Associations of obesity with socioeconomic and lifestyle factors in middle-aged and elderly men: European Male Aging Study (EMAS)

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Abstract

Background: Social and lifestyle influences on age-related changes in body morphology are complex because lifestyle and physiological response to social stress can affect body fat differently.

Objective: In this study, we examined the associations of socioeconomic status (SES) and lifestyle factors with BMI and waist circumference (WC) in middle-aged and elderly European men.

Design and setting: A cross-sectional study of 3319 men aged 40–79 years recruited from eight European centres.

Outcomes: We estimated relative risk ratios (RRRs) of overweight/obesity associated with unfavourable SES and lifestyles.

Results: The prevalence of BMI $\geq$30 kg/m^2 or WC $\geq$102 cm rose linearly with age, except in the eighth decade when high BMI, but not high WC, declined. Among men aged 40–59 years, compared with non-smokers or most active men, centre and BMI-adjusted RRRs for having a WC between 94 and 101.9 cm increased by 1.6-fold in current smokers, 2.7-fold in least active men and maximal at 2.8-fold in least active men who smoked. Similar patterns but greater RRRs were observed for men with WC $\geq$102 cm, notably 8.4-fold greater in least active men who smoked. Compared with men in employment, those who were not in employment had increased risk of having a high WC by 1.4-fold in the 40–65 years group and by 1.3-fold in the 40–75 years group. These relationships were weaker among elderly men.

Conclusion: Unfavourable SES and lifestyles associate with increased risk of obesity, especially in middle-aged men. The combination of inactivity and smoking was the strongest predictor of high WC, providing a focus for health promotion and prevention at an early age.

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Introduction

Overweight and obesity continue to rise at alarming rates both in western and developing countries, imposing enormous burdens on social and health care systems. Drug prescribing costs are higher in almost all overweight/obese categories, and are twofold higher when comparing individuals with BMI values of 20 and 40 kg/m^2 (1, 2). Associated with obesity and adverse body fat distribution are some specific clusters of symptoms and secondary chronic diseases, including coronary heart disease and type 2 diabetes mellitus (3, 4), which are exacerbated by smoking and physical inactivity and are most prevalent among those with lower socioeconomic status (SES). The relationship between alcohol consumption and adiposity remains unclear. Life-style factors vary between and within countries, but it is constantly found that poor lifestyles and socioeconomic deprivation are underlying drivers of the ever increasing prevalence in obesity in post-industrial societies, and this pattern arises rapidly with urbanisation in transitional countries.

Social and lifestyle influences on age-related changes in body morphology are complex because lifestyle and physiological response to social stress can affect body fat and skeletal muscle differently. The European Male Ageing Study (EMAS) collected health data from middle-aged and elderly men from eight European Centres, including anthropometry, socioeconomic and lifestyle factors as well as reported health status. The objectives of this study were to assess the associations of SES and lifestyle factors with BMI and waist circumference (WC) in middle-aged and elderly European men.

Subjects and methods

Subjects and study design

A total of 3319 men aged 40–79 years were recruited from population registers in eight European centres, five from non-transitional (Florence, Italy; Leuven, Belgium; Malmö, Sweden; Manchester, UK; Santiago de Compostela, Spain) and three from transitional countries (Łódź, Poland; Szeged, Hungary; Tartu, Estonia). Stratified random sampling was used, aiming to recruit equal numbers of men in each centre and into each decade (40–49, 50–59, 60–69, and 70–79 years). After completing a postal questionnaire including information about SES (peak education attainment and employment status) and lifestyle factors (smoking habits, alcohol consumption and physical activity level), the subjects attended research clinics for a health screen as previously described (5). Each participant completed interviewer-assisted questionnaires and underwent clinical assessments including anthropometry (weight, height, and WC). Ethics approval for the study was obtained in accordance with local institutional requirements in each centre and participants gave informed consent.

