Preventive Medicine 50 (2010) 50–55

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Overall and central obesity incidence in an urban Portuguese population

Miguel Camões, Carla Lopes *, Andreia Oliveira, Ana Cristina Santos, Henrique Barros

Department of Hygiene and Epidemiology, University of Porto Medical School, Alameda Prof. Hernani Monteiro, 4200-319 Porto, Portugal
Cardiovascular Research and Development Unit, University of Porto Medical School, Portugal
Praça Gomes Teixeira, Edifício Gomes Teixeira, S/N – 4° andar, sala 419, 4000 Porto, Portugal

A R T I C L E I N F O

Available online 26 November 2009

Keywords:
Incidence
Obesity
Central obesity
Age
Education
Gender effect

A B S T R A C T

Objective. To provide overall and central obesity incidence estimates by gender, age and educational level in an urban Portuguese population.

Methods. As part of the EPIPorto study, 1,621 Porto, Portugal adult residents were evaluated in 1999–2003 and 2005–2008. Overall obesity was defined by a BMI $\geq$30.0 kg/m^2 and central obesity by a WC >88.0 cm in women and >102.0 cm in men. Relative risks (RR) and 95% confidence intervals (95% CI) were computed using Poisson regression. Survival analysis was also performed.

Results. The age-adjusted incidence rates/100 person-years of overall and central obesity were, respectively, 1.70, 95% CI: 1.34–2.19 and 5.97, 95% CI: 5.09–7.03 in women; 1.08, 95% CI: 0.73–1.64 and 2.38, 95% CI: 1.81–3.20 in men. In multivariate analysis, older women presented a higher risk of overall obesity. Moreover, a significant inverse association was found between obesity and education in women (>11 vs. <5 years: RR = 0.43, 95% CI: 0.22–0.84, for overall obesity; RR = 0.45 95% CI: 0.29–0.69, for central obesity). For overall obesity, 10.1% of women and 5.1% of men became obese during the 5-year study period. Higher proportions were observed regarding central obesity, 29.1% and 11.4% for women and men, respectively.

Conclusions. Over time, individuals developed central obesity faster than overall obesity. Our results support that increasing levels of education limit this ongoing development of obesity, particularly among women.

Introduction

Obesity is a serious worldwide public health concern (Ogden et al., 2007). Rapidly increasing prevalence trends were observed in the United States (Ogden et al., 2006) and in Europe (Berghofer et al., 2008). The highest European prevalences, defined as those greater than 25%, were found in both sexes in Italy and Spain as well as in women in Portugal, Poland, the Czech Republic, Romania and Albania (Berghofer et al., 2008).

The single National Portuguese survey of adults aged 18 to 64 years based on reliable and objective height and weight measurements indicates that overall overweight/obesity prevalence increased from 49.6% in 1995–1998 to 53.6% in 2003–2005 (Carmo et al., 2008).

Studies describing the prevalence of obesity in adults have been limited primarily to BMI, with less information available regarding abdominal adiposity measured by waist circumference (WC) (Formiguera and Canton, 2004). Nevertheless, central obesity is also an independent risk factor for cardiovascular disease (Bergman et al., 2007). In fact, central obesity is one of the most prevalent features of the metabolic syndrome in our population, affecting 23.9% of the subjects (27.0% of women and 19.1% of men) (Santos et al., 2005). However, in Portugal there is no longitudinal data on BMI or WC allowing the evaluation of total or central obesity incidence. Also, worldwide longitudinal analyses are scarce (Gonzalez-Villalpando et al., 2003, Nemesure et al., 2007, Williamson et al., 1990, 1991), emphasizing the relevance of providing obesity incidence evidence.

Although several obesity determinants have been analyzed and prevalence estimates are well known, there is a clear need to explore longitudinal data, namely, the incidence of central obesity at the population level, which will support future public health interventions. Using a representative sample of urban adults and considering objective measurements of BMI and WC, this study will provide the first obesity incidence estimates by gender, age and educational level in Portugal.

Methods

Subjects

Participants are part of a cohort study, the EPIPorto study, that comprises a representative sample of 2,485 Portuguese adults (61.8% women) aged 18 to 92 years residing in Porto, an urban center in northwest Portugal. The baseline evaluation was conducted during 1999–2003, and the re-evaluation of the cohort during 2005–2008.

* Corresponding author. Carla Lopes, Department of Hygiene and Epidemiology, University of Porto Medical School, Alameda Prof. Hernani Monteiro, 4200-319 Porto, Portugal. Fax: +351 225513653.
E-mail address: carlal@med.up.pt (C. Lopes).

