

# Hip osteoarthritis: influence of work with heavy lifting, climbing stairs or ladders, or combining kneeling/squatting with heavy lifting

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## ABSTRACT

The aim of the study was to evaluate the evidence for an association between hip osteoarthritis (OA) and physical work demands. Systematic searches were made and epidemiological studies on hip OA and heavy lifting, including farming and construction work and climbing stairs, were reviewed for the period 1966–2007 inclusive. The quality of the studies was assessed and best-evidence syntheses of a causal relation between hip OA and physical demanding work have been made using specific criteria of the different degrees of evidence of causality. Limitations of the studies include few participants, use of different diagnostic criteria, and a poor description of the exposure. It is concluded that moderate to strong evidence was found for a relation between heavy lifting and hip OA. The burdens have to be at least 10–20 kg and the duration at least 10–20 years to give a clearly increased risk of hip OA. For farmers the risk of hip OA seems doubled after approximately 10 years of farming and the evidence is considered as moderate to strong. The evidence for a relation between hip OA for construction workers is limited and there is insufficient or no evidence that climbing stairs or ladders causes hip OA.

Hip osteoarthritis (OA) is the most common reason for total hip replacement (THR) and a major source of disability in developed countries. Symptomatic hip OA occurs in 0.7–4.4% of adults.<sup>1–3</sup> Hip OA can be inherited.<sup>4</sup> Congenital dislocation, Legg-Calve-Perthe disease, slipped femoral capital epiphysis, body mass index (BMI) >25,<sup>5</sup> major hip injuries,<sup>6</sup> and some sports activities result in an increased risk of developing hip OA in later life.<sup>7–11</sup>

The aim of this study was to critically review the epidemiological evidence for a causal relation between hip OA and an exposure to heavy lifting, climbing stairs or ladders and exposure to heavy lifting combined with kneeling or squatting. The review is based on a scientific report<sup>12</sup> made on behalf of the Scientific Committee of the Danish Society of Occupational and Environmental Medicine for the use of the Danish National Board of Industrial Injuries in their evaluation of whether knee OA and hip OA caused by physical work demands should be included on their list of occupational diseases that may be compensated through the Danish Worker Compensation act. The relation between knee OA and occupational work demands is presented in another paper.<sup>13</sup>

## MATERIAL AND METHODS

The relevant studies were identified through searches in the following literature databases:

MEDLINE (1966–May 2007), NIOSH-tic (1990–May 2007), EMBASE and HSEline (1990–May 2007). The following keywords were used: [Hip and (osteoarthritis or osteoarthrosis) and (work or occupation)]. Further relevant literature was found by screening the reference lists of all relevant articles identified.

A study was selected for a more detailed review if it fulfilled specific criteria described in Jensen, 2007.<sup>13</sup> The diagnostic criteria for hip OA was: (a) radiological verified hip OA including radiological joint space narrowing (JSN) or the Kellgren and Lawrence criteria for hip OA; (b) a diagnostic code of hip OA (WHO International Classification of Diseases: ICD-8 = 713.00 or ICD-10 = M16 (hip OA)); (c) had a THR or (d) were on a waiting list for THR.

The quality of the studies, and the strengths and the weaknesses of the studies were evaluated according to the aspects outlined in Jensen, 2007.<sup>13</sup> The quality assessment is shown in table 1.

The studies were considered to be heterogeneous with regard to the population studied, outcome measures for hip OA, and exposure measurement and it was therefore refrained to make statistically pooling of the data. There was instead carried through a “best evidence” synthesis<sup>5 14</sup> according to the aspects described in Jensen, 2007.<sup>13</sup>

## RESULTS

### Identification and selection of literature

The electronic search retrieved a total of 491 references. Of these the 19 articles shown in table 1 met the inclusion criteria. Three articles were found in references of the retrieved literature. Of 22 articles, 14 studies investigated an association between hip OA and heavy lifting;<sup>15–29</sup> 14 studies investigated hip OA among farmers<sup>15 16 20 24 26 27 29–36</sup> and six among construction workers.<sup>15 16 24 26 27 32</sup> Five studies investigated the relation between hip OA and climbing stairs or working on ladders;<sup>15 16 21 28 29</sup> and no study dealt with heavy lifting combined with kneeling/squatting. Figure 1 shows the results of the searches, and the number of epidemiological studies that remained after applying the inclusion criteria on the search.

### Description of the studies

#### Heavy lifting

Fourteen epidemiological studies focused on the relation between hip OA and heavy lifting (see table 2 for study details).