Statistical analysis

Statistical analyses were conducted using STATA SE version 13.1 (Stata Corp., College Station, TX, USA). The individuals were categorised according to their BMI (<25, 25–29.9 and ≥ 30 kg/m^2) or WC 'action levels' (<94, 94–101.9, and ≥ 102 cm) (6, 7). For the purpose of this analysis, peak education attainment was classified as below high school, high school or college/university level; employment status as either employed or unemployment employment or non-employment; smoking status as never, former or current smokers; alcohol consumption as non-drinkers, infrequent alcohol drinkers (1–4 days/week) or frequent alcohol drinkers (≥ 5 days/week); and physical activity according to quartiles of physical activity scale for the elderly (PASE) questionnaire score.

The prevalence of overweight and obesity based on BMI 25–29.9 or ≥ 30 kg/m^2 and WC 94–101.9 or ≥ 102 cm in different categories of age, SES, and lifestyle factors was computed in all centres. χ^2 test of independence was used to assess their associations. Linear regression analysis was used to determine the relationships between indices of adiposity and age. Multinomial logistic regression analysis was conducted to obtain the relative risk ratios (RRRs) to assess the likelihood that men with low SES or adverse lifestyle factors (predictor variables) would have a high BMI (25–29.9 or ≥ 30 kg/m^2) or a high WC (94–101.9 or ≥ 102 cm) (dependent variables). A composite variable comprising a combination of modifiable lifestyle factors (smoking and physical activity) was created. Age and centre adjustment was made for relationships with both BMI and WC, as there were centre differences in the rates of obesity. In addition, adjustment for BMI and subgroup analysis stratified by age at 60 years was made for the relationship with WC. As we did not have reliable information on retirement status, we decided to classify subjects into employment and non-employment groups for men below 65 years old (working age in most countries). We assumed that the non-employment group comprises mostly men who were unemployed, with a smaller proportion who took early retirement. We also repeated this analysis for men below 75 years old to see if the outcome would differ from those below 65 years old as there would proportionally be more retired men (rather than unemployed) in the non-employment group.

Results

Table 1 shows that overall, high BMI (≥30 kg/m^2) or high WC (≥102 cm) was found in 25 and 35% of men respectively. There were 3% of men with final education below high school level and 19% below 65 years and 30.5% below 75 years not in employment, 21% were current smokers, 36% drank frequently and 25% had very low levels of physical activity.

Table 1 Mean (s.d.) age and indices of adiposity and proportions of men in different categories of BMI, WC, socioeconomic status and lifestyle factors in European middle-aged and elderly men (n=3319).

Characteristics	Values
Age (years; mean (s.d.))	60.0 (11.0)
BMI (kg/m^2; mean (s.d.))	27.7 (4.1)
WC (cm; mean (s.d.))	98.5 (11.1)
BMI (n (%))	
BMI <25 kg/m^2	870 (26.3)
Overweight (25–29.9 kg/m^2)	1629 (49.2)
Obesity (≥30 kg/m^2)	814 (24.6)
WC (n (%))	
Below action level 1 (<94 cm)	1142 (34.4)
Below action level 1–2 (94–101.9 cm)	1006 (30.3)
Above action level 2 (≥102 cm)	1171 (35.3)
Educational level (n (%))	
College/University	1734 (53.3)
High school	1428 (43.9)
Below high school	93 (2.9)
Employment status (n (%))	
Employment (<65 years old)	1702 (80.9)
Non-employment (<65 years old)	401 (19.1)
Employment (<75 years old)	2061 (69.5)
Non-employment (<75 years old)	906 (30.5)
Smoking habit (n (%))	
Never-smokers	970 (29.6)
Former smokers	1599 (49.0)
Current smokers	693 (21.2)
Alcohol consumption (n (%))	
Non-drinkers	541 (16.3)
Infrequent drinkers (1–4 days/week)	2010 (60.7)
Frequent drinkers (≥5 days/week)	759 (22.9)
Physical level of activity (n (%))	
High (PASE score quartile 4)	776 (24.9)
Moderate (PASE score quartile 3)	778 (25.0)
Low (PASE score quartile 2)	779 (25.0)
Very low (PASE score quartile 1)	778 (25.0)
Never-smokers and PASE quartile 4 (n (%))	263 (8.0)
Former/current smokers and PASE quartile 1 (n (%))	581 (18.4)

PASE, Physical Activity Scale for the Elderly; WC, waist circumference.