0091-7435/$ – see front matter © 2009 Elsevier Inc. All rights reserved.
doi:10.1016/j.ypmed.2009.11.004

As previously described (Ramos et al., 2004), participants were recruited by random digit dialing using households as the sampling unit. The local ethics committee approved the study protocol. All participants gave informed written consent to participate in the study, which was carried out in accordance with the Helsinki Declaration.

Regarding the cross-sectional evaluation, a participation proportion of 70.0% was achieved (Ramos et al., 2004) and 66.1% of the total cohort was re-evaluated. The present analysis included a final sample of 1,621 individuals, with two anthropometry evaluations (5-year study period). In comparison with the individuals who did not participate in the follow-up evaluation (818 subjects), participants (vs. refusals) had a similar age (52.5 vs. 53.6 mean years, $p=0.096$), baseline BMI (26.8 vs. 26.8, kg/m^2, $p=0.617$) and equivalent gender distribution (proportion of women: 62.4% vs. 60.3%, $p=0.439$). Significant differences between groups were found for education level (8.8 *vs.* 8.0 mean years, $p<0.001$).

Data collection

Study participants were invited to visit the University of Porto Medical School's Department of Hygiene and Epidemiology to be evaluated. Information was collected by trained interviewers using structured questionnaires comprising questions on social, demographic, personal and family medical history and behavioral characteristics (physical activity and diet) (Camões et al., 2009, Lopes et al., 2007). Anthropometrics were obtained with the participant wearing light clothing and no footwear and after 12 h of fasting. Body weight was measured to the nearest 0.1 kg using a digital scale, and height was measured to the nearest centimeter in a standing position using a wall stadiometer. WC was evaluated on the midway between the lower limit of the rib cage and the iliac crest to the nearest centimeter, with a flexible and non-distendable tape avoiding exertion of pressure on the tissues and with the subject standing.

Obesity definitions

Overall obesity was defined by BMI, and participants were classified as underweight to normal weight (BMI <25.0 kg/m^2), overweight (BMI, 25.0–29.9 kg/m^2) or obese (BMI ≥30.0 kg/m^2) according to the World Health Organization's (WHO) categories and nomenclature (Guidelines, 1998). Due to the small sample size of the underweight category [(BMI <18.5 kg/m^2) ($n=26$)], data from this group were pooled with normal weight individuals.

Central obesity was defined by WC, and individuals with central obesity were classified according to the WHO criteria (Guidelines, 1998): WC higher than 102 cm for men and 88 cm for women.

Statistical analysis

Sex stratified incidence rates (IR) were reported per 100 person-years with respective 95% confidence intervals (95% CI). Direct standardization for age was done based on overall and central obesity incidence using the adult population of Porto as the standard.

To calculate IR, subjects classified as obese at the baseline evaluation were excluded ($n=349$, those with a BMI ≥30.0 kg/m^2 and $n=494$, those whose WC was higher than 88 cm for women, or 102 cm for men). The mean of years between evaluations for individuals at risk of obesity was 5.0 (standard deviation = 2.5; min. = 1.0, max. = 10.9). For individuals who did not develop overall or central obesity, the time at risk was considered as the total time between evaluations. For incident cases, the time to obesity was estimated as the time at which BMI reached 30.0 kg/m^2 or WC reached 88 cm in women and 102 cm in men, determined by linear interpolation using time information from the visit at which obesity was determined and the previous visit.

To estimate the magnitude of the association between obesity and sociodemographic characteristics, relative risks (RR) and 95% CI were computed using Poisson regression. Cumulative hazard of the individual outcome was computed using Kaplan–Meier curves and Cox proportional hazards models; a log-rank test was used to compare the survival distributions (i.e., obesity IR) between groups. Leisure-time physical activity (MET*h/day) and total energy intake (kcal/day) entered as continuous variables in the *Poisson* models and in the survival analysis to adjust the incidence estimates. All statistical analyses were conducted using STATA® version 9.0.

Results

Within the 1,272 individuals classified as non-obese at baseline, 100 became obese (70.0% women) during the study's follow-up. Out of the 100 cases of overall obesity identified, 5.0% had a BMI ≤24.9 kg/m^2 at the baseline, and all subjects were women (data not shown). Among subjects with normal WC at baseline ($n=1123$), 229 developed central obesity (73.8% women). After standardization for age, IR were consistently higher among women: 1.70 (95% CI: 1.34–2.19) vs.1.08 (95% CI: 0.73–1.64) for overall obesity and 6.51 (95% CI: 5.60–7.57) vs. 2.44 (95% CI: 1.89–3.14) for central obesity (Table 1).

