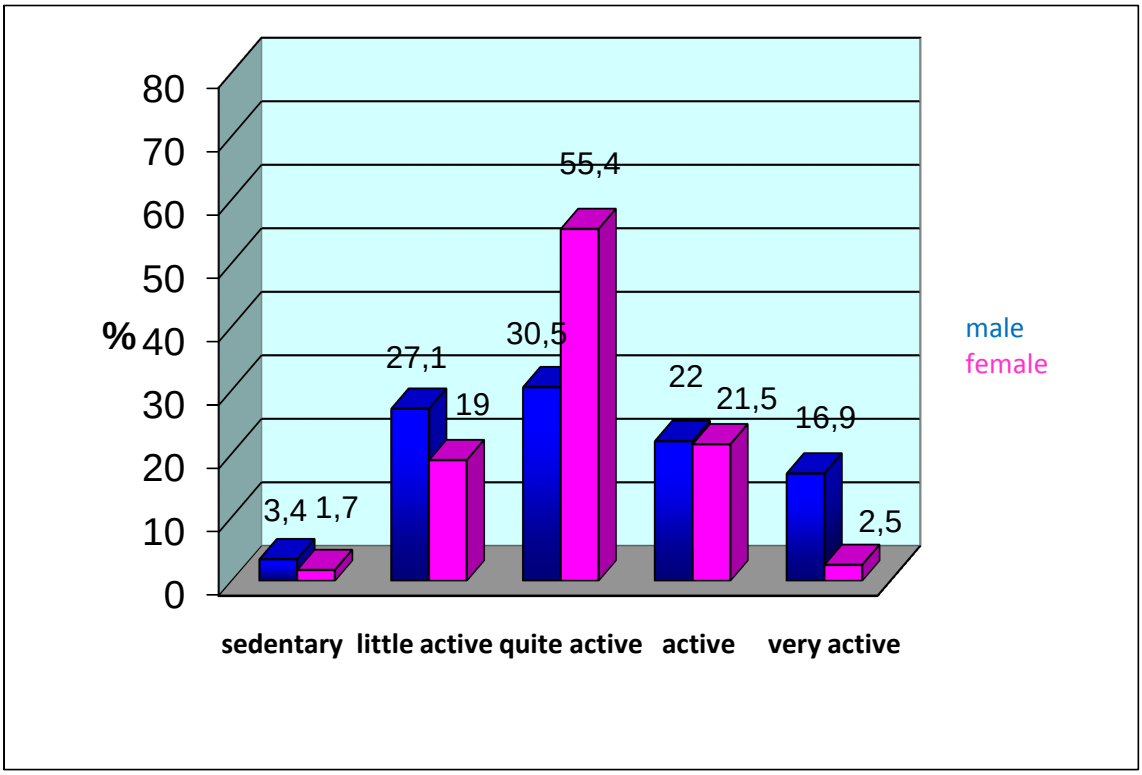
The table and graph below represent the distribution of the population considered for categories of physical activity and age.

		Level of activity				
Age	**Subjects**	**Sedentary**	**Little active**	**Quite active**	**Active**	**Very active**
6 years (N=60)	N (% at this age)	0 (0%)	12 (20%)	24 (40%)	16 (26,7%)	8 (13,3%)
7 years (N=86)	N (% at this age)	2 (2,3%)	14 (16,3%)	38 (44,2%)	24 (27,9%)	8 (9,3%)
8 years (N=54)	N (% at this age)	0 (0%)	4 (7,4%)	32 (59,3%)	14 (25,9%)	4 (7,4%)
9 years (N=90)	N (% at this age)	4 (4,4%)	22 (24,4%)	40 (44,4%)	20 (22,2%)	4 (4,4%)
10 years (N=50)	N (% at this age)	2 (4%)	20 (40%)	24 (48%)	4 (8%)	0 (0%)
11 years (N=20)	N (% at this age)	0 (0%)	6 (30%)	12 (60%)	0 (0%)	2 (10%)
Totale (%)		8 (2,2%)	78 (21,7%)	170 (47,2%)	78 (21,7%)	26 (7,2%)