The prevalence of obesity (BMI ≥30 kg/m^2) was significantly different across centres (P<0.001) and generally lower in non-transitional countries (17.1% in Florence, 19.8% in Leuven, 21.0% in Malmö, 21.3% in Manchester and 27.2% in Santiago de Compostela) than transitional countries (21.9% in Łódź, 35.2% in Szeged, and 32.9% in Tartu).

Linear regression analysis revealed that age correlated weakly with BMI (P=0.03) (Fig. 1A) and more strongly with WC (P=0.001) (Fig. 1B). Figure 2 shows that within each decade of age, the proportions of overweight men were consistently higher than the proportions of obese men. By contrast, there were higher proportions of men with WC above action level 2 (≥102 cm) compared with those with WC between action level 1 and 2 (94–101.9 cm). This contrast was more evident in older men (age ≥60 years). Figure 3A, B, C, D, and E represents the associations of adiposity with SES and lifestyle factors. There was a linear inverse trend in the prevalence of BMI between 25 and 29.9 kg/m^2 with education attainment, whilst the prevalence of BMI ≥30 kg/m^2 was observed to be higher among the men with middle-level education than those with either lowest or highest education (Fig. 3A). The prevalence of men with large waist (either 94–101.9 cm or ≥102 cm) did not differ between educational levels. Figure 3B shows that BMI did not associate with employment status, whereas higher proportions of non-working men had large WC than those who were in employment. Figure 3C shows that the prevalence of men with BMI ≥30 kg/m^2 or with WC ≥102 cm was highest among former smoking group. Figure 3D shows that the prevalence of men with BMI ≥30 kg/m^2 or men with WC ≥102 cm was higher in men who consumed alcohol ≤4 days a week than those who consumed ≥5 or more days a week. Figure 3E shows that the prevalence of men with BMI ≥30 kg/m^2 was not significantly different across quartiles of physical activity, whilst the prevalence of men with WC ≥102 cm was greatest (44%) in the lowest quartile (least active) and this prevalence decreases linearly with physical activity, being lowest (31%) in the most active group of men (highest quartile).

Former/current smoking and physical inactivity were significantly more prevalent in men who achieved education below high school or were in the non-employment category. Alcohol consumption was more frequent in men who were in employment (Supplementary Table 1, see section on supplementary data given at the end of this article).