In both sexes, overall obesity IR increased with increasing age categories; however, significant trends of the IR by age categories were only observed among women (p for trend, 0.015). After adjustment (RRadj), age was a determinant in developing overall obesity in women. Subjects older than 64 years had significantly more risk of becoming obese compared to younger subjects (RRadj = 3.39, 95% CI: 1.43–8.00) (Table 2).

On the other hand, IR of overall obesity declined with increasing educational level. A significant inverse association between overall obesity incidence and education was observed only in women, with a significant trend according to increasing education categories (RRadj = 1 (ref.), 0.53 (0.29–0.96), 0.43 (0.22–0.84), p for trend = 0.023).

Older individuals of both genders presented higher IR of central obesity compared with the younger ones. After adjustment, the positive association between central obesity incidence and age only remained statistically significant among men. As in overall obesity, educational level proved to be a strong determinant of central obesity incidence, but only among women (p for trend, 0.004). Independently of age, total energy intake and leisure-time physical activity, women with more than 11 years of education had a significantly lower risk of developing central obesity (RRadj = 0.45, 95% CI: 0.29–0.79) compared with less educated women (<5 years). In contrast, no significant associations were observed in men. A gender effect of education on central obesity was found (p for interaction, 0.017) (Table 3).

Kaplan–Meier curves (Fig. 1) showed an increase of the cumulative hazard for overall and central obesity incidence, significantly different between sexes (overall obesity ($p=0.016$) and central obesity ($p<0.001$)). This increase was markedly steeper in central obesity. For overall obesity, among those individuals at risk, 10.1% of women and 5.1% of men became obese at 5 years of follow-up. Higher rates for central obesity, during the same period, were observed, 29.1% in women and 11.4% in men. After adjustment for age, education, total energy intake and leisure-time physical activity the same increasing trend was observed for both overall and central obesity.

Discussion

EPIPorto study provides reliable new information at the population level on overall and central obesity incidence stratified by sex, age

Table 1
Overall and central obesity incidence, by gender. EPIPorto study, Portugal, 1999-2008.

	n	Events	Person-time[a]	Incidence rate (95% CI)[b]	Incidence rate (95% CI)[c]
Overall obesity[d]					
Women	748	70	3582.0	1.95 (1.54–2.47)	1.70 (1.34–2.19)
Men	524	30	2589.5	1.15 (0.81–1.65)	1.08 (0.73–1.64)
Central obesity[e]					
Women	607	169	2595.3	6.51 (5.60–7.57)	5.97 (5.09–7.03)
Men	516	60	2455.4	2.44 (1.89–3.14)	2.38 (1.81–3.20)

[a] Time determined by linear interpolation using information from the visit at which obesity was ascertained and the previous visit for incident cases.
[b] Incident rates per 100 person-years.
[c] Standardized for age (Porto population as reference).
[d] Overall Obesity: BMI ≥30.0 kg/m^2.
[e] Central obesity: WC>88 cm for women and WC>102 cm for men.

Table 2
Overall obesity incidence by demographic characteristics at baseline, by gender. EPIPorto study, Portugal, 1999–2008.

	Overall obesity[a]					
	n	Events	Person-time[b]	Incidence rate (95% CI)[c]	Crude RR (95% CI)	Adjusted RR (95% CI)[d]
Women						
Age (years)						
18–44	254	10	1080.2	0.92 (0.49–1.72)	1 (ref.)	1 (ref.)
45–64	345	37	1844.9	2.00 (1.45–2.76)	2.16 (1.07–4.35)	1.76 (0.83–3.72)
≥65	149	23	656.9	3.50 (2.32–5.26)	3.78 (1.80–7.94)	3.39 (1.43–8.00)
p for trend					0.001	0.015
Education (years)						
<5	246	40	1188.0	3.36 (2.46–4.59)	1 (ref.)	1 (ref.)
5–11	206	16	1029.1	1.55 (0.95–2.53)	0.46 (0.25–0.82)	0.53 (0.29–0.96)
>11	296	14	1364.8	1.02 (0.60–1.73)	0.30 (0.16–0.55)	0.43 (0.22–0.84)
p for trend					<0.001	0.023
Men						
Age (years)						
18–44	152	4	652.1	0.61 (0.23–1.63)	1 (ref.)	1 (ref.)
45–64	248	17	1343.2	1.26 (0.78–2.03)	2.06 (0.69–6.13)	1.77 (0.57–5.45)
≥65	124	9	594.1	1.51 (0.78–2.91)	2.46 (0.76–8.01)	1.82 (0.49–6.76)
p for trend					0.198	0.712
Education (years)						
<5	154	12	789.1	1.52 (0.86–2.67)	1 (ref.)	1 (ref.)
5–11	180	11	890.9	1.23 (0.68–2.22)	0.81 (0.35–1.84)	0.93 (0.39–2.19)
>11	190	7	909.3	0.76 (0.36–1.61)	0.50 (0.19–1.28)	0.61 (0.22–1.66)
p for trend					0.092	0.164

