Meta- and Pooled Analyses

The Association Between Obesity and Low Back Pain: A Meta-Analysis

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This meta-analysis assessed the association between overweight/obesity and low back pain. The authors systematically searched the Medline (National Library of Medicine, Bethesda, Maryland) and Embase (Elsevier, Amsterdam, the Netherlands) databases until May 2009. Ninety-five studies were reviewed and 33 included in the meta-analyses. In cross-sectional studies, obesity was associated with increased prevalence of low back pain in the past 12 months (pooled odds ratio (OR) = 1.33, 95% confidence interval (CI): 1.14, 1.54), seeking care for low back pain (OR = 1.56, 95% CI: 1.46, 1.67), and chronic low back pain (OR = 1.43, 95% CI: 1.28, 1.60). Compared with nonoverweight people, overweight people had a higher prevalence of low back pain but a lower prevalence of low back pain compared with obese people. In cohort studies, only obesity was associated with increased incidence of low back pain for ≥1 day in the past 12 months (OR = 1.53, 95% CI: 1.22, 1.92). Results remained consistent after adjusting for publication bias and limiting the analyses to studies that controlled for potential confounders. Findings indicate that overweight and obesity increase the risk of low back pain. Overweight and obesity have the strongest association with seeking care for low back pain and chronic low back pain.

incidence; overweight; prevalence; publication bias; referral and consultation

Abbreviation: BMI, body mass index.

Obesity is a growing public health concern. Globally, the number of overweight or obese people is dramatically increasing (1). Obesity contributes substantially to the burden of chronic medical conditions, and these medical conditions place a high economic burden on the health care systems (1).

Low back pain is also a common health problem (2). It is a common cause of work-related disability and sickness absence (3). In the general population, the 1-month prevalence of low back pain ranges from 30% to 40% (3, 4); the annual prevalence of low back pain ranges from 25% to 60% (3–5) and of chronic low back pain from 10% to 13% (6, 7). Low back pain is more common in women than in men (4, 8).

The association between obesity and low back pain remains controversial. Few reviews on the relation between obesity and low back pain have been published so far. Five of them were nonsystematic, including only 6–8 studies (9–12) or only studies published between 2000 and March 2006 (13). The only known systematic review reported inconsistent results regarding the link between weight-related factors and low back pain (14). None of these reviews performed a meta-analysis or reported evidence of a temporal relation between obesity and low back pain.

Our aim was to provide a systematic literature review of the association between overweight/obesity and low back pain and to estimate the magnitude of such an association using meta-analysis. To address causality of associations, cross-sectional and cohort studies were analyzed separately.

MATERIALS AND METHODS

Search strategy

Studies of interest were identified by searches of the Medline (National Library of Medicine, Bethesda, Maryland) and Embase (Elsevier, Amsterdam, the Netherlands) databases from 1966 until May 2009 using predefined keywords (Web Table 1; this information is described in the first of

4 supplementary tables, each referred to as "Web table" in the text and posted on the *Journal*'s website (http://aje.oupjournals.org/)). In addition to overweight/obesity, which is the focus of this review, our search covered a larger set of cardiovascular or lifestyle risk factors, such as smoking, physical activity/inactivity, hypertension, dyslipidemia, diabetes, and inflammatory factors (15–17). Our search was limited to human populations. All languages were accepted. We excluded reviews, case reports, letters, editorials, guidelines, and comments. We also searched the reference lists of included studies.

Study selection

Two authors independently examined all titles and abstracts. We scrutinized the full text of relevant papers and determined whether they met the inclusion criteria. We included original articles on human populations with a cohort, case-control, or cross-sectional design. Studies focusing solely on clinical populations, case-control studies with controls derived from the patient populations, studies with a sample size of less than 30, and studies with a response rate of less than 60% or not reported were excluded (Figure 1). We also excluded studies on specific back disorders (16), musculoskeletal or spinal pain without specification to the back, the prognosis of low back pain, and height only.

Quality assessment

Two reviewers independently assessed the quality of the studies by using a modification of the Cochrane quality criteria for systematic assessment of nonexperimental studies (18). Disagreements were solved through discussion.

We assessed the occurrence and severity of 4 possible sources of bias: selection, performance, detection, and attrition (Web Table 2). Studies with any definite biases were excluded from our review. Only those studies with no or minor selection bias were included in the meta-analysis.

Meta-analysis

We used cutpoints recommended by the World Health Organization for body mass index (BMI) and defining overweight as a BMI of 25–29.9 kg/m^2 and obesity as a BMI of $\geq$30 kg/m^2 (19, 20). Because a number of studies did not distinguish between overweight and obesity, we also conducted meta-analyses for overweight/obesity, defining BMI as $\geq$25 kg/m^2. In addition, studies of adults that reported an estimated BMI of $\geq$24 kg/m^2 for overweight/obesity or BMI of >28.5 kg/m^2 for obesity were included in the meta-analyses. Studies of adolescents that defined overweight or obesity by using internationally acceptable age- and sex-specific cutpoints for BMI (21) were also included in the meta-analyses.

Studies that reported a risk estimate (odds ratio or relative risk) for overweight or obesity were eligible for the meta-analysis. A minimum requirement was adjustment for age and gender. A study was also chosen if the study population was of either gender, represented a narrow age group, or included stratified analysis by age and gender. We contacted the authors of the studies that reported only unadjusted risk estimates, did not use World Health Organization–recommended cutpoints for BMI, or did not report gender-specific results. Of 12 contacted authors, 7 (22–28) provided additional gender-specific confounder-adjusted results.
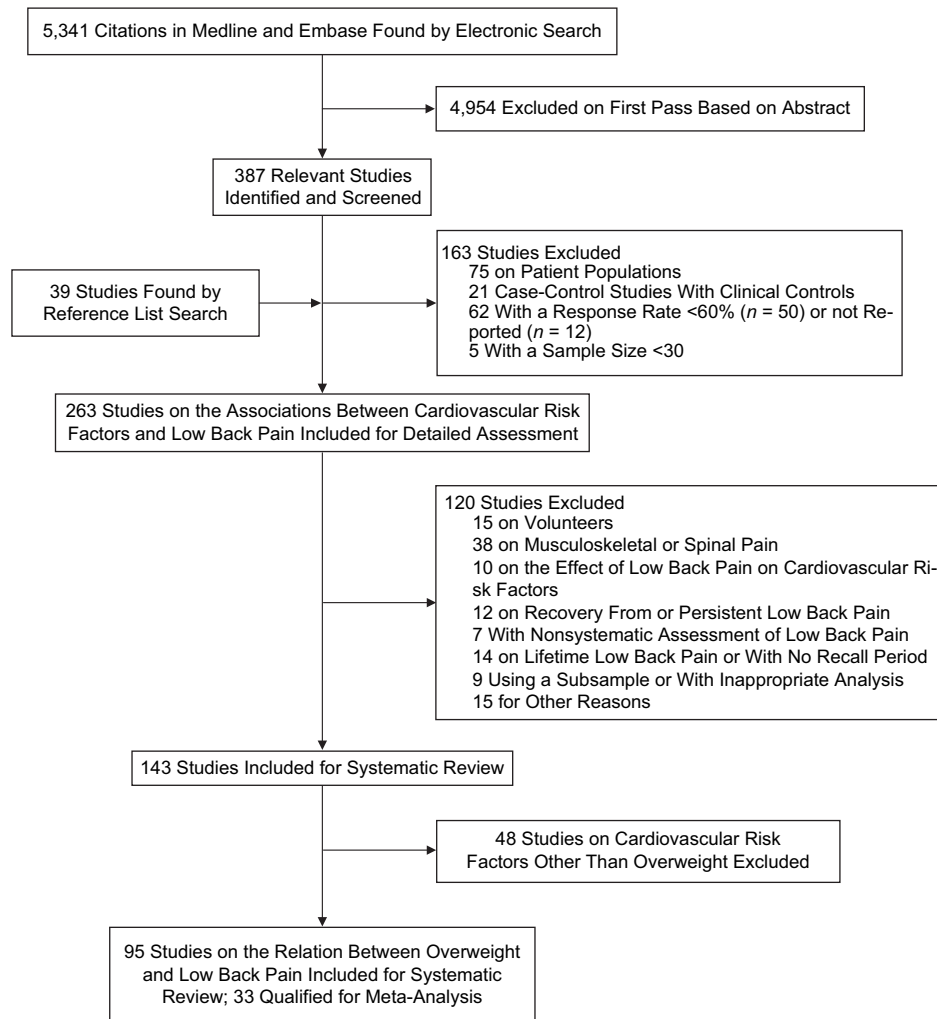
We used combinable low back pain outcomes suggested by the Meta-Analysis of Pain in the Lower Back and Work Exposures (MAPLE) collaborative group (29). Chronic low back pain was defined as pain that lasts for longer than 7–12 weeks (3) or pain experienced for more than 30 days in the past 12 months (29). Disabling low back pain was defined as recurrent or continuous low back pain of a moderate to severe degree or low back pain with functional impairment. Prevalent low back pain was defined on the basis of cross-sectional studies and incident low back pain on the basis of cohort studies.

