Association Between Overweight or Obesity and Lumbar Disk Diseases

A Meta-Analysis

Xian Xu, MD, Xu Li, MD, and Wei Wu, MD

Study Design: A meta-analysis.

Objective: We performed this meta-analysis to evaluate the association between overweight and lumbar disease.

Summary of Background Data: An extensive English language literature retrieval regarding the association between overweight and the risk of lumbar disease was conducted on Public Medline and Excerpta Medica Database until May 2014.

Methods: Meta-analysis for all the included literatures was performed by STATA 11.0 to summarize test performance with forest plots after heterogeneity test. Moreover, subgroup and sensitivity analyses were performed to examine the potential candidate effect factors. Afterward, the likelihood of publication bias was assessed by constructing funnel plots and performing Begg rank correlation test and Egger linear regression method.

Results: A total of 5 studies satisfied the predefined eligibility criteria, including 1749 cases with lumbar disk diseases and 1885 controls. Altogether, overweight was associated with increased risk of lumbar disease [odds ratio (OR) = 1.45; 95% confidence interval (CI), 1.27, 1.66; $P < 0.001$]. Moreover, subgroup analysis proved that overweight was a predominant factor in development of lumbar disease compared with age and sex. Although significant publication bias was observed in our meta-analysis, we proved high credibility of meta-analysis result using trim and fill method (OR = 1.27; 95% CI, 1.06, 1.53).

Conclusions: We suggest that overweight might increase the risk of lumbar diseases, and weight control should be considered for overweight or obese population to reduce the occurrence and development of lumbar disease.

Key Words: overweight, obesity, lumbar diseases, meta-analysis

(*J Spinal Disord Tech* 2015;28:370–376)

Overweight or obesity has become a significant public health issue around the world. In 2010, overweight and obesity were estimated to cause 3.4 million deaths, 3.9% of years of life lost, and 3.8% of disability-adjusted life-years worldwide.[1] Traditionally, disk degeneration is primarily due to insults and injuries related to physical loading and changes associated with the normal aging process.[2] Lumbar disk degeneration (LDD), lumbar disk herniation (LDH), and lumbar disk space narrowing (LDN) are recognized as common lumbar disk diseases.[3,4] It is reported that the prevalence of the disease ranged from 10% to >80% in the asymptomatic samples studied.[5]

The association between obesity and lumbar disk disease risk has been the focus in the past decade.[6] Obesity, as the most prevalent manifestation of metabolic syndrome, has been shown to be responsible for various diseases, such as type-2 diabetes, metabolic syndrome, cancer, and cardiovascular diseases.[7] However, available data from researches on the association between obesity and lumbar disk disease remains controversial. In a cross-sectional survey, overweight people seem to be strongly overrepresented among the patients requiring removal of lumbar intervertebral disk herniation.[8] A study by Takatalo et al[9] reported that the risk of LDD in abdominal obese males was significantly higher than that of normal males. However, Schumann et al[10] claimed that the association between overweight/obesity and LDH/LDN was not statistically significant. Similarly, Hassett et al[11] reported that they did not find a statistical significance in the correlation between obesity and LDD.

Therefore, given the conflicting opinion from previous studies on the association of obesity or overweight with lumbar disk diseases, we systematically reviewed the relationship of obesity and overweight with lumbar disk diseases by meta-analyzing relevant published studies with a careful reinvestigation strategy.

MATERIALS AND METHODS

Selection of Published Studies

We performed a systematic literature search for published articles through the database of Public Medline (PubMed) and Excerpta Medica Database (Embase) until May 2014 using the keywords: "lumbar disc" or "lumbar disc herniation" or "lumbar diseases" or "disc degeneration"

Received for publication August 2, 2014; accepted November 19, 2014.
From the Department of Trauma Surgery, East Hospital Affliliated Tongji University, Shanghai 200085, China.
X.X. and X.L. are the co-first authors.
The authors declare no conflict of interest.
Reprints: Wei Wu, MD, Department of Trauma Surgery, East Hospital Affliliated Tongji University, 150 Jimo Road, Pudong New District, Shanghai, China (e-mail: weiwuortho@hotmail.com).

in combination with "BMI" or "body mass index" or "overweight" or "obesity." The scope of article search was expanded according to the reference list of retrieved studies.