[a] Overall obesity: BMI ≥30.0 kg/m^2.
[b] Time determined by linear interpolation using time information from the visit at which obesity was ascertained and the previous visit for incident cases.
[c] Incident rates per 100 person-years.
[d] Adjusted for age, education, total energy intake (kcal/day) and leisure-time physical activity (MET*h/day).

and educational level. Among women, we observed increased IR by increasing age categories and an inverse trend by educational level. A proportion of 29.1% of women and 11.4% of men developed excessive abdominal fat over a 5-year period. In this study, individuals developed central obesity faster than overall obesity, particularly women.

Although it is well documented that obesity is continuing to rise, most published reports have focused on cross-sectional data (Berghofer et al., 2008, Flegal et al., 2002, Lewis et al., 2000, Mokdad et al., 1999, Okosun et al., 2004, Williamson, 1993). The longitudinal data from the present study provide the first incidence estimates for obesity in Portugal, in which the prevalence of overweight and obesity

Table 3
Central obesity incidence by demographic characteristics at baseline, by gender. EPIPorto study, Portugal, 1999–2008.

	Central obesity[a]					
	n	Events	Person-time[b]	Incidence rate (95% CI)[c]	Crude RR (95% CI)	Adjusted RR (95% CI)[d]
Women						
Age (years)						
18–44	246	45	965.2	4.66 (3.48–6.24)	1 (ref.)	1 (ref.)
45–64	281	97	1342.6	7.22 (5.92–8.81)	1.54 (1.08–2.20)	1.18 (0.80–1.75)
≥65	80	27	287.4	9.39 (6.44–13.69)	2.01 (1.25–3.24)	1.37 (0.77–2.42)
p for trend					*<0.001*	*0.073*
Education (years)						
<5	163	69	676.2	10.20 (8.05–12.91)	1 (ref.)	1 (ref.)
5–11	172	55	749.5	7.33 (5.63–9.55)	0.71 (0.50–1.02)	0.79 (0.54–1.14)
>11	272	45	1169.5	3.84 (2.87–5.15)	0.37 (0.25–0.54)	0.45 (0.29–0.69)
p for trend					*<0.001*	*0.004*
Men						
Age (years)						
18–44	157	10	665.3	1.50 (0.80–2.79)	1 (ref.)	1 (ref.)
45–64	245	36	1273.6	2.82 (2.03–3.91)	1.88 (0.93–3.78)	2.07 (1.00–4.28)
≥65	114	14	516.3	2.71 (1.60–4.57)	1.80 (0.80–4.06)	2.27 (0.92–5.59)
p for trend					*0.184*	*0.118*
Education (years)						
<5	147	17	718.7	2.36 (1.47–3.80)	1 (ref.)	1 (ref.)
5–11	179	22	857.3	2.56 (1.68–3.89)	1.08 (0.57–2.04)	1.18 (0.61–2.28)
>11	190	21	879.2	2.38 (1.55–3.66)	1.00 (0.53–1.91)	1.31 (0.65–2.60)
p for trend					*0.740*	*0.899*

[a] Central obesity: WC >88 cm for women and WC >102 cm for men.
[b] Time determined by linear interpolation using time information from the visit at which obesity was ascertained and the previous visit for incident cases.
[c] Incident rates per 100 person-years.
[d] Adjusted for age, education, total energy intake (kcal/day) and leisure-time physical activity (MET*h/day).