**Table 1** Hip osteoarthritis: assessment of study quality\*

Authors†	Design and material	Adjusted for confounders	Measurement of outcome	Measurement of exposure	Data presentation, statistical analysis	Quality assessment total score‡
Lindberg, 1984 <sup>37</sup>	1	0	1	1	0	3 +
Typpö T, 1985 <sup>24</sup>	2	0	1	1	1	5 +
Jacobsen, 1987 <sup>20</sup>	1	0	0	1	1	3 +
Thelin, 1990 <sup>34</sup>	2	1	3	2	2	10 ++
Vingard, 1991 <sup>27</sup>	2	1	1	2	2	8 ++
Vingard, 1991 <sup>22 25</sup>	3	3	2	2	3	13 +++
Vingard, 1992 <sup>26</sup>	1	0	1	2	2	6 ++
Croft, 1992 <sup>16</sup>	2	3	3	2	3	13 +++
Croft, 1992 <sup>31</sup>	2	2	2	1	3	10 +++
Axmacher, 1993 <sup>30</sup>	2	1	0	2	0	5 +
Roach, 1994 <sup>23</sup>	2	2	1	2	2	9 ++
Jensen, 1994 <sup>32</sup>	2	1	2	1	2	8 ++
Vingard, 1997 <sup>28</sup>	3	3	3	2	3	14 +++
Thelin, 1997 <sup>33</sup>	3	2	2	2	2	11 +++
Coggon, 1998 <sup>15 §</sup>	2	2	3	2	3	12 +++
Cviteticl, 1999 <sup>17</sup>	2	2	0	1	2	7 ++
Yoshimura, 2000 <sup>29</sup>	2	2	2	1	2	9 ++
Lau, 2000 <sup>21</sup>	1	1	2	2	2	8 ++
Flugsrud, 2002 <sup>18</sup>	2	2	3	1	3	11 +++
Tüchsen, 2003 <sup>36</sup>	3	1	2	2	3	11 +++
Thelin, 2004 <sup>35</sup>	2	2	2	2	2	10 ++
Jacobsen, 2004 <sup>38</sup>	1	0	3	3	0	7 ++

\*Each item was scored from 1–3. Quality of the study was assessed by the sum of the scores, the maximum being 15 points.

†Several of the studies included more than one exposure, and have been cited more than once.

‡The papers were subdivided into “+” poor quality (score 1–5); “++” medium quality (score 6–10); “+++” high quality (score 11–15).

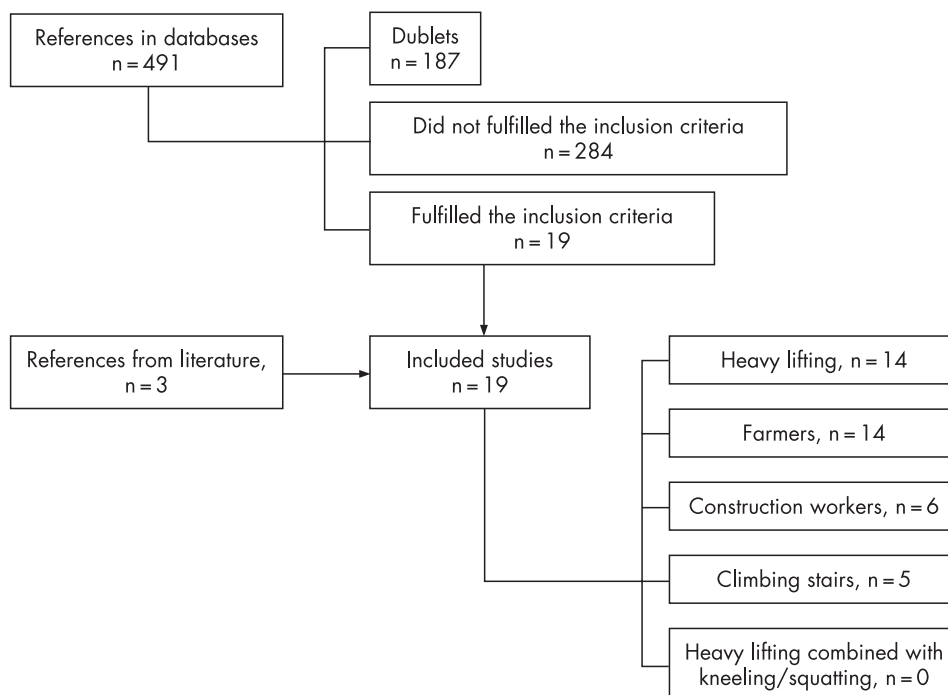
§The study only scored 5 points (+) in relation to the study of farmers.

Twelve of 14 studies showed a significant association with an OR range of 1.97 to 8.5 or relative risk range (RR) of 1.5 to 12.4. Four studies were considered to be of the highest quality.<sup>15 16 18 25</sup>

In the case-control study by Vingard *et al*<sup>25</sup> 233 men receiving the first THR were compared with 322 controls randomly selected from the study population. The workload was assessed by interview. Men with high exposure to heavy lifting,

age 30–49 years, had a high risk of hipOA (RR 3.31, 95% CI 1.97 to 5.57) (results adjusted for age, BMI, smoking and sports activities). The strengths of the study were the specified exposure, the high number of participants, high participation rate, the description of the study and the analysis. Exposure was divided into three groups. Unexposed and the 5% lowest exposed were defined as low exposure, and medium and high

**Figure 1** Hip osteoarthritis. Material, number of references in the electronic search, and literature references (some of the studies included more than one exposure).



