

REVIEW

Atherosclerosis and Disc Degeneration/Low-Back Pain — A Systematic Review

L.I. Kauppila*

Terveystalo Healthcare, Mäkelänkatu 2 C, 00500 Helsinki, Finland

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KEYWORDS

Aortic calcification;
Lumbar arteries;
Middle sacral artery;
Lipids;
Cholesterol

Abstract Objectives: Atherosclerosis can obstruct branching arteries of the abdominal aorta, including four paired lumbar arteries and the middle sacral artery that feed the lumbar spine. The diminished blood flow could result in various back problems. The aim of this systematic literature review was to assess associations between atherosclerosis and disc degeneration (DD) or low-back pain (LBP).

Data sources: A systematic search of the Medline/PubMed database for all original articles on atherosclerosis and DD/LBP published until October 2008. The search was performed with the medical subject headings atherosclerosis, cardiovascular risk factor, or vascular disease and keywords “disc degeneration”, “disc herniation”, and “back pain” on the basis of MeSH tree and as a text search. In addition reference lists were studied and searched manually. Observational studies investigating the association of atherosclerosis or its risk factors and lumbar DD/LBP were selected.

Review methods: The following data were extracted: study characteristics, duration of follow-up, year of publication, findings of atherosclerosis/cardiovascular risk factors and DD/LBP. Disc herniation was regarded as a form of disc degeneration and cardiovascular risk factors were regarded as surrogate for atherosclerosis in epidemiological studies.

Results: One hundred and seventy-nine papers were identified. After exclusion of case reports, letters, editorials, papers not related to the lumbar spine, and animal studies, 25 papers were included. Post-mortem studies showed an association between atheromatous lesions in the aorta and DD, as well as between occluded lumbar arteries and life-time LBP. In clinical studies, aortic calcification was associated with LBP, and stenosis of lumbar arteries was associated with both DD and LBP. In epidemiological studies, smoking and high serum cholesterol levels were found to have the most consistent associations with DD and LBP.

* Tel.: +358 44 5995757.

E-mail address: leena.kauppila@fimnet.fi

Conclusion: Aortic atherosclerosis and stenosis of the feeding arteries of the lumbar spine were associated with DD and LBP. Cardiovascular risk factors had weaker associations, being clearly apparent only in cohorts on elderly people or in large study samples. More prospective clinical studies are needed to further clarify the association of atherosclerosis and low-back disorders.

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Introduction

Back problems are the second leading cause of disability and the leading cause of job-related disability.¹ The prevalence of lumbar intervertebral disc degeneration (DD) grows steadily from early adulthood onwards, and the incidence of low-back pain (LBP) increases linearly to reach its highest prevalence after the age of 45 years.^{2–4} Though both DD and LBP are fairly common, they are only weakly connected to each other.⁴ DD may develop without LBP symptoms, or a patient may have considerable LBP without radiologically observable DD. Since ischemia is capable of causing both pain and degeneration of the involved structures, atherothrombotic disease of the feeding arteries of the lumbar spine has received growing attention as one of the possible underlying factors for both LBP and DD.

Atheromatous plaques begin to appear in the abdominal aorta early in adult life, and by the age of 20 years roughly 10% of the population in the developed countries already has advanced lesions (i.e. fibrous plaques) in the abdominal aorta (Fig. 1). The most rapid increase in the amount of complicated lesions (i.e. plaques with necrosis, ulcerations, thrombi, calcification) occurs between 44 and

64 years of age.^{5,6} These lesions tend to build up in the bifurcation and around orifices of branching arteries. The lumbar spine, which is supplied by these branching arteries, can suffer if the arteries become obstructed. Segmental lumbar arteries, originating from the posterior wall of the abdominal aorta, supply the first through the fourth lumbar segments. The fifth lumbar segment is supplied by branches of the middle sacral artery, which originates in the aortic bifurcation, and also by tributaries of the iliolumbar arteries branching from the internal iliac arteries.^{7–9} In addition to lumbar vertebrae, these arteries also supply surrounding structures such as intervertebral discs, nerve roots, and paraspinal muscles (Fig. 2). The spinal cord is less dependent on these arteries because its main blood supply comes from above the lumbar spine.^{7,9}

After preliminary findings from a necropsy study in 1993, suggesting an association between diminished blood supply of the lumbar spine and LBP,¹⁰ atherosclerosis and cardiovascular risk factors have received growing attention as one of the possible underlying factors for back disorders. The aim of this review was to examine the associations between atherosclerosis/its risk factors and DD/LBP, and to discuss possible mechanisms for observed associations.