Table 2: distribution by categories of physical activity and age



Graph. 4: distribution of categories of physical activity in different age



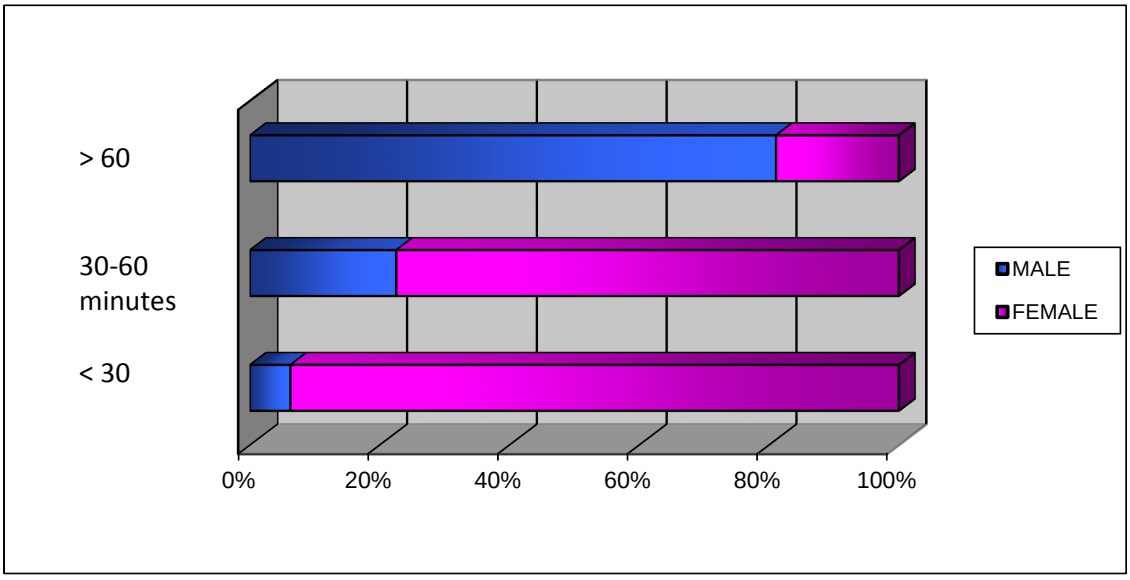
Graph. 5: distribution of children according to gender and activity level (p<0,01)

The average daily minutes of physical activity of moderate-vigorous intensity (greater than 3 METs) was 41,5 minuti (median 38,3, minimum 17,2, maximum 89,8, SD 14,1).

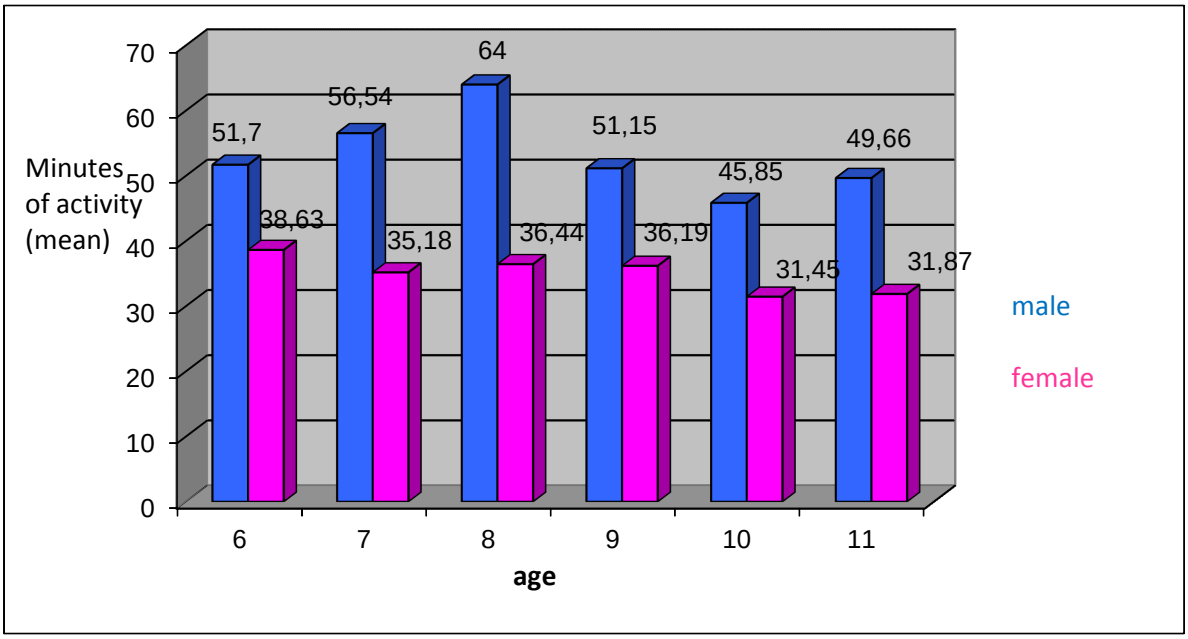
The comparison of the average number of daily minutes of physical activity between the two sexes at different ages shows that the males engaged in physical activity intensity greater than 3 METs more than females (p<0,05).

