Nutrition, Metabolism & Cardiovascular Diseases (2019) **29**, 383–389

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

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

Estimating the impact of obesity and metabolic phenotype on sickness absence. Results from the ICARIA study

C. Catalina-Romero [a,*], M.A. Sanchez Chaparro [b], P. Valdivielso [b], L. Quevedo-Aguado [a], C. Brotons [c], L.M. Ruilope [d], E. Calvo-Bonacho [a]

[a] Ibermutuamur (Mutua colaboradora con la Seguridad Social 274), Madrid, Spain
[b] Department of Internal Medicine, University Hospital "Virgen de la Victoria", and University of Malaga, Malaga, Spain
[c] Research Unit, Sardenya Primary Health Care Centre-Biomedical Research Institute Sant Pau (IIB Sant Pau), Barcelona, Spain
[d] Research Institute Hospital 12 de Octubre, Madrid, Spain

Received 21 June 2018; received in revised form 5 November 2018; accepted 17 December 2018
Handling Editor: A. Siani
Available online 27 December 2018

KEYWORDS
Sickness absence;
Body mass index;
Obesity;
Overweight;
Multimorbidity;
Occupational health;
Occupational injury;
Work ability

Abstract *Background and aims:* To assess the impact of obesity and being overweight on sickness absence (SA) as a function of healthy/unhealthy metabolic phenotype.
Methods and results: A total of 173 120 healthy workers who underwent a routine check-up, consisting of a structured interview, anthropometric measurements and blood pressure and fasting blood analysis, were included as the study sample (67.1% males; 49.2% manual workers; mean age 40.6 ± 21.9 years). Workers were classified according to their body mass index (BMI) and metabolic phenotype. A metabolically unhealthy phenotype was defined as the presence of three or more of the following criteria: glycaemia ≥110 mg/dL or previously diagnosed type I/II diabetes or treatment for diabetes; triglycerides ≥150 mg/dL or lipid-lowering therapy; HDL <40/50 mg/dL M/F; blood pressure ≥130/85 mmHg or previously diagnosed hypertension or antihypertensive therapy; waist circumference >102/88 cm M/F. A one-year follow-up was conducted to evaluate the incidence of work-related and non-work-related SA (WRSA/NWRSA). The association of BMI with SA was tested using Poisson regression (standard error correction), segmenting on the basis of metabolic phenotype.

The overall percentages of workers who were overweight, obese and/or had a metabolically unhealthy phenotype were 37.7%, 16.3% and 8.8%, respectively. BMI was associated with increased incidence of NWRSA in both phenotypes. It was also associated with WRSA in subjects with a BMI in the range of 35–39.99 kg/m^2 and in metabolically healthy individuals. WRSA was lower in subjects with a BMI ≥40 kg/m^2 and among metabolically unhealthy individuals.
Conclusion: Obesity is associated with health problems that have a significant impact on SA.

Introduction

Health problems linked to high body mass index (BMI) are increasingly relevant from an epidemiological perspective. In the last few decades, the worldwide prevalence of obesity almost tripled [1]. As far as obesity epidemic progresses, its health, social and economic consequences also increase. Between 1990 and 2013, the numbers of deaths

* Corresponding author. Ibermutuamur, C/ Ramírez de Arellano, 27, 28043 Madrid, Spain. Fax: +34 91 4169699.
E-mail address: carloscatalina@ibermutuamur.es (C. Catalina-Romero).

https://doi.org/10.1016/j.numecd.2018.12.005
0939-4753/

and people with disabilities attributable to this factor grew by 63.2% and 71.3%, respectively [2].

Previous research has linked obesity to an increase in sickness absence (SA) [3–8]. Moreover, in recent decades, the impact of obesity on SA may have exceeded that of tobacco consumption [9]. However, several studies published on this topic were based exclusively on data from surveys [5–8]. Other reports concentrated on selected populations from an occupational perspective [6,9] or were focused on SA due to specific health conditions [10,11]. In addition, study designs are often cross-sectional, or SA is assessed through self-reporting by workers [4].

The healthcare costs and productivity losses associated with obesity have been estimated to be millions of euros or dollars [12,13]. For example, the absenteeism-related lost productivity costs associated with obesity and being overweight were estimated to be €2 180 million in Germany [12]. In the USA, the total costs of absenteeism attributed to obesity were reported to be between 6.5% and 12.6% [13].