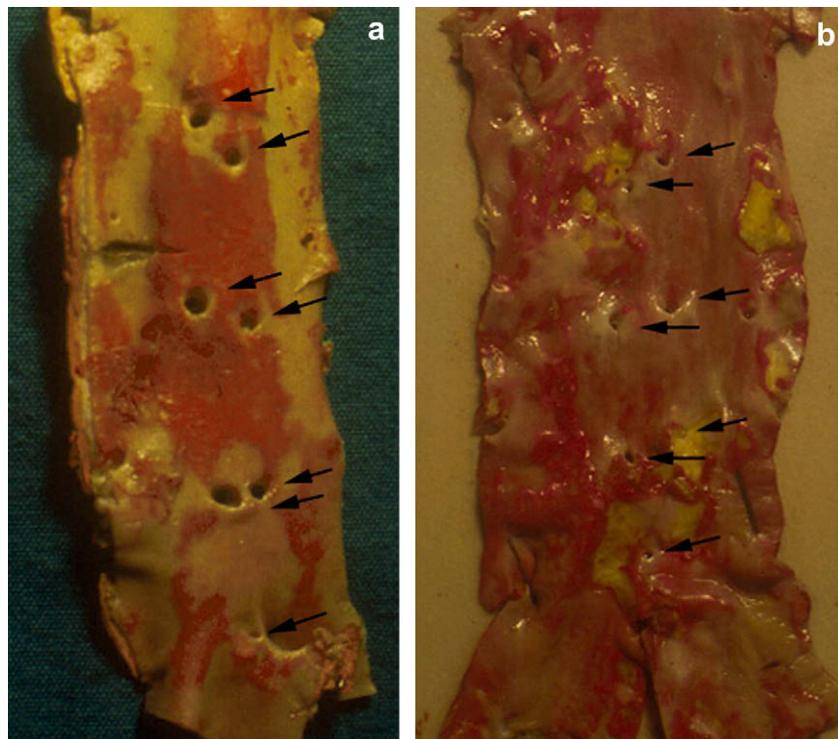


Figure 1 a. Well-preserved orifices of the 2nd–4th lumbar arteries and the middle sacral artery (lowest orifice) in the posterior wall of the abdominal aorta. Red staining shows fatty streaks. b. Several stenotic orifices of the lumbar arteries.

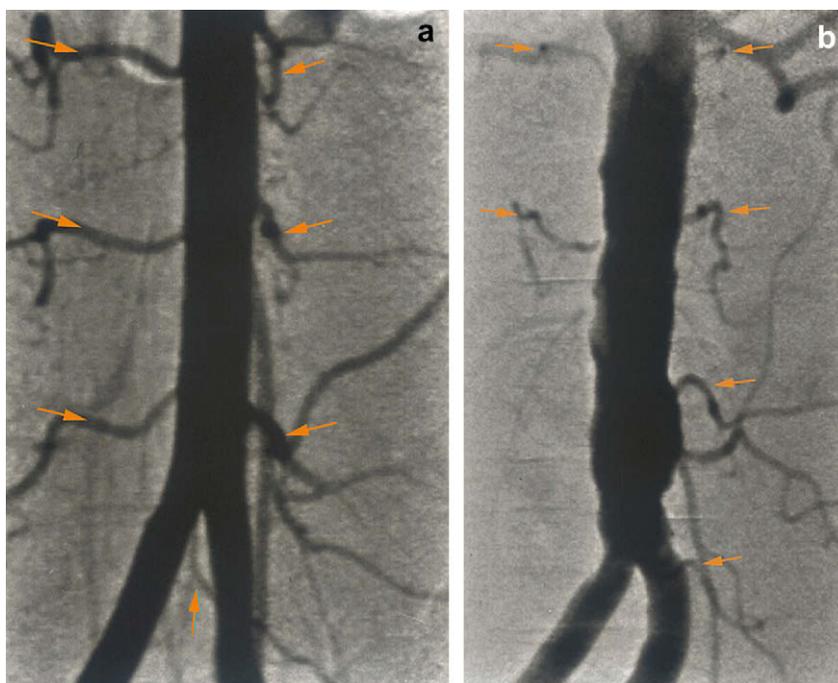


Figure 2 a. DSA aortograph showing the pairs of normal 2nd–4th lumbar arteries and the middle sacral artery below the bifurcation (arrows). b. The right 4th lumbar artery is occluded. The 2nd and 3rd arteries on the right hand side are narrowed.