\* some of the studies included more than one exposure

Table 2 Osteoarthritis of the hip and heavy lifting

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/matched by	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++)	Strength/weakness
Typfö, 1985 <sup>24</sup>	919 (416 males & 503 females) radiologically examined by veno-, angio-, uro-, colo-, or cystography, hips and abdomen	16–86 (mean 57)	–	Questionnaire Present occupation: mental (sic) light moderate heavy	Retrospective radiological hip OA: mild, moderate, severe	–	Heavy manual work vs no controls (mental (sic)/white collar workers)	1.97 (1.14 to 3.41)	Case-control	+	Strength: none. Weakness: participation rate missing. No statistical testing. No adjustment for potential confounders. Data for only part of the study population (n = 505)
Jacobsson 1987 <sup>20</sup>	85 males waiting for hip replacement, 262 males who have had urography	70–76	–	Questionnaire Job title classified as heavy/others	Joint-space <3 mm or waiting for THR	Age, height, weight	Heavy labour vs others Heavy lifting vs others	2.2 (1.34 to 4.36) 2.37 (1.32 to 4.28)	Case-control	+	Strength: none. Weakness: participation rate not described. Results only sparsely described. No statistical analyses carried out
Vinggaard 1991 <sup>21</sup> , Olsen 1994 <sup>22</sup>	Cases: 233 males with hip replacement Controls: 302 randomly selected from general population	50–70	89%	Telephone interview Occupational history for the last 20 years Questionnaire Lifting in all occupations	Cases with THR	Age, earlier diseases, sports activities, BMI	Lifted tons Medium exposure <30 years >30 years High exposure <30 years >30 years Number of lifts >40 kg Medium exposure <30 years >30 years High exposure <30 years >30 years	Relative risk 1.73 (1.06 to 2.83) 1.63 (0.98 to 2.73) 1.95 (1.23 to 3.09) 2.74 (1.70 to 4.43) 1.73 (1.06 to 2.82) 1.60 (0.81 to 3.15)	Case-control	+++ Strength: design and material well described. High number of participants. Interviews with specification of different physical activities. Inclusion of subjects having their first myocardial infarction as validation of the exposure measurement. Weakness: use of THR (risk of selection bias). Workload divided in light, medium, and heavy may be a risk of misclassification. Retrospective exposure information (risk of recall bias)	
Vinggaard 1991 <sup>21</sup>	High exposure: Males: 116581 (914 OA) Females: 18434 (109 OA) Low exposure: Males: 91057 (320 OA) Females: 24145 (112 OA)	Born 1905–45	Register-based	Occupation Job title classified by occupational physicians Low/high exposure	Hospitalised in 1981–3 ICD-8 713.00 Hip OA	Age, residence	High vs low exposure Born 1905–24 Males Females Born 1925–45 Males Females	Relative risk 2.35 (1.47 to 3.74) 3.31 (1.97 to 5.57)	Cohort	++ Strength: design and material well described. High number of participants. Weakness: Exposure classified by job title and in light, medium, heavy work (risk of misclassification). Case definition: "hospitalised because of hipOA" (risk of selection bias)	
Vinggaard 1992 <sup>26</sup>	Cases: 140 males disability pension due to hip OA Controls: 298 males from the general population	Born 1915–34	73%	Interview Occupational history Job title classified by experienced persons Low/medium/high exposure	Primary diagnosis made by a physician hip OA	Age	High vs low exposure Medium High	Relative risk 4.1 (2.4 to 7.1) 12.4 (9.7 to 23.0)	Case-control	++ Strength: description of material and design. Weakness: diagnosis (physician certificates, risk of misclassification). Subjects in heavy work may have increased risk of getting disability pension (risk of selection bias). Exposure: "high workload on hips," not especially related to heavy lifting (risk of misclassification)	

Table 2 Continued

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++)	Strength/weakness
Croft 1992 <sup>16</sup>	Cases: 245 males with hip OA Controls: 294 males without hip OA examined by urography	60–75	68%	Blinded interview Occupational history Specified physical activity	Joint space All Severe <1.5 mm	Age, sport, BMI	Lifting or moving weights >25.4 kg All JSN <2.5 mm 1–19 years ≥20 years Severe JSN <1.5 mm	0.9 (0.6 to 1.4) 1.2 (0.7 to 1.9)	Case-control	+++ Strength: use of intravenous urograms may avoid selection bias. JSN defined. Results and analysis well described. Weakness: number of severe cases relatively small. Exposure measurement: "lift >25.4 kg", frequency not further explained (risk of misclassification)	
Roach 1994 <sup>23</sup>	Cases: 99 with primary hip OA Controls: 233 with no radiographic hip OA examined by intravenous urography	Average: 68	77% (total 48% chosen from a population of 693)	Questionnaire Occupational history Classified in light, intermediate and heavy work	Kellgren & Lawrence grade 3–4 (joint space <1.5 mm)	Obesity, age, sports activities, cancer	Intermediate vs light work Heavy vs light work	1.2 (0.5 to 2.9) 2.5 (1.1 to 5.7) 1.9 (1.0 to 3.8) 2.4 (1.3 to 4.3)	Case-control	++ Strength: JSN defined. Adjustment for obesity, age, sport. Weakness: high exclusion rate. Retrospective exposure measurement (risk of recall bias). Exposure divided in light or heavy work (risk of misclassification)	
Vinggaard 1997 <sup>28</sup>	Cases: 273 females with THR in 4 areas of Sweden Controls: 273 females random sample from same areas	50–70	90%	Interview Occupational history Specified physical activity	THR	Age, BMI, sports activity, number of children, hormone therapy	Heavy lifts vs light Medium High	Relative risk 1.1 (0.7 to 1.7) 1.5 (0.9 to 2.5)	Case-control	++ Strength: high participation rate. Occupational history by interview with specification of different physical activities. Adjustment for age, BMI, sports. Weakness: retrospective exposure data (risk of misclassification). Only number of heavy lifts (not further defined) reported	
Coggon 1998 <sup>15</sup>	Cases: 210 males 401 females waiting for surgery in three English districts Controls: 210 males, 401 females (random sample from general practices in the same area)	45–91, mean: 70	68%	Interview Occupation held for >1 year from school age Specified physical activity	Cases waiting for surgery hip OA in right hip Lawrence grade 2–4	BMI, hip injury, Heberden's nodes. Matched by age and gender	Heavy lifts at least 10 years Males Lift >10 kg Lift >25 kg Lift >50 kg Females	2.3 (1.2 to 4.2) 2.7 (1.4 to 5.1) 3.2 (1.6 to 6.5) No significant differences	Case-control	+++ Strength: high number of participants. Well described study. Exposure collected by interviews with specification of different physical activities. Results adjusted. Weakness: participation rate 84% of cases, 58% of controls. Cases from a waiting list for THR (risk of selection bias). Retrospective exposure measurement (risk of recall bias). Few women in high exposure group	
Cvrtic 1999 <sup>17</sup>	590 (292 males 298 females) random sample from Zagreb city records 1981–3	>45, mean: 63	–	Questionnaire Occupation divided in 4 categories: mostly sedentary; mostly standing; no sitting; high physical strain	Clinical and radiological hip OA in right hip Kellgren & Lawrence grade 2–4	–	Standing or lifting vs >80% sitting or standing Males Females Standing, walking, light work Males Females Standing, walking, often heavy lifting >5 kg Males Females	1.5 (0.6 to 3.21) 1.45 (0.49 to 3.58) 1.16 (0.58 to 2.3) 1.19 (0.65 to 2.32) 1.15 (0.52 to 2.52) 1.34 (0.52 to 3.04)	Cohort	+ Strength: high number of participants. Weakness: participation rate not described. Results not controlled for confounders. Heavy lifting defined as lifts >5 kg (risk of misclassification)	