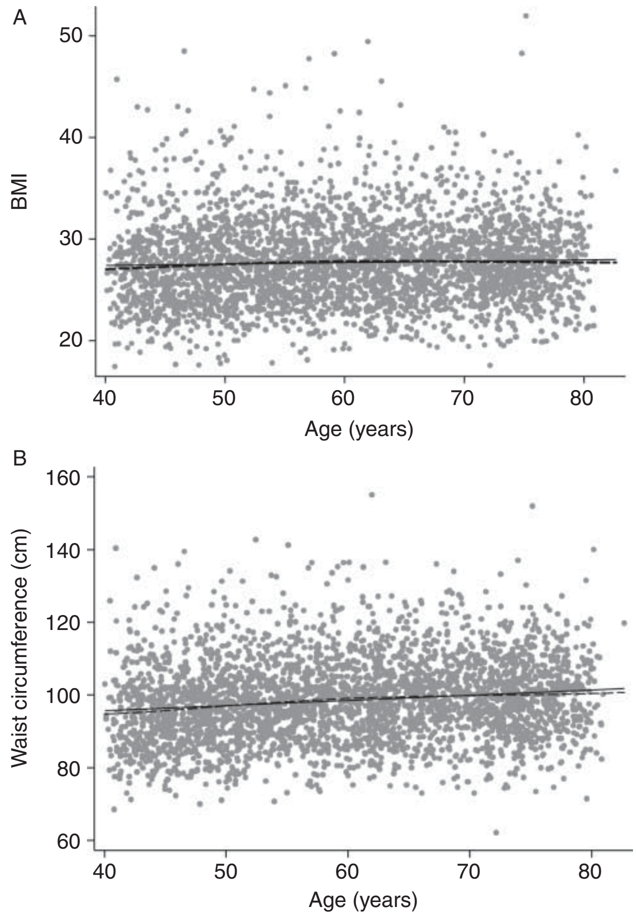

Figure 1
Association of age with (A) BMI and (B) waist circumference (WC). The solid lines represent the linear relationship and the dashed lines represent locally weighted scatterplot smoothing (LOWESS). Linear regression equations: (A) BMI$=$26.8$+$0.014$\times$ age ($P$$=$0.030), (B) WC$=89.9+0.143\times$age ($P$$=$0.001).

Table 2 shows that when the analysis was adjusted for age and centre, compared with referent groups, there were greater RRRs for having a WC $\geq$102 cm in men who attained high school level of education by 1.3-fold and men who fell in the non-employment category by 1.4-fold in the below 65 years and 1.3-fold in the below 75 years. Compared with non-smokers, the RRR of having a WC $\geq$102 cm was higher by 1.6-fold in former smokers, but was not significantly different in current smokers. Compared with non-drinkers, men who drank alcohol up to 4 days a week had a 1.5-fold higher a RRR for having a WC between 94 and 101.9 cm, whereas there was a lower RRR (0.74, CI: 0.56, 0.98) for having a high WC in men who drank frequently ($\geq$5 days/week), but these associations disappeared after adjustment for BMI was made. This pattern largely persisted when subjects were analysed separately in each centre. The RRR for having a WC $\geq$102 cm was higher by 2.1-fold in former/current smokers and least physically active men. Additional adjustment for BMI showed that the RRR for having high a WC between 94 and 101.9 was greater by 1.4-fold amongst current smokers or in men who achieved lower level of physical activity – by 1.7-fold in the lowest PASE quartile. The RRR for having a WC $\geq$102 cm was greater by 2.2-fold in current smokers, 1.8-fold, 1.7-fold, and 3.9-fold in men whose physical activity level was in quartile 3, 2, and 1 respectively. Amongst men who both smoked (former/current) and least physically active, the RRRs of having a WC between 94 and 101.9 or WC $\geq$102 cm were higher by 2.2- or 5.1-fold respectively. The association between BMI, SES and lifestyle factors was much weaker (Supplementary Table 2).

Table 2 shows that within the 40–59 age band, compared with referent groups, the age, centre, and BMI-adjusted RRR for having a WC between 94 and 101.9 cm was 1.6-fold higher in current smokers, and 2.7-fold higher in men reporting the lowest physical activity levels (PASE quartile 1). This risk was numerically higher (2.8-fold higher than referent) in men who both smoked and were least physically active. Similar patterns but greater RRRs were observed for having a WC $\geq$102 cm in men with low SES and adverse lifestyle factors; notably an 8.4-fold higher risk was observed in men who were current smokers and were least physically active. Within the 60–79 age band, compared with referent groups, the risk for having a WC between 94 and 101.9 or $\geq$102 cm was lower and less frequently observed in relation with poor lifestyle

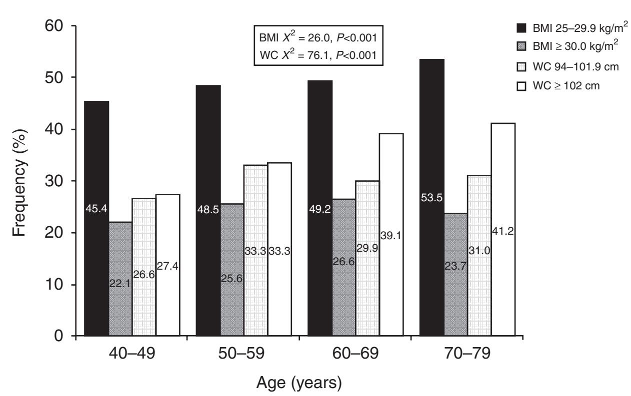

Figure 2
Distribution of subjects with high BMI (25–29.9 kg/m^2 or $\geq$30 kg/m^2) or high waist circumference (94–101.9 cm or $\geq$102 cm) by 10-year age groups.