Systematic Literature Search

Studies of interest were identified by a search of the Medline/PubMed database through September 2008 using predefined keywords. The following medical subject headings were used: atherosclerosis, cardiovascular risk factor, vascular disease, and keywords “disc degeneration”, “disc herniation”, and “back pain” on the basis of MeSH tree and as a text search. The search was restricted to four languages: English, German, French and Italian.

Cardiovascular risk factors of interest were: smoking, hypertension, high total cholesterol, high LDL cholesterol, high triglyceride, carotid intima-media thickness, and diabetes.

Abstracts were reviewed and relevant articles obtained. Reference lists of these articles were reviewed for additional studies. Since two systematic reviews have been published on smoking and LBP, these reviews, and not individual studies on this topic, were included in this paper.

Results

One hundred and seventy-nine papers were identified. After exclusion of case reports (39), letters (3), animal studies (1), editorials (3), and articles not related to lumbar spine (107), 25 papers from 23 studies were included. Of these 23 studies 8 were cross-sectional, 3 case-control and 12 cohort studies.

Two of the studies were necropsy studies, 14 were epidemiological studies and 7 were clinical studies. Four systematic reviews related to cardiovascular risk factors and DD or LBP were found and were included in this review. Two of them were on smoking and LBP,^{11,12} one on

comorbidity with LBP,¹³ and one on cardiovascular and lifestyle risk factors and lumbar radicular pain (Table 1).¹⁴

Necropsy Studies

Post-mortem studies on atherosclerosis in connection to back problems have been done at the department of the forensic medicine in the Helsinki university. Kauppila and Tallroth^{10,15} assessed stenotic changes and occlusions of the lumbar and middle sacral arteries on post-mortem aortograms. Altogether 140 angiographies were performed on subjects ranging from 16 to 89 years of age. Stenotic findings and occlusion of an artery were most common in the middle sacral artery, which originates in the aortic bifurcation, followed by the fourth lumbar arteries arising just above the bifurcation. These arteries supply the fifth and fourth lumbar segments accordingly. Most of the stenotic changes were seen at the orifices or in the first part of the arteries. The number of collateral arteries was found to increase with occluded and narrowed arteries. The mean age for men with stenotic arteries was 50 years and for women 59 years. Subjects with one or more stenotic arteries were 8.5 times (95% CI 2.9–24) more likely to have suffered from LBP (≥ 3 months at some point during their life) than were those without such findings.

In another necropsy study Kauppila et al.¹⁶ assessed atheromatous lesions in the abdominal aorta and the stage of DD in the lumbar radiographs, 774 orifices of the lumbar and middle sacral arteries were studied and the corresponding intervertebral spaces were assessed for DD. In this group of 36–69 year old males, 18% of the ostia of these arteries were severely stenotic or occluded (Fig. 1a,b). Advanced atherosclerotic manifestations in the aorta, and

Table 1 Summary of published studies and reviews reporting associations between atherosclerosis/cardiovascular risk factors and disk degeneration (DD) or low-back pain (LBP) in the order of the year of publication.