Table 2 Continued

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/matched by	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++, ++++), strength/weakness
Yoshimura 2000 <sup>29</sup>	Cases: 103 females 11 males waiting for hip replacement in 2 districts in Japan Controls: 114 from the local population	>45, mean: 64	91%	Questionnaire Occupation since leaving school; Physical activity in their first and main job	Waiting for hip replacement	Age, gender, residence matched	Lift vs no lift First job Lifting >10 kg Lifting >25 kg Lifting >50 kg Main job Lifting >10 kg Lifting >25 kg Lifting >50 kg	1.2 (0.6 to 2.4) 3.5 (1.3 to 9.7) —	Case-control	+ Strength: same design as Coggon <i>et al</i> and Lau <i>et al</i> . Weakness: few participants, especially among males. Few women reported heavy lifting. Case definition (THR, risk of selection bias). Retrospective exposure data (risk of recall bias)
Lau 2000 <sup>21</sup>	Cases: 30 males, 108 females hospitalised in Hong Kong with hip OA Controls: 90 males, 324 females from general practice over a 3-year period.	—	—	Interview Physical activity in the job in which they had work for the longest period before symptom	THR (71%) Waiting for surgery (10%) Radiographic grade 3–4 OA (19%)	Matched by gender and age	Lift of 10 kg vs no lift 1–10 times per week Males Females >10 times per week Males Females Lift of 50 kg vs no lift 1–10 times per week Males Females >10 times per week	1.9 (0.6 to 6.6) 0.7 (0.4 to 1.5) 5.3 (1.8 to 15.8) 0.7 (0.4 to 1.5) 8.5 (1.6 to 45.3) 2.9 (0.9 to 4.6)	Case-control	++ Strength: same design as Coggon <i>et al</i> and Yoshimura <i>et al</i> . Weakness: only very few Chinese subjects with THR, especially in men. Case definition (THR, risk of selection bias). Retrospective exposure data (risk of recall bias)
Flugsrud 2002 <sup>6</sup>	278 males; 391 females from the Norwegian Arthroplasty Register 24884 males, 24874 females from the Cardiovascular Screening Register 1981–3	Mean: 55	92%	Questionnaire Graduated physical activity "during the last year" in sedentary; walking; walking and lifting; heavy manual labour Follow-up length 9 years	THR	Age, height, marital status, smoking	Heavy lifting vs sedentary work Moderate Males Females Intermediate Males Females Intensive Males Females	9.6 (2.2 to 42.2) 2.9 (1.5 to 5.6) 1.5 (1.0 to 2.2) 1.1 (0.8 to 1.6) 1.7 (1.1 to 2.4) 1.4 (0.9 to 2.0)	Cohort	+++ Strength: large number of participants; high participation rate, prospective design. Weakness: Case definition (THR, risk of selection bias). Exposure measurement "physical activity during the 12 months" 1981–3 (risk of misclassification)
Jacobsen 2004 <sup>19</sup>	1533 males 2618 females from Copenhagen City Heart Study Hip OA cases 105 males 167 females	23–93 mean: 63–65	— 41% of the initial cohort selected for radiography	Questionnaire Physical activity since leaving school Mostly seated, standing/ walking, no lifting Lifting 1 ton Lifting 1–2 tons Lifting 2–5 tons Lifting >5 tons	Standing radiographs Case definition: JSN <2 mm	Age, BMI	Mostly seated, standing, walking, no lifting Lifting 1 tons Lifting 1–2 tons Lifting 2–5 tons Lifting <5 tons	No significant relations between type and duration of occupations (sedentary or involving repeated daily lifting) OR 0.7–1.0	Cohort	++ Strength: high number of participants; prospective design, well described exposure measurements. Weakness: data and statistical analysis are not shown

THR, total hip replacement; SHR, standardised hospitalisation ratio; BMI, body mass index (weight/height<sup>2</sup>); OA, osteoarthritis.  
+ Poor quality score 1–5; ++ medium quality score 6–10; +++ high quality score >10.

