Public Health Nutrition: 13(7), 1090–1098 doi:10.1017/S1368980009993193

BMI ≥ 50 kg/m^2 is associated with a younger age of onset of overweight and a high prevalence of adverse metabolic profiles

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Submitted 26 June 2009: Accepted 7 December 2009: First published online 26 January 2010

Abstract

Objective: To study the demographic and clinical parameters of three different categories of obesity, with particular focus on a cohort of individuals with BMI ≥ 50 kg/m^2, the fastest growing category of obesity.

Design: Over 700 obese individuals were studied (186 with BMI = 30–39 kg/m^2, 316 with BMI = 40–49 kg/m^2 and 290 with BMI ≥ 50 kg/m^2).

Results: Median BMI was 51 kg/m^2 for patients who reported onset of overweight before 15 years of age, 47 kg/m^2 for patients who reported onset between 15 and 30 years, and 42 kg/m^2 for patients who became overweight after 30 years of age. The BMI ≥ 50 kg/m^2 group was notably younger than the group with BMI = 30–39 kg/m^2 (44 (SD 11) years *v.* 50 (SD 15) years; $P < 0{\cdot}0001$). Eighteen per cent of obese patients studied were considered metabolically healthy according to standard cut-off points for blood pressure, fasting glucose and lipid profiles. However, the proportion of metabolically healthy individuals was significantly higher in the BMI = 30–39 kg/m^2 group than in the BMI = 40–49 kg/m^2 and BMI ≥ 50 kg/m^2 groups (31 % *v.* 17 % and 12 % respectively; $P < 0{\cdot}05$ and $P < 0{\cdot}005$). When compared with people of similar age in the general population, individuals with BMI ≥ 50 kg/m^2 had lower rates of marriage (51 % *v.* 72 %) and a higher prevalence of unemployment (14 % *v.* 5 %).

Conclusions: The current study suggests that the increasing prevalence of childhood obesity worldwide will lead to many more individuals achieving a higher BMI at a younger age. Furthermore, an earlier onset of overweight does not appear to prevent the adverse metabolic health outcomes associated with extreme obesity.

Keywords
Severe obesity
Age of onset
Overweight
Metabolically healthy

The worldwide prevalence of overweight (BMI = 25–30 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) is increasing at an alarming rate. The prevalence of extremely obese individuals (BMI ≥ 40 kg/m^2 and ≥50 kg/m^2) might be expected to rise in parallel. However, trends for these higher weight categories are in fact even more dramatic. One large American study tracked health behaviours between the years 1986 and 2005[1]. The prevalence of BMI > 30 kg/m^2 increased by 24 % between 2000 and 2005, but the prevalence of BMI > 40 kg/m^2 increased twice as fast (52 % higher in 2005 than in 2000) and the prevalence of BMI > 50 kg/m^2 increased three times as fast (75 % higher in 2005 than in 2000).

Data from the US National Health Examination Survey (NHES) and the National Health and Nutrition Examination Surveys (NHANES) have shown that the heaviest children were markedly heavier 20 to 30 years later, whereas children with lower BMI changed little or not at all[2]. Increased rates of paediatric obesity may be a key factor underlying the current high prevalence of extreme obesity.

It has been proposed that some unknown metabolic adaptation may lead to better insulin sensitivity in those individuals with early-onset obesity. Increasing duration of obesity has been shown to be associated with greater insulin sensitivity and a more favourable lipid profile[3,4]. This may be one reason why substantial heterogeneity exists within obese populations with regard to metabolic risks. Metabolically healthy individuals have been described at all degrees of overweight and obesity, including those with BMI ≥ 50 kg/m^2[5].

We have studied the demographic and clinical characteristics of a cohort of obese individuals referred to our hospital-based weight management clinic, with particular

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attention to the age of onset of overweight and the metabolic profile of each category of obesity.

Methods

The current study analyses baseline data for all patients who attended a multidisciplinary weight management service between 2003 and 2008. We compared clinical and demographic data between three different categories of obesity, adapted from currently accepted classifications[6]. A BMI of 30·0–39·9 kg/m^2 was defined as class 1 obesity, BMI of 40·0–49·9 kg/m^2 was considered class 2 obesity, and BMI ≥ 50·0 kg/m^2 was termed class 3 obesity.