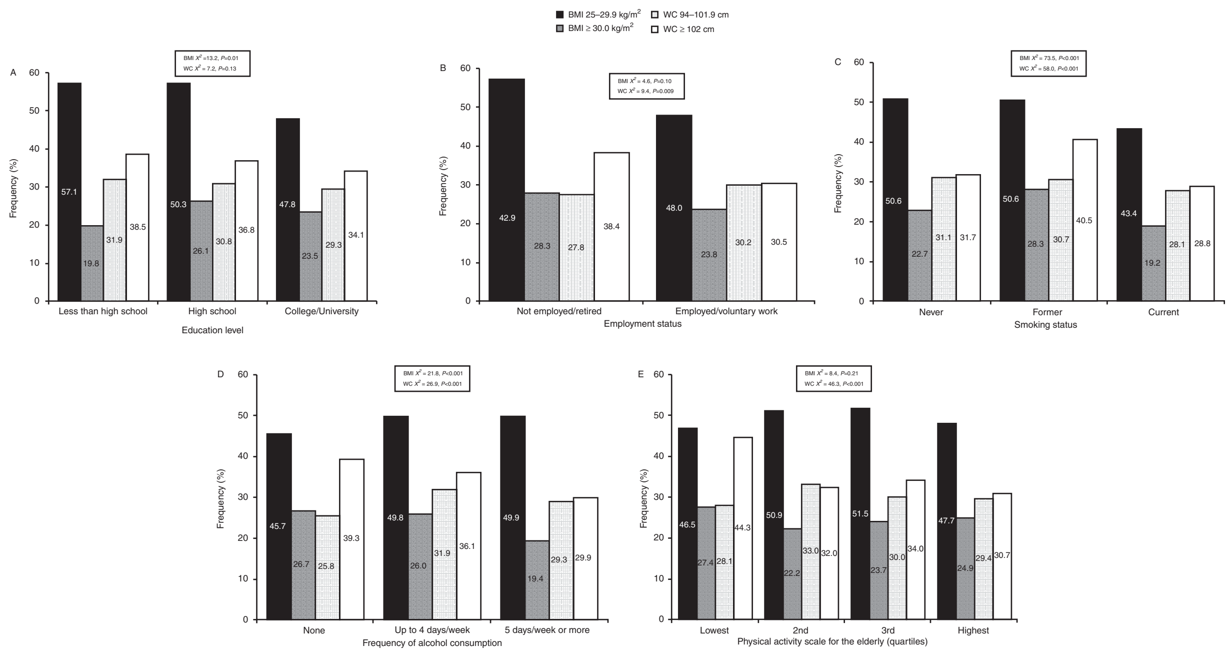

Figure 3

Proportions of men with high BMI (≥30 kg/m^2, n=814) or high waist circumference (≥102 cm, n=1171) in different categories of (A) education level, (B) employment status (<65 years old), (C) smoking habits, (D) alcohol consumption, and (E) physical activity.

factors than that observed in younger men (*vida supra*). In this older age band, the risk of having a WC ≥102 cm was 3.5-fold higher in the least active men, and this risk was 5.5-fold higher than referent group in those that both smoked and were least physically active.

There were 66% of men with WC <94 cm and BMI <25 kg/m^2, whilst 64% of men with WC ≥102 cm had BMI ≥30 kg/m^2. In contrast, 87% of men with BMI <25 kg/m^2 had WC <94 cm whilst 91% of men with BMI ≥30 kg/m^2 had WC ≥102 cm. There were <1% of men with a combination of WC <94 cm and BMI ≥30 kg/m^2, or WC ≥102 cm and BMI <25 kg/m^2, and similarly a combination of BMI <25 kg/m^2 and WC ≥102 cm or BMI ≥30 kg/m^2 and WC <94 cm.