**Table 3** Hip osteoarthritis and occupations which involve heavy lifting: farming

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/matched by:	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++)	Strength/weakness
Typöb, 1985 <sup>24</sup>	Cases: 224 with hip OA (incl 90 farmers) Controls: 255 without hip OA (incl 70 farmers) All radiologically examined by veno-, angio-, uro-, colo-, or cystography, hips and abdomen	16–86, mean: 57	– Selected among 416 males and 503 females	Questionnaire Present occupation (job/radiological hip title)	Retrospective OA mild, moderate, severe	–	Farmers vs office workers Mild/moderate hip OA Severe hip OA	1.8 (0.97 to 3.34) 1.98 (1.01 to 3.87)	Case-control	+	Strength: none. Weakness: participation rate missing. No statistical testing. No adjustment for potential confounders. Only data for a part of the study population (n = 505)
Jacobsson 1987 <sup>25</sup>	85 males waiting for hip replacement 262 males who have had urography of whom 106 had hip OA	70–76	–	Questionnaire “working as a farmer”	Joint-space <3 mm or waiting for THR	Age, height, weight	Farm work vs others THR JSN	1.8 (1.12 to 3.02) 2.9 (1.2 to 7.37)	Case-control	+	Strength: none. Weakness: participation rate not described. Results only sparsely described. No statistical analyses
Theilin 1990 <sup>26</sup>	Cases: 98 males who have had THR at two hospitals in Sweden Controls: 201 random sample of Swedish males	55–70, mean 65	91%	Questionnaire Occupational history from age 15	THR	Age, injuries, tobacco, hospital	Farming vs no farming (<1 year) 1–10 years >10 years Drove tractor regularly Milking regularly	2.1 (1.1 to 4.3) 3.2 (1.8 to 5.5) 2.2 (1.3 to 3.9) 2.2 (1.3 to 3.7)	Case-control	++	Strength: high participation rate. Specified exposure. Weakness: relatively few cases (but narrow confidence intervals around the point estimates indicate adequate statistical power). Case definition (THR, risk of selection bias). Exposure definition (job title, risk of recall bias)
Vingård 1991 <sup>27</sup>	Male farmers: 35981 (479 OA) Female farmers: 1739 (12 OA) Controls: male: 91057 (320 OA); female: 24145 (112 OA)	Born 1905–45	Register-based	Physical demands classified by two occupational health physicians Same occupation in 1960 and 1970	Hospitalised in 1981–3 ICD-8 713.00 (hip OA)	Age, county	Farmers vs workers with low exposure to physical work demands Males Females	3.78 (2.1 to 4.4) 1.47 (0.86 to 2.9)	Cohort	++	Strength: design and material well described. High number of participants. Weakness: exposure (job title + light, medium, heavy exposure, risk of misclassification). Case definition (hospitalised because of hipOA, risk of selection bias)
Croft 1992 <sup>16</sup>	Cases: 245 males with hip OA severe: 19 OA Controls: 294 without hip OA farmers: 65 examined by urography	60–75	68%	Blinded interview Occupational history Job title classified by experienced persons <1.5 mm	Joint-space All <2.5 mm Severe	Age, sport, BMI	All OA cases (<2.5 mm) Severe cases (<1.5 mm) Farming vs <1 year 1–9 years ≥10 years	0.9 (0.6 to 1.4) 1.6 (0.8 to 3.1) 1.0 (0.3 to 3.1) 2.0 (0.9 to 4.4)	Case-control	+++	Strength: use of intravenous urograms (may avoid selection bias). JSN definition. Results and analysis well described. Weakness: exposure measurement (lift >25.4 kg, frequency not further explained, risk of misclassification)
Croft 1992 <sup>21</sup>	167 male farmers (28 OA) 71 (83) sedentary workers (20 OA) from general practice of 1231 males	60–76	60%	Questionnaire Interview Years as farmer at least 1 year	Radiological hip OA Joint space <1.5 mm or hip replacement	Age, height, weight, Heberden's nodes	Farmers 1–9 years ≥10 years	5.8 (1.1 to 31.5) 10.1 (2.2 to 45.9)	Cross-sectional	+++	Strength: selected from general practice, outcome measurement = JSN <1.5 mm. Weakness: low participation rate (60%). Over-representation of symptomatic farmers among the participants. No exclusion criteria described
Vingård 1992 <sup>28</sup>	Cases: 140 males, disability pension due to hip OA (17 farmers) Controls: 298 males from the general population	Born 1915–34	73%	Interview Occupational history Job title classified by experienced persons	Primary diagnosis of hip OA made by a physician	Age	Farmers and forest workers vs others	Relative risk 13.8 (4.0 to 48.1)	Case-control	++	Strength: description of design and material. Weakness: diagnosis from physician certificates (risk of misclassification). Subjects in heavy occupations may have an increased risk of getting disability pension (risk of selection bias). Exposure “high workload on hips” may not be especially related to heavy lifting (risk of misclassification)