Study characteristics	Summary of findings	Author, year of publication
940 men, 40–47 years, cross-sectional	LBP was associated with calf pain on exertion and smoking	Svensson et al., 1983
56 medicolegal necropsies, 16–80 years, case-control	88% of subjects with LBP history had missing lumbar arteries compared to 59% of age-matched controls and 22% of young (i.e. age < or = 30 years) controls.	Kauppila & Tallroth, 1993
140 medicolegal necropsies, 16–89 years, case-control	Subjects with occluded/narrowed lumbar arteries were more likely to have suffered from chronic LBP during their life than were those without such findings (OR 8.5; 95% CI 2.9, 24; $P < 0.001$). The mean age for men with occluded/narrowed arteries was 50 years and for women 59 years. The middle sacral artery was most often affected, followed by the 4th lumbar arteries. The number of collateral arteries increased with occluded ($P < 0.001$) and narrowed arteries ($P < 0.01$).	Kauppila, 1997
86 males, medicolegal necropsies, 36–69 years, cross-sectional	The grade of DD was associated with the stenosis of the ostia of the arteries supplying the disc. The association was stronger at upper lumbar levels ($0.001 < P < 0.01$) than at lower ones ($0.01 < P < 0.05$). DD at all lumbar levels increased with complicated lesions in the abdominal aorta.	Kauppila et al., 1994
8816 male farmers, 30–49 years, 13-year-follow-up	Men reporting LBP during the preceding year at the beginning of follow-up had a significantly increased risk of dying of ischemic heart disease during the follow-up than those of the same age with no LBP (RR 4.6, 95% CI 1.06–19.6, $P = 0.04$). For men ≥ 50 LBP did not precede death from ischaemic heart disease.	Penttinen, 1994
332 male farmers, nested case-control study, 30–49 years, 13-year-follow-up	Patients with myocardial infarction visited a doctor because of non-specific LBP less frequently than controls (OR 0.51; 95% CI 0.25–1.05).	Penttinen, 1995
7217 subjects, age ≥ 30 years, 11–13-year-follow-up	LBP did not predict mortality in cardiovascular diseases.	Heliövaara et al., 1995
606 subjects, Framingham cohort, mean age 54 ± 4.6 years, 25-year-follow-up	Aortic calcification was associated with general DD (OR 1.6; 95% CI 1.0–2.5; $P = 0.034$). Baseline aortic calcifications predicted disc deterioration at the matching lumbar levels (OR 1.5; 95% CI 1.3–1.8; $P < 0.001$). Subjects in whom aortic calcifications developed during the follow-up had disc deterioration twice as frequently as those in whom aortic calcifications did not develop (OR 2.0; 95% CI 1.2–3.5; $P = 0.013$). Individuals with marked aortic calcification in front of any lumbar segment reported more often than others LBP during adult life (OR 1.6; 95% CI 1.1–2.2; $P = 0.014$).	Kauppila et al., 1997
1492 women, mean age 71 years, mean follow-up 3,7 years	Women with cardiovascular disease were more likely to have LBP and disability as a result of LBP than women free of cardiovascular disease; At the follow-up examination, the back-related disability was more than twice as likely to have worsened in the cardiovascular disease group. No correlation was found between lower extremity arterial disease and back problems.	Vogt et al., 1997
4886 civil servants, 35–55 years, mean 4-years-follow-up	In men, triglycerides were associated with short and long spells of sickness absence because of back pain, RR 1.53 (95% CI 1.1–2.1) and 1.75 (1.0–3.2) respectively.	Hemingway et al., 1999
81 patients, case-control	Patients with LBP had atherosclerotic calcifications in the abdominal aorta on CT scans significantly more often than age-matched controls (55% versus 21%). For subjects ≤ 50 years the difference was even more marked (48% versus 8%).	Kurunlahti et al., 1999
systematic review on, smoking and LBP, 41 papers	No consistency of statistically significant positive associations was found between smoking and LBP. The association, when present, was usually weak and clearly apparent only in large study samples.	Leboeuf-Yde, 1999

Table 1 (continued)

Study characteristics	Summary of findings	Author, year of publication
systematic review on, smoking and LBP, 34 papers	Consistency of statistically significant positive associations was found between smoking and both the incidence and prevalence of non-specific LBP.	Goldberg et al., 2000
37 volunteers, 22–68 years, cross-sectional	The degree of DD was assessed from 98 lumbar intervertebral disks, and MR angiography was performed on the corresponding 98 lumbar artery pairs (total arteries = 196). Impaired flow in lumbar arteries was associated with decreased diffusion in lumbar disks. No correlation was found between DD and diffusion.	Kurunlahti et al., 2001
systematic review on comorbidity with LBP, 23 papers	LBP had positive associations to all disorders investigated (headache/migraine, respiratory disorders, cardiovascular disease, general health, and others) with the exception of diabetes. Authors' conclusion: diseases cluster in some individuals and LBP is part of this pattern.	Hestbaek et al., 2003
51 patients, 35–70 years, cross-sectional	77% of patients suffering from severe long-term non-specific LBP (i.e. without specific findings in MRIs) had occluded lumbar/middle sacral arteries. DD was associated with occluded arteries ($P = 0.035$). Patients with above normal serum LDL cholesterol scored higher in neurogenic symptoms ($P = 0.031$) and complained more often severe pain ($P = 0.049$) than those with normal LDL cholesterol.	Kaupilla et al., 2004
147 patients, 3-year-follow-up	Baseline lumbar artery stenosis was associated with intensity of back pain at 1 year, leg pain at 2 years, and self-efficacy at every follow-up assessment. The associations of arterial stenosis at 3 years were similar but weaker. Newly formed stenosis was associated with the preceding year's medical consultations due to LBP and prolonged LBP during the first follow-up year. Arterial stenosis was strongly and consistently associated with patient-estimated physical ability, but only slightly with subjective pain symptoms.	Kurunlahti et al., 2004
1013 male farmers + 769 referents, 40–60 years, case-control	No association between LBP and cardiovascular diseases.	Holmberg et al., 2005
98,407 women, Nurses' health study, 30–55 years, 16-year-follow-up	The relative risk of disc herniation was for diabetes 1.52 (95% CI 1.17–1.98); for hypertension 1.25 (95% CI, 1.11–1.41); for high cholesterol 1.26 (95% CI, 1.10–1.44), and for having a parent who had suffered a myocardial infarction before age 60 1.13 (95% CI, 1.02–1.26). Compared with never smokers, the relative risk for past smokers was 1.10 (95% CI, 1.00–1.20), for current smokers the risk increased with the number of cigarettes smoked per day. A decrease in risk occurred after cessation.	Jhavar et al., 2006
902 industrial employers, 27-year-follow-up	In men, high triglyceride and diastolic blood pressure levels and being a past smoker predicted frequent local LBP at follow-up. A high serum total cholesterol, triglyceride, systolic and diastolic blood pressure levels, and smoking status predicted an increased LBP score. An overall score of cardiovascular disease risk factors showed a graded association with increased LBP. In women smoking predicted an increased LBP score.	Leino-Arjas et al., 2006
43 patients, 50–87 years, cross-sectional	The frequency of LBP before surgery was significantly higher in the HAO (high aortic obstruction) group than that in the AAA (abdominal aortic aneurysm) group. LBP in the HAO group was improved after surgery. Authors' conclusion: the finding that LBP was improved by merely performing treatment for the vascular system might provide support for the presence of vascular backache. 23 patients who underwent surgery for AAA, did not postoperatively show more marked DD or atrophy of the multifidus muscle than a control group of 15 subjects without known vascular diseases.	Takeyachi et al., 2006