Selection Criteria and Quality Control

Studies were included in this meta-analysis if they met all of the following criteria: (1) case-control study or cohort study, where the case group was overweight or obese patients with lumbar diseases, whereas the control group was based on normal population; (2) literature about the correlation of overweight or obesity with lumbar diseases risk was published in English only; and (3) risk ratio or odds ratio (OR) and 95% confidence interval (CI) have been provided or could be obtained by calculation.

Articles were excluded with the following criteria: (1) duplicate of previous publication; (2) review, comment, letter, meeting abstract, or other kinds of literature; and (3) cross-section studies were excluded in our meta-analysis because the cross-sectional study is a type of observational study that provides data on the entire population without specific characteristics.

The quality evaluation of the included articles was carried out based on Newcastle-Ottawa Scale, which set a rigid standard of rating for case-control studies and cohort studies.[12] Both ratings consisted of 8 items, as shown in Table 1. In the scale, the item "control for important factor or additional factor" scored 2, and other items were all given 1 point. Thus, the total scores for the evaluation of each kind of study were all 9. A study was considered excellent if the score was >7; it was worse if the score was <7.

Data Extraction

All data were extracted independently by 2 reviewers according to the above selection criteria. The data were extracted using a standardized data extraction form, including the first authors' name, publication year, country, age and sex of the subjects, type of studies, measurement method for exposed factors, range of exposed factors, evaluation method for outcome, type of outcome, correction factor, and corrected OR and 95% CI. The extracted results of each reviewer were exchanged for examination after the process, and the difference was resolved by discussion with a third investigator.

Statistical Analysis

In this study, we used the body mass index (BMI) criterion recommended by World Health Organization (WHO) to screen overweight and obesity.[16,17] People with BMI in the range of 25–29.9 kg/m^2 were defined as overweight, and those with BMI $> 30\ kg/m^2$ were defined as obese. Although overweight and obesity were not well distinguished in several studies, we defined these people as excess body weight in our study.[13–15]

The meta-analysis was performed with OR and 95% CI obtained from the studies using STATA 11.0 (Stata Corporation, College Station, TX). The pooled OR and 95% CI were used to compare outcomes of individual

TABLE 1. Methodological Quality of Cohort/Case-Control Studies Included in the Meta-Analysis*

Cohort	First author	Selection of the								Total Quality Scores
		Representativeness of the Exposed Cohort	Unexposed Cohort	Ascertainment of Exposure	Outcome of Interest not Present at Start of Study	Control for Important Factor or Additional Factor†	Outcome Assessment	Follow-up Long Enough for Outcomes to Occur	Adequacy of Follow-up of Cohorts	
(1)	Takatalo et al[13]	*	*	*	*	*	*	*	—	7
(2)	Liuke et al[14]	—	*	—	*	**	*	*	*	7
(3)	Hassett et al[11]	*	*	*	—	*	*	*	*	8
Case-Control	First Author	Representativeness of the Cases	Case Definition Adequate	Ascertainment of Exposure	Same Method of Ascertainment for Cases and Controls	Control for Important Factor or Additional Factor2	Selection of Controls	Definition of Controls	Nonresponse rate	Total Quality Scores
(1)	Saftić et al[15]	*	*	—	*	*	*	*	*	7
(2)	Schumann et al[10]	*	*	—	*	**	*	—	*	7

*A study could be awarded a maximum of 1 star for each item, except for the item Control for important factor or additional factor.
†A maximum of 2 stars could be awarded for this item.

studies. Heterogeneity among studies was evaluated using the Q test and I^2 statistics.[18] Fixed effects model would be used when there was no heterogeneity among the included studies ($P \geq 0.05$ in Q statistical and $I^2 < 50\%$). Otherwise, the random effects model would be used ($P < 0.05$ and/or $I^2 \geq 50\%$).