Among obese individuals, a phenotype of patients who do not present metabolic abnormalities, the so-called metabolically healthy obese (MHO) phenotype, has been described [14]. The clinical significance of metabolic phenotype lies in its potential to define a high-risk population on which actions aimed to fight against obesity should be focussed [14]. A metabolically unhealthy phenotype is present in approximately 12.9% of overweight and 44.9% of obese workers [14]. A metabolically healthy phenotype could represent an intermediate stage in terms of cardiometabolic risk [14]. If that were true, an intermediate level of SA should be expected among those patients.

The objective of the current study was to analyse the impact of obesity and being overweight on SA. Furthermore, the potential use of assigning a metabolically healthy or unhealthy phenotype to individual workers was evaluated.

Methods

The current research was part of the ICARIA (Ibermutuamur CArdiovascular RIsk Assessment) study, the methodology of which has been described in detail elsewhere [15,16]. Briefly, cardiovascular risk factors and global CVR, as estimated using the SCORE (Systematic COronary Risk Evaluation) chart for European low-risk countries, were assessed in a broad and representative sample of the Spanish working population [15]. The ICARIA cohort includes workers from all activity sectors and occupational categories, with a broad age range and of both genders. Furthermore, the sample is balanced with regard to the Spanish geographical areas, as defined by actual cardiovascular mortality adjusted for age [16]. All participants who underwent a routine medical examination were approached and included in the ICARIA cohort, provided they gave informed consent [15–17].

For the current analyses, a sample of 173 120 healthy workers (workers without an active SA episode when selected) were enrolled during a routine medical examination. A prospective cohort design was followed. Baseline medical assessment included standardised anthropometric and blood pressure measurements (average values of two measures with the semiautomatic device OMRON M4-1, Omron Electronics, Hoofddorp, The Netherlands), fasting blood test and a structured interview conducted by a trained physician. The anthropometric measurements were taken under standard conditions by a physician, with the workers wearing light clothes and no shoes.

Recruitment took place from 1 January 2012 to 31 December 2013. Only workers for whom a minimal data set was available were included in the analysis. We excluded those with missing values for the main explanatory variables (BMI, blood pressure, prior hypertension diagnosis, antihypertensive treatment, triglycerides, high-density lipoprotein-cholesterol (HDL-C), lipid-lowering therapy, glycaemia, prior type I/II diabetes diagnosis and anti-diabetic treatment and waist circumference).

Variables

Demographic variables were workers' sex, age and occupation (manual or blue collar; non-manual or white collar). The main explanatory variable was BMI. BMI was categorised as 6 groups: low weight (<18.5 kg/m^2); normal weight (18.5–24.99 kg/m^2); overweight (25–29.99 kg/m^2); obesity (30–34.99 kg/m^2); severe obesity (35–39.99 kg/m^2) and morbid obesity (≥ 40 kg/m^2).

Other variables were also assessed. An unhealthy metabolic phenotype was defined as the presence of three or more of the following five criteria (modified criteria for metabolic syndrome of National Cholesterol Education Program (NCEP) – Adult Treatment Panel III –ATPIII) [18]:

- Waist circumference >102 cm (males)/>88 cm (females).
- Hyperlipidaemia: triglycerides ≥ 150 mg/dL or lipid-lowering therapy.
- HDL-C <40 mg/dL (males)/<50 mg/dL (females).
- Blood pressure $\geq 130/85$ mmHg or prior hypertension diagnosis or anti-hypertensive treatment.
- Fasting glycaemia ≥ 110 mg/dL or prior type I or type II diabetes diagnosis or antidiabetic treatment.

After the baseline medical assessment, a 365-day follow-up was carried out to evaluate SA episodes throughout that period. In Spain, SA is covered for both work-related and non-work-related injuries and diseases but with different regulations [19]. Classification as an occupational disease is constrained by a specific list of conditions for defined occupations, developed according to the influence of specific exposures [20]. Injuries that occurred when working or commuting are also considered work related. The remainder injuries and diseases are considered non-work related. Data of SA were obtained from the workers' Mutual Insurance Company official registers. Mutual insurance companies provide for health

care related to occupational injuries and diseases. They also collaborate with the National Social Security System in case management and distribution of economic support for both work-related and non-work-related SA episodes. Regarding dependent variables, the occurrence of sick leave episodes (yes; no) was the main outcome. The total count of SA days associated with the episodes initiated during the 1-year follow-up period was also documented. Both variables were assessed for SA of all causes, with differentiation made between work-related SA (SA caused by work injuries and occupational diseases) and non-work-related SA (SA due to non-occupational injuries and diseases).