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Table 1 (continued)

Study characteristics	Summary of findings	Author, year of publication
1386 subjects, 45–74 years, cohort study	Carotid intima-media thickness was associated with continuous radiating LBP and with a positive unilateral clinical sign of sciatica among men. Each standard deviation (0.23 mm) increment in carotid intima-media thickness showed an OR 1.6 (95% CI 1.1–2.3) for continuous radiating LBP and 1.7 (95% CI 1.3–2.1) for a positive unilateral clinical sign of sciatica. Carotid intima-media thickness was not associated with local LBP.	Shiri et al., 2007
systematic review on cardiovascular and lifestyle risk factors and sciatica 22 papers	Long smoking history, high physical activity and a high serum C-reactive protein level showed associations with lumbar radicular pain or sciatica, whereas no consistent associations was found between sciatica and serum lipids levels or high blood pressure.	Shiri et al., 2007
65 patients with LBP (260 intervertebral discs) cross-sectional	Association between the diminished flow in lumbar arteries and the decreased diffusion of lumbar intervertebral disks at all intervertebral levels except at L4–5 ($P < 0.001$)	Tokuda et al., 2007
7124, 18–79-years, cross-sectional	The most common comorbidities associated with LBP were musculoskeletal disorders followed by cardiovascular and cerebrovascular disease.	Schneider et al., 2007
1484 women, 70–85 years, 5-year-follow-up	Daily back pain was associated with greater overall mortality risk (RR 2.03; 95% CI 1.14–3.60) and greater risk of coronary heart disease (CHD) mortality and new CHD diagnosis (RR 2.13; 95% CI, 1.35–3.34). The effects remained significant after further adjustment for cardiovascular risk factors and physical activity level.	Zhu et al., 2007
8028 subjects, 30–95 years, cohort study	In men without hyperlipidemia treatment, lumbar radicular pain (sciatica) was associated with total cholesterol (high versus low tertile: OR 2.28, 95% CI 1.14–4.55), LDL cholesterol (2.12; 1.11–4.05), and triglycerides (1.92; 1.04–3.55). For men in the highest tertile of both total cholesterol and triglycerides, the OR of sciatica was 3.89 (1.68–8.99) in comparison to men with cholesterol in the lowest tertile and triglycerides in the lowest or the middle tertile. In women, pharmacologically treated hyperlipidemia was associated with sciatica (OR 2.02; 1.01–4.04).	Leino-Arjas et al., 2008
270 subjects, 51–86 years, cross-sectional	Correlations between DD (on MR images) and various risk factors were assessed. High LDL cholesterol correlated with DD at L4/5 level (OR, 2.65).	Hangai et al., 2008
81 subjects, cross-sectional	Positive correlation between degree of aortic wall calcification and DD score was found ($r = 0.306$, $P < 0.01$)	Turgut et al., 2008

OR = odds ratio; RR = relative risk; CI = confidence interval; LDL = low density lipoprotein.

especially stenosis of the orifices of segmental arteries above and below the disc, were found to correlate with increased grade of DD.