We pooled the odds ratios of low back pain for the BMI subgroups to obtain an overall estimate for overweight/obesity. We also pooled the odds ratios of low back pain for the study population subgroups to obtain an estimate for the total study population. We calculated a new odds ratio of low back pain for overweight or obese subjects for studies that used underweight as a reference category and compared normal, overweight, or obese people with underweight subjects (24, 30–33). For these studies, we calculated the standard error from the natural logarithm of the odds ratio and confidence intervals, divided the odds ratio of overweight or obesity by the odds ratio of normal weight, and then estimated new confidence intervals for the obtained odds ratios.

We conducted random-effects meta-analyses. Random-effects meta-analysis assumes that there are real differences between individual studies regarding the magnitude of the association between overweight/obesity and low back pain. It considers both between-study and within-study variability. The random-effects model usually produces a confidence interval wider than the fixed-effect model does. Results from a random-effects model are usually more conservative than those of a fixed-effect model (18).

Heterogeneity was assessed by the Cochran's chi-square (Q test) and I^2 statistic (34, 35). Heterogeneity is any kind of variability in the association between overweight/obesity and low back pain among different studies. Significant heterogeneity shows that this variability is not due to chance alone. Testing for heterogeneity may be insensitive to true between-study variability for certain study characteristics. Values of the I^2 statistic range from 0% to 100% and show the proportion of total variation across studies not due to chance. Values of 25%, 50%, and 75% correspond to low, moderate, and high heterogeneity, respectively (35).

The small-study effect and the effect of low-quality studies were assessed by cumulative meta-analysis and by subgroup analysis. For cumulative meta-analysis, the studies were ranked in descending order first by the tools used for anthropometry (measured vs. self-reported weight and height), second by the presence or absence of detection or attrition bias, and third by sample size.

5,341 Citations in Medline and Embase Found by Electronic Search

4,954 Excluded on First Pass Based on Abstract

387 Relevant Studies Identified and Screened

39 Studies Found by Reference List Search

163 Studies Excluded
  75 on Patient Populations
  21 Case-Control Studies With Clinical Controls
  62 With a Response Rate <60% (*n* = 50) or not Reported (*n* = 12)
  5 With a Sample Size <30

263 Studies on the Associations Between Cardiovascular Risk Factors and Low Back Pain Included for Detailed Assessment

120 Studies Excluded
  15 on Volunteers
  38 on Musculoskeletal or Spinal Pain
  10 on the Effect of Low Back Pain on Cardiovascular Risk Factors
  12 on Recovery From or Persistent Low Back Pain
  7 With Nonsystematic Assessment of Low Back Pain
  14 on Lifetime Low Back Pain or With No Recall Period
  9 Using a Subsample or With Inappropriate Analysis
  15 for Other Reasons

143 Studies Included for Systematic Review

48 Studies on Cardiovascular Risk Factors Other Than Overweight Excluded

95 Studies on the Relation Between Overweight and Low Back Pain Included for Systematic Review; 33 Qualified for Meta-Analysis

Figure 1.   Flowchart of the search strategy and selection of studies to assess the association between obesity and low back pain.

Publication bias was examined with funnel plots. A funnel plot is a scatter plot of studies included in the meta-analysis, with the magnitude of the overweight/obesity effect on the horizontal axis and the weight of the study, such as the inverse standard error or sample size, on the vertical axis. The funnel plot is based on the fact that precision in assessing the association between overweight/obesity and low back pain will increase as the sample size of studies increases. An asymmetrical appearance of dots in the funnel plot can be due to the presence of publication bias (36). Asymmetry of the funnel plots was assessed by using 3 statistical methods: the rank correlation method (Begg's test) (37), regression analysis (Egger's test) (38), and the trim and fill method (39). In the trim and fill method, we used the fixed-effect model for trimming and the random-effects model for filling to obtain the adjusted pooled estimates. We assessed publication bias for cross-sectional and cohort studies as well as for each low back pain outcome. Stata software (Stata Corporation, College

Station, Texas), versions 8.2 and 10, was used to perform the meta-analyses.

RESULTS

We identified 263 relevant study reports on the associations between cardiovascular risk factors and low back pain for detailed assessment (Figure 1). Of the relevant studies, 95 on the relation between overweight/obesity and low back pain were included in the systematic review (Web Tables 3 and 4). Of these 95, studies were excluded from the meta-analysis for the following reasons: selection bias (*n* = 16, Web Table 3), noncombinable outcome (only one study representing an outcome, e.g., recurrent low back pain, hospitalization due to low back pain, disability retirement due to back pain; *n* = 6) (40–45), focus on only weight without any report of an adjusted risk estimate (*n* = 8) (46–53), no report of unadjusted prevalence/incidence in subgroups of BMI or

Table 1. Association Between Overweight/Obesity and the Prevalence of Low Back Pain in the Past Month or Past 12 Months (Cross-Sectional Studies)