Blood pressure measurements were performed in a seated position after participants had rested for at least 15 min. A standard, large or thigh cuff size was used, depending on the patient's arm circumference, and the arm was supported at heart level. Three measurements were taken at 1 min intervals. For analysis, the mean of the three readings was recorded.

All blood samples were drawn following an overnight fast. Serum glucose was collected in fluoride tubes and measured using the hexokinase methodology on a model AU640 analyser (Olympus). Serum total cholesterol, LDL cholesterol, HDL cholesterol and TAG were measured using enzymatic reagents in an automated analyser (Olympus AU640; Olympus, Hamburg, Germany). Glycosylated haemoglobin (HbA1c) was measured with an automated HPLC instrument–reagent system (model HLC-723 G7; Tosoh Europe NV, Tessenderlo, Belgium). Serum thyroid-stimulating hormone was measured using a chemiluminescent microparticle immunoassay (Architect TSH assay; Abbott Diagnostics, Longford, Ireland). Serum insulin was measured using an automated monoclonal antibody-based two-site immunoenzymometric assay (AIA-1800 system; Tosoh Europe NV).

Childhood overweight was recorded retrospectively by self-report. Age of onset of overweight was based on the question 'During your childhood, were you considered overweight, compared to other boys/girls of the same age?', and further categorised by age bracket: <5 years, 5–10 years or 11–20 years. Those subjects who recalled first being overweight in adulthood were asked to self-report age of onset in the following brackets: 21–30 years, 31–40 years or >40 years.

From 2005, full metabolic profiles were performed routinely on all new obese patients attending the service. We were therefore able to obtain a metabolic phenotype for 382 patients. Metabolically healthy individuals were defined using target values adapted from the International Diabetes Federation worldwide consensus definition of the metabolic syndrome, 2006. They were classified as metabolically healthy if they had no history of cardiovascular, respiratory or metabolic diseases and were not taking any lipid-lowering, antihypertensive or hypoglycaemic agents. Fasting glucose level was ≤5·6 mmol/l, blood pressure was ≤135/85 mmHg, and TAG/HDL cholesterol ratio was ≤1·65 (men) or ≤1·32 (women).

When comparisons were made between our obese cohort and general population data, we used age- and gender-matched data if possible. Complete data were not available for all patients, so analysis reports include patient numbers in that cohort.

Statistical analyses

JMP 7.0.2 statistical software (SAS Institute Inc., Cary, NC, USA) was used to analyse the data. Prevalence results in the text and tables are presented as the proportion (percentage value) of that BMI cohort, with the upper and lower 95 % confidence intervals for the true population. BMI cohorts were deemed significantly different when confidence intervals did not overlap (level of confidence, $\alpha = 0{\cdot}05$).

All parameters were inspected for normality. Results are presented as mean and standard deviation, or median with the range, as appropriate. In the case of continuous variables such as age and metabolic parameters, comparisons between groups were performed using one-way ANOVA, with the Tukey HSD test for *post hoc* comparisons, or the Kruskal–Wallis test, as appropriate. *Post hoc* comparisons for Kruskal–Wallis tests were carried out using Mann–Whitney U tests between pairs of groups, with a Bonferroni correction applied to the α values. Linear trend was investigated using the Mantel–Haenszel χ^2 test for categorical variables and ANOVA for continuous variables. $P < 0{\cdot}05$ was considered statistically significant.

Results

Demographic data

Table 1 summarises demographic information for the three obese cohorts. Seven hundred and seventy-two patients have attended our weight management service to date, 70 % of whom were female. The gender ratio was similar across all three BMI cohorts.

The mean age for the entire group, and for male and female groups separately, was 46 (SD 13) years. However, those with BMI ≥ 50 kg/m^2 had a significantly lower mean age than those with obesity in the range BMI = 30–39 kg/m^2 (44 (SD 11) years *v.* 50 (SD 15) years; $P < 0{\cdot}0001$).