Atherosclerosis/Cardiovascular Risk Factors and DD or LBP

Cardiovascular risk factors or cardiovascular mortality are generally used as a surrogate for atherosclerosis in epidemiological studies. Only in one cohort study,¹⁷ atherosclerosis itself (i.e. aortic calcification) was used to examine associations between atherosclerosis and DD/LBP.

Comorbidities

Svensson et al.¹⁸ were the first to study the relationship of LBP to comorbidities and cardiovascular risk factors. In

their random sample of 940 men (40–47 years of age), they found nine variables to be correlated to LBP: angina pectoris, calf pain, breathlessness on exertion, smoking, physical activity at work, physical activity during leisure time, worry and tension, fatigue at the end of the workday, and perception of stress. When the influence of other variables was assessed by analysis of covariance, calf pain on exertion, smoking, a high physical activity at work, and a frequent feeling of worry and tension maintained a direct association with LBP. Hestbaek et al.¹³ made a systematic review of comorbidities with LBP. Their conclusion from 23 included papers was that LBP showed positive associations to all disorders investigated (headache/migraine, respiratory disorders, cardiovascular disease, general health, and others) with the exception of diabetes. Later, Holmberg et al.¹⁹ studied comorbidities on Swedes aged 40–60 years and Schneider et al.²⁰ on Germans aged 18–79 years. While Holmberg found LBP to correlate especially to respiratory

and digestive disorders, Schneider found it to correlate with musculoskeletal disorders like rheumatoid arthritis and osteoporosis, followed by cardiovascular and cerebrovascular diseases.

Cardiovascular Mortality

The association between cardiovascular mortality and LBP has been controversial: while Penttinen²¹ found in a large cohort of Finnish farmers that those who reported back pain preceding the onset of the study had a significantly increased risk of dying of ischemic heart disease during the 13-year-follow-up (RR 4.6; 95% CI 1.06–19.6), Heliövaara et al.²² could not find an association in another large cohort in Finland. Furthermore, Penttinen²³ could not find an association between myocardial infarction and the number of visits to a doctor due to LBP in a nested case-control (83 patients with myocardial infarction and 249 matched controls) study of the Finnish farmers.

Cardiovascular Diseases

Vogt et al.²⁴ found LBP to be associated with cardiovascular diseases. In their study of 1492 elderly women (mean age 71 years), those with cardiovascular disease were more likely to have LBP and disability as a result of LBP than women free of cardiovascular disease. During their follow-up (mean 3.7 years), the back-related disability was more than twice as likely to have worsened in the cardiovascular disease group. Zhu et al.²⁵ found similar association in their study on elderly women in Australia. In their group of 1484 women (70–85 years of age), daily back pain was associated with greater overall mortality risk (RR 2.03; 95% CI 1.14–3.60) and with greater risk of coronary heart disease (CHD) mortality and new CHD diagnosis (RR 2.13; 95% CI, 1.35–3.34). The effects remained significant after further adjustment for cardiovascular risk factors and physical activity level. Kauppila et al.¹⁷ found, in the Framingham cohort (mean age at baseline 54 ± 4.6), that individuals with marked aortic calcification were more likely than others to report LBP during adult life. Furthermore, calcific deposits in the posterior wall of the abdominal aorta predicted DD at the matching lumbar level during the 25-year-follow-up time.

Cigarette Smoking

Association between cigarette smoking, a well-known cardiovascular risk factor, and LBP have been known from early 1980s. Two large systematic reviews of the epidemiologic literature have been published on this topic: in a review by Leboeuf-Yde¹¹ a weak association was found, whereas in another by Goldberg et al.¹² a more consistent association between smoking and non-specific LBP was found. Battie et al.²⁶ showed, in their study on identical twins, that smoking was associated with DD. Later, the dose-related association of smoking with disc herniation has been shown in a large prospective nurses' health study (98,407 female nurses, 16-years-follow-up) by Jhawar et al.²⁷ They found that the risk of lumbar disc herniation

was slightly increased for past smokers compared with never smokers. For current smokers, the risk increased with the number of cigarettes smoked per day. A decrease in risk was seen after cessation.