To determine other potential factors that might influence the development of lumbar disk diseases, subgroup analyses were performed by calculating pooled OR and 95% CI and heterogeneity test based on exposure level, ascertainment of exposure, type of research, type of outcome, age at baseline, and sex. Subsequently, sensitivity analysis was used to evaluate the stability of this meta-analysis using the trim and fill method[19] and random effects model. Finally, the likelihood of publication bias was assessed by constructing funnel plots, Begg adjusted rank correlation test, and Egger linear regression method.[20,21] $P < 0.05$ was considered statistically significant publication bias both in Begg rank correlation method and Egger linear regression method.

RESULTS

Characteristics of the Studies

A flow chart describing the process of study selection is shown in Figure 1. First, a total of 358 articles were identified after the initial retrieval. Of these, 220 articles were retrieved from PubMed and 138 from Embase (Fig. 1). After reviewing the titles and abstracts, we excluded 89 duplicated articles and 258 papers that were not relevant. Among the last 11 articles, 6 articles were excluded, including 4 cross-sectional studies,[9,22–24] and 2 studies that did not provide available OR and 95% CI or enough details for calculating[25,26] after we further reviewed the full texts. Finally, 5 articles were included in this meta-analysis, including 2 case-control studies[10,15] and 3 cohort studies.[11,13,14]

The general characteristics of each study are provided in Table 2. The enrolled studies were all carried out in Europe, including 1749 cases with lumbar diseases and 1885 controls. Among the 17 subgroups in the 5 studies, 8 of them researched on the association between weight and LDD, 5 researched on LDH, and 4 were carried out on LDN. According to sex, 7 subgroups included males, 9 subgroups included females, and only 1 subgroup studied both males and females.

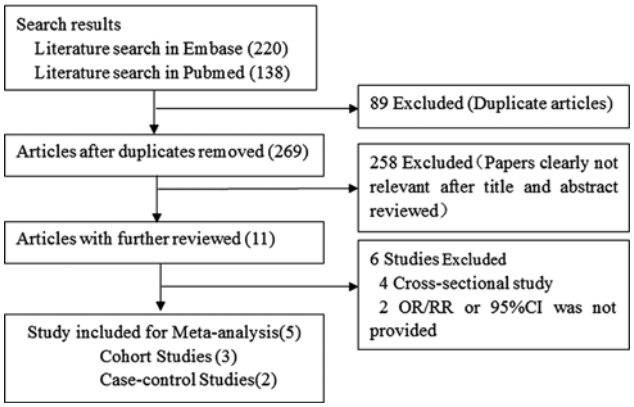

FIGURE 1. Flow diagram of study selection process.

The quality evaluation results of the enrolled studies, as shown in Table 2, show that all the 5 articles were of high quality as their scores were >7 points, which claimed that these literatures were suitable for meta-analysis with high quality.

Meta-Analysis of Association Between Body Weight and Risk of Lumbar Disk Disease

Heterogeneity among all the studies were not significant ($P = 0.166$, $I^2 = 25.0\%$), thus the fixed effects model was used for analysis. The results, as shown in Figure 2, indicate that overweight and obesity are highly associated with the occurrence of lumbar disk diseases (OR = 1.45; 95% CI, 1.27, 1.66).

To explore the potential factors that may influence the role of body weight on the risk of lumbar disk disease, we performed subgroup analyses based on the covariates, including weight, sex, age, ascertainment of exposure, type of outcome, and disease outcomes on the risk of lumbar disease. From Table 3, we found that all covariates in the 6 subgroups did not reverse the role of body weight in the lumbar disk disease.