Statistical analysis

Descriptive statistics were calculated for all variables. categorical data were expressed as percentages, and quantitative variables were expressed as means and standard deviations. The percentage of workers in each BMI group was calculated with adjustment for sex and age to accurately resemble the composition of the Spanish working-age population. In addition, differences among BMI groups in terms of demographic variables and metabolic phenotype, and each of its components, were tested. Pearson's chi-square test was used in the case of categorical variables. A one-way ANOVA was carried out to test differences in quantitative variables between BMI groups.

Incidence was defined as the percentage of workers who started at least one SA episode during the follow-up period. As mentioned above, incidence rates were separately obtained for all causes, work-related SA and non-work-related SA.

Finally, Poisson regression analyses (standard error correction) were performed to assess the association of the BMI group with the incidence of SA. Two different models were calculated: a crude model where BMI was the unique predictor and a model adjusted for workers' sex, age and occupation. The results are presented as rate ratios (RR) and their 95% confidence intervals (95% CIs).

Analyses regarding SA were conducted for the overall sample and subgroups on the basis of metabolic phenotype (metabolically healthy vs. unhealthy).

All statistical analyses were performed using IBM SPSS Statistics, version 22.

Ethical issues

Signed informed consent was obtained from all participants before enrolment in the ICARIA study, in accordance with the principles stated in the Declaration of Helsinki. The protocol was reviewed and approved by the Ibermutuamur Ethics Committee.

Results

The sample consisted of 67.1% males and 49.2% blue collar workers. The mean age of the participants was 40.62 ± 21.91 years (Table 1). The percentages of workers who were overweight or obese were 37.7% and 16.3%, respectively, after adjustment for sex and age (Table 1). In both groups, there were higher percentages of men and blue collar workers, and the mean age was higher with regard to workers with normal weight ($p < 0.001$).

Table 2 shows the distribution of metabolic phenotypes, as well as the individual components, in the sample (Table 2). The percentage of workers with a metabolically unhealthy phenotype was 8.8%. The most prevalent component of the unhealthy phenotype was hypertension (36.2%), whereas fasting glycaemia ≥110 mg/dL, prior type I or type II diabetes diagnosis or antidiabetic treatment was the least frequent component (6.2%). There was an increase in the metabolically unhealthy phenotype and its components with increasing BMI ($p < 0.001$).

Tables 3 and 4 present the incidence of SA and total count of SA days during follow-up as a function of workers' BMI and metabolic phenotype. Overall, we observed an upward trend in all-cause SA incidence as BMI increased, both in the overall sample and in the metabolically healthy phenotype group ($p < 0.001$) (Table 3). The same groups also displayed higher total counts of SA days ($p > 0.001$) (Table 4). In addition, subjects with metabolically unhealthy phenotype also showed an increased incidence of non-work-related SA ($p = 0.035$) (Table 3).

Among subjects with metabolically healthy phenotype, BMI (35–39.9 kg/m^2 vs. 18.5–24.9 kg/m^2) remained associated with an increased risk of all-cause (RR = 1.42, 95% CI: 1.28–1.59), non-work-related (RR = 1.40, 95% CI: 1.25–1.57) and work-related (RR = 1.55, 95% CI: 1.38–1.74) SA, after adjusting regression models for sex, age and occupation (Table 5). Participants who were at the most severe obesity level with a metabolically healthy phenotype showed a lower risk of work-related SA (RR = 0.64, 95% CI: 0.44–0.92). For subjects with a metabolically unhealthy phenotype, a BMI of 35–39.9 kg/m^2 (RR = 1.43, 95% CI: 1.06–1.92) or ≥40 kg/m^2 (RR = 1.65, 95% CI: 1.14–2.39) was associated with an increased risk of non-work-related SA, while all ranges of obesity were significantly associated with a lower risk of work-related SA (Table 5).

Discussion

The current findings provide evidence of the relevance of obesity from the perspective of disease burden, especially in terms of SA. In our study, obesity was consistently associated with SA, in particular, in terms of increased incidence and duration of non-work-related SA. Workers' metabolic phenotype also played an important role. Metabolically unhealthy obese workers showed a higher risk for non-work-related SA than their metabolically healthy counterparts. Interestingly, compared to subjects with morbid obesity (BMI ≥ 40 kg/m^2) and a metabolically healthy phenotype, those who were merely obese (BMI 35–39.9 kg/m^2) with a metabolically unhealthy phenotype had a much greater likelihood of initiating a non-work-related SA episode than the others. Unexpectedly, subjects with morbid obesity and metabolically healthy

Table 1 Descriptive analysis of the sample. Distribution of workers by body mass index (BMI) range, sex, age and occupation.