Other Risk Factors

Several other cardiovascular risk factors have been studied in relation to DD or LBP. Hemingway et al.²⁸ found in a study of 4886 office-based civil servants (35–55 years of age), that low apo A1 was in both genders and high triglycerides in men associated with sickness absence because of back pain. Leino-Arjas et al.^{29–31} found an association between high triglycerides and LBP in three separate studies. Furthermore, high blood pressure,²⁹ high cholesterol,^{29,30} high LDL cholesterol,³¹ and increased carotid intima-media thickness³² have been found to be significantly and independently associated with LBP. In the above-mentioned large nurse's health study, Jhavar et al.²⁷ also showed diabetes, hypertension, high cholesterol, and having a parent who had suffered a myocardial infarction before age 60 to predict lumbar disc herniation. In a systematic review on associations between cardiovascular or lifestyle risk factors and lumbar radicular pain (sciatica), Shiri et al.¹⁴ found obesity, long smoking history, and serum C-reactive protein to be associated with sciatica, whereas they found no consistent associations between sciatica and serum lipid levels or high blood pressure.

Clinical Studies

Apart from case reports, a limited number of clinical studies have been published on atherosclerosis and LBP or DD.

Kurunlahti et al.³³ found patients with LBP to have atherosclerotic calcifications in the abdominal aorta significantly more often than age-matched controls (55% versus 21%). The difference was even larger for patients 50 years of age or less (48% versus 8%). Their findings were based on the assessment of atheromatous calcified lesions in the abdominal aorta by computed tomographic scans in 29 patients and 52 controls. Later, Turgut et al.³⁴ found positive correlation between aortic calcification and the score of DD in a cross-sectional study of 81 patients. In a 3-year-follow-up study on 147 patients, Kurunlahti et al.³⁵ compared occlusion of lumbar arteries in magnetic resonance (MR) angiography with sciatica symptoms and physical ability. They found stenosis of lumbar arteries to be associated with intensity of LBP at 1 year, leg pain (sciatica) at 2 years, and self-efficacy at every follow-up assessment. Newly formed stenosis was associated with the preceding year's medical consultations due to LBP and prolonged LBP during the first follow-up year. Kauppila et al.³⁶ found in a study on 51 patients with severe long-term LBP, but without specific findings in regular lumbar MRIs (such as spinal or nerve root compression), that 78% of men and 77% of women had one or more occluded lumbar/middle sacral arteries in MR angiographies.

Both Kurunlahti et al.³⁷ and Tokuda et al.³⁸ studied MR angiographies of the lumbar artery pairs and diffusion of the corresponding intervertebral discs. Both groups found

a significant correlation between diminished flow in lumbar arteries and the decreased diffusion of the corresponding lumbar intervertebral disks. Hangai et al.³⁹ evaluated lumbar DD on MR images and compared findings with LBP and various risk factors, including cardiovascular ones such as LDL cholesterol, triglyceride, brachial-ankle pulse wave velocity, and smoking. They found high LDL cholesterol to be associated with DD at L4–5 level (OR, 2.65), but not at other levels.

Abdominal aortic aneurysm (AAA) and high aortic occlusion (HAO) offer interesting disorders which are frequently associated with impaired lumbar blood flow, as well as with LBP. Takeyachi et al.⁴⁰ studied retrospectively the presence of LBP before and after surgery for 34 patients with AAA and 9 patients with high aortic occlusion (HAO). The frequency of long-term LBP (≥ 3 months) before surgery was significantly higher in the HAO group than that in the AAA group. After surgery, the frequency of LBP decreased especially in the HAO group (HAO, from 77 to 26%; AAA, from 32 to 23%). The authors discuss that vascular reconstruction for HAO had a more positive effect on collateral circulation in the lumbar region than surgery for AAA. Patients with HAO had circulatory disturbances both in the arteries of the lumbar region and lower extremities, whereas patients with AAA had disturbances only in the lumbar region. After reconstruction for HAO, there was considerable improvement of circulation in the lower extremity arteries which also increased blood flow to the lumbar region through ascending collateral arteries (originating from iliolumbar and deep iliac circumflex arteries). In the AAA group, collateral circulation to the lumbar region was supposed to be mostly through descending collateral arteries (originating from intercostal and superior mesenteric arteries) which had been developed earlier and were not affected by reconstructive surgery.