First Author (Reference No.)	Population	Country	Year	Sample, No.	BMI Cutpoint, kg/m²	Tool Used	OR	95% CI	Heterogeneity P	I²	95% CI	Detection or Attrition Bias
Low back pain in the past month												
Overweight or obesity (BMI ≥24)												
Adults												
Croft (30)	General	United Kingdom	1994	9,003	≥24.7	Measured	1.11	0.98, 1.25				1
Mutsui (107)	Occupational	Japan	1997	3,042	>24 m; >25 w	Self-report	1.03	0.87, 1.22				0
Leino-Arjas (108)	General	Finland	1998	7,544	≥24	Self-report	1.24	1.13, 1.36				1
Pooled				19,589			1.14	1.03, 1.27	0.11	54	0, 87	
Adolescents												
Watson (109)	Children	United Kingdom	2003	1,376	≥20.3	Measured	1.30	0.98, 1.73				0
Pooled (adults + adolescents)				20,965			1.16	1.05, 1.27	0.17	39	0, 79	
Overweight or obesity (BMI ≥27)												
Schneider (110)	General	Germany	2005	3,488	≥27.3 m; ≥27.8 w	Measured	1.24	1.05, 1.46				0
Croft (30)	General	United Kingdom	1994	9,003	>27.3	Measured	1.15	0.95, 1.38				1
Leino-Arjas (108)	General	Finland	1998	7,544	≥27	Self-report	1.24	1.07, 1.42				1
Pooled				20,035			1.22	1.11, 1.34	0.79	0	0, 90	
Low back pain in the past 12 months												
Overweight												
Shiri (92)	General	Finland	2008	2,515	25–29.9	Measured	1.00	0.80, 1.24				0
Leino-Arjas (93)	Occupational	Finland	2006	901	25–29.9	Measured	1.34	0.92, 1.95				0
Leboeuf-Yde (111)	Twins	Denmark	1998	29,424	25–29.0	Self-report	1.30	1.20, 1.40				0
Miranda (23)	Occupational	Finland	2008	3,609	25–29.9	Self-report	1.30	1.12, 1.50				0
Karahan (28)	Occupational	Turkey	2009	1,600	25–29.9	Self-report	1.24	0.93, 1.65				0
Raanaas (27)	Occupational	Norway	2008	801	25–29.9	Self-report	1.00	0.70, 1.41				0
Wright (112)	General	United Kingdom	1995	24,000	25–29.9 m; 23.8–28.5 w	Self-report	1.20	1.12, 1.28				1
Pooled				62,850			1.23	1.15, 1.31	0.23	25	0, 67	
Adolescents												
Hestbaek (24)	Twins	Denmark	2006	9,497	Age and gender specific	Self-report	1.12	0.95, 1.33				0
Pooled (adults + adolescents)				72,347			1.22	1.14, 1.29	0.24	24	0, 65	

							OR	95% CI			
Overweight or obesity											
Adults											
Shiri (92)	General	Finland	2008	2,515	≥25	Measured	1.07	0.88, 1.31			0
Leino-Arjas (93)	Occupational	Finland	2006	901	≥25	Measured	1.55	1.12, 2.13			0
Strine (94)	General	United States	2007	29,828	≥25	Self-report	1.20	1.10, 1.30			0
Leboeuf-Yde (111)	Twins	Denmark	1998	29,424	≥25	Self-report	1.27	1.18, 1.36			0
Miranda (23)	Occupational	Finland	2008	3,609	≥25	Self-report	1.29	1.14, 1.47			0
Karahan (28)	Occupational	Turkey	2009	1,600	≥25	Self-report	1.23	0.94, 1.62			0
Raanaas (27)	Occupational	Norway	2008	801	≥25	Self-report	1.05	0.80, 1.37			0
Ozguler (32)	Occupational	France	2000	680	>24.9	Self-report	1.66	1.03, 2.68			0
Wright (112)	General	United Kingdom	1995	24,000	≥25 m; ≥23.8 w	Self-report	1.30	1.23, 1.37			1
Pooled				93,358			1.26	1.20, 1.32	0.26	20	0, 61
Adjusted for publication bias							1.25	1.19, 1.32			
Adolescents											
Sjolie (113)	Children	Norway	2004	88	>20.4	Measured	3.40	1.20, 9.30			0
Hestbaek (24)	Twins	Denmark	2006	9,497	Age and gender specific	Self-report	1.15	0.99, 1.34			0
Pooled (adults + adolescents)				102,943			1.25	1.18, 1.32	0.13	34	0, 67
Adjusted for publication bias							1.24	1.17, 1.32			
Obesity											
Shiri (92)	General	Finland	2008	2,515	≥30	Measured	1.28	0.95, 1.72			0
Leino-Arjas (93)	Occupational	Finland	2006	901	≥30	Measured	2.25	1.23, 4.12			0
Leboeuf-Yde (111)	Twins	Denmark	1998	29,424	>29	Self-report	1.10	0.90, 1.30			0
Miranda (23)	Occupational	Finland	2008	3,609	≥30	Self-report	1.28	0.99, 1.64			0
Karahan (28)	Occupational	Turkey	2009	1,600	≥30	Self-report	1.17	0.62, 2.20			0
Raanaas (27)	Occupational	Norway	2008	801	≥30	Self-report	1.13	0.74, 1.72			0
Wright (112)	General	United Kingdom	1995	24,000	>29.9 m; >28.5 w	Self-report	1.55	1.40, 1.71			1
Pooled				62,850			1.32	1.12, 1.56	0.02	60	9, 83
Adolescents											
Hestbaek (24)	Twins	Denmark	2006	9,497	Age and gender specific	Self-report	1.36	0.88, 2.10			0
Pooled (adults + adolescents)				72,347			1.33	1.14, 1.54	0.03	54	0, 79

Abbreviations: BMI, body mass index; CI, confidence interval; m, men; OR, odds ratio; w, women.

Table 2. Association Between Overweight/Obesity and the Prevalence of Seeking Care for Low Back Pain or Chronic Low Back Pain (Cross-Sectional Studies)

First Author (Reference No.)	Population	Country	Year	Sample, No.	BMI Cutpoint, kg/m^2	Tool Used	OR	95% CI	Heterogeneity P	Heterogeneity I^2	Heterogeneity 95% CI	Detection or Attrition Bias
Seeking care for low back pain												
Overweight												
Calza (114)	General	Italy	2008	115,019	25–29.9	Self-report	1.32	1.24, 1.40				0
Wright (112)[a]	General	United Kingdom	1995	24,000	25–29.9 m; 23.8–28.5 w	Self-report	1.24	1.14, 1.35				1
Leino-Arjas (108)	General	Finland	1998	7,544	24–26.9	Self-report	1.29	1.08, 1.54				1
Pooled				146,563			1.29	1.23, 1.36	0.50	0	0, 90	
Overweight or obesity												
Calza (114)	General	Italy	2008	115,019	≥25	Self-report	1.40	1.33, 1.47				0
Ozguler (32)	Occupational	France	2000	680	>24.9	Self-report	2.10	1.18, 3.72				0
Wright (112)[a]	General	United Kingdom	1995	24,000	≥25 m; ≥23.8 w	Self-report	1.35	1.26, 1.45				1
Leino-Arjas (108)	General	Finland	1998	7,544	≥24	Self-report	1.42	1.25, 1.62				1
Pooled				147,243			1.39	1.33, 1.45	0.41	0	0, 85	
Adjusted for publication bias							1.38	1.32, 1.46				
Obesity												
Torres (115)	General	United States	2006	6,038	≥30	Measured	1.50	1.20, 1.90				1
Calza (114)	General	Italy	2008	115,019	≥30	Self-report	1.56	1.43, 1.70				0
Wright (112)[a]	General	United Kingdom	1995	24,000	>29.9 m; >28.5 w	Self-report	1.59	1.40, 1.79				1
Pooled				145,057			1.56	1.46, 1.67	0.90	0	0, 90	
Chronic low back pain												
Overweight												
Adults												
Björck-van Dijken (26)	General	Sweden	2008	5,798	25–29.0	Measured	1.17	0.97, 1.40				0
Leboeuf-Yde (111)	Twins	Denmark	1998	29,424	25–29.0	Self-report	1.60	1.40, 1.80				0
Leclerc (22)	General	France	2008	15,534	25–29.9	Self-report	1.25	1.13, 1.39				0
Silva (31)	General	Brazil	2004	3,182	25–29.9	Self-report	1.12	0.50, 2.52				0
Pooled				53,938			1.33	1.11, 1.58	0.009	74	28, 91	
Adolescents												
Hestbaek (24)	Twins	Denmark	2006	9,608	24–28.9	Self-report	1.41	0.82, 2.43				0
Pooled (adults + adolescents)				63,546			1.33	1.14, 1.56	0.02	66	11, 87	
Overweight or obesity												
Adults												
Björck-van Dijken (26)	General	Sweden	2008	5,798	≥25	Measured	1.22	1.05, 1.40				0
Leboeuf-Yde (111)	Twins	Denmark	1998	29,424	≥25	Self-report	1.62	1.45, 1.80				0
Leclerc (22)	General	France	2008	15,534	≥25	Self-report	1.31	1.21, 1.43				0
Silva (31)	General	Brazil	2004	3,182	≥25	Self-report	1.34	0.75, 2.41				0
Ozguler (32)	Occupational	France	2000	680	>24.9	Self-report	1.64	0.83, 3.23				0
Pooled				54,618			1.39	1.20, 1.59	0.01	69	21, 88	