Variable	n	%	% Adjusted[a]	% males	p-value[b]	% blue-collar	p-value[b]	Mean age (years)	Standard deviation	p-value[c]
<18.5 Kg/m^2	2324	1.3	1.6	19.7	<0.001	30.9	<0.001	34.28	9.00	<0.001
18.5–24.9 Kg/m^2	73 459	42.4	44.4	52.0		39.9		38.14	21.43	
25–29.9 Kg/m^2	68 509	39.6	37.7	79.6		53.9		42.23	25.74	
30–34.9 Kg/m^2	22 684	13.1	12.8	81.3		61.3		43.81	9.83	
35–39.9 Kg/m^2	4916	2.8	2.8	75.9		63.7		43.17	9.83	
≥40 Kg/m^2	1228	0.7	0.7	70.0		62.5		42.07	9.62	
Total	173 120	100	100	67.1		49.2		40.62	21.91	

[a] Adjusted percentage of the sample in each BMI range, adjusted by sex and age.
[b] Chi-squared test.
[c] One-way analysis of variance (ANOVA).

phenotype and subjects with overweight or obesity and metabolically unhealthy phenotype showed a lower risk of work-related SA. Although it has been previously suggested that subjects at a more advanced stage of obesity progression may be excluded from certain professional activities, leading to reduced incidence of occupational injuries and illnesses, such explanation needs further research [21].

Regarding the prevalence of morbid obesity, obesity and being overweight, current results are coherent with those in prior reports from the ICARIA study and confirm a sustained progression of the obesity epidemic in the Spanish working population [14]. Such increase could be, at least partially, a reflection of the changes currently affecting the demographic composition of Spanish workforce, i.e. decreasing rates of men, blue collar occupations and ageing of the working population [14]. In the case of overweight workers, the trend seems to be more stable, with even a slight reduction in the prevalence rate [14].

The finding of positive associations between obesity and increased incidence of non-work-related SA in both subjects with healthy and unhealthy phenotypes (although more intensive in the latter) could be due to multiple mechanisms [22–27]. The increased cardiometabolic risk associated with obesity would be the only factor among a wide variety of potential pathogenic mechanisms. Healthy obese subjects show higher odds of mobility limitation and disability than healthy normal-weight subjects [21]. In fact, a fourfold increase in the risk of suffering work-disabling musculoskeletal pain has been reported for workers who are overweight or obese [22]. This association could be explained by overload on bones, joints and soft tissues, which predispose individuals to musculoskeletal injuries [23]. In addition, obesity and mental disorders such as depression are often comorbid conditions [24]. Both obesity and depression are risk factors for one another and reciprocally modulate prognosis and treatment outcomes [24]. An increase in the prevalence of cardiovascular risk factors has been widely described for obese subjects [25]. Finally, obesity has been previously related to numerous types of cancer [26]. Overall, our findings are consistent with those reported in other studies that suggest that the functional consequences of obesity could precede metabolic disturbances [21,27].

There is an urgent need for the design and implementation of efficient measures for fighting against obesity in the workplace, especially considering the previously described increase in its prevalence [14]. When BMI is in the range of overweight or obese or there is a

Table 2 Distribution of metabolically unhealthy phenotype and its components in a sample of 173 120 workers, by body mass index (BMI) range.

Variable	n[a]	<18.5 Kg/m^2	18.5–24.9 Kg/m^2	25–29.9 Kg/m^2	30–34.9 Kg/m2	35–39.9 Kg/m^2	≥40 Kg/m^2	Total	p-value[b]
Unhealthy metabolic phenotype	15 179	0.1	1.0	7.7	28.4	44.0	46.1	8.8	<0.001
Fasting glycaemia ≥110 mg/dL, prior type I or type II diabetes diagnosis, or antidiabetic treatment	7440	0.8	2.2	6.5	14.6	20.9	24.7	6.2	<0.001
Hyperlipidaemia: triglycerides ≥150 mg/dL or lipid-lowering therapy	30 648	1.9	7.5	21.9	34.1	38.2	34.4	17.7	<0.001
HDL-cholesterol <40 mg/dL (males)/<50 mg/dL (females)	28 946	6.5	9.8	19.0	28.2	34.6	38.8	16.7	<0.001
Blood pressure ≥130/85 mmHg, or prior hypertension diagnosis, or antihypertensive treatment	62 586	8.7	21.2	42.7	58.9	68.3	69.3	36.2	<0.001
Waist circumference >102 cm (males)/>88 cm (females)	27 669	0.2	1.4	12.0	57.5	87.3	87.5	16.0	<0.001

[a] n: number of subjects meeting the criteria in the sample of 173 120 workers.
[b] Chi-squared test.