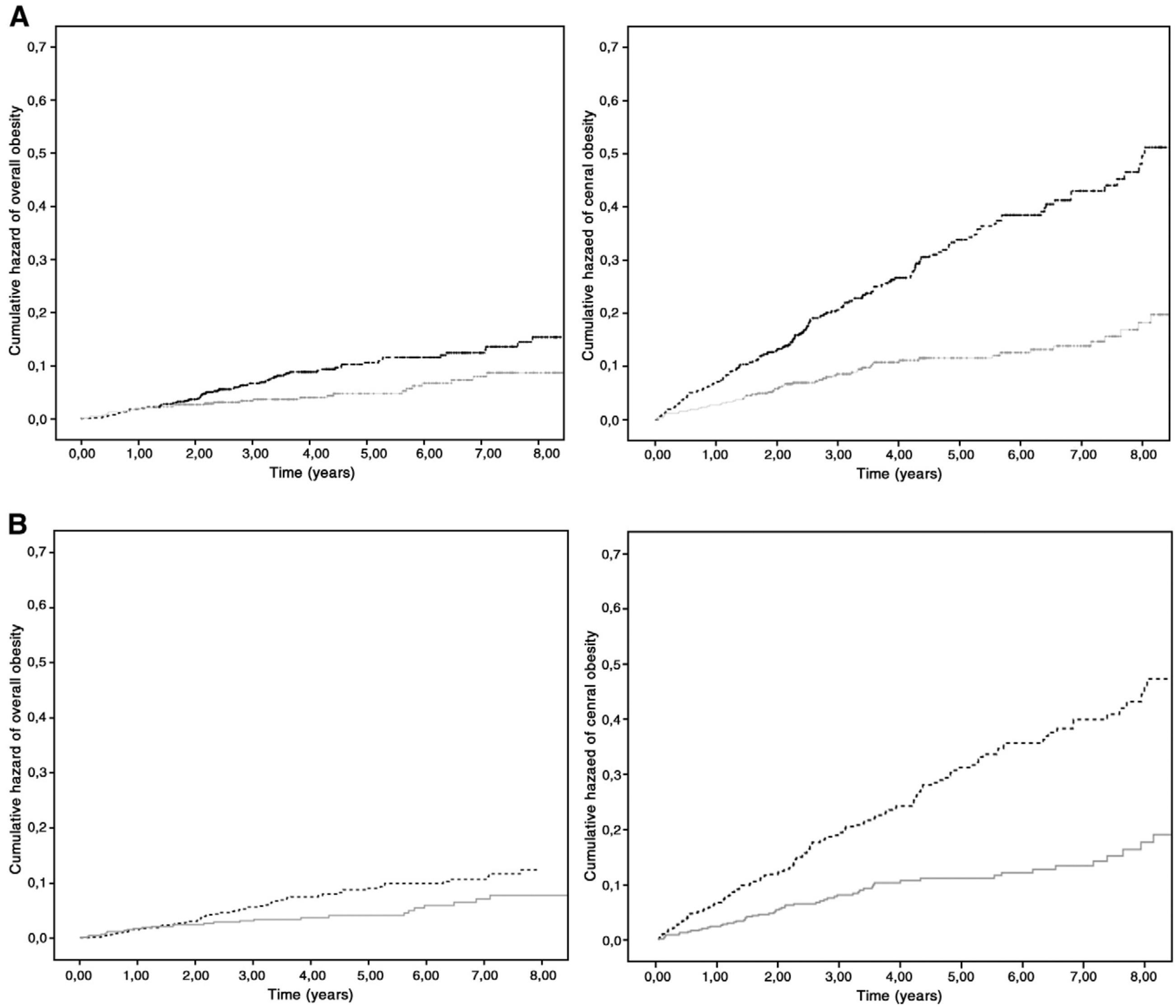

Fig. 1. Survival analysis of overall and central obesity incidence, by gender. EPIPorto study, Portugal, 1999–2008. (A) Crude Kaplan–Meier curves; (B) Adjusted Kaplan–Meier curves (age, education, total energy intake (kcal/day) and leisure-time physical activity (MET*h/day)).

are known to be high (Carmo et al., 2008, Marques-Vidal and Dias, 2005, Santos and Barros, 2003).

Few studies (Balkau et al., 2003, Burke et al., 1996, Gonzalez-Villalpando et al., 2003, Kahn et al., 1991, McTigue et al., 2002, Parikh et al., 2007, Sheehan et al., 2003, Stevens et al., 1991, Vasan et al., 2005, Williamson et al., 1991) have reported longitudinal changes in BMI and WC. To our knowledge, in Europe, with the exception of the French cohort study (Balkau et al., 2003), no longitudinal data on obesity incidence were published gathering both BMI and WC objective measurements.

Although comparisons between studies must be made with caution due to the different age, sex and race distributions, as well as different lengths of follow-up and height and weight assessment, it seems that results from the present investigation were consistent with other studies that described women as at higher risk of developing obesity (Gonzalez-Villalpando et al., 2003, Ogden et al., 2007, Vasan et al., 2005). The higher obesity rates observed among women as compared with men could be mainly explained by differences in lifestyle and sociodemographic variables. Our Portuguese population has a very high prevalence of sedentarism, particularly among women (Gal et al., 2005), and women have significantly lower educational levels compared with men. Additionally, we cannot exclude the possible effect of genetics or physiologic factors on the observed sex differences.