Table 3 Continued

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by:	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++, +++): strength/weakness
Axmacher 1993 <sup>30</sup>	565 male farmers (45 OA) chosen among 16250 active farmers in the population in Malmö county 1250 from general population in another study used as controls (10 OA)	40–64	83%	Questionnaire Working as a farmer	Retrospective review of colon- and urography + non-weight-bearing joint space <4 mm	Age, gender	Farmers vs urban controls Males Females	12.0 (6.7 to 21.4) 2.3 (0.33 to 12.3)	Cohort	+ Strength: high number of farmers included. Weakness: results are compared with an earlier population study (use as controls). No statistical analysis. Non-weight-bearing radiographs (risk of non-differential misclassification). Case definition: JSN <4 mm (high risk of misclassification)
Jensen 1994 <sup>32</sup>	Male farmers: total 63990 (1131 hip OA) Total: 125159 males (9674 hip OA)	20–59 in 1981	Register-based	Job title in 1981	Hospitalised 1981–90 ICD-8 713.00 hip OA	Age	Farmers vs other occupations	SHR 273 258–7290	Cohort	++ Strength: high number of participants. Longitudinal design (may avoid information bias). Weakness: use of job title (risk of misclassification). Main job registered during 5-year periods (risk of misclassification of workers who only have worked a few years in their main job). Case definition: diagnostic code (risk of misclassification + risk of selection bias). Danish report, not peer-reviewed
Theilin 1997 <sup>33</sup>	Cases 216 with radiological hip OA (136 farmers) Controls: 479 randomly selected from a local population register. (185 farmers)	<70	86%	Questionnaire Worked as farmer at least 1 year Specified physical activity as a farmer	Retrospective readings of radiological hip OA joint space <3 mm	Age, gender, matched investigation of an association between hip OA sports, and smoking	Farming vs no farming 1–10 years 11–20 years 21–30 years >30 years Farm worker 1–10 years 11–20 years 21–30 years >30 years In agriculture Y/N Drive tractor Y/N Milk full-time Y/N Farmers vs others	1.58 (0.59 to 4.23) 2.81 (1.31 to 6.03) 7.35 (2.87 to 18.8) 3.82 (2.41 to 6.06) 1.88 (1.23 to 2.86) 2.53 (1.36 to 4.72) 4.41 (1.31 to 14.8) 6.43 (1.83 to 22.5) 2.70 (1.94 to 3.77) 2.05 (1.45 to 2.88) 2.88 (2.07 to 4.28) 2.5 (1.10 to 5.70)	Case-control	+++ Strength: well described design and material. High number of participants, high participation rate. Case definition: radiological findings in previously taken x rays may avoid some risk of selection bias. Specified exposure in farming. Weakness: farmers with heavy physical demands may seek hospital (and have x ray taken) more often than other subjects (risk of selection bias)
Coggon 1998 <sup>15</sup>	Cases: 210 males 401 females (19 farmers) waiting for hip replacement in three English districts Controls: 210 males, 401 females (8 farmers), random sample from general practice in same area	45–91, mean: 70	68% of cases, 58% of controls	Interview Occupation held for >1 year from school age Specified physical activity	Cases waiting for surgery	–	Farmers vs non fishermen or fishermen	2.5 (1.10 to 5.70)	Case-control	+ Strength: the same study also investigated heavy lifting (table 2). Weakness: only the numbers of farmers are mentioned. No analysis was made. Case definition: waiting list for THR (risk of selection bias). Participation rate relatively low Retrospective exposure measurement (risk of recall bias). No adjustment for confounders
Yoshimura 2000 <sup>34</sup>	Cases: (103 females 11 males) waiting for hip replacement in 2 districts in Japan (19 farmers or fishermen) Controls: 114 from the local population (17 farmers or fishermen)	>45, mean: 64	91%	Questionnaire: Occupation since leaving school; physical activity in their first and main job	Waiting for hip replacement	Matched by age, gender, residence	Farmers or fishermen vs non fishermen or fishermen	1.14 (0.57 to 2.33)	Case-control	+ Strength: same design as Coggon <i>et al</i> , 1998. The study also investigated the exposure heavy lifting. Weakness: few participants, especially few males (including farmers). Farmers and fishermen included in same group. Case definition (THR, risk of selection bias). Retrospective exposure data (risk of recall bias)

Table 3 Continued

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by:	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++, +++): strength/weakness
Tüchsen 2003 <sup>38</sup>	Total between 34068 (355 OA) and 63990 (458 OA) All actively working males in Denmark in 1981, 1986, 1991, 1994	20–59	Register-based	Occupation classified by occupation (job title) 1980, 1985, 1990, 1981–5, 1993	Hospitalised with hip OA (ICD-8 713.00 or ICD-10 M16)		Farmers vs others 1981–5 1986–90 1991–3 1994–9 Farm worker vs others	SHR 281 (259 to 304) 283 (269 to 298) 285 (268 to 302) 286 (262 to 313)	Cohort	+++ Strength: all hospital admissions due to hip OA during 20 years are included. Longitudinal design. Relatively young subjects (20–59 years), although the results showed increased risk of hip OA. Weakness: case definition (diagnostic code, risk of misclassification). No adjustment for age, BMI, traumas, or sports activities. Subjects not active in their trade were not included (risk of healthy worker effect)
Thelin 2004 <sup>35</sup>	Cases: 369 farmers with hip OA Controls: 389 farmers without hip pain From a Norwegian farmers' cooperative (30000 persons)	40–71	86%	Interview Work tasks as a farmer	Retrospective and renewed radiological hip OA <3 mm	Age, sex, residence-matched	Working >5 h/day in livestock housing Milking >40 cows daily Working at large farms >100 ha	114 (89 to 147) 138 (118 to 161) 160 (140 to 183) 189 (158 to 227) 13.3 (1.2 to 145) 4.5 (1.9 to 11.0) 0.14 (0.05 to 0.4)	Case-control	++ Strength: high number of farmer participants. Weakness: no control group of non-farmers. The study cannot conclude if there is a higher risk among farmers than non-farmers, but can investigate if there are risks within specific work tasks

THR, total hip replacement; SHR, standardised hospitalisation ratio; BMI, body mass index (weight/height<sup>2</sup>); OA, osteoarthritis.  
+, Poor quality score 1–5; ++, medium quality score 6–10; +++, high quality score >10.

exposure were divided into two equally large groups. This may lead to a risk of misclassification, and to a dilution of the results. 335 men, treated for myocardial infarction in the same hospitals, were also included to investigate possible recall bias in relation to the exposure measurement giving strength to the study. The differences between these men and men from the general population in relation to self-reported physical workload were very small and non-significant.