Table 3 Incidence of sickness absence during 1-year follow-up in a sample of 173 120 workers, by body mass index (BMI) range and metabolic phenotype (metabolically healthy vs. unhealthy).

Body Mass Index	n	All-causes sickness absence			Non-work-related sickness absence			Work-related sickness absence		
		Number of workers with at least 1 sickness absence episode	%[a]	p-value[b]	Number of workers with at least 1 sickness absence episode	%[a]	p-value[b]	Number of workers with at least 1 sickness absence episode	%[a]	p-value[b]
Overall sample										
<18.5 Kg/m^2	2324	140	6.0	<0.001	128	5.5	<0.001	19	0.8	<0.001
18.5–24.9 Kg/m^2	73 459	5017	6.8		4243	5.8		976	1.3	
25–29.9 Kg/m^2	68 509	5472	8.0		4305	6.2		1410	2.1	
30–34.9 Kg/m^2	22 684	1908	8.4		1473	6.5		553	2.4	
35–39.9 Kg/m^2	4916	513	10.4		414	8.4		136	2.8	
≥40 Kg/m^2	1228	126	10.3		112	9.1		22	1.8	
Total	173 120	13 176	7.6		10 675	6.2		3116	1.8	
Metabolically healthy										
<18.5 Kg/m^2	2322	140	6.0	<0.001	128	5.5	<0.001	19	0.8	<0.001
18.5–24.9 Kg/m^2	72 692	4944	6.8		4193	5.8		947	1.3	
25–29.9 Kg/m^2	63 262	4986	7.9		3929	6.2		1284	2.0	
30–34.9 Kg/m^2	16 252	1333	8.2		1034	6.4		380	2.3	
35–39.9 Kg/m^2	2751	300	10.9		237	8.6		86	3.1	
≥40 Kg/m^2	662	62	9.4		55	8.3		9	1.4	
Total	157 941	11 765	7.4		9576	6.1		2725	1.7	
Metabolically unhealthy										
<18.5 Kg/m^2	2	0	–	0.454	0	–	0.035	0	–	0.283
18.5–24.9 Kg/m^2	767	73	9.5		50	6.5		29	3.8	
25–29.9 Kg/m^2	5247	486	9.3		376	7.2		126	2.4	
30–34.9 Kg/m^2	6432	575	8.9		439	6.8		173	2.7	
35–39.9 Kg/m^2	2165	213	9.8		177	8.2		50	2.3	
≥40 Kg/m^2	566	64	11.3		57	10.1		13	2.3	
Total	15 179	1411	9.3		1099	7.2		391	2.6	

[a] Incidence: Percentage of workers with at least one sickness absence episode during follow-up among workers in each Body Mass Index Group.
[b] Chi-squared test.

Table 4 Total count of sickness absence days associated with episodes initiated during the 1-year follow-up in a sample of 173 120 workers, by body mass index (BMI) range and metabolic phenotype (metabolically healthy vs. unhealthy).

Body Mass Index	All-causes sickness absence			Non-work-related sickness absence			Work-related sickness absence		
	Mean	Standard deviation	p-value[a]	Mean	Standard deviation	p-value[a]	Mean	Standard deviation	p-value[a]
Overall sample									
<18.5 Kg/m^2	23.91	39.10	<0.001	22.95	39.27	<0.001	21.58	22.32	0.251
18.5–24.9 Kg/m^2	38.88	79.52		38.32	82.38		33.25	53.64	
25–29.9 Kg/m^2	44.41	88.84		44.52	92.39		36.41	63.77	
30–34.9 Kg/m^2	48.34	93.41		47.99	96.58		38.97	67.26	
35–39.9 Kg/m^2	46.49	93.63		43.18	95.57		43.90	67.65	
≥40 Kg/m^2	42.55	61.88		40.51	58.09		37.45	50.55	
Total	42.72	85.77		42.18	88.60		36.12	61.38	
Metabolically healthy									
<18.5 Kg/m^2	23.91	39.10	<0.001	22.95	39.27	<0.001	21.58	22.32	0.524
18.5–24.9 Kg/m^2	38.86	79.58		38.31	82.39		33.27	53.79	
25–29.9 Kg/m^2	43.62	87.85		43.36	90.71		36.69	65.40	
30–34.9 Kg/m^2	46.17	94.11		45.22	95.96		38.92	70.38	
35–39.9 Kg/m^2	39.39	73.49		35.66	74.22		39.13	55.35	
≥40 Kg/m^2	41.89	63.21		40.24	61.66		42.67	58.24	
Total	41.56	84.39		40.87	86.78		35.80	61.83	
Metabolically unhealthy									
<18.5 Kg/m^2			0.699			0.707			0.402
18.5–24.9 Kg/m^2	40.26	76.06		39.88	81.92		32.59	49.48	
25–29.9 Kg/m^2	52.53	98.12		56.65	107.81		33.57	43.90	
30–34.9 Kg/m^2	53.37	91.65		54.50	97.81		39.08	60.01	
35–39.9 Kg/m^2	56.49	115.70		53.26	117.76		52.12	84.76	
≥40 Kg/m^2	43.19	61.05		40.77	54.98		33.85	46.66	
Total	52.41	96.02		53.66	102.38		38.32	58.19	