Reference	Population	Country	Year	No.ᵃ	BMI, kg/m²	BMI source	OR	95% CI	P	I²	I² 95% CI	
Adolescents												
Hestbaek (24)	Twins	Denmark	2006	9,608	≥24	Self-report	1.38	1.06, 1.79	0.02	62	6, 84	0
Pooled (adults + adolescents)				64,226			1.38	1.23, 1.56				
Obesity												
Adults												
Björck-van Dijken (26)	General	Sweden	2008	5,798	≥30	Measured	1.29	1.03, 1.62				0
Leboeuf-Yde (111)	Twins	Denmark	1998	29,424	>29	Self-report	1.70	1.20, 2.20				0
Leclerc (22)	General	France	2008	15,534	≥30	Self-report	1.44	1.24, 1.65				0
Silva (31)	General	Brazil	2004	3,182	≥30	Self-report	1.63	0.70, 3.83				0
Pooled				53,938			1.44	1.28, 1.61	0.54	0	0, 85	
Adjusted for publication bias							1.40	1.26, 1.55				
Adolescents												
Hestbaek (24)	Twins	Denmark	2006	9,608	≥29	Self-report	1.01	0.41, 2.49				0
Pooled (adults + adolescents)				63,546			1.43	1.28, 1.60	0.60	0	0, 79	

Abbreviations: BMI, body mass index; CI, confidence interval; m, men; OR, odds ratio; w, women.
ᵃ Sample size is approximate.

P value or risk estimate (*n* = 16) (54–69), reporting only an unadjusted *P* value (*n* = 4) (70–73), reporting only unadjusted prevalence of low back pain in subgroups of BMI (74) or only mean BMI in those with or without low back pain (75), reporting only an age- and gender-adjusted *P* value (76) or averaged odds ratios for overweight/obesity (77), reporting an unadjusted odds ratio (78), and noncombinable studies because of using different cutpoints for BMI (*n* = 6) (79–84). Finally, 33 studies qualified for the meta-analyses: 24 cross-sectional and 9 cohort (Tables 1–7).

Cross-sectional studies

Of the 24 cross-sectional studies, 11 provided measured data for weight and 10 for height. In the other 13 studies, information on weight and height was gathered by self-reports. Three of 24 studies had moderate detection bias, and one had possible attrition bias.

The meta-analyses of cross-sectional studies showed a statistically significant association between BMI and low back pain (Tables 1, 2, and 6). Compared with those of normal BMI, overweight and obese people had a higher prevalence of low back pain in the past 12 months, seeking care for low back pain, and chronic low back pain. The prevalence of low back pain in the past month was also higher among the overweight/obese (BMI cutoff ≥24 kg/m² or ≥27 kg/m²) compared with those of normal BMI. The association was stronger for obesity than for overweight. Overweight and obesity had a stronger association with seeking care for low back pain or chronic low back pain than low back pain in the past month or past 12 months.

Cohort studies

Of the 9 cohort studies, 3 provided measured data for weight and 2 for height. Four studies had possible attrition bias, and 1 study had both moderate detection and possible attrition bias.

The meta-analysis showed an association between obesity and the incidence of low back pain for at least a day in the past 12 months (pooled odds ratio = 1.53, 95% confidence interval: 1.22, 1.92) (Tables 3 and 6). Overweight was not associated with the incidence of low back pain. Overweight, but not obesity, was associated with sickness absence due to low-back disorder (pooled odds ratio = 1.35, 95% confidence interval: 1.02, 1.79) (Table 3).

Gender-specific analyses

In cross-sectional studies, for women, both overweight and obesity were associated with an increased prevalence of back pain in the past 12 months, seeking care for low back pain, and chronic low back pain (Tables 4, 5, and 7). For men, overweight and obesity were convincingly associated with seeking care for low back pain and chronic low back pain. Overweight/obesity (BMI cutoff ≥24 kg/m² or ≥27 kg/m²) was also associated with low back pain in the past month among women.

In cohort studies, for both men and women, obesity, but not overweight, was associated with an increased incidence of low back pain in the past 12 months (Tables 4, 5, and 7).

Table 3. Association Between Overweight/Obesity and the Incidence of Low Back Pain (Cohort Studies)

First Author (Reference No.)	Population	Country	Year	Sample, No.	BMI Cutpoint, kg/m²	BMI Tool Used	OR	95% CI	Heterogeneity P	Heterogeneity I²	Heterogeneity 95% CI	Detection or Attrition Bias
					Low back pain in the past 12 months							
Overweight												
Adults												
Leino-Arjas (93)	Occupational	Finland	2006	544	25–29.9	Measured	1.31	0.86, 1.98				0
Andersen (25)	Occupational	Denmark	2007	1,513	25–29.9	Self-report	1.07	0.74, 1.54				0
Van Nieuwenhuyse (116)	Occupational	Belgium	2009	322	25–29.9	Self-report	0.72	0.25, 2.12				0
Miranda (23)	Occupational	Finland	2008	1,676	25–29.9	Self-report	1.08	0.88, 1.33				1
Pooled				4,055			1.10	0.93, 1.30	0.72	0	0, 85	
Overweight or obesity												
Adults												
Leino-Arjas (93)	Occupational	Finland	2006	544	≥25	Measured	1.43	0.96, 2.13				0
Andersen (25)	Occupational	Denmark	2007	1,513	≥25	Self-report	1.19	0.88, 1.61				0
Van Nieuwenhuyse (116)	Occupational	Belgium	2009	322	≥25	Self-report	1.56	0.80, 3.05				0
Lake (117)	General	United Kingdom	2000	2,773	>70th percentile	Self-report	1.22	0.93, 1.61				1
Miranda (23)	Occupational	Finland	2008	1,676	≥25	Self-report	1.15	0.97, 1.37				1
Pooled				6,828			1.21	1.07, 1.37	0.81	0	0, 79	
Adjusted for publication bias							1.17	1.04, 1.32				
Adolescents												
Mustard (118)	Children	Canada	2005	1,039	≥70th percentile	Self-report	1.08	0.69, 1.69				2
Pooled (adults + adolescents)				7,867			1.20	1.06, 1.35	0.87	0	0, 75	
Adjusted for publication bias							1.19	1.06, 1.34				
Obesity												
Adults												
Leino-Arjas (93)	Occupational	Finland	2006	544	≥30	Measured	2.35	1.03, 5.35				0
Andersen (25)	Occupational	Denmark	2007	1,513	≥30	Self-report	1.48	0.87, 2.51				0
Van Nieuwenhuyse (116)	Occupational	Belgium	2009	322	≥30	Self-report	2.57	1.09, 6.09				0
Miranda (23)	Occupational	Finland	2008	1,676	≥30	Self-report	1.34	0.98, 1.84				1
Pooled				4,055			1.53	1.18, 1.98	0.37	4	0, 85	
Adjusted for publication bias							1.38	1.01, 1.90				