Sensitivity Analyses and Publication Bias

To assess the effect of studies on the overall pooled ORs, a sensitivity analysis was conducted by repeating meta-analysis using the trim and fill method through the addition of 6 potential missing articles. The association of obesity or overweight with lumbar disk disease showed no significant change (OR = 1.27; 95% CI, 1.06, 1.53) after increasing the number of articles, indicating consistent increased risk of obesity or overweight in the occurrence of lumbar disk diseases. The same result was also proved by repeating the meta-analysis with a random effects model (OR = 1.50; 95% CI, 1.28, 1.76).

The funnel plots suggest significant publication bias in our meta-analysis (Fig. 3). The Begg adjusted rank correlation test ($P = 0.015$) and Egger linear regression test ($P = 0.008$) also show the same results.

DISCUSSION

Given the controversial point on the association of obesity or overweight with lumbar disk diseases, we performed the research by meta-analyzing relevant published studies with a careful reinvestigation strategy. Results suggested that obesity and overweight were highly associated with an increased risk of lumbar diseases, including LDD, LHD, and LHN. Moreover, subgroup analyses convincingly showed that overweight was more likely associated with the occurrence of lumbar disk disease compared with age and sex. Although significant publication bias was observed in meta-analysis, the whole article was proved to be reliable by the results of quality evaluation and sensitivity analysis.

TABLE 2. Characteristics of Included Studies on Overweight/Obesity and Lumbar Diseases

References	Location	Type of Study	Ascertainment of Exposure	Ascertainment of Outcome	Case/N	Age (y)/Sex	Outcome	Adjusted ORs (95% CI)	Exposure Range	Adjustment for Covariates
Takatalo et al[13]	Finland	Cohort	Physical examinations	MRI	301/558	19/M	LDD	2.22 (1.14, 4.33)	Overweight and obesity	Crude
						F		1.09 (0.61, 1.92)		
Saftić et al[15]	Croatia	Case-control	Self-reported	Medical records	67/335	≥40/M and F	LDH	2.77 (1.05, 4.49)	Overweight and obesity	Age, sex, and village of residence/immigrant status
Liuke et al[14]	Finland	Cohort	Self-reported	MRI	70/129	25/M	LDD	3.8 (1.4, 10.4)	Overweight and obesity	Occupation, smoking, and back accidents
						40–45/M		1.3 (0.7, 2.7)		
Schumann et al[10]	Germany	Case-control	Self-reported	CT, MRI	915/1816	25–70/M	LDH	2.1 (1.3, 3.6)	Overweight	Age, region, and cumulative physical workload (or BMI and smoking)
								1.6 (0.7, 3.8)	Obesity	
						F		1.3 (0.8, 1.9)	Overweight	
								2.0 (1.1, 3.7)	Obesity	
				X-rays		25–70/M	LDN	1.2 (0.6, 2.3)	Overweight	Age, region, body building, whole-body vibrations, and psychosocial workload (or BMI)
								2.3 (0.9, 5.9)	Obesity	
						F		1.7 (1.0, 2.7)	Overweight	
								1.5 (0.7, 3.1)	Obesity	
Hassett et al[11]	UK	Cohort	Physical examination	Radiographs	148/796	Mean 53.8/F	LDD-DSN	1.0 (0.7, 1.6)	Overweight	Age
								1.3 (0.7, 2.3)	Obesity	
					248/796		LDD-AO	1.1 (0.8, 1.5)	Overweight	
								1.5 (0.9, 2.4)	Obesity	

AO indicates anterior vertebral osteophytes; CI, confidence interval; CT, computerized tomography; DSN, disk space narrowing; F, female; LDD, lumbar disk degeneration; LDH, lumbar disk herniation; LDN, lumbar disk narrowing; M, male; MRI, magnetic resonance imaging; NA, not available; OR, odds ratio.