[a] One-way analysis of variance (ANOVA).

Table 5 Association between body mass index (BMI) range and the risk of starting a sickness absence episode during 1-year follow-up in a sample of 173 120 workers, by metabolic phenotype (metabolically healthy vs. unhealthy). Poisson regression analysis (standard error correction).

Body Mass Index	All-causes sickness absence				Non-work-related sickness absence				Work-related sickness absence			
	Crude RR[a]	95% CI[b]	RR[a] adjusted by sex, age, and occupation	95% CI[b]	Crude RR[a]	95% CI[b]	RR[a] adjusted by sex, age, and occupation	95% CI[b]	Crude RR[a]	95% CI[b]	RR[a] adjusted by sex, age, and occupation	95% CI[b]
Metabolically healthy												
<18.5 Kg/m^2	0.88	0.78–1.00	1.05	0.84–1.38	0.95	0.85–1.08	1.06	0.92–1.23	0.63	0.52–0.76	1.09	0.44–0.92
18.5–24.9 Kg/m^2	1		1		1		1		1		1	
25–29.9 Kg/m^2	1.17	1.13–1.20	1.02	0.98–1.06	1.08	1.05–1.11	1.01	0.97–1.05	1.57	1.51–1.62	1.07	1.02–1.12
30–34.9 Kg/m^2	1.21	1.16–1.27	1.03	0.97–1.09	1.10	1.05–1.16	1.01	0.95–1.08	1.80	1.72–1.90	1.13	1.06–1.20
35–39.9 Kg/m^2	1.65	1.51–1.79	1.42	1.28–1.59	1.52	1.39–1.67	1.40	1.25–1.57	2.43	2.21–2.66	1.55	1.38–1.74
≥40 Kg/m^2	1.38	1.15–1.67	1.08	0.84–1.38	1.47	1.22–1.76	1.18	0.92–1.51	0.93	0.70–1.25	0.64	0.44–0.92
Metabolically unhealthy												
<18.5 Kg/m^2												
18.5–24.9 Kg/m^2	1		1		1		1		1		1	
25–29.9 Kg/m^2	0.97	0.79–1.18	1.03	0.80–1.33	1.11	0.90–2.15	1.24	0.94–1.63	0.62	0.51–0.75	0.57	0.45–0.73
30–34.9 Kg/m^2	0.93	0.76–1.13	0.97	0.76–1.25	1.05	0.85–1.29	1.15	0.87–1.51	0.70	0.58–0.84	0.63	0.50–0.80
35–39.9 Kg/m^2	1.13	0.92–1.38	1.08	0.82–1.42	1.27	1.01–1.59	1.43	1.06–1.92	0.60	0.48–0.75	0.48	0.37–0.64
≥40 Kg/m^2	1.22	0.94–1.60	1.24	0.87–1.76	1.63	1.24–2.15	1.65	1.14–2.39	0.59	0.43–0.81	0.60	0.41–0.88

[a] RR: rate ratio.
[b] 95% CI: 95% confidence interval.

significant increase in a worker's BMI, a more detailed evaluation of the case is recommended, with the purpose of finding a successful strategy to prevent further disability [17]. In relation to this, a trial aimed to test the impact of an intervention program to reduce obesity and its associated consequences among Danish healthcare workers has been performed [28]. In this occupational group, obesity could be an important mediator of SA, as it may produce relevant limitations for jobs with high physical workload [26]. However, despite the fact that the intervention program was able to reduce obesity incidence, the authors did not find any positive effects on attendance and absenteeism [29]. Health promotion at work programs could be essential to diminish obesity epidemics among workers and the resulting impact on SA; however, there is a need for new high-quality randomised clinical trials to accurately determine the effectiveness of these programs [30].