An analysis including American participants in the Framingham Heart Study found that <1% of both men and women with normal BMI at baseline developed obesity, and among overweight individuals about 16% to 23% of women and 12% to 13% of men progressed to obesity within 4 years (Vasan et al., 2005). With a similar follow-up period, the proportions of change in our population were 1.3% of women and 0% of men (normal BMI to obesity) and 17.8% of women and 9.9% of men (overweight to obesity). Also, the 7-year incidence study in a Mexican population aged 35 to 64 years (Gonzalez-Villalpando et al., 2003) found that, among the 608 women at risk, 1.7% of those with normal BMI ($\geq$18.5 and $\leq$24.9 kg/m^2) and 24.5% of those who were overweight ($\geq$25.0 and <30.0 kg/m^2) at baseline became obese within 7 years. The corresponding rates among the 521 men were 0% and 17.3%, respectively.

The mentioned French cohort of adults (Balkau et al., 2003), described that over 3 years of follow-up, 7.4 and 4.4 person-years for women and men, respectively, developed central obesity, using the same thresholds of WC used in our study. The same study described

WC as the most stable feature of metabolic syndrome (Balkau et al., 2003). Once this abnormality is developed, 80% of individuals persisted with abdominal obesity after 3 years of follow-up. WC changes were also evaluated in a large population-based prospective Mexican study (Gonzalez-Villalpando et al., 2003), but IR were not presented. In a prospective cohort study in US adults (Stevens et al., 1991), authors described that subjects increased in abdominal girth over the 25 years (10.3 cm in the younger groups vs. 4.7 cm in the older ones), and this increase was independently of BMI. Similar alarming increase of the IR were observed among our adult population, namely in females, with almost three times higher incidence of central adiposity than men.

Independently of several confounders, education was a clear determinant of developing obesity in women. More educated women had more than 50% decreased risk of disease. These results confirm cross-sectional data in three samples of Central and Eastern European populations, which exhibited an inverse relation between the prevalence of obesity and educational level (Pikhart et al., 2007). The same inverse association was observed in a Portuguese survey intended to obtain the national prevalence of obesity (Carmo et al., 2008). In addition, in a representative sample of Montreal residents (Moore et al., 2009), it was described that higher individual network social capital is associated with a lower WC and BMI.

Data from a North American survey of nutrition and health showed that the increased prevalence of obesity are currently more notable in those individuals with a lower education level, and this tendency is more accentuated among females (Jeffery and Utter, 2003). These findings support our results, showing that obesity is clearly influenced by socioeconomic factors, particularly among women. Various factors would explain why there is a larger social gradient in obesity among women than among men. It has been suggested that different social and family pressures have a stronger effect on women of a higher socioeconomic status (Rodriguez Artalejo et al., 2002).

A recent paper described that low socioeconomic and occupational levels facilitate some unhealthy habits, such as high alcohol consumption, sedentary lifestyles and food consumption patterns that strays from the traditional Mediterranean diet, last of all influencing the obesity epidemic, since they are the major behavioral risk factors linked to obesity (Martin et al., 2008).

The prevalence of obesity in developing countries (Monteiro et al., 2004) sustains that obesity can no longer be considered a problem of higher socioeconomic groups. A gender modifying effect on the association of education with central obesity was found in the present study. Only in women education was inversely associated with central obesity. We could hypothesize that the remarkably increased cumulative hazard of central obesity over time, observed particularly among women, is explained by the strong effect of education observed but also by other non-socioeconomic factors, such as physical activity and diet. However, after adjustment for such variables the trend remained almost the same. This supports that even other aspects of diet and physical activity or other social, behavioral or genetic factors, not considered in the present analysis, may play a significant role on central obesity incidence, which deserves future research.

Measurement errors do not seem to be a limitation in this study since the outcomes of interest (weight, height and WC) were objectively measured, using standard procedures, by trained and periodically supervised observers. Losses to follow-up due to death or the inability to complete the study examination are inherent problems in longitudinal studies and may have biased the results. Despite of this, we found no differences in sex, age and BMI distribution between the participants in the present study and individuals who did not participate in the follow-up assessment, although it should be noted that these subjects presented lower educational levels. This fact could result in an underestimation of the overall IR, but would not affect the incidence by education strata.