Discussion

This study has shown that the prevalence of obesity increased with age, but in the oldest group, the prevalence of high BMI declined whilst high WC continued to rise. Low SES as well as modifiable lifestyle factors was associated with higher risk of large WC, more strongly in middle-aged men even after adjusting for BMI.

In this study, the prevalence of high WC was only observed in men in the oldest decade, whilst a drop in the prevalence of high BMI probably reflects a loss of total lean mass in older men who continue to accumulate fat, and may shift its distribution to a more central, intra-abdominal deposition. This change has been described previously and interpreted as an age-related trend towards sarcopenia, which is associated with loss of physical function and a range of co-morbidities (8). These findings are important when adiposity is measured in the elderly populations as BMI is likely to underestimate their body fatness. WC appears to be a better adiposity index through all ages (9), and older men with large WC appear to be at greater risk of many disease outcomes (10). These findings support the Rotterdam Study (11), which showed that high WC, but not BMI, predicted mortality in older men. Prevention of weight gain at earlier ages may reduce multiple adverse health consequences.

Our findings of higher risk of high WC among men who were not in employment were consistent with previous studies showing that obesity is more prevalent in people with low SES (12, 13), compounding health inequality. Poor lifestyle such as high-fat diets and lack of exercise as well as social stress may explain this association (14, 15). Areas of low SES harbours poorer food quality, where there is a focus on cheaper processed fast foods which outsell fresh fruit and vegetables (16, 17).

Table 2 Multinomial logistic regression analysis of the risk in men having large waist circumference (WC) related to individual lifestyle factors and socioeconomic status and with two adverse modifiable lifestyle factors (i.e. former/current smoking and very low physical activity) in all subjects (aged 40–79, $n=3319$), and in middle-aged men (40–59.9 years, $n=1674$) and elderly men (60–79 years, $n=1645$) with adjustments for age, centre, and BMI. Statistically significant differences are in bold face.