The main strengths of current study are its prospective design and the fact that the variables under consideration were objectively assessed. To our knowledge, this research is the first to include metabolic phenotype as a moderating factor for the association between obesity and SA. In contrast with prior studies, which estimated weight and height by subjects' self-reporting, we used objective and standardised anthropometric measurements, and SA was evaluated from official registers [4,5,7,8]. In addition, contrary to the studies that focussed exclusively on specific occupational groups [9], the ICARIA cohort widely represented all occupations, activity sectors and demographic groups that represent the Spanish working population [15]. Finally, the current study considered all types of SA, without focusing uniquely on a limited group of illnesses [10,11].

Our analysis was also subject to certain limitations, including the fact that there are large geographical and cultural differences in relevant variables that affect health (e.g. low cardiovascular risk countries or Mediterranean diet); therefore, the results obtained are not generalisable to the global working population. In addition, our study did not include all the variables potentially involved in the association between obesity, metabolic phenotype and SA (e.g. physical activity) [25].

In conclusion, our results suggest that obesity is associated with an increase in SA incidence. Furthermore, metabolic phenotype is also relevant with regard to this, although cardiometabolic risk does not seem to be a unique factor involved in such an association. Future research should delve deeper into the mechanisms underlying the observed increase in SA in patients with a high BMI, and more importantly, it should facilitate the design of successful interventions to reduce obesity incidence and the associated SA among the working population.

Funding

This study was funded by a research project grant (FIS PI12/02812) from the Health Institute Carlos III and the

Spanish Ministry of Economy and Competitiveness of Spain.

Conflict of interest

None declared.

Acknowledgements

The authors thank Joan Minguet, Katherine Smith and Helen Sims, from Institute for Research and Medicine Advancement, for the editorial assistance provided in the preparation of this manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.numecd.2018.12.005.

