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Full Length Research Paper

Longitudinal study on obesity trends in urban school children of Sousse, Tunisia: A 4-year analysis

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Our objective was to examine tracking patterns of body mass index (BMI) as well as their predictors between childhood and adolescence. A cohort of 452 Tunisian children aged 13 - 15 years was followed for 4 years (1999 - 2003). Tracking of BMI was defined as in individual maintaining a certain status or relative position (relative BMI quartile) overtime. After 4 years, almost 50% of the subjects had maintained their relative positions, but 25% had moved into a lower or higher quartile. The BMIs of thin and fat were more likely to track: 61.9 and 66.7% remained in the bottom and upper quartiles, respectively. Overweight children were 2.6 times as likely as all other children to become overweight adolescents. Individual's initial BMIs, sex and socioeconomic status helped to predict tracking and change in BMI. Predictors of overweight tracking found in this study would be useful to select children at risk for preventive intervention.

Key words: Obesity, adolescents, cardiovascular risk factor.

INTRODUCTION

Obesity/overweight has been declared an epidemic (Freedman et al., 2005; Andersen et al., 2005; Clarke and Lauer, 1993) and a "public health crisis" among children worldwide due to alarming increases in its preva-lence (Cole et al., 2000)Adolescence has been identified as a critical period for the development of persistent overweight and obesity on the basic of the strong evi-dence for tracking of adolescent adiposity into adulthood (Dietz, 2004; Engeland et al., 2004; (Ferraro et al., 2003) Adolescent adiposity is associated with all the long term risks of adult obesity. Childhood overweight is a risk factor for severe obesity over the life course. Further-more, overweight/obesity is related to morbidity and mortality from several diseases (Freedman et al., 2005; Freedman et al., 2001) such as cardiovascular disease (Frontini et al., 2001; Gaskin and Walker, 2003; Gunnell et al., 1998) including hypertension (Guo and Chumlea, 1999), cancer (Frontini et al., 2001) and diabetes (Guo et al., 2000). Findings from the Bogalusa Heart Study (BHS) revealed that childhood overweight was an important de-terminant of cardiovascular risk factors in young adult-hood (Hamidi et al., 2006).

Although several overweight/obesity treatment programs are available for the adults, most of them are not very successful owing to their unproven long-term efficacy (Hardly et al., 2000; Julia et al., 2008) . Thus, prevention as well as treatment of overweight and obesity in adulthood necessitates the detection of children who are likely to become overweight/obesity as adults. Epidemiologic studies such as tracking of overweight are crucial (Kelder et al., 2002) in identifying the children with a high probability of becoming overweight as adults. In Tunisia, obesity in children was studied throughout few cross sectional surveys. However, no study had a longitudinal follow allowing a verification of the stability and the prediction of children obesity. Our study focused on tracking on BMI patterns as well as their predictors between childhood and adolescence.

SUBJECTS AND METHODS

Study and design

It is a longitudinal prospective study of juvenile overweight in Sousse Tunisia started in 1999 and proceeded as a cohort study.

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The first survey (in 1999) of a random sample of 789 Sousse school children was carried when the examinees were 13 - 15 years old. Only 452 pupils of the first survey were re-examined four years later in 2003.

Data collection

General function: Children were questioned about their smoking habits, television watching, and physical activity and about their family history of hypertension or diabetes.

Socioeconomic Status was defined on the basis of the father's occupation and its prestige (Kochanek et al., 2002).

Anthropometric measurements: Measurements were taken both at baseline and follow up by trained personnel, after breakfast with subjects in light clothing and without shoes. Weight was measured with a beam balance to nearest 0.1 kg. Weight was measured with a stadiometer to the nearest 0.5 cm.

Blood pressure measurement: Blood pressure was measured seated using a Dinamap oscillometric BP recorder. Blood pressure was measured twice, after 10 min of rest and we used the average for the analysis (Kohn and Booth, 2003).

Serum lipid determinations: Blood samples were obtained in vaccutainers after 12 flashing, before breakfast in the morning. Following collection, blood samples were put in ice and transported immediately to the laboratory, they were analysed on the same day. All measurements were reproducible. Total cholesterol (TC) and triglycerides (TG) were assayed enzymatically and HDL cholesterol (HDL-C) with a non immunologic enzymatic reaction. LDL-C was calculated from the Friedewald Formula LDL-C=TC-(HDL-C+TG/5) Serum lipid determinations were performed at baseline.

High cholesterol was defined as levels 5.2 mmol/l, low HDL-C as levels < 0.9mmol/l and high triglyceride as levels 1.94 mmol/l

Body- composition measures: Body composition was measured by using BMI (Body mass Index)BMI was calculated from the formula: weight (kg)/height² (m²)The International obesity Task Force (IOTF) data set for the definition of overweight and obesity was used, in order to classify subjects as normal weight, overweight or obese (Krassas and Tzotzas, 2004).