All three obese groups had significantly lower rates of marriage than general population data for persons aged 40–50 years, as shown in Fig. 1. The number of single persons in each group increased with increasing BMI category. There were significantly more single people in the BMI ≥ 50 kg/m^2 group (38 %, 95 % CI 35, 41) than in the BMI = 30–39 kg/m^2 group (23 %, 95 % CI 20, 26) and the BMI = 40–49 kg/m^2 group (30 %, 95 % CI 27, 33), and also compared with the general population (16 % overall, 14 % females only)[7]. Rates of divorce and separation were

https://doi.org/10.1017/S1368980009993193 Published online by Cambridge University Press

Table 1 Demographic profile by BMI category in obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008

		BMI (kg/m^2)			
	General population†	30–39 (class 1 obese)	40–49 (class 2 obese)	≥50 (class 3 obese)	*P* for linear trend
Obese population (%)					
%		23	40	37	
n		186	316	290	
Female (%)	51	67	71	68	
Age (years)					
Mean	45–49	50	46	44***	<0·0001
SD		15	13	11	
Duration of overweight/obesity (years)					
Mean		26	28	30	<0·05
SD		14	13	11	
Marital status					
Married					
%	72	64§	59§	51§*	<0·05
95 % CI		60, 69	56, 62	48, 55	
Single					
%	16	23§	30§	38§*	<0·05
95 % CI		20, 26	27, 33	35, 41	
Divorced/separated‡					
%	11	12	11	15§	
95 % CI		10, 14	9, 12	13, 17	
Occupation					
Unemployed					
%	5	7	6	14§*	
95 % CI		6, 8	5, 7	12, 15	
Sedentary job					
%		54	52	50	
95 % CI		50, 59	48, 55	47, 54	
Driving job					
%		3·5	8	9*	
95 % CI		3, 4	7, 9	8, 10	
Home maker					
%		6	15	15*	
95 % CI		5, 7	14, 17	13, 16	
Education level					
Primary					
%	11	15	14	16	
95 % CI		11, 19	11, 17	14, 18	
Secondary					
%	56	53	55	56	
95 % CI		46, 59	51, 60	53, 60	
Tertiary					
%	26	32	31	28	
95 % CI		26, 38	26, 35	24, 31	
Smoking status					
Current					
%	29	19§	23§	18§	
95 % CI		16, 22	21, 25	16, 20	
Ex					
%		38	30	29	
95 % CI		33, 42	28, 33	27, 31	
Never					
%		43	46	53*	
95 % CI		39, 48	43, 49	50, 55	
Alcohol status – females					
Never or occasional					
%		49	62	66	
95 % CI		44, 54	57, 67	62, 70	
Exceeding recommended intake					
%	6	4	8	6	
95 % CI		3, 5	4, 12	4, 8	
Alcohol status – males					
Never or occasional					
%		48	44	66	
95 % CI		43, 52	40, 49	61, 71	

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Table 1 *Continued*

	General population†	BMI (kg/m^2) 30–39 (class 1 obese)	40–49 (class 2 obese)	≥50 (class 3 obese)	*P* for linear trend
Exceeding recommended intake					
%	18	10	18	13	
95 % CI		6, 13	12, 23	9, 18	

*BMI ≥ 50 kg/m^2 cohort differs significantly from the BMI = 30–39 kg/m^2 cohort, 95 % confidence level.
***BMI ≥ 50 kg/m^2 cohort differs significantly from the BMI = 30–39 kg/m^2 cohort, $P < 0{\cdot}0005$.
†General population data from the Irish census 2006[7–9] (age range 40–50 years) except for alcohol status and smoking data, taken from the Irish SLAN (Survey of Lifestyle, Attitudes and Nutrition) 2007 report[10] (age range 45–64 years).
‡Percentage of divorced or separated persons as a percentage of married persons in that cohort.
§General population differs significantly from an obese cohort, 95 % confidence level.

similar in the three obese groups (11–15 %). However, individuals with BMI ≥ 50 kg/m^2 had a significantly higher rate of marital breakdown compared with the general population (15 %, 95 % CI 13, 17 *v.* 11 %)[7]. There were no gender differences in marital status between the different obese categories.