	Relative risk ratios (95% CIs)							
	Adjusted for age and centre		Adjusted for age, centre, and BMI		Middle-aged men (40–59.9 years)		Elderly men (60–79 years)	
	WC 94 to <102	WC ≥102 cm	WC 94 to <102	WC ≥102 cm	WC 94 to <102	WC ≥102 cm	WC 94 to <102	WC ≥102 cm
College/University (reference)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
High school	1.19 (0.98, 1.43)	**1.31 (1.09, 1.57)**	1.03 (0.80, 1.32)	0.89 (0.64, 1.24)	1.23 (0.88, 1.71)	1.13 (0.71, 1.80)	0.94 (0.65, 1.37)	0.80 (0.49, 1.30)
Below high school	1.30 (0.74, 2.29)	1.69 (0.96, 2.96)	1.05 (0.50, 2.20)	1.39 (0.55, 3.53)	1.68 (0.45, 6.25)	2.08 (0.33, 13.15)	0.96 (0.37, 2.47)	1.28 (0.41, 4.04)
<65 years old								
Employed (reference)	1.0	1.0	1.0	1.0				
Unemployed	0.93 (0.69, 1.26)	**1.44 (1.09, 1.91)**	1.13 (0.77, 1.68)	1.59 (0.93, 2.71)				
<75 years old								
Employed (reference)	1.0	1.0	1.0	1.0				
Unemployed	1.06 (0.85, 1.33)	**1.31 (1.05, 1.64)**	1.21 (0.90, 1.64)	1.35 (0.90, 2.01)				
Never-smokers (reference)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Former smokers	1.18 (0.96, 1.44)	**1.57 (1.29, 1.92)**	1.10 (0.85, 1.44)	1.35 (0.95, 1.92)	1.27 (0.88, 1.83)	1.46 (0.88, 2.45)	1.03 (0.70, 1.52)	1.43 (0.88, 2.34)
Current smokers	**0.78 (0.61, 0.99)**	0.84 (0.66, 1.07)	1.37 (0.99, 1.90)	**2.17 (1.39, 3.41)**	**1.56 (1.03, 2.36)**	**1.96 (1.08, 3.56)**	0.94 (0.54, 1.61)	1.92 (0.96, 3.85)
Alcohol drinkers								
Non-drinkers (reference)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Infrequent drinkers (1–4 days/week)	**1.51 (1.17, 1.94)**	1.14 (0.90, 1.44)	1.26 (0.90, 1.78)	0.89 (0.58, 1.39)	1.22 (0.72, 2.07)	0.66 (0.33, 1.32)	1.26 (0.80, 1.98)	0.98 (0.56, 1.74)
Frequent drinkers (≥5 days/week)	1.08 (0.80, 1.45)	**0.74 (0.56, 0.98)**	1.21 (0.82, 1.79)	1.01 (0.60, 1.69)	1.38 (0.76, 2.52)	0.85 (0.37, 1.94)	1.02 (0.60, 1.71)	0.98 (0.50, 1.91)
Levels of physical activity								
High (PASE score quartile 4) (reference)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Moderate (PASE score quartile 3)	1.05 (0.82, 1.35)	1.21 (0.94, 1.55)	1.11 (0.80, 1.55)	**1.75 (1.11, 2.74)**	1.19 (0.80, 1.76)	**2.16 (1.24, 3.78)**	1.06 (0.57, 1.96)	1.34 (0.61, 2.95)
Low (PASE score quartile 2)	1.07 (0.83, 1.40)	1.10 (0.85, 1.44)	1.32 (0.93, 1.88)	**1.69 (1.04, 2.73)**	1.36 (0.87, 2.14)	**2.04 (1.06, 3.94)**	1.43 (0.80, 2.57)	1.61 (0.77, 3.40)
Very low (PASE score quartile 1)	1.03 (0.77, 1.38)	**1.75 (1.32, 2.32)**	**1.70 (1.15, 2.53)**	**3.92 (2.31, 6.63)**	**2.70 (1.50, 4.85)**	**8.44 (3.74, 19.04)**	1.66 (0.91, 3.00)	**3.49 (1.66, 7.37)**
Never-smokers and PASE quartile 4 (reference)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Former/current smokers and PASE quartile 1	1.06 (0.66, 1.72)	**2.06 (1.28, 3.30)**	**2.17 (1.12, 4.18)**	**5.08 (2.13, 12.13)**	**2.84 (1.17, 6.91)**	**8.40 (2.43, 28.96)**	2.34 (0.87, 6.34)	**5.50 (1.61, 18.82)**

PASE, physical activity scale for the elderly.

We found the men in lower SES were more likely to be smokers or sedentary while more frequent drinkers were found among men who were working.

Our study did not have reliable information on retirement; therefore, we classified men below 65 years old into employment and non-employment groups. There were 81% of men in employment and 19% in unemployment (unemployed plus retired men). These figures are similar to the MORGEN study of 5733 Dutch men below 65 years old, showing 78.6% of men in employment and 18.1% in unemployment (12.6% unemployed and 7.5% retired early) (8). The MORGEN study has shown that men who retired early, and similarly men in employment, had a lower risk of high WC than unemployed men (8), suggesting that RRRs for having high WC in the non-employment group in our study would likely to be greater if retired men were excluded, i.e. leaving only unemployed men in the non-employment group. Our study has also shown that RRRs for having high WC or BMI in the non-employment group did not differ substantially whether the cut off at 65 or 75 years was used, suggesting that the age of retirement had little effect on obesity.

This study has shown that modifiable lifestyle factors all associate consistently with greater risk of large WC irrespective of BMI. The high proportion of men with large WC in former smokers may reflect men who gave up smoking due to poor health and are also least physically active. These relationships were less apparent with BMI. Greater WC and BMI have previously been reported in former smokers (18, 19). The association of high WC with physical inactivity seems obvious, whereas that of high WC and smoking do not. Although current smokers were at reduced risk of high BMI, they were at increased risk of having high WC (after BMI adjustment), indicating the adverse effects of smoking on changes in body morphology – losing muscle mass while accumulating abdominal fat. A study of rats by Liu *et al*. (20) has found that ubiquitin-specific protease-19 (an enzyme involved in removal of ubiquitin from specific target proteins for cellular processes by tagging them for degradation) was upregulated with muscle atrophy on exposure to chronic cigarette smoke, and that cigarette smoke extract promoted myotube wasting *in vitro* by inhibiting myogenic differentiation and acted via phosphorylated MAPKs to stimulate the expression of ubiquitin-specific protease-19. How cigarette smoke promotes increased abdominal fat accumulation remains unclear.