Source	Country	Year	No.	BMI category	Weight measurement	OR	95% CI			
Adolescents										
Mustard (118)	Canada	2005	1,039	>85th percentile	Self-report	1.61	0.94, 2.76			2
Pooled (adults + adolescents)			5,094			1.53	1.22, 1.92	0.53	0	0, 79
Adjusted for publication bias						1.43	1.13, 1.81			0
Sickness absence (≥1 day)										
Overweight										
Hemingway (33)	United Kingdom	1999	4,886	25–29.9	Measured	1.33	0.96, 1.85			
van den Heuvel (119)	The Netherlands	2004	629	25–29.9	Measured	1.41	0.82, 2.41			
Pooled			5,515			1.35	1.02, 1.79	0.85		1
Adjusted for publication bias						1.33	1.03, 1.71			
Obesity										
Hemingway (33)	United Kingdom	1999	4,886	≥30	Measured	0.99	0.63, 1.55			
van den Heuvel (119)	The Netherlands	2004	629	≥30	Measured	1.30	0.46, 3.62			
Pooled			5,515			1.03	0.68, 1.56	0.63		1
Adjusted for publication bias						0.99	0.67, 1.45			

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

Publication bias

The funnel plot of the 33 studies included in our meta-analysis of the association between overweight (14 studies) or obesity (19 studies) and any low back pain was asymmetrical (Figure 2). The results suggest that some medium-sized and small studies with negative or null findings were not published. Only Begg's test ($P = 0.01$), but not Egger's test ($P = 0.41$), showed evidence of publication bias. The trim and fill method imputed 7 missing studies.

In the design-specific analysis, the funnel plots for both cross-sectional and cohort studies were asymmetrical. However, neither Begg's ($P = 0.15$) nor Egger's ($P = 0.86$) tests showed evidence of publication bias for cross-sectional studies. Both Begg's ($P = 0.076$) and Egger's ($P = 0.057$) tests were significant for cohort studies. Three missing cross-sectional studies and 3 missing cohort studies were imputed by the trim and fill method.

Sensitivity analysis

Adjusting for publication bias had little effect on pooled estimates (Tables 1–3). Doing so attenuated the association between only obesity and the incidence of low back pain. Cumulative meta-analyses showed that the pooled estimates were not affected by the small or low-quality studies. Moreover, results remained consistent when the meta-analyses were restricted to those studies that controlled the obtained odds ratios for physical workload and/or psychosocial factors (Table 6).

Results of studies excluded from meta-analysis

Of 62 studies excluded from meta-analysis, 46 (33 cross-sectional and 13 cohort) showed no or minor selection bias. All cross-sectional studies except one (49), on recurrent low back pain, disabling low back pain, and seeking care for low back pain, showed a positive association between BMI or weight and low back pain (40, 41, 43, 45, 51, 62, 73). Of the remaining 25 cross-sectional studies on low back pain in the past month or past 12 months or chronic low back pain, 8 showed a positive association between BMI or weight and low back pain (46, 56, 74, 75, 77–79, 81). Seven studies reported a *P* value for the association between BMI or weight and low back pain in the past month or past 12 months; the pooled *P* value was not statistically significant for low back pain in the past month ($P = 0.09$, 5 studies) (46, 48, 70, 72, 82) or low back pain in the past 12 months ($P = 0.33$, 4 studies) (50, 70, 72, 76). Of 13 cohort studies excluded from meta-analysis, 3 showed a positive association (42, 44, 52) and 4 a nonsignificant association (64, 71, 83, 84). It was not possible to assess quantitatively the results of 10 cross-sectional and 6 cohort studies that did not report a *P* value, odds ratio, or even the prevalence/incidence of low back pain in the subgroups of BMI.

DISCUSSION

This meta-analysis shows that both overweight and obesity increase the risk of low back pain. Overweight and

Table 4.   Association Between Overweight/Obesity and Low Back Pain in Men

First Author (Reference No.)	Population	Country	Year	Sample, No.	BMI Cutpoint, kg/m²	BMI Tool Used	OR	95% CI	Heterogeneity P	Heterogeneity I²	Heterogeneity 95% CI	Detection or Attrition Bias
Cross-sectional studies: low back pain in the past month												
Overweight or obesity (BMI ≥24)												
Croft (30)	General	United Kingdom	1994	3,905	≥24.7	Measured	0.99	0.82, 1.20				1
Leino-Arjas (108)	General	Finland	1998	3,629	≥24	Self-report	1.12	0.98, 1.28				1
Matsui (107)	Occupational	Japan	1997	2,517	>25	Self-report	1.00	0.80, 1.20				1
Pooled				10,051			1.06	0.96, 1.65	0.48	0	0, 90	
Overweight or obesity (BMI ≥27)												
Schneider (110)	General	Germany	2005	1,997	≥27.8	Measured	1.08	0.87, 1.34				0
Croft (30)	General	United Kingdom	1994	3,905	>27.3	Measured	0.98	0.72, 1.35				1
Leino-Arjas (108)	General	Finland	1998	3,629	≥27	Self-report	1.06	0.87, 1.29				1
Pooled				9,531			1.05	0.92, 1.20	0.87	0	0, 90	
Cross-sectional studies: low back pain in the past 12 months												
Overweight												
Shiri (92)	General	Finland	2008	1,157	25–29.9	Measured	0.79	0.57, 1.09				0
Leino-Arjas (93)	Occupational	Finland	2006	608	25–29.9	Measured	1.51	0.96, 2.38				0
Hestbaek (24)	Twins	Denmark	2006	4,605	Age specific	Self-report	0.97	0.77, 1.22				0
Miranda (23)	Occupational	Finland	2008	2,678	25–29.9	Self-report	1.16	0.98, 1.37				0
Raanaas (27)	Occupational	Norway	2008	686	25–29.9	Self-report	0.85	0.59, 1.23				0
Karahan (28)	Occupational	Turkey	2009	500	25–29.9	Self-report	1.41	0.95, 2.08				0
Pooled				10,234			1.06	0.89, 1.27	0.06	53	0, 81	
Obesity												
Shiri (92)	General	Finland	2008	1,157	≥30	Measured	0.77	0.48, 1.23				0
Leino-Arjas (93)	Occupational	Finland	2006	608	≥30	Measured	2.46	1.17, 5.16				0
Hestbaek (24)	Twins	Denmark	2006	4,605	Age specific	Self-report	1.29	0.63, 2.55				0
Miranda (23)	Occupational	Finland	2008	2,678	≥30	Self-report	1.20	0.90, 1.60				0
Raanaas (27)	Occupational	Norway	2008	686	≥30	Self-report	1.02	0.65, 1.58				0
Karahan (28)	Occupational	Turkey	2009	500	≥30	Self-report	0.91	0.38, 2.16				0
Pooled				10,234			1.13	0.87, 1.47	0.18	34	0, 73	
Cross-sectional studies: seeking care for low back pain												
Overweight												
Mattila (120)	Conscripts	Finland	2008	7,040	25–29.9	Measured	1.10	0.90, 1.30				0
Calza (114)	General	Italy	2008	55,303	25–29.9	Self-report	1.26	1.15, 1.38				0
Pooled				63,029			1.21	1.06, 1.37	0.19			