Relative BMI: In order to study Tracking of BMI we computed relative BMI, that is the individuals BMI divided by a standard BMI for his or her age and sex (100% x individual's BMI / sex and age specific BMI cut offs from a reference population) as a measure of body composition. The meaning of relative BMI is easily understood. Although BMI changes with age, relative BMI remains stable; consequently children of different age and sex can be treated as one group (Moller et al., 2006).

Tracking and changes in BMI: Tracking was defined as the maintenance of a relative position in the population overtime. If individuals remained overweight (or obese) between 1999 and 2003, this was defined as tracking of overweight. We examined each individual's relative position in this cohort on the basis of the sex, age and group specific relative BMI.

Statistical analysis

Data were analysed using the SPSS software: Chi-square statistic or t tests were used as appropriate. Statistical significance was determinate at the p <0.05 level throughout. A logistic regression model and multiple linear regression models were used to study respectively the predictors of tracking of overweight and the predictors of change in relative BMI.

RESULTS

Baseline characteristics of the study population

Children's baseline characteristics are presented in Table 1, 56% were girls and 44% were boys. At baseline 21.1% of boys and 23.7% of girls were overweight respectively, p = 0.43.Statistically significant differences were seen in a higher level of diastolic blood pressure among girls (p = 0.005) who also showed higher BMI, total cholesterol and LDL-cholesterol. Time spent watching T.V and socioeconomic status did not differ significantly between boys and girls. However there were significant differences associated with activity levels, 24.1% of boys were classified as active VS 14.6% of girls (p = 0.01)

Tracking of BMI

At follow up 20.3% were overweight and 6.6% were obese. 64.7% of overweight children remained overweight in 2003. Overweight children were 2.6 times as likely as all other children to become overweight adolescent. As shown in Table 2, on the basis of the BMI quartiles, tracking and changes in children's BMI coexisted. After four years of follow up, 50.9% of these children remained in the same quartiles. Boys were less likely than girls to move to higher quartile overtime. The proportion was 34.7% compared with 17.4%. The BMIs of children from medium income families were more likely to move to a lower quartiles than those from low and high income families (P = NS*).* Active children were less likely to remain in the same quartile than others. Thin and fat children (those who were in the lowest and the highest quartiles, respectively were more likely to remain in those quartiles than others (P = NS) .In our study there was a significant correlation between baseline BMI and follow up BMI (overall Pearson's r = 0.81 $p < 10^{-3}$).

The predictors of tracking of overweight

Results of logistic regression of risk for tracking of overweight are presented in Table 3.There was a significant association between individual's initial relative BMI and the risk of overweight OR = 1.31 (95% CI.1.22.1.42), p < 0.0001

Children who had high triglyceride levels at baseline were more likely to show tracking of fatness. (OR = 4.12)

The predictors of changes in relative BMI

We also studied the predictors of changes in relative BMI using multiple linear regression models. An individual's 1999 relative BMI was regressed on baseline relative BMI and other covariates. After baseline relative BMI and sex,

Table 1. Baseline characteristics.

	Boys, N = 199	Girls, N = 253	P
Anthropometric measures			
Weight (Kg)	52.83 (12.75)	53.60 (10.57)	0.485
Height (m²)	161.76 (9.05)	159.74 (6.17)	0.005*
BMI (Kg /m²)	19.99 (3.49)	20.95 (3.72)	0.005*
Percentage overweight (%)	42 (21.1)	60 (23.7)	0.434
Percentage obese (%)	14 (7.0)	13 (5.1)	0.714
Blood pression			
Systolic BP	119.81 (12.73	120.56 (12.08)	0.526
Diastolic BP	69.34 (9.02)	71.58 (7.66)	0.005*
Biological parameters			
Blood glucose	4.91 (1.15)	4.76 (1.12)	0.144
Total cholesterol	4.05 (0.70)	4.29 (0.78)	0.001*
LDL	2.05 (0.58)	2.22 (0.66)	0.005*
HDL	1.57 (0.31)	1.63 (0.28)	0.028*
TG	0.92 (0.33	0.94 (0.41)	0.664
Socioeconomic status			
High	60 (30.2)	70 (27.7)	0.560
Medium	70 (35.2)	98 (38.7)	0.437
Low	69 (34.9)	85 (33.6)	0.811
Physical activity			
Sedentary	8 (4.0)	12 (4.7)	0.711
Slightly active	143 (71.9)	204 (80.6)	0.028*
Active	48 (24.1)	37 (14.6)	0.01*
Watching television			
2h	8 (4.0)	37 (14.6)	0.745
>2H	191 (96.0)	216(85.4)	0.213
Smoking			
Yes	188 (94.5)	252 (99.6)	0.123
No	11 (5.5)	1 (0.4)	0.842

those children from low socio-economic status were likely to have an increase in their relative BMI (that is, to become fatter) Table 4.

DISCUSSION

Internal validity

Data were collected by the same questionnaire and with the same procedure in the baseline and 4 years later. Anthropometric measures were conducted by the same person to minimize measure errors.

In 2003, 57% were re-examined in 2003. But there is no significant difference between participants and non-participants in 2003 concerning anthropometric data.