In a case-control study by Coggon *et al*<sup>15</sup> cases comprised 210 men and 401 women placed on a waiting list for THR and 611 controls selected from the general population matched by age, sex and general practice. The exposure was estimated by interviews and specified for each job. Hip OA was more common in men lifting burdens of 10 kg before the age of 30 (OR 2.3, 95% CI 1.2 to 4.2) adjusted for potential confounders. No association with heavy lifting was shown in women. The strengths of the study were the high number of participants, the specified work demands, the description of the study and the analysis. A weakness was the participation rate. Of those who were invited to participate 84% of cases and 58% of controls were included in the analysis. This might lead to bias if subjects with heavy lifting were under-represented among the controls or if subjects with hip OA reported their past exposure more completely than the controls (recall bias).

Croft *et al*<sup>16</sup> selected 60–75-year-old men who had had an outpatient intravenous urogram. 245 cases (THR or JSN <2.5 mm in at least one hip) were compared with 294 controls (JSN >3.5 mm). Exposure included lifetime occupational history with specified physical activity. Associations were found among severe cases (JSN <1.5 mm) and heavy lifting (OR 2.5 (95% CI 1.1 to 5.7)) (adjusted for age and hospital group). The strength of the study was the use of intravenous urogram. A bias which can be caused if cases with symptomatic hip disorders seek hospital treatment more often than the general population may be avoided by this selection method. The exposure measurement was defined as lift >25 kg. The frequency of lifting was not described. Many workers may lift 25 kg every day or week, and it is questionable if this criterion is sufficient to classify workers as subjects with heavy lifting. This may lead to a misclassification of non-cases as cases, most probably non-differential and thereby diluting the associations.

A cohort study by Flugsrud *et al*<sup>18</sup> used data from a cardiovascular screening including 50 034 participants matched with nine years of national data on THR. During follow-up, 672 people had a first THR because of primary hip OA. Exposure data were collected by questionnaire during cardiovascular screening. The question was: "During the last year, have you had: mostly sedentary work; moderate (mostly walking); intermediate (walking and lifting); intensive (heavy manual labour)". Intensive versus sedentary physical activity had an RR of 2.1 (95% CI 1.5 to 3.0) (men) and 2.1 (95% CI 1.3 to 3.3) (women). A large number of participants, high participation rate (92%) and the prospective design gave strength to the study. A weakness may be the exposure measurement. The information on physical work activity was collected during a 12-month period. This may not describe the physical activity during the whole work-life. The study included middle-age subjects. In general people have jobs with highest physical demands when young and still capable of lifting and carrying, and tend to change occupation to less heavy work as they get older. It seems likely that middle-aged workers with heavy work will also have had heavy work when younger. This may lead to a non-differential misclassification, and thereby dilute the associations.



### Dose-response relation

There seemed to be a dose-response relation with higher risks for the high exposure groups (OR range 1.5–12)<sup>18 25–28</sup> than for the medium exposed groups (OR range 1.1–4.1)<sup>18 25 26 28</sup> compared with the low exposure groups. In three studies,<sup>15 21 29</sup> there seems to be a dose-response relation with an increase in OR range of 1.2–1.9 for lifts of burdens >10 kg to OR range 1.5–2.7 for >25 kg and OR range 3.2–8.5 for >50 kg. The risk increased in relation to the amount lifted, with the frequency of lifting, and with the duration of lifted loads.

### Farming

Fourteen epidemiological studies focused on the relation between hip OA and farming (see table 3 for study details).

Thirteen studies showed a significant increased risk of hip OA among farmers with an OR range of 1.98–12.0, an RR of 13.8 (one study) or an SHR of 273–286 (two studies). Four studies<sup>16 31 33 36</sup> were assessed as being of high quality.

In the case-control study by Croft *et al*<sup>16</sup> (already described) of 245 cases and 294 controls, farmers who had >10 years of employment showed a higher risk of severe hip OA compared with farmers with <1 year of employment, OR 2.0 (95% CI 0.9 to 4.4). No difference was shown for the farmers in total, or for farmers with 1–9 years of employment (OR 1.0). The number of farmers with severe hip OA who have worked as farmers >1 year was relatively small (n = 19), which may explain the non-significant differences.

Croft *et al*<sup>31</sup> selected 1231 men, aged 60–76 years, from five rural practitioners at random. 890 (72%) answered questionnaires and 412 had worked as farmers or as office workers. Of those, 167 male farmers (cases) and 83 sedentary workers (controls) underwent x ray examination. The risk of hip OA was increased in farmers, especially in farmers employed >10 years (OR 9.3, 95% CI 1.9 to 44.5) (adjusted for age, height, weight and presence of Heberden's nodes). One of the strengths of the study is the selection of the study population which in the primary questionnaire did not focus on farming or hip disease. Therefore farmers had no reason to reply more often than men from other occupations. The greatest limitation is the relatively low participation rate and the over-representation of symptomatic farmers (78%) compared with asymptomatic farmers (54%). Even though there had been no further cases of hip OA among the non-responding farmers, it could not explain the big differences between the cases and controls.