Overweight or obesity												
Mattila (120)	Conscripts	Finland	2008	7,040	≥25	Measured	1.01	0.86, 1.18				0
Calza (114)	General	Italy	2008	55,303	≥25	Self-report	1.31	1.21, 1.41				0
Leino-Arjas (108)	General	Finland	1998	3,915	≥24	Self-report	1.21	1.01, 1.45				1
Pooled				66,258			1.18	1.00, 1.39	0.01	77	23, 93	
Obesity												
Mattila (120)	Conscripts	Finland	2008	7,040	>30	Measured	0.8	0.60, 1.10				0
Calza (114)	General	Italy	2008	55,303	≥30	Self-report	1.42	1.24, 1.62				0
Wright (112)[a]	General	United Kingdom	1995	10,600	>29.9	Self-report	1.91	1.54, 2.35				1
Pooled							1.32	0.89, 1.95	<0.001	91	75, 96	
Leino-Arjas (108)	General	Finland	1998	3,915	≥27	Self-report	1.27	0.98, 1.65				1
Pooled				76,858			1.31	0.98, 1.76	<0.001	86	67, 94	
Cross-sectional studies: chronic low back pain												
Overweight												
Björck-van Dijken (26)	General	Sweden	2008	2,850	25–29.9	Measured	1.05	0.80, 1.39				0
Leclerc (22)	General	France	2008	7,292	25–29.9	Self-report	1.21	1.05, 1.41				0
				10,142			1.17	1.03, 1.34	0.37			
Obesity												
Björck-van Dijken (26)	General	Sweden	2008	2,850	≥30	Measured	1.34	0.94, 1.90				0
Leclerc (22)	General	France	2008	7,292	≥30	Self-report	1.24	1.00, 1.54				0
				10,142			1.27	1.05, 1.52	0.71			
Cohort studies: low back pain in the past 12 months												
Overweight												
Leino-Arjas (93)	Occupational	Finland	2006	353	25–29.9	Measured	1.34	0.81, 2.22				0
Andersen (25)	Occupational	Denmark	2007	824	25–29.9	Self-report	0.81	0.49, 1.36				0
Miranda (23)	Occupational	Finland	2008	1,541	25–29.9	Self-report	1.33	1.02, 1.73				1
Pooled				2,718			1.19	0.89, 1.58	0.22	34	0, 78	
Overweight or obesity												
Leino-Arjas (93)	Occupational	Finland	2006	353	≥25	Measured	1.55	0.96, 2.50				0
Andersen (25)	Occupational	Denmark	2007	824	≥25	Self-report	0.95	0.60, 1.48				0
Miranda (23)	Occupational	Finland	2008	1,541	≥25	Self-report	1.30	1.03, 1.64				1
Pooled				2,718			1.26	1.02, 1.56	0.31	13	0, 91	
Obesity												
Leino-Arjas (93)	Occupational	Finland	2006	353	≥30	Measured	4.23	1.44, 12.45				0
Andersen (25)	Occupational	Denmark	2007	824	≥30	Self-report	1.32	0.61, 2.86				0
Miranda (23)	Occupational	Finland	2008	1,541	≥30	Self-report	1.22	0.78, 1.93				1
Elders (121)	Occupational	The Netherlands	2004	96	≥27	Self-report	1.97	0.91, 4.27				1
Pooled				2,814			1.66	1.04, 2.63	0.17	39	0, 79	

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.
[a] Sample size is approximate.

Table 5. Association Between Overweight/Obesity and Low Back Pain in Women

First Author (Reference No.)	Population	Country	Year	Sample, No.	BMI Cutpoint, kg/m²	Tool Used	OR	95% CI	P	I²	95% CI	Detection or Attrition Bias
Cross-sectional studies: low back pain in the past month												
Overweight or obesity (BMI ≥24)												
Erbay Dündar (122)	General	Turkey	2006	269	>25	Measured	3.80	1.70, 8.30				0
Croft (30)	General	United Kingdom	1994	5,098	≥24.7	Measured	1.20	1.02, 1.41				1
Mutsui (107)	Occupational	Japan	1997	525	>24	Self-report	1.30	0.80, 2.20				0
Leino-Arjas (108)	General	Finland	1998	3,915	≥24	Self-report	1.36	1.20, 1.55				1
Pooled				9,807			1.38	1.11, 1.72	0.03	64	0, 88	
Overweight or obesity (BMI ≥27)												
Schneider (110)	General	Germany	2005	1,491	≥27.3	Measured	1.51	1.16, 1.95				0
Croft (30)	General	United Kingdom	1994	5,098	>27.3	Measured	1.25	0.99, 1.58				1
Leino-Arjas (108)	General	Finland	1998	3,915	≥27	Self-report	1.44	1.18, 1.75				1
Pooled				10,504			1.40	1.22, 1.59	0.52	0	0, 90	
Cross-sectional studies: low back pain in the past 12 months												
Overweight												
Shiri (92)	General	Finland	2008	1,358	25–29.9	Measured	1.17	0.86, 1.58				0
Leino-Arjas (93)	Occupational	Finland	2006	293	25–29.9	Measured	1.02	0.52, 2.02				0
Hestbaek (24)	Twins	Denmark	2006	4,892	Age specific	Self-report	1.31	1.04, 1.66				0
Karahan (28)	Occupational	Turkey	2009	1,100	25–29.9	Self-report	1.13	0.74, 1.71				0
Miranda (23)	Occupational	Finland	2008	931	25–29.9	Self-report	1.92	1.40, 2.63				0
Raanaas (27)	Occupational	Norway	2008	115	25–29.9	Self-report	2.94	1.12, 7.72				0
Pooled				8,689			1.38	1.10, 1.72	0.09	47	0, 79	
Obesity												
Shiri (92)	General	Finland	2008	1,358	≥30	Measured	1.79	1.20, 2.67				0
Leino-Arjas (93)	Occupational	Finland	2006	293	≥30	Measured	1.90	0.68, 5.37				0
Hestbaek (24)	Twins	Denmark	2006	4,892	Age specific	Self-report	1.41	0.81, 2.44				0
Karahan (28)	Occupational	Turkey	2009	1,100	≥30	Self-report	1.65	0.60, 4.48				0
Miranda (23)	Occupational	Finland	2008	931	≥30	Self-report	1.56	0.93, 2.61				0
Raanaas (27)	Occupational	Norway	2008	115	≥30	Self-report	15.86	1.73, 145.0				0
Pooled				8,689			1.69	1.31, 2.18	0.47	0	0, 75	
Cross-sectional studies: seeking care for low back pain												
Overweight or obesity												
Calza (114)	General	Italy	2008	59,716	≥25	Self-report	1.47	1.37, 1.57				0
Leino-Arjas (108)	General	Finland	1998	3,629	≥24	Self-report	1.67	1.40, 2.00				1
Pooled				63,345			1.52	1.36, 1.71	0.19			