Conclusions

The present investigation is the first analysis of obesity incidence in an urban Portuguese population. Individuals developed central obesity (IR/100 person-years: 5.97 in women and 2.38 in men) faster than overall obesity (IR/100 person-years: 1.70 in women and 1.08 in men).

IR of obesity were consistently higher among older individuals and less educated women. A gender effect of education on central obesity was found.

The raising incidence of obesity in Portugal supports the need of public health interventions, particularly in women of lower socio-economic status.

Conflict of interest statement

The author(s) declare that they have no competing interests.

Acknowledgments

This study was funded by the Fundação para a Ciência e a Tecnologia, Praxis POCTI/ESP/42361/2001 and POCI/SAU-ESP/61160/2004.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ypmed.2009.11.004.

References

Balkau, B., Vernay, M., Mhamdi, L., Novak, M., Arondel, D., Vol, S., et al., 2003. The incidence and persistence of the NCEP (National Cholesterol Education Program) metabolic syndrome. The French D.E.S.I.R. study. Diabetes Metab. 29, 526–532.

Berghofer, A., Pischon, T., Reinhold, T., Apovian, C.M., Sharma, A.M., Willich, S.N., 2008. Obesity prevalence from a European perspective: a systematic review. BMC Public. Health. 8, 200.

Bergman, R.N., Kim, S.P., Hsu, I.R., Catalano, K.J., Chiu, J.D., Kabir, M., et al., 2007. Abdominal obesity: role in the pathophysiology of metabolic disease and cardiovascular risk. Am. J. Med. 120, S3–S8 discussion S29-32.

Burke, G.L., Bild, D.E., Hilner, J.E., Folsom, A.R., Wagenknecht, L.E., Sidney, S., 1996. Differences in weight gain in relation to race, gender, age and education in young adults: the CARDIA Study. Coronary Artery Risk Development in Young Adults. Ethn. Health 1, 327–335.

Camões M., Severo M., Santos A.C., Barros H., Lopes C., 2009. Testing an adaptation of the EPIC Physical Activity Questionnaire in Portuguese Adults: a validation study that assesses the seasonal bias of self-report. Ann. Hum. Biol.

Carmo, I., Dos Santos, O., Camolas, J., Vieira, J., Carreira, M., Medina, L., et al., 2008. Overweight and obesity in Portugal: national prevalence in 2003–2005. Obes. Rev. 9, 11–19.

Flegal, K.M., Carroll, M.D., Ogden, C.L., Johnson, C.L., 2002. Prevalence and trends in obesity among US adults, 1999–2000. JAMA 288, 1723–1727.

Formiguera, X., Canton, A., 2004. Obesity: epidemiology and clinical aspects. Best Pract. Res. Clin. Gastroenterol. 18, 1125–1146.

Gal, D.L., Santos, A.C., Barros, H., 2005. Leisure-time versus full-day energy expenditure: a cross-sectional study of sedentarism in a Portuguese urban population. BMC Public Health 5, 16.

Gonzalez-Villalpando, C., Rivera-Martinez, D., Cisneros-Castolo, M., Gonzalez-Villalpando, M.E., Simon, J., Williams, K., et al., 2003. Seven-year incidence and progression of obesity. Characterization of body fat pattern evolution in low-income Mexico City urban population. Arch. Med. Res. 34, 348–353.

Guidelines, 1998. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—the evidence report. National Institutes of Health. Obes. Res. 6 (Suppl. 2), 51S–209S.

Jeffery, R.W., Utter, J., 2003. The changing environment and population obesity in the United States. Obes. Res. 11 (Suppl), 12S–22S.

Kahn, H.S., Williamson, D.F., Stevens, J.A., 1991. Race and weight change in US women: the roles of socioeconomic and marital status. Am. J. Public. Health. 81, 319–323.

Lewis, C.E., Jacobs Jr., D.R., McCreath, H., Kiefe, C.I., Schreiner, P.J., Smith, D.E., et al., 2000. Weight gain continues in the 1990s: 10-year trends in weight and overweight from the CARDIA study. Coronary Artery Risk Development in Young Adults. Am. J. Epidemiol. 151, 1172–1181.

Lopes, C., Aro, A., Azevedo, A., Ramos, E., Barros, H., 2007. Intake and adipose tissue composition of fatty acids and risk of myocardial infarction in a male Portuguese community sample. J. Am. Diet. Assoc. 107, 276–286.