With regard to data on occupation, the rate of unemployment in the BMI ≥ 50 kg/m^2 group was 14 % (95 % CI 12, 15). This was significantly higher than the unemployment prevalence in the other obesity cohorts (7 %, 95 % CI 6, 8 for BMI = 30–39 kg/m^2 group; 6 %, 95 % CI 5, 7 for BMI = 40–49 kg/m^2 group). This is also higher than unemployment rates in the general population, approximately 4·6 % at the time of the study[8].

Overall, the education level achieved was similar in all three obese cohorts and did not differ significantly from general population data[9]. However, there was a trend towards a higher prevalence of obese individuals having completed primary level education only, and this was significantly higher in the BMI ≥ 50 kg/m^2 group.

Age of onset of overweight/obesity

Patients with BMI ≥ 50 kg/m^2 were much more likely to report onset of excess weight at a young age. Thirty-nine per cent of this group became overweight before 10 years of age, 60 % before 15 years of age, and 74 % were overweight before 20 years of age. In contrast to this, only 15 % of patients with BMI = 30–40 kg/m^2 were overweight before 10 years, 30 % before 15 years of age, and 39 % before 20 years of age.

When the patients were grouped according to age of onset of overweight, there was a clear trend towards higher BMI as the age of onset decreased (Fig. 2, Table 2). When duration of obesity was taken into account, this association remained significant. The duration of overweight/obesity (calculated from the patient's age and reported onset of overweight) was similar in all three obese categories (Table 1). In addition, the mean age of the group with the highest median BMI (age of onset of overweight <15 years) was 40 (SD 12) years, compared with a mean age of 56 (SD 9) years in the group with lowest BMI (age of onset of overweight >30 years).

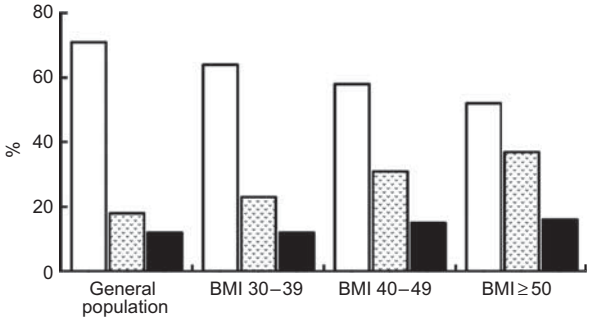

Fig. 1 Marital status (□, married; ▨, single; ■, separated/divorced) in the general Irish population and the different BMI (kg/m^2) cohorts of obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008

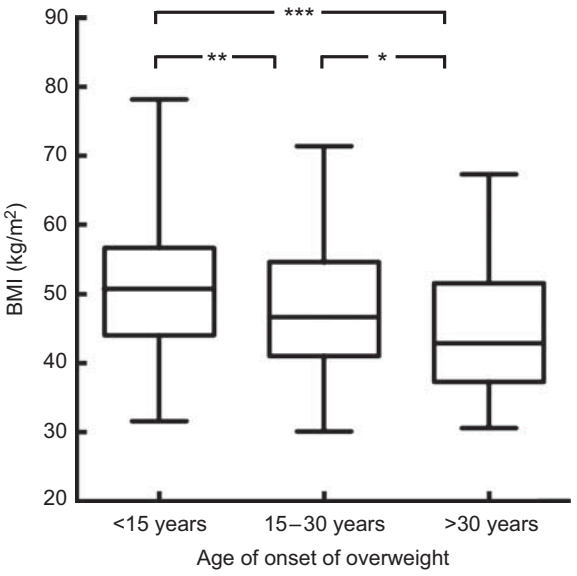

Fig. 2 Box-and-whisker plots of BMI for age of onset of overweight categories in obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008. Median BMI (represented by the solid line inside the box) is 51 kg/m^2 for patients who reported being overweight before 15 years, 47 kg/m^2 for patients who reported becoming overweight between 15 and 30 years of age, and 42 kg/m^2 for patients who became overweight after the age of 40 years. BMI was significantly different across age of onset of overweight groups: *$P < 0{\cdot}05$, **$P < 0{\cdot}005$, ***$P < 0{\cdot}0005$

https://doi.org/10.1017/S1368980009993193 Published online by Cambridge University Press

Metabolic profile

Complete metabolic phenotype data were available for 382 patients. Patients with BMI $\geq 50\,kg/m^2$ had significantly higher systolic blood pressure, fasting blood glucose and HbA1c levels compared with the other BMI cohorts. They had significantly higher C-reactive protein levels and lower HDL cholesterol compared with the BMI = 30–39 kg/m^2 group. This information is displayed in Table 3.