							OR	95% CI	P	I^2	I^2 CI	
Obesity												
Calza (114)	General	Italy	2008	59,716	≥30	Self-report	1.67	1.49, 1.87				0
Wright (112)[a]	General	United Kingdom	1995	13,400	>28.5	Self-report	1.40	1.20, 1.63				1
Leino-Arjas (108)	General	Finland	1998	3,629	≥27	Self-report	1.98	1.52, 2.58				1
Pooled				76,745			1.63	1.38, 1.92	0.05	66	0, 90	
Cross-sectional studies: chronic low back pain												
Overweight												
Björck-van Dijken (26)	General	Sweden	2008	2,948	25–29.9	Measured	1.27	0.99, 1.63				0
Leclerc (22)	General	France	2008	8,242	25–29.9	Self-report	1.29	1.12, 1.49				0
Pooled				11,190			1.29	1.13, 1.46	0.91			
Overweight or obesity												
Wijnhoven (123)	General	The Netherlands	2006	11,428	>25	Measured	1.01	0.87, 1.18				0
Björck-van Dijken (26)	General	Sweden	2008	2,948	≥25	Measured	1.27	1.04, 1.53				0
Leclerc (22)	General	France	2008	8,242	≥25	Self-report	1.40	1.25, 1.57				0
Pooled				22,618			1.22	0.99, 1.50	0.003	82	46, 94	
Obesity												
Björck-van Dijken (26)	General	Sweden	2008	2,948	≥30	Measured	1.26	0.94, 1.69				0
Leclerc (22)	General	France	2008	8,242	≥30	Self-report	1.60	1.33, 1.93				0
Pooled				11,190			1.46	1.16, 1.84	0.17			
Cohort studies: low back pain in the past 12 months												
Overweight												
Leino-Arjas (93)	Occupational	Finland	2006	191	25–29.9	Measured	1.24	0.60, 2.59				0
Andersen (25)	Occupational	Denmark	2007	824	25–29.9	Self-report	1.43	0.85, 2.39				0
Miranda (23)	Occupational	Finland	2008	538	25–29.9	Self-report	0.64	0.36, 1.13				1
Pooled				1,553			1.04	0.62, 1.74	0.10	55	0, 87	
Overweight or obesity												
Leino-Arjas (93)	Occupational	Finland	2006	191	≥25	Measured	1.21	0.60, 2.46				0
Andersen (25)	Occupational	Denmark	2007	824	≥25	Self-report	1.50	0.98, 2.80				0
Power (124)	General	United Kingdom	2001	2,273	>24.9	Self-report	1.78	1.07, 2.95				1
Miranda (23)	Occupational	Finland	2008	538	≥25	Self-report	0.79	0.50, 1.26				1
Pooled				3,826			1.25	0.85, 1.84	0.10	51	0, 84	
Obesity												
Leino-Arjas (93)	Occupational	Finland	2006	191	≥30	Measured	1.05	0.30, 3.77				0
Andersen (25)	Occupational	Denmark	2007	824	≥30	Self-report	1.64	0.80, 3.36				0
Miranda (23)	Occupational	Finland	2008	538	≥30	Self-report	1.21	0.54, 2.71				1
Pooled				1,553			1.37	0.83, 2.24	0.77	0	0, 90	

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] Sample size is approximate.

Table 6. Summary Pooled Odds Ratios of Low Back Pain for Overweight and Obesity[a]

	All					Studies That Controlled for Potential Confounders[b]				
	No. of Studies	Reference Nos.	Sample, No.	OR	95% CI	No. of Studies	Reference Nos.	Sample, No.	OR	95% CI
Prevalence (cross-sectional studies)										
Low back pain in the past month										
Overweight or obesity (BMI ≥24)	4	30, 107–109	20,965	1.16	1.05, 1.27					
Overweight or obesity (BMI ≥27)	3	30, 108, 110	20,035	1.22	1.11, 1.34	2	108, 110	16,547	1.24	1.11, 1.38
Low back pain in the past 12 months										
Overweight	8	23, 24, 27, 28, 92, 93, 111, 112	72,347	1.22	1.14, 1.29	4	23, 27, 28, 112	30,010	1.21	1.14, 1.29
Overweight or obesity	11	23, 24, 27, 28, 32, 92–94, 111–113	102,943	1.25	1.18, 1.32	5	23, 27, 28, 32, 112	30,690	1.29	1.23, 1.36
Obesity	8	23, 24, 27, 28, 92, 93, 111, 112	72,347	1.33	1.14, 1.54	4	23, 27, 28, 112	30,010	1.41	1.21, 1.64
Seeking care for low back pain										
Overweight	3	108, 112, 114	146,563	1.29	1.23, 1.36	2	108, 112	31,544	1.25	1.15, 1.35
Overweight or obesity	4	32, 108, 112, 114	147,243	1.39	1.33, 1.45	3	32, 108, 112	32,224	1.38	1.27, 1.51
Obesity	3	112, 114, 115	145,057	1.56	1.46, 1.67					
Chronic low back pain										
Overweight	5	22, 24, 26, 31, 111	63,546	1.33	1.14, 1.56	3	22, 26, 31	24,514	1.23	1.12, 1.35
Overweight or obesity	6	22, 24, 26, 31, 32, 111	64,226	1.38	1.23, 1.56	4	22, 26, 31, 32	25,194	1.29	1.20, 1.39
Obesity	5	22, 24, 26, 31, 111	63,546	1.43	1.28, 1.60	3	22, 26, 31	24,514	1.40	1.24, 1.58
Incidence (cohort studies)										
Low back pain in the past 12 months										
Overweight	4	23, 25, 93, 116	4,055	1.10	0.93, 1.30	2	23, 25	3,189	1.08	0.90, 1.29
Overweight or obesity	6	23, 25, 93, 116–118	7,867	1.20	1.06, 1.35	4	23, 25, 117, 118	7,001	1.17	1.03, 1.32
Obesity	5	23, 25, 93, 116, 118	5,094	1.53	1.22, 1.92	3	23, 25, 118	4,228	1.42	1.11, 1.81
Sickness absence (≥1 day)										
Overweight	2	33, 119	5,515	1.35	1.02, 1.79					
Obesity	2	33, 119	5,515	1.03	0.68, 1.56					

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] Overweight was defined as a BMI of 25–29.9 kg/m², obesity as a BMI of ≥30 kg/m², and overweight and obesity combined as a BMI of ≥25 kg/m².

[b] Studies that controlled the obtained estimates for at least age, gender, physical workload factors, and/or psychosocial factors.

Table 7. Summary Gender-specific Pooled Odds Ratios of Low Back Pain for Overweight and Obesity[a]

	Males					Females				
	No. of Studies	Reference Nos.	Sample, No.	OR	95% CI	No. of Studies	Reference Nos.	Sample, No.	OR	95% CI
Prevalence (cross-sectional studies)										
Low back pain in the past month										
Overweight or obesity (BMI ≥24)	3	30, 107, 108	10,051	1.06	0.96, 1.65	4	30, 107, 108, 122	9,807	1.38	1.11, 1.72
Overweight or obesity (BMI ≥27)	3	30, 108, 110	9,531	1.05	0.92, 1.20	3	30, 108, 110	10,504	1.40	1.22, 1.59
Low back pain in the past 12 months										
Overweight	6	23, 24, 27, 28, 92, 93	10,234	1.06	0.89, 1.27	6	23, 24, 27, 28, 92, 93	8,689	1.38	1.10, 1.72
Obesity	6	23, 24, 27, 28, 92, 93	10,234	1.13	0.87, 1.47	6	23, 24, 27, 28, 92, 93	8,689	1.69	1.31, 2.18
Seeking care for low back pain										
Overweight	2	114, 120	63,029	1.21	1.06, 1.37					
Overweight or obesity	3	108, 114, 120	66,258	1.18	1.00, 1.39	2	108, 114	63,345	1.52	1.36, 1.71
Obesity	4	108, 112, 114, 120	76,858	1.31	0.98, 1.76	3	108, 112, 114	76,745	1.63	1.38, 1.92
Chronic low back pain										
Overweight	2	22, 26	10,142	1.17	1.03, 1.34	2	22, 26	11,190	1.29	1.13, 1.46
Obesity	2	22, 26	10,142	1.27	1.05, 1.52	2	22, 26	11,190	1.46	1.16, 1.84
Incidence (cohort studies)										
Low back pain in the past 12 months										
Overweight	3	23, 25, 93	2,718	1.19	0.89, 1.58	3	23, 25, 93	1,553	1.04	0.62, 1.74
Overweight or obesity	3	23, 25, 93	2,718	1.26	1.02, 1.56	4	23, 25, 93, 124	3,826	1.25	0.85, 1.84
Obesity	4	23, 25, 93, 121	2,814	1.66	1.04, 2.63	3	23, 25, 93	1,553	1.37	0.83, 2.24