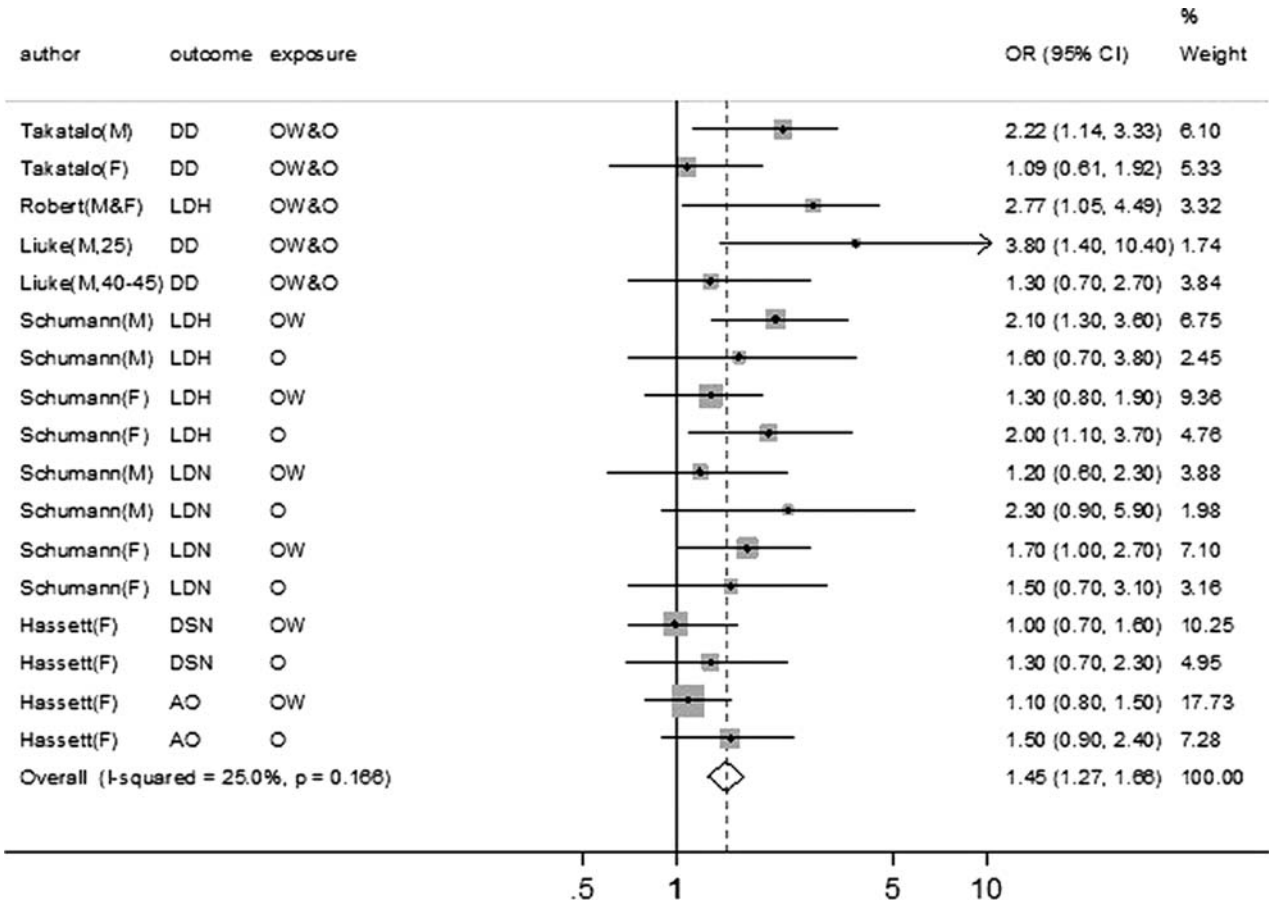

FIGURE 2. Forest plot (fixed effects model) of the association of overweight and obesity with the risk of lumbar disk disease. AO indicates anterior vertebral osteophytes; CI, confidence interval; DD, lumbar disk degeneration; DSN, disk space narrowing; F, female; LDH, lumbar disk herniation; LDN, lumbar disk narrowing; M, male; O, obesity; OR, odds ratio; OW, overweight.