Overall, 18 % of the obese cohort was classified as metabolically healthy. Increasing BMI resulted in a smaller number of metabolically healthy individuals, as seen in Fig. 3. Twenty per cent of patients in the group with youngest age of onset of overweight were metabolically healthy. This was slightly higher than the other age of onset groups but this difference was not statistically significant (Fig. 3).

Table 2 Trend in median BMI for each 5-year rise in age of onset of overweight in obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008

n (total = 438)	Age of onset of overweight (years)	BMI (kg/m^2)	
		Median	Range
56	<5	52·3	38·9–78·2
77	5–10	51·2	31·6–73·2
84	11–15	48·3	32·4–72·6
60	16–20	48·0	30·1–70·5
54	21–25	47·8	32·3–81·1
44	26–30	43·9	32·1–68·9
27	>30	42·9	30·6–67·3

Median BMI was significantly different among age of onset of overweight categories (between-groups ANOVA for linear trend): $P < 0{\cdot}0001$.

Lifestyle data

Smoking and alcohol

All three groups of obese patients had a lower prevalence of smoking compared with individuals in the general population[9] (19 %, 23 % and 18 % *v.* 29 %). Obese men

Table 3 Metabolic profile by BMI category in obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008

	BMI (kg/m^2)		
	30–39 (*n* 84)	40–40 (*n* 142)	≥50 (*n* 156)
Systolic blood pressure (mmHg)			
Median	130	130	140
IQR	90, 170	90, 195	90, 210
P†	<0·0001	<0·001	
Diastolic blood pressure (mmHg)			
Median	80	80	82
IQR	40, 110	50, 120	46, 130
Fasting cholesterol (mmol/l)			
Median	5·2	5·3	5·1
IQR	2·1, 8·6	1·5, 8·2	2·5, 8·7
Fasting TAG (mmol/l)			
Median	1·70	1·79	1·60
IQR	0·5, 15·2	0·4, 8·0	0·6, 11·0
HDL cholesterol (mmol/l)			
Median	1·21	1·17	1·16
IQR	0·8, 2·1	0·7, 2·5	0·6, 2·9
P	<0·005		
Fasting blood glucose (mmol/l)			
Median	5·1	5·4	5·8
IQR	4·2, 23·4	4·6, 13·6	3·8, 16·9
P	<0·0001	<0·0001	
HbA1c (%)			
Median	5·6	5·6	5·9
IQR	4·8, 12·0	4·4, 13·1	4·4, 12·1
P	<0·005	<0·001	
Fasting insulin (μU/ml)			
Median	15·7	18·4	22·2
IQR	5·8, 57·7	4·2, 61·7	7·7, 65·8
C-reactive protein (mg/l)			
Median	5	9	11
IQR	4, 30	5, 22	1, 71
P	<0·0005		
Thyroid-stimulating hormone (mU/l)			
Median	1·63	1·90	2·05
IQR	0·01, 21·2	0·01, 10·3	0·01, 17·1

IQR, interquartile range; HbA1c, glycosylated haemoglobin.
†*P* value given if the results differ significantly from those of the BMI $\geq 50\,kg/m^2$ group. Bonferroni adjustment reset α level at $P < 0{\cdot}005$.

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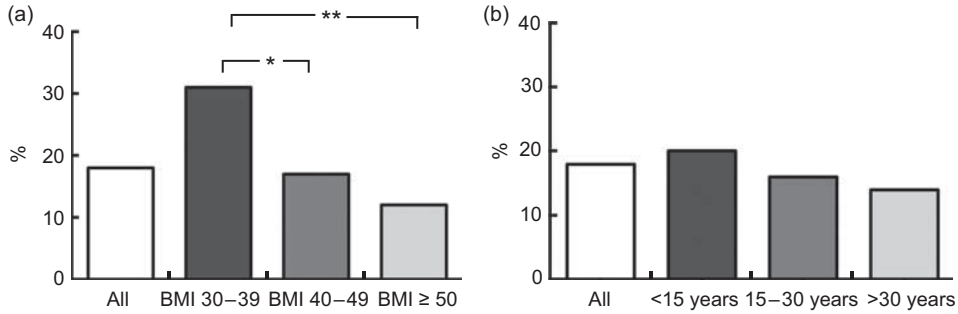