Age	children N°	Average duration of physical activity > 3 METs (minutes)	Median	Range
6	60	42,9	38,9	24,9 - 83,7
7	86	43,6	39,1	17,2 - 78
8	54	44,6	36,8	20,8 – 89,8
9	90	39,8	37,8	19,8 – 69,9
10	50	35,4	31,3	22,3 - 62

Table 3: average duration of physical activity > 3 METs (mean, median and range) divided by age (p = 0,16)



Graph. 6: prevalence of gender respect to the duration of sustained physical activity



Graph. 7: average duration daily of physical activity (>3 METs) in both sexes.

The correlation analysis showed a statistically significant relationship between BMI and the percentage of average number of daily (p=0,04) and the average minutes of activity (p=0,03); in particular increasing BMI, the number of steps and minutes of activity decrease. The description of the results obtained from accelerometer according to BMI classes is summarized in the table.

Classes of BMI	Average number of steps daily	Average minutes of activity daily
Underweight (N=4)	12164,0	43,3
Normal weight (N=284)	12985,4	46,2
Overweight (N=60)	11907,5	41,0
Obese (N=12)	8508,5	26,6

Table 7: results obtained from accelerometer according to BMI classes

Was set up an exercise program of 30 minutes a day and after 1 year reevaluated classes of BMI.

There were no significant changes of BMI classes.

The average number steps a day for different classes is shown in the table below.

BMI classes	Average number of steps daily	Average minutes of activity daily
underweight (N=5)	12423,0	45,2
Normal weight (N=283)	13005	47,0
overweight (N=60)	12408,7	44,1
Obese (N=12)	9300	32,2

At the time of recruitment for the study subjects with respiratory problems /asthma were 40 of 288 (14%) in the underweight-normal weight and 14 of 72 (19,44%) in the overweight-obese category.
The episodes of respiratory diseases /asthma in the initial period were 486 (mean 12,15) in the underweight-normal weight and 207 in the class of overweight-obese (mean 14,78).
At a distance of 1 year with increase of physical activity were found 447 episodes of respiratory problems /asthma in the underweight-normal weight (mean 11,18) and 166 in overweight-obese category (mean 11,86).

	Respiratory disease /asthma initial evaluation	**Respiratory disease /asthma II evaluation**
Underweight + Normal weight	486	447
Overweight + Obese	207	166

DISCUSSION

Using the reference curves of Cole (2000 and 2007) as recommended by the International Obesity Task Force for the interpretation of BMI in childhood we assessed the prevalence of underweight, normal weight, overweight and obesity in our population.

The results obtained in our study were detected in children examined the prevalence of overweight equal to 16,67% and obesity equal to 3,3% percentage.

The data analysis shows as already demonstrated in the literature that physical activity significant lower in females than in males (p00,5) and decreases as the age.

The analysis of the categories of physical activity in the two genders shows that females are distributed mainly in the levels of activity “little active”, “quite active”, “active”, while the males are distributed more evenly in all categories (except that of “sedentary”), and prevail in category of “very active”.

Also with regard to the intensity of physical activity the males are on average more minutes of moderate and vigorous intensity of physical activity than females.

The inverse correlation between BMI and the percentage of the average number of daily steps (p= 0,04) and average minutes of activity (p=0,03) is confirmed.

It was found that obese less active subjects had a greater number of episodes of asthma than subjects more lean and active, in addition increasing physical activity decrease the number of asthma attacks in particular in obese children.

CONCLUSIONS

The peculiarity of our study lies in having brought in relation to body composition measured by BMI and physical activity measured directly with portable instrumentation data reporting both the quantity and intensity exercise performed by a pediatric population.

Our work shows a correlation between physical activity and BMI.

We also highlighted the correlation between BMI and asthma episodes.

The increase in BMI predisposes to respiratory disease.

This research shows that an educational intervention on physical activity , pointing the pediatric population, in the age with more risk, can reduce the occurrence of systemic diseases.

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