Degeneration of the intervertebral disk is a complex and multifactorial process.[27] Different factors such as sex, age, obesity, arteriosclerosis, genetic heritability, environmental factors, and smoking have been suggested to be influencing variables in degenerative disk disease.[28–30] The present study based on observational data demonstrated an increased risk of lumbar disk diseases with obesity and overweight. The inclusion of age, sex, and BMI may result in a more complete evaluation, therefore further subgroup analyses were conducted in our study. Moreover, the results from subgroup analyses suggested the absolute predominance of body weight compared with sex and age. In addition, males are more likely to be affected by lumbar disk disease compared with females, and population below 50 years of age is more likely to develop lumbar disk diseases in the subgroup analyses. Of course, further clinical evidences for the results are needed to be explored.

Many studies have proved that biomechanics, atherosclerotic, and inflammation processes might contribute to the potential association between obesity and the risk of lumbar disk disease. First, the physical load on the lumbar disks caused by overweight would result in mechanical damage of the spine[31] and histologic degenerative abnormalities in lumbar disks.[32] Second, high levels of cholesterol and other blood lipids associated with overweight might enhance atherosclerotic processes in lumbar vessels and thus cause insufficient supply to lumbar disks.[31] Third, elevated serum levels of C-reactive protein, interleukin-6, tumor necrosis factor-α, and leptin, known as markers of inflammation, in overweight and obese individuals might be the common link between overweight or obesity and LDD.[33,34] Das and colleagues claimed that overweight or obesity could induce a low-grade systemic inflammatory state and further caused or accelerated LDD.[33,35] Besides, increased free insulin-like growth factor 1, free sex hormones, and insulin in overweight or obesity patients were well known to stimulate bone formation.[36] These results suggested that lumbar diseases may be caused by the dysregulation of these hormones influenced by overweight or obesity.

Although we designed our research based on a rigorous systematic procedure, some limitations should be

TABLE 3. Subgroup Analyses of Overweight/Obesity and the Risk of Lumber Disease

Group	No. Studies	OR (95% CI)	Heterogeneity Test		Significance Test (*P*)
			P	I^2 (%)	
All studies	17	1.45 (1.27, 1.66)	0.166	25.0	< 0.001
Exposure					
Overweight	6	1.28 (1.07, 1.53)	0.207	30.4	0.007
Obesity	6	1.61 (1.23, 2.10)	0.894	0.0	0.001
Excess body weight	5	1.81 (1.35, 2.42)	0.095	49.4	< 0.001
Ascertainment of exposure					
Self-reported	11	1.71 (1.42, 2.07)	0.553	0.0	< 0.001
Examinations	6	1.24 (1.03, 1.50)	0.226	27.9	0.020
Type of research					
Cohort	8	1.29 (1.08, 1.54)	0.177	39.4	0.004
Case-control	9	1.70 (1.39, 2.08)	0.680	0.0	< 0.001
Type of outcome					
LDD	8	1.29 (1.08, 1.54)	0.117	39.4	0.004
LHD	5	1.78 (1.37, 2.29)	0.398	1.4	< 0.001
LHN	4	1.58 (1.14, 2.20)	0.715	0.0	0.006
Age at baseline (y)					
< 50	8	1.67 (1.35, 2.05)	0.272	19.9	< 0.001
≥ 50	9	1.32 (1.12, 1.57)	0.278	18.5	0.001
Sex					
Male	7	1.87 (1.45, 2.41)	0.467	0.0	< 0.001
Female	9	1.28 (1.09, 1.50)	0.593	0.0	0.002
Male and female	1	2.77 (1.34, 5.73)	—	—	0.006

CI indicates confidence interval; LDD, lumbar disk degeneration; LDH, lumbar disk herniation; LDN, lumbar disk narrowing; OR, odds ratio.