External validity

In this study, we saw a substantial degree of tracking of BMI from adolescence into young adulthood. Several studies have investigated BMI tracking between or within childhood and adolescence (Moller et al., 2006; Kvaavik et al., 2003; Laitinen et al., 2001) or within adulthood (Lobstein et al., 2004), and one study has mainly dealt with BMI rebound (age at BMI, that is, the point in childhood before BMI starts to increase) (Margarey et al., 2003). While the methods used to investigate tracking of BMI vary, the results consistently show a high degree of tracking from adolescence into adulthood, a finding supported by our study.

In the present study, the correlations of baseline BMI to

Table 2. BMI tracking patterns: percentage of children who remained in the same quartile, moved to a lower quartile, or moved to a higher quartile during 1999 - 2003.

	Tracked	Moved down	Moved up
All (n=452)	50.9	24.1	25.0
Boys (n=199)	49.7	15.6	34.7
Girls (n=253)	51.8	30.8	17.4
Social class High	46.2	29.2	24.6
Social class Medium	56.0	23.8	20.2
Social class Low	49.4	20.1	30.5
Sedentary	45.0	30.0	25.0
Slight active	54.5	23.3	22.2
active	37.6	25.9	36.5
Stratified by initial body composition			
1st quartile	61.9	0	38.1
2nd quartile	38.9	26.5	34.5
3rd quartile	36.3	36.3	27.4
4th quartile	66.4	33.6	0

Tracked, remained in the same quartile in both yearsI; moved down, moved to a lower quartile by 2003I; moved up, moved to a higher quartile by 2003.

Table 3. Logistic regression modelling: baseline predictors of tracking of overweight

Predictors	OR(95%CI)	P
Gender	1.76 (0.63 - 4.89)	0.27
Baseline relative BMI	1.31 (1.22 - 1.42)	0.0000

Table 4. Linear regression modelling: baseline predictors of children's 1999 relative BMI.

Variable	Parameter ±SE	P
Baseline relative BMI	0.82 ± 0.027	0.000
Sex	-3.04 ± 0.85	0.000
Social class High		
Social class Medium	1.27 ± 1.05	0.227
Social class Low	3.09 ± 1.07	0.004

follow up BMI were significantly high (r value > 0.8). These positive correlations suggested that children who were overweight at baseline remained overweight at follow up. The BMI correlations from childhood to adolescence observed in this study were analogous to the BMI correlations observed in some other studies (0.8, in the black Jamaican children for follow up from 7 - 8 to 11 - 12 years of age (Manus et al., 2001) 0.6 - 0.9 I, Iin US children for follow up from 9 - 18 to 23 - 33 years of age (McGee, 2005) and >0.6, in Australian children for follow up from 6 - 20 years of age (Morgenstern, 2002).

In the current study two third of the participants from the lowest and highest BMI quartiles in childhood remained in their respective BMI quartile at follow up. Findings from the CATCH cohort study revealed that 96% of the students stayed within ±1 quintile of BMI from third to fifth grades and 90% stayed within that range from third to eighth grades (Mo-suwan et al., 2000). Results from the Bogalusa Heart Study, more than half of the participants from the lowest and the highest BMI quartiles in childhood remained in their respective BMI quartile in young adulthood (Must et al., 1992).

Unlike some previous studies, our study used relative BMI as an indicator of tracking, and we investigated the characteristics of the different tracking groups. Girls were more likely than boys to move down in BMI rank, whereas boys tended to move up. This is accordance with studies that have shown that weight among men has increased more than among women during recent decades (Ogden et al., 2003).

Like other studies, the subjects' own BMI during adolescence is the strongest independent predictors of adult BMI (Reilly et al., 2005; Savva et al., 2004; Sokol, 2000; Sorof et al., 2004; Taeymens et al., 2008; Tasker et al., 2005; Twisk et al., 1994). In multiple linear regression model, after baseline relative BMI, low socioeconomic status is a good predictor for relative BMI at follow up. Our findings on the relation between BMI and social class add to the evidence emerging from other longitudinal studies that show a consistent inverse relation between socioeconomic status and obesity (Kochanek et al., 2002; Wang et al., 2000). On the contrary, other studies found an association of overweight tracking with higher income (Kvaavik et al., 2003; Wardle et al., 2006). But other studies found no differences in the tracking of overweight and obesity between social classes (WHO, 1998; Williams et al., 1999; Wilsgaard et al., 2001).

In summary there was substantial tracking of overweight in our study. The subjects' own BMI is the most independent of BMI four years later. These results strongly support intervention in early childhood to prevent development of overweight and the progression of overweight to obesity. The WHO advocates that prevention and management of the global epidemic obesity requires strategies that focus in environmental changes that will affect the weight status of the wider population as well as those that focus on individuals and groups who are at increased risk of obesity and its co-morbidity (Freedman et al., 2005). The greater risk of overweight in these children identifies a group for targeted intervention that promotes increased physical activity, decreased inactivity and decreased consumption of energy dense foods, in an environment that favours the opposite behavior.

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