Fig. 3 The proportion of metabolically healthy individuals in (a) each BMI (kg/m^2) category and (b) each reported age of onset of overweight group among obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008. The proportion was significantly higher in those patients with BMI = 30–39 kg/m^2 compared with patients with BMI = 40–49 kg/m^2 and BMI ≥ 50 kg/m^2 (31 % *v.* 17 % and 12 %, respectively): *$P < 0{\cdot}05$, **$P < 0{\cdot}005$. The proportion was not significantly different across age of onset of overweight groups

reported drinking excess alcohol more than twice as often as obese women in all groups (Table 1).

Diet

The prevalence of patients eating their evening meal after 8 pm (11 %, 95 % CI 9, 12), missing breakfast more than three times per week (37 %, 95 % CI 33, 41), eating more or less than the recommended three meals per day (45 %, 95 % CI 39, 50) and eating fast food twice or more per week (34 %, 95 % CI 30, 38) was significantly higher in the BMI ≥ 50 kg/m^2 obese category compared with the other two BMI groups. Intake of the recommended amount of portions of fruit and vegetables was low in all three groups, and significantly lower than the 65 % of respondents reporting five or more servings of fruit and vegetables per day in the national SLAN (Survey of Lifestyle, Attitudes and Nutrition) 2007[10] (Table 4).

Exercise

Individuals who reported no exercise had a median BMI of 52 (range 36–75) kg/m^2, significantly higher than those who reported walking regularly (median BMI 46 (range 31–81) kg/m^2; $P < 0{\cdot}0001$) and those who reported regular gym attendance (median BMI 43 (range 33–78) kg/m^2; $P = 0{\cdot}02$). Patients with BMI ≥ 50 kg/m^2 watched more hours of television per week; they were less likely to exercise, and if they did exercise, did so less frequently and for a shorter duration than the other BMI groups (Table 4).

Women played less sport than men at all ages, particularly as adults, in both the BMI = 30–39 kg/m^2 group and the BMI = 40–49 kg/m^2 group. Within the BMI = 30–39 kg/m^2 group, 93 % (95 % CI 89, 96) of men reported playing sport as a child, compared with 71 % (95 % CI 61, 82) of women, dropping to 63 % (95 % CI 46, 79) of men playing sport as an adult, compared with 50 % (95 % CI 33, 67) of women. This pattern was not seen in the BMI ≥ 50 kg/m^2 group, accounted for by men reporting significantly less sport at all ages than men in the other two groups.

Discussion

We have studied the clinical and demographic characteristics of 772 obese patients attending a weight management service. We have also obtained metabolic phenotypes for a subgroup of 382 patients. Just over a third of these patients have BMI ≥ 50 kg/m^2. This category of obesity is increasing three times as fast as the lowest category of obesity (BMI = 30–39 kg/m^2)[1]. Patients with this condition incur much greater weight-related health risks, including an increased risk of death, as well as numerous social and psychological complications.

The current study has shown that individuals in the highest category of obesity are more likely to report onset of overweight at a young age. The association remained significant when controlled for the duration of overweight/obesity. There was a trend towards more years overweight in the BMI ≥ 50 kg/m^2 group; however, the mean difference between the groups was only 4 years. Sixty per cent of this obese group reported becoming overweight before 15 years of age, compared with 30 % of the patients with BMI = 30–39 kg/m^2. Previous research has reported that overweight at adolescence has a stronger association with adult overweight, compared with overweight at childhood[11,12]. We have shown that for each 5-year increment decrease in the age of onset of overweight, the median BMI increased. Those individuals reporting age of onset before 5 years of age had the highest median BMI of 52 kg/m^2. This is consistent with a previous study that reported that childhood overweight was 5·2 times more likely to result in severe obesity in adulthood[13]. That study also used self-report as a retrospective measure of childhood overweight, although severe obesity was defined as BMI ≥ 35 kg/m^2.