One very interesting study, published already in 1976 by Doppman and DiChiro,⁴¹ describes a series of 16 patients with lumbar artery embolization for angiomatous spinal lesions. Though this paper is not related to atherosclerosis, it deserves to be mentioned here since the most common complication after the occlusion of a lumbar artery was severe LBP with muscle spasm and acute scoliosis on the side of the occluded lumbar artery. These symptoms developed 0–3 h after embolization and subsided gradually over a period of 5–10 days. Symptoms were attributed to minor muscle infarctions, but their resemblance to acute lumbago is remarkable.

Discussion

The current literature review covered post-mortem, clinical, and epidemiological studies on atherosclerosis/cardiometabolic risk factors and DD or LBP. Necropsy studies showed a marked association between atheromatous lesions in the aorta and lumbar DD, as well as between stenosis of the feeding arteries of the lumbar spine and LBP during life. Compared to other studies, the strength of post-mortem studies is that they allow direct assessment of atherosclerosis. Their weakness, however, is their cross-sectional nature. Though some retrospective information on life-time symptoms can be collected from close relatives

and from medical records, post-mortem studies, generally, leave cause–effect relationships undetermined. To prove a cause and effect association, a clinical follow-up study is the art of choice. In this review, only one such study was found. It showed that lumbar artery stenosis was preceded by LBP and that prolonged LBP was also present during the first follow-up year.³⁵ All other clinical studies were cross-sectional. Their findings were consistent on association between atherosclerosis/stenosis of lumbar arteries and DD/LBP. In epidemiological studies, associations between cardiovascular risk factors and DD/LBP were weaker. They were more consistent in cohort studies on older participants and in very large studies. In studies with younger participants and without distinction between different types of LBP (i.e. sports related, idiopathic etc.) the findings were likely to be biased toward null.

AAA offers an interesting example of a circulation disturbance in lumbar arteries. In this disorder, either atheromatous plaques or thrombotic layers build up slowly inside an aneurysm. This gradually occludes the corresponding lumbar arteries but allows time for collateral arteries to develop. The trunk seems to have an exceptional ability to open collateral pathways to bypass stenotic arteries since ischemic symptoms and necrotic changes in the lumbar region are rarely seen even after surgery for AAA. In a series of 224 patients undergoing abdominal aortic surgery, Bertrand et al.⁴² found that 4% of patients suffered from severe postoperative LBP with elevated levels of creatine phosphokinase, suggesting muscle infarction and necrosis. Though some of these cases of rhabdomyolysis may have been due to the posture of the patient during the surgery (hyperlordotic), compromised lumbar blood flow probably also played a significant role. In this study, prevalence of milder back symptoms was not reported. These less severe symptoms may have been effectively alleviated by postoperative pain medication, convalescence period after this major surgery, or pre-existing well-developed collateral network. By the time of surgery many of the lumbar arteries may already have been occluded and the main vascular supply has been arranged through collateral pathways. Severe ischemic pain is more likely to occur after sudden occlusion of a normally functioning lumbar artery, such as was found to follow embolization of an artery for angiomatous lesions.⁴¹

Lumbar blood supply is principally segmental. However, the trunk offers plenty of small anastomoses which are able to open to serve as collateral arteries. Depending on a patient's ability to develop collateral pathways, lumbar ischemia may have several different outcomes: anastomotic arteries may open at the pace of arterial narrowing and prevent ischemic symptoms (LBP) from emerging; development of an efficient collateral network may take more time than the occlusion of an artery and ischemic symptoms will occur for some time; or no efficient collateral circulation develops and structures such as nerve roots, vertebral bodies, intervertebral discs, and muscles suffer. Depending on the structures having the most compromised blood supply, symptoms may vary: ischemia of the vertebral bone may cause constant dull pain, typical of bone ischemia, whereas nerve root ischemia may evoke radicular pain. The intervertebral disc is supplied by diffusion from vertebral bodies above and below it. Its

oxygen tension is low even under normal condition. Furthermore, the disc is located at the end of the nutrient chain, making it one of the first structures to suffer during insufficient nutrient supply.

Both atherosclerosis and back problems have been subject to intense research: Medline search on atherosclerosis offers over 66,000 articles and over 16,000 on LBP. However, relatively few papers are to be found on combined search terms. Back problems are the second leading cause of disability (after arthritis) and cardiovascular diseases are the third one.¹ The studies of this review give a solid basis for the presumption that there is a connection between these two major health problems. However, to prove a cause and effect relationship and to find effective treatments for LBP or DD, we need large longitudinal observational and intervention studies. Taking into account the huge burden of low-back disorders both on society and on individual, there is an explicit need for more research on this field.

Competing Interests

None.

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