noted. First, differences in operational definitions and judgments of degenerative changes made by the assessors might be responsible for much of the variation, which may have an impact on the results for correlations between overweight or obesity and lumbar disk diseases. Second, the BMI of subjects involved in some studies is self-reported, which may magnify the association of BMI with the development of lumbar disk diseases. Although we have used the BMI criterion recommended by WHO to screen overweight and obesity, overweight and obesity were not well distinguished in several studies. Finally, incomprehensive coverage of information of the current analysis is another limitation. All studies were conducted in Europe in this analysis. Surveys on people in other regions should also be carried out to test the generality of the results.

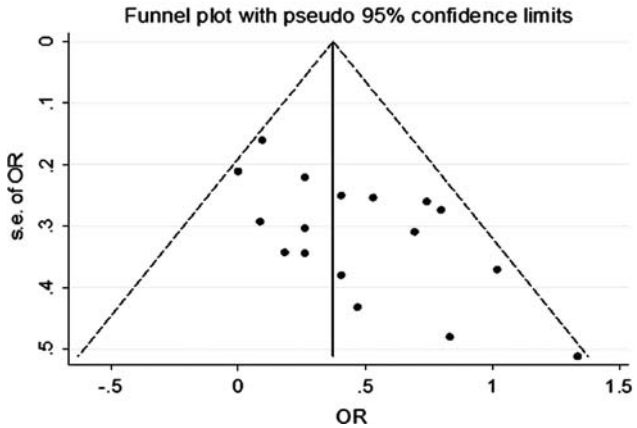

FIGURE 3. Funnel plots of the included subgroups. OR indicates odds ratio.

In conclusion, overweight and obesity are highly associated with increased risk of lumbar disk diseases, and weight control may be an effective measure to prevent lumbar lesions, although the specific mechanisms are still not clear. Further researches are still needed to explore the extent of the damage associated with overweight and whether body weight control could prevent the occurrence of lumbar disk diseases among obese and overweight population.

REFERENCES

1. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384:766–781.
2. Battie MC, Videman T. Lumbar disc degeneration: epidemiology and genetics. *J Bone Joint Surg Am*. 2006;88(suppl 2):3–9.
3. Battié MC, Videman T, Parent E. Lumbar disc degeneration: epidemiology and genetic influences. *Spine*. 2004;29:2679–2690.
4. Suk K-S, Lee H-M, Moon S-H, et al. Recurrent lumbar disc herniation: results of operative management. *Spine*. 2001;26:672–676.
5. Battie MC, Videman T, Parent E. Lumbar disc degeneration: epidemiology and genetic influences. *Spine (Phila Pa 1976)*. 2004; 29:2679–2690.
6. Heliovaara M. Body height, obesity, and risk of herniated lumbar intervertebral disc. *Spine (Phila Pa 1976)*. 1987;12:469–472.
7. Ellery C, Weiler H, Hazell T. Physical activity assessment tools for use in overweight and obese children. *Int J Obes*. 2013;1:1–10.
8. Bostman OM. Prevalence of obesity among patients admitted for elective orthopaedic surgery. *Int J Obes Relat Metab Disord*. 1994; 18:709–713.
9. Takatalo J, Karppinen J, Taimela S, et al. Association of abdominal obesity with lumbar disc degeneration–a magnetic resonance imaging study. *PLoS One*. 2013;8:e56244.
10. Schumann B, Bolm-Audorff U, Bergmann A, et al. Lifestyle factors and lumbar disc disease: results of a German multi-center case-control study (EPILIFT). *Arthritis Res Ther*. 2010;12:R193.