The BMI ≥ 50 kg/m^2 obese cohort in our study had a younger mean age than the cohort of people with BMI = 30–39 kg/m^2. A recent American study of high-school students demonstrated a similar pattern, in this case with higher degrees of overweight, where successive cohorts studied over time became overweight at

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Table 4 Dietary patterns and exercise data in obese patients who attended a multidisciplinary weight management service, Dublin, between 2003 and 2008

	BMI (kg/m^2)		
	30–39 (*n* 98)	40–49 (*n* 108)	≥50 (*n* 117)
Time of evening meal			
After 8 pm			
%	2	5	11†
95 % CI	1, 3	4, 6	9, 12
After 7 pm			
%	20	19	25
95 % CI	15, 24	17, 22	21, 28
Missed breakfast			
>5 times/week			
%	15	16	25†
95 % CI	12, 18	13, 18	22, 28
>3 times/week			
%	28	24	37†
95 % CI	24, 32	20, 27	33, 41
Meals per day			
Three			
%	73	69	55†
95 % CI	68, 78	65, 72	51, 59
Two			
%	16	23	25
95 % CI	13, 20	20, 26	22, 28
One			
%	6	4	10†
95 % CI	4, 7	3, 5	8, 11
Four or more			
%	5	4	10†
95 % CI	4, 6	3, 5	9, 11
Fruit and vegetables			
5 or more servings/d			
%	10	9	11
95 % CI	8, 12	7, 10	10, 13
Eating fast food			
Never			
%	36	32	24†
95 % CI	30, 42	28, 36	22, 27
Once per week			
%	50	46	42
95 % CI	43, 57	42, 50	38, 45
Twice or more per week			
%	14	22	34†
95 % CI	11, 17	19, 25	30, 38
Exercise			
None			
%	12	19	40†
95 % CI	9, 15	16, 22	35, 44
Walking			
%	65	62	46†
95 % CI	59, 72	57, 66	41, 50
Gym			
%	22	12	3†
95 % CI	18, 27	10, 14	2, 3
Other			
%	10	11	19†
95 % CI	8, 13	9, 13	16, 22
Of those who take exercise			
Hours per week			
Median	4	2	1***
Range	0·5–14	0·5–14	0·5–9
Days per week			
Median	4	3	1***
Range	1–7	1–7	1–5
3 or more days per week			
%	73	56	37†
95 % CI	68, 78	51, 60	33, 41
Hours of television per week			
Median	14	16	21*
Range	3–40	5–70	5–84

Linear trend across all three obese categories: *$P < 0{\cdot}05$, ***$P < 0{\cdot}0005$.
†BMI ≥ 50 kg/m^2 cohort differs significantly from both the BMI = 30–39 kg/m^2 cohort and the BMI = 40–49 kg/m^2 cohort, 95 % confidence interval.

increasingly earlier points in the life course[14]. The authors suggested that BMI later in adulthood might have less to do with age than with recent historical changes in factors influencing energy balance. This theory could also explain why the most obese group in our study population is also the youngest of the three groups.

It has been proposed that individuals with a younger age of onset of obesity might be protected from the adverse metabolic impact associated with higher BMI[4]. We compared the metabolic profiles of the different BMI categories, and age of onset of overweight groups, by determining the proportion of metabolically healthy obese (MHO) individuals within each group. The term MHO has been used to describe obese individuals who do not display the expected features of metabolic dysfunction usually associated with excess adiposity[15–17]. The overall prevalence of MHO in our population was 31 %. However, this figure decreased to only 12 % in those individuals with BMI ≥ 50 kg/m^2. This is particularly striking, as the BMI ≥ 50 kg/m^2 group is a significantly younger group.

The proportion of MHO in the group with the youngest onset of overweight was 20 %, compared with 15 % in the group who became overweight at an older age. This difference was not statistically significant. After controlling for the effect of age, by studying metabolic data for those aged 40–60 years only, the proportion of MHO in the group with the youngest onset of overweight was 11 %, compared with 10 % in the group who became overweight at an older age. A younger onset of overweight was not associated with a higher proportion of metabolically healthy individuals.