The association between lower alcohol intake frequency and obesity seems paradoxical and may be explained by a number of ways including affordability and under-reporting, as well as quality of drink, but this information was not available in this study. Another possibility is those who reported drinking the least amount of alcohol presently, associated with greater WC or BMI, may be less healthy if they included abstinence. We found that those who were drinking $\leq$4 days/week were not associated with SES but tended to be less active and former/current smokers. Another possible explanation is that the frequency of alcohol consumption may not reflect total amounts because binge drinking may fall in the low frequency category and these habits may vary between centres. We did not collect information on binge drinking in this study. A thorough review of the literature and how data analyses from the UK were performed has suggested that the amount of alcohol consumed and the frequency of consumption may be disconnected and have opposite influence on adiposity (21).

The present analysis has shown that when BMI or WC alone was related with adverse SES and lifestyle factors, few significant relationships were observed. The relationships were revealed when WC was adjusted for BMI, showing how adverse lifestyle factors such as physical inactivity and smoking were associated with greater WC. Previous studies have demonstrated that WC predicts mortality more strongly after adjustment for BMI (22). However, it is difficult to interpret these associations, as WC and BMI are highly correlated (r=0.894, P<0.001) and both are similar predictors of total body fat, while BMI is also influenced by muscle mass (23). A possible explanation could be that by adjusting for BMI, the muscle component is eliminated. This concept is supported by the strengthening of the relationship between high WC and physical inactivity or smoking (both factors lead to muscle atrophy) when BMI was taken into account in this study.

Interesting findings emerged in this study with regard to age. Physical inactivity and smoking were associated with high WC more strongly in middle-aged men than in older men. These differences may be explained by selection or survivor bias – older men with large WC may have poor health that prevents them from participating in the study. Another possible explanation is that lifestyles may exert stronger influences on WC in younger than older men, resulting in more distinct differences between low WC and high WC among younger men. Based on this evidence, we suggest the practice of healthy lifestyles from early age order to prevent obesity, particularly high WC.

The present data add to current concern that BMI is not the best simple indicator of adiposity or of disease risk.

WC is a better indicator of total body fat than BMI. The lowest category of WC contained only 66% men with BMI in the lowest category while the other 33% had BMI between 25 and 29.9 kg/m^2. This is probably due to a number of men whose BMI reflected muscularity rather than overweight. Conversely, only 64% men with BMI $\geq$30 kg/m^2 fell with the highest WC category. This may indicate that the 36% with BMI 25–29.9 kg/m^2 within highest category were associated with muscle atrophy.

The main strengths of EMAS are a large community-based sample and use of uniform methods to assess adiposity, lifestyle factors and potential confounders. Although limitations of the study have been described previously (5), certain factors need to be highlighted in this study. We enrolled mainly Caucasian men with a study response rate of 41%, which could limit generalisability. Those who participated may have differed with respect to SES, lifestyle factors and anthropometric measures from those who did not participate, thus some caution is needed in the interpretation of the data. Small proportions of subjects appeared in some categories, such as those with an educational attainment below high school level, potentially introducing bias in these results. The main findings, however, were based on an internal comparison of responders, and therefore any selection factors were unlikely to have had any important effect on these data. The cross-sectional design precluded study of the temporal nature of associations, for which prospective data are required.

In conclusion, unfavourable SES and poor lifestyles were associated with risk of obesity, with greater impact on WC than BMI, especially in middle-aged men. The combination of inactivity and smoking was the strongest predictor of high WC, providing a focus for health promotion and prevention at an early age.

Supplementary data

This is linked to the online version of the paper at http://dx.doi.org/10.1530/EJE-14-0739.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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