References

[1] World Health Organization (WHO). Non communicable diseases country profiles 2018. Geneva: WHO; 2018.
[2] Forouzanfar MH, Alexander L, Anderson HR, Bachman VF, Biryukov S, Brauer M, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2015;386:2287–323.
[3] Howard JT, Potter LB. An assessment of the relationships between overweight, obesity, related chronic health conditions and worker absenteeism. Obes Res Clin Pract 2014;8:e1–15.
[4] Nigatu YT, Roelen CA, Reijneveld SA, Bültmann U. Overweight and distress have a joint association with long-term sickness absence among Dutch employees. J Occup Environ Med 2015;57:52–7.
[5] Su W, Huang J, Chen F, Iacobucci W, Mocarski M, Dall TM, et al. Modeling the clinical and economic implications of obesity using microsimulation. J Med Econ 2015;18:886–97.
[6] Kirkham HS, Clark BL, Bolas CA, Lewis GH, Jackson AS, Fisher D, et al. Which modifiable health risks are associated with changes in productivity costs? Popul Health Manag 2015;18:30–8.
[7] Roos E, Laaksonen M, Rahkonen O, Lahelma E, Lallukka T. Weight change and sickness absence–a prospective study among middle-aged employees. Eur J Public Health 2015;25:263–7.
[8] Sanchez Bustillos A, Vargas 3rd KG, Gomero-Cuadra R. Work productivity among adults with varied Body Mass Index: results from a Canadian population-based survey. J Epidemiol Glob Health 2015;5:191–9.
[9] Bhojani FA, Tsai SP, Wendt JK, Koller KL. Simulating the impact of changing trends in smoking and obesity on productivity of an industrial population: an observational study. BMJ Open 2014;4:e004788.
[10] Hansen ML, Thulstrup AM, Juhl M, Kristensen JK, Ramlau-Hansen CH. Predictors of sickness absence in pregnancy: a Danish cohort study. Scand J Work Environ Health 2015;41:184–93.
[11] de Azevedo JW, de Oliveira AB, Nascimento Vd, de Paiva Jr HR, Viecili L, Rocha MA. Profile of patients on sick leave with carpal tunnel syndrome. Acta Ortopédica Bras 2015;23:244–6.
[12] Lehnert T, Stuhldreher N, Streltchenia P, Riedel-Heller SG, König HH. Sick leave days and costs associated with overweight and obesity in Germany. J Occup Environ Med 2014;56:20–7.
[13] Andreyeva T, Luedicke J, Wang YC. State-level estimates of obesity-attributable costs of absenteeism. J Occup Environ Med 2014;56:1120–7.
[14] Goday A, Calvo E, Vázquez LA, Caveda E, Margallo T, Catalina-Romero C, et al. Prevalence and clinical characteristics of metabolically healthy obese individuals and other obese/non-obese metabolic phenotypes in a working population: results from the Icaria study. BMC Publ Health 2016;16:248.
[15] Sánchez-Chaparro MA, Román-García J, Calvo-Bonacho E, Gómez-Larios T, Fernández-Meseguer A, Sáinz-Gutiérrez JC, et al. Prevalence of cardiovascular risk factors in the Spanish working population. Rev Esp Cardiol 2006;59:421–30.
[16] Sánchez Chaparro MA, Calvo Bonacho E, González Quintela A, Cabrera M, Sáinz JC, Fernández-Labander C, et al. ICARIA (Ibermutuamur CArdiovascular RIsk asessment) study group. High cardiovascular risk in Spanish workers. Nutr Metabol Cardiovasc Dis 2011;21:231–6.
[17] Calvo-Bonacho E, Ruilope LM, Sánchez-Chaparro MA, Cerezo C, Catalina-Romero C, Martínez-Muñoz P, et al. Influence of high cardiovascular risk in asymptomatic people on the duration and cost of sick leave: results of the ICARIA study. Eur Heart J 2014;35:299–306.
[18] Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. International diabetes federation task force on epidemiology and prevention; hational heart, lung, and blood Institute; American heart association; world heart federation; international atherosclerosis society; international association for the study of obesity. Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood Institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. Circulation 2009;120:1640–5.
[19] Ministry of Labor, Migration and Social Security. Real Decreto Legislativo 8/2015, de 30 de octubre, por el que se aprueba el texto refundido de la Ley General de la Seguridad Social. Spanish Official State Gazette; 2015 Oct 31. n. 261 [accessed 1 october 2018], https://www.boe.es/boe/dias/2015/10/31/pdfs/BOE-A-2015-11724.pdf.
[20] Ministry of Labor, Migration and Social Security. Real Decreto 1299/2006, de 10 de noviembre, por el que se aprueba el cuadro de enfermedades profesionales en el sistema de la Seguridad Social y se establecen criterios para su notificación y registro. Spanish Official State Gazette; 2006 Dec 19. n. 302 [accessed 1 october 2018], https://www.boe.es/buscar/pdf/2006/BOE-A-2006-22169-consolidado.pdf.
[21] Ropponen A, Silventoinen K, Koskenvuo M, Svedberg P, Kaprio J. Stability and change of body mass index as a predictor of disability pension. Scand J Publ Health 2016;44:369–76.
[22] Bell JA, Sabia S, Singh-Manoux A, Hamer M, Kivimäki M. Healthy obesity and risk of accelerated functional decline and disability. Int J Obes (Lond) 2017;41:866–72.
[23] Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. Musculoskeletal disorders associated with obesity: a biomechanical perspective. Obes Rev 2006;7:239–50.
[24] Jantaratnotai N, Mosikanon K, Lee Y, McIntyre RS. The interface of depression and obesity. Obes Res Clin Pract 2017;11:1–10.
[25] Lavie CJ, De Schutter A, Parto P, Jahangir E, Kokkinos P, Ortega FB, et al. Obesity and prevalence of cardiovascular diseases and prognosis-The obesity paradox updated. Prog Cardiovasc Dis 2016;58:537–47.
[26] Dobbins M, Decorby K, Choi BC. The association between obesity and cancer risk: a meta-analysis of observational studies from 1985 to 2011. ISRN Prev Med 2013:680536.
[27] Donini LM, Merola G, Poggiogalle E, Lubrano C, Gnessi L, Mariani S, et al. Disability, physical inactivity, and impaired health-related quality of life are not different in metabolically healthy vs. unhealthy obese subjects. Nutrients 2016;8:759.
[28] Christensen JR, Faber A, Ekner D, Overgaard K, Holtermann A, Søgaard K. Diet, physical exercise and cognitive behavioral training as a combined workplace based intervention to reduce body weight and increase physical capacity in health care workers - a randomized controlled trial. BMC Publ Health 2011;11:671.
[29] Christensen JR, Overgaard K, Hansen K, Søgaard K, Holtermann A. Effects on presenteeism and absenteeism from a 1-year workplace randomized controlled trial among health care workers. J Occup Environ Med 2013;55:1186–90.
[30] van der Starre RE, Coffeng JK, Hendriksen IJ, van Mechelen W, Boot CR. Associations between overweight, obesity, health measures and need for recovery in office employees: a cross-sectional analysis. BMC Publ Health 2013;13:1207.