Marques-Vidal, P., Dias, C.M., 2005. Trends in overweight and obesity in Portugal: the National Health Surveys 1995–6 and 1998–9. Obes. Res. 13, 1141–1145.
Martin, A.R., Nieto, J.M., Ruiz, J.P., Jimenez, L.E., 2008. Overweight and obesity: the role of education, employment and income in Spanish adults. Appetite 51, 266–272.
McTigue, K.M., Garrett, J.M., Popkin, B.M., 2002. The natural history of the development of obesity in a cohort of young U.S. adults between 1981 and 1998. Ann. Intern. Med. 136, 857–864.
Mokdad, A.H., Serdula, M.K., Dietz, W.H., Bowman, B.A., Marks, J.S., Koplan, J.P., 1999. The spread of the obesity epidemic in the United States, 1991–1998. JAMA 282, 1519–1522.
Monteiro, C.A., Moura, E.C., Conde, W.L., Popkin, B.M., 2004. Socioeconomic status and obesity in adult populations of developing countries: a review. Bull. World Health Organ. 82, 940–946.
Moore, S., Daniel, M., Paquet, C., Dube, L., Gauvin, L., 2009. Association of individual network social capital with abdominal adiposity, overweight and obesity. J. Public Health (Oxf) 31, 175–183.
Nemesure, B., Wu, S.Y., Hennis, A., Leske, M.C., 2007. Nine-year incidence of obesity and overweight in an African-origin population. Int. J. Obes. (Lond) 32 (2), 329–335.
Ogden, C.L., Carroll, M.D., Curtin, L.R., McDowell, M.A., Tabak, C.J., Flegal, K.M., 2006. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA 295, 1549–1555.
Ogden, C.L., Yanovski, S.Z., Carroll, M.D., Flegal, K.M., 2007. The epidemiology of obesity. Gastroenterology 132, 2087–2102.
Okosun, I.S., Chandra, K.M., Boev, A., Boltri, J.M., Choi, S.T., Parish, D.C., et al., 2004. Abdominal adiposity in U.S. adults: prevalence and trends, 1960-2000. Prev. Med. 39, 197–206.
Parikh, N.I., Pencina, M.J., Wang, T.J., Lanier, K.J., Fox, C.S., D'Agostino, R.B., et al., 2007. Increasing trends in incidence of overweight and obesity over 5 decades. Am. J. Med. 120, 242–250.
Pikhart, H., Bobak, M., Malyutina, S., Pajak, A., Kubinova, R., Marmot, M., 2007. Obesity and education in three countries of the Central and Eastern Europe: the HAPIEE study. Cent. Eur. J. Public Health 15, 140–142.
Ramos, E., Lopes, C., Barros, H., 2004. Investigating the effect of nonparticipation using a population-based case–control study on myocardial infarction. Ann. Epidemiol. 14, 437–441.
Rodriguez Artalejo, F., Lopez Garcia, E., Gutierrez-Fisac, J.L., Banegas Banegas, J.R., Lafuente Urdinguio, P.J., Dominguez Rojas, V., 2002. Changes in the prevalence of overweight and obesity and their risk factors in Spain, 1987–1997. Prev. Med. 34, 72–81.
Santos, A.C., Barros, H., 2003. Prevalence and determinants of obesity in an urban sample of Portuguese adults. Public Health 117, 430–437.
Santos, A.C., Lopes, C., Guimaraes, J.T., Barros, H., 2005. Central obesity as a major determinant of increased high-sensitivity C-reactive protein in metabolic syndrome. Int. J. Obes. (Lond) 29, 1452–1456.
Sheehan, T.J., DuBrava, S., DeChello, L.M., Fang, Z., 2003. Rates of weight change for black and white Americans over a twenty year period. Int. J. Obes. Relat. Metab. Disord. 27, 498–504.
Stevens, J., Knapp, R.G., Keil, J.E., Verdugo, R.R., 1991. Changes in body weight and girths in black and white adults studied over a 25 year interval. Int. J. Obes. 15, 803–808.
Vasan, R.S., Pencina, M.J., Cobain, M., Freiberg, M.S., D'Agostino, R.B., 2005. Estimated risks for developing obesity in the Framingham Heart Study. Ann. Intern. Med. 143, 473–480.
Williamson, D.F., 1993. Descriptive epidemiology of body weight and weight change in U.S. adults. Ann. Intern. Med. 119, 646–649.
Williamson, D.F., Kahn, H.S., Byers, T., 1991. The 10-y incidence of obesity and major weight gain in black and white US women aged 30–55 y. Am. J. Clin. Nutr. 53, 1515S–1518S.
Williamson, D.F., Kahn, H.S., Remington, P.L., Anda, R.F., 1990. The 10-year incidence of overweight and major weight gain in US adults. Arch. Intern. Med. 150, 665–672.