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.
[a] Overweight was defined as a BMI of 25–29.9 kg/m^2, obesity as a BMI of ≥30 kg/m^2, and overweight and obesity combined as BMI ≥25 kg/m^2.
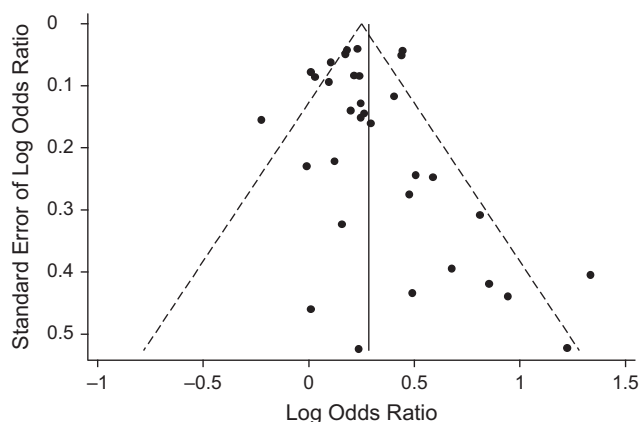
Figure 2. Funnel plot with pseudo 95% confidence limits for publication bias in studies of the association between overweight (14 studies) or obesity (19 studies) and low back pain.

obesity have the strongest association with seeking care for low back pain and chronic low back pain.

Most of the studies included in the meta-analysis controlled the obtained estimates for potential confounders, such as physical or psychosocial workload factors. Therefore, the observed association between overweight/obesity and low back pain is less likely due to potential confounders.

Our findings suggest that the association between overweight or obesity and the prevalence of low back pain is stronger for women than for men. The gender difference was less evident regarding the prevalence of seeking care for low back pain and chronic low back pain. Furthermore, we found no clear difference in the association between overweight or obesity and the incidence of low back pain in the cohort studies. The gender-related differences in the association of overweight or obesity with low back pain could be due to hormone-related obesity and associated changes in pain sensitivity (85). In addition, the association between overweight/obesity and low back pain could be related to differences in the distribution of body fat mass or to proportion of lean body mass (86). In men, high BMI may reflect high muscle mass; in women, it may indicate amount of adipose tissue. The slight gender difference in the association between obesity and the incidence of low back pain can be due to the small sample size of studies included in the gender-specific meta-analyses.

The reviewed studies had some major limitations. In many studies, the outcomes did not include information on the frequency and severity of low back pain. Different recall periods and different case definitions of low back pain were used. A limited number of prospective studies on the role of overweight/obesity in low back pain have been published. Furthermore, studies have used different cutpoints for overweight and obesity. Some did not use the World Health Organization–recommended BMI cutpoints to define overweight and obesity, defining overweight/obesity as a BMI of >24 kg/m^2 and obesity as a BMI of >27 kg/m^2 or >28.5 kg/m^2. These differences in the classification of overweight or obesity may have led to underestimation of

the strength of the association between overweight or obesity and low back pain.

We excluded studies on clinical populations and case-control studies that included clinical controls because clinical populations are usually selected in many ways that are difficult to control for. To avoid selection bias, we also excluded studies with a response rate of less than 60% ($n = 50$) or not reported ($n = 12$). Scrutiny of studies excluded from the meta-analysis showed that most of those that reported a quantitative result showed a positive association or a tendency for a positive association between BMI or weight and low back pain, supporting the results of our meta-analysis.

There may be a publication bias in favor of positive results between obesity and low back pain. Publication bias arises when studies showing a statistically significant positive association are more likely to be reported or published than studies with a negative or null association. Publication bias is more likely to affect small studies, which tend to show larger risk estimates than larger studies. Funnel plot asymmetry may be caused by a number of factors other than publication bias (38). Statistical methods for the assessment of publication bias are unable to distinguish publication bias from other causes of funnel plot asymmetry (87). In our meta-analyses, adjusting for publication bias had very little effect on the pooled estimates.

The majority of the reviewed studies were cross-sectional. Therefore, the association between obesity and low back pain could be bidirectional; that is, obesity may cause low back pain, or obesity can be a consequence of low back pain. Obesity is more likely in people who are sedentary during work or leisure activities. Low back pain could also lead to physical inactivity and hence to increased adiposity. Obesity and low back pain could also be comorbid conditions that share common risk factors.

The association between obesity and low back pain may be causal, since we observed it in both cross-sectional and cohort studies. Several possible mechanisms can explain this association. First, obesity could increase the mechanical load on the spine by causing a higher compressive force or increased shear on the lumbar spine structures during various activities. Obese people may also be more liable to incur accidental injuries (88). Second, obesity may cause low back pain through systemic chronic inflammation. Obesity is associated with increased production of cytokines and acute-phase reactants and with activation of proinflammatory pathways (89), which, in turn, may lead to pain (90). Third, population-based studies have shown a stronger association of abdominal obesity than generalized obesity with low back pain (91, 92). Other studies have reported the associations of hypertension and dyslipidemia with low back pain (93, 94). The metabolic syndrome may be involved in the pathomechanical pathway of low back pain because abdominal obesity, hypertension, and dyslipidemia are its components.

Fourth, obesity is associated with disc degeneration (95) and vertebral endplate (Modic) changes (96). Spinal mobility decreases with increasing body weight (97), which may interfere with disc nutrition. Obese people have increased serum levels of triglycerides and low density lipoprotein cholesterol and decreased levels of high density lipoprotein cholesterol

(98). Dyslipidemia plays a major role in the development of atherosclerosis in obese individuals (98). Atherosclerosis could cause malnutrition of the disc cells (99, 100), which may predispose to disc degeneration. People with severe disc degeneration are more likely to have low back pain (101).

There is little information on the prevention of low back pain with weight reduction via lifestyle modification. Among working subjects with hypertension, a lifestyle intervention did not affect low back pain in the total study group, even though it had significant favorable effects on weight, BMI, and physical activity (102). However, among those with jobs involving moderately heavy or heavy work, the lifestyle intervention reduced low back pain. There is also preliminary evidence that weight reduction after bariatric surgery may result in recovery from low back pain (103–106).

In summary, this meta-analysis shows that overweight and obesity are associated with an increased risk of low back pain. The association is strongest for seeking care for low back pain and chronic low back pain. Our study suggests that obesity is a potentially modifiable risk factor for low back pain. However, well-conducted prospective studies, including intervention studies, are needed to confirm our findings.

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