Several studies have reported that the prevalence of MHO individuals ranges from 20 % to 40 %[4,5,18–21]. However, only one of these studies[5] included obese subjects with BMI ≥ 40 kg/m^2. That Italian study reported a prevalence of uncomplicated obesity in 28 % of their study population and this was the same across all BMI categories, including a group with BMI ≥ 50 kg/m^2. Mean age and gender balance were similar between the Irish and Italian obese groups, so it is unclear why there are fewer metabolically healthy individuals in the Irish cohort. It may be that diet and/or exercise patterns are different between the two cohorts. It is also possible that the referral patterns of patients to our clinic have influenced these results. Family physicians may be more likely to encounter and refer extremely obese patients with one or more co-morbidities, thus contributing to an unhealthier cohort than would be found in the general population. Nevertheless, we have demonstrated that an obese cohort with BMI ≥ 50 kg/m^2, with an overall younger age of self-reported onset of overweight, is associated with a high prevalence of metabolic abnormalities.

Our study focused on obese patients attending a weight management clinic. Factors such as the gender ratio of our cohort (70 % female) and physician referral

https://doi.org/10.1017/S1368980009993193 Published online by Cambridge University Press

patterns to the clinic may have resulted in a study group that is not a true reflection of obese individuals in the general population. Some studies have shown that the link between childhood overweight and adult obesity is stronger for females[12], while others have shown a stronger link for males[22]. Our data demonstrated that differences between mean adult BMI, depending on the age of onset of overweight, were more significant for females compared with males ($P < 0{\cdot}0005$ *v.* $P < 0{\cdot}05$). However, this may be secondary to smaller numbers of men in our study population.

The use of retrospective self-report of age of onset of overweight, instead of measured weight and height data, is another limitation. We were unable to reliably assess degree of overweight or obesity in childhood, and the impact of this on adult BMI. However, a comparison of measured data from the NHES, and the NHANES III, indicated that the heaviest children became markedly heavier adults at follow-up 20–30 years later, with little change over time seen in the lower degrees of childhood BMI[2].

The social cost of obesity is high, and our study has revealed significant demographic differences between the BMI ≥ 50 kg/m^2 group and the general population. In particular, individuals with this degree of obesity were more likely to be single, separated or divorced compared with the general population. The proportion of single individuals in the general population decreases with increasing age; national census data from 2006 recorded that 20 % of individuals in the 40–44 year age group, and 16 % of individuals in the 45–49 year age group, were single. However, the proportion of single people in the highest BMI category is considerably greater than that in the lowest BMI category (38 % *v.* 23 %). This difference is therefore unlikely to be explained by younger age alone.

In addition, unemployment rates were significantly higher in all obese subjects. The BMI ≥ 50 kg/m^2 group had a rate of unemployment that was twice as high the other obese groups, and almost three times that of the general population. Socio-economic status has a complex relationship with obesity. In developed countries, weight and BMI tend to have a strong inverse association with low socio-economic status, particularly for women[23]. The results of the current study highlight the vicious cycle of unemployment, poverty and poor health that is highly prevalent in extremely obese populations.

In summary, we have demonstrated that individuals with BMI ≥ 50 kg/m^2 are a younger population, with a younger age of self-reported onset of overweight. They have a higher prevalence of unemployment and marital difficulty compared with the general population and other obese individuals. They have an extremely high prevalence of metabolic complications. Attention needs to be focused on prevention and treatment of paediatric overweight and obesity, in order to reduce the future prevalence of obese adults and the numerous social, medical and economic complications associated with this condition.

Acknowledgements

This work was supported by a clinical fellowship from the Irish Health Research Board and an award from the Medical Research Charities Group and Diabetes Federation of Ireland. There are no conflicts of interest to report. All authors were fully involved in the study and each author has seen and approved the contents of the submitted manuscript. J.O.C. co-conceived and co-developed the idea for the study, coordinated collection and input of patient data, performed statistical analysis of the data and wrote several drafts of the paper. P.K., K.G. and T.A. were involved in the collection, input and analysis of patient data. T.J.C. was involved with statistical analysis of the data and contributed to reviewing of paper drafts and rewriting of the paper. D.O.S. was the study supervisor and as such was involved at all stages of the study, including co-conceiving and co-development of the study and reviewing of paper drafts and rewriting of the paper.

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