11. Hassett G, Hart DJ, Manek NJ, et al. Risk factors for progression of lumbar spine disc degeneration: the Chingford Study. *Arthritis Rheum*. 2003;48:3112–3117.
12. Wells G, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. 2011; Available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.
13. Takatalo J, Karppinen J, Taimela S, et al. Body mass index is associated with lumbar disc degeneration in young Finnish males: subsample of Northern Finland birth cohort study 1986. *BMC Musculoskelet Disord*. 2013;14:87.
14. Liuke M, Solovieva S, Lamminen A, et al. Disc degeneration of the lumbar spine in relation to overweight. *Int J Obes (Lond)*. 2005;29:903–908.
15. Saftić R, Grgic M, Ebling B, et al. Case-control study of risk factors for lumbar intervertebral disc herniation in Croatian island populations. *Croat Med J*. 2006;47:593–600.
16. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser*. 1995;854:1–452.
17. Consultation WE. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363:157–163.
18. Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327:557–560.
19. Duval S, Tweedie R. Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*. 2000;56:455–463.
20. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics*. 1994;50:1088–1101.
21. Egger M, Davey Smith G, Schneider M, et al. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315:629–634.
22. Samartzis D, Karppinen J, Chan D, et al. The association of lumbar intervertebral disc degeneration on magnetic resonance imaging with body mass index in overweight and obese adults: a population-based study. *Arthritis Rheum*. 2012;64:1488–1496.
23. Samartzis D, Karppinen J, Mok F, et al. A population-based study of juvenile disc degeneration and its association with overweight and obesity, low back pain, and diminished functional status. *J Bone Joint Surg Am*. 2011;93:662–670.
24. Kanayama M, Togawa D, Takahashi C, et al. Cross-sectional magnetic resonance imaging study of lumbar disc degeneration in 200 healthy individuals. *J Neurosurg Spine*. 2009;11:501–507.
25. Elfering A, Semmer N, Birkhofer D, et al. Risk factors for lumbar disc degeneration: a 5-year prospective MRI study in asymptomatic individuals. *Spine*. 2002;27:125–134.
26. Nagashima M, Abe H, Amaya K, et al. Risk factors for lumbar disc degeneration in high school American football players: a prospective 2-year follow-up study. *Am J Sports Med*. 2013;41:2059–2064.
27. Zirbel SA, Stolworthy DK, Howell LL, et al. Intervertebral disc degeneration alters lumbar spine segmental stiffness in all modes of loading under a compressive follower load. *Spine J*. 2013;13:1134–1147.
28. Zukowski LA, Falsetti AB, Tillman MD. The influence of sex, age and BMI on the degeneration of the lumbar spine. *J Anat*. 2012;220:57–66.
29. Battie MC, Videman T, Gill K, et al. 1991 Volvo Award in clinical sciences. Smoking and lumbar intervertebral disc degeneration: an MRI study of identical twins. *Spine (Phila Pa 1976)*. 1991;16:1015–1021.
30. Keorochana G, Taghavi CE, Lee KB, et al. Effect of sagittal alignment on kinematic changes and degree of disc degeneration in the lumbar spine: an analysis using positional MRI. *Spine (Phila Pa 1976)*. 2011;36:893–898.
31. Kauppila L. Atherosclerosis and disc degeneration/low-back pain—a systematic review. *Eur J Vasc Endovasc Surg*. 2009;37:661–670.
32. Weiler C, Lopez-Ramos M, Mayer H, et al. Histological analysis of surgical lumbar intervertebral disc tissue provides evidence for an association between disc degeneration and increased body mass index. *BMC Res Notes*. 2011;4:497.
33. Das U. Is obesity an inflammatory condition? *Nutrition*. 2001;17:953–966.
34. Visser M, Bouter LM, McQuillan GM, et al. Elevated C-reactive protein levels in overweight and obese adults. *JAMA*. 1999;282:2131–2135.
35. Girn H, Orsi N, Homer-Vanniasinkam S. An overview of cytokine interactions in atherosclerosis and implications for peripheral arterial disease. *Vasc Med*. 2007;12:299–309.
36. Artz E, Haqq A, Freemark M. Hormonal and metabolic consequences of childhood obesity. *Endocrinol Metab Clin North Am*. 2005;34:643–658.