In a case-control study by Thelin *et al*<sup>33</sup> 269 cases of radiologically diagnosed hip OA (JSN <3 mm) were compared with 538 randomly selected controls matched for age, gender and place of residence. Radiological examinations of the pelvis and hip joint in a two-year period were re-evaluated. Farmers showed an increasing risk at increasing number of years of farming compared to controls: 1–10 years, OR 1.58 (95% CI 0.59 to 4.23); 11–20 years, OR 2.81 (95% CI 1.31 to 6.03); and 21–30 years, OR 7.35 (95% CI 2.87 to 18.82). By using radiological findings on previously taken x rays as case definitions, selection bias may be avoided which gives strength to the study. On the other hand farmers with heavy physical demands may seek medical treatment and have x rays taken because of hip symptoms more often than the general population, leading to selection bias. There is also the possibility that farmers may be less likely to consult hospitals if they live far from hospitals and traditions in the trade.

Tüchsen *et al*<sup>36</sup> investigated four consecutive cohorts of all employed Danish men, aged 20–59 years with follow-up for five years in relation to hip OA. Exposure was classified by job title.

Self-employed farmers had a SHR for hip OA of 286 (262 to 313) (only age-adjusted) (1994–9). The risk of hip OA showed a 0.14% average annual increase in the predicted SHR in the period 1981–99. The strengths of the study were that all first hospital admissions due to hip OA in Denmark were included, and the longitudinal design. A limitation may occur if farmers seek medical care because of hip pain more often than the general population (selection bias). Another limitation is the definition of hip OA (use of a diagnostic code) which is not as valid as radiological JSN (risk of misclassification), which may dilute the risk. The mean age for developing hip OA is approximately 60–65 years. Although this study includes relatively young subjects aged 20–59 years there may be a possibility of underestimation of the real risk. Farmers who had left their earlier occupation in farming because of hip OA were not included (healthy worker effect). This will probably have diluted the calculated risk which despite this showed significant results.

### Construction work

The association between hip OA and construction work has been investigated in six studies. The study details are presented in table 4. Four of the six studies showed significant increased risk of hip OA with RR range of 1.66 to 7.0,<sup>26 27</sup> OR 3.3,<sup>16</sup> or SHR 151.<sup>32</sup> Only the earlier described case-control study by Croft *et al*<sup>16</sup> was evaluated as being of high quality. It showed significantly increased hip OA among workers with employment of 1–9 years (OR 3.3, 95% CI 1.2–9.2), but not for >10 years of employment (OR 0.5, 95% CI 0.1 to 2.3). The association between construction work and hip OA was not as strong as for farmers. This may be the result of inclusion of too few participants, and of misclassification of the workloads. There may be great differences between different kinds of construction work in relation to lifted burdens, in frequency and in weight.<sup>15 39</sup> The results may therefore be diluted by only using the job title “construction workers”.

### Climbing stairs or ladders

Five studies investigated the relation between climbing flights of stairs and hipOA (see table 5 for study details).

Three of the five studies showed significantly increased risk of hipOA with an OR range of 2.3 to 2.5<sup>15 21</sup> or RR of 2.1. Only the study by Croft *et al*<sup>16</sup> was evaluated as being of high quality (described in detail earlier). It used radiographic OA as inclusion criteria. The association in this study was not statistically significant.

### Best evidence synthesis

The studies were considered to be of high quality if the methodological quality score was >10.

Of 14 studies on the association between hip OA and heavy lifting, four reached the level of high quality.<sup>15 16 18 25</sup> All these studies showed significantly increased risk of hipOA with an RR range or OR range of 2.3 to 3.3. One had a cohort design<sup>18</sup> and three a case-control design. All studies showed a positive association, and for 12 of 14 studies the relation was significant. A number of studies with different design from several countries indicated an increasing risk of hip OA with an increasing degree of heavy lifting. All 14 studies showed a positive association. With regard to the various indices of heavy lifting, many studies showed a dose-response relation and it seemed that burdens should be at least 10–25 kg and the duration at least 10–20 years to give a clearly increased risk of hip OA. It is not possible to

**Table 4** Hip osteoarthritis and occupations which involve heavy lifting: construction work

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for: Matched by:	Comparisons	Results, OR (95% CI)	Design	Quality of the study (+, ++, +++)	Strength/weakness
Typpö, 1985 <sup>24</sup>	Cases: 224 hip OA (22 construction workers) Controls: 255 without hip OA (14 construction workers) within a population of 919	16–86, mean: 57	–	Present occupation: job title described in questionnaires	Retrospective radiological hip OA, mild, moderate, severe	–	Construction workers vs others	1.54 (0.8 to 2.98)	Case-control	+	Strength: none. Weakness: participation rate missing. No statistical testing. No adjustment for potential confounders. Only data for part of the study population (n = 505)
Vingård 1991 <sup>27</sup>	38095 construction workers (223 OA) Controls: 91057 Low exposure group: (320 OA)	Born 1905–45	Register-based	Job title Same occupation in 1960 and 1970	Hospitalised in 1981–3 ICD-8 713.00 (hipOA)	Age, county	Construction workers vs low exposure	RR 1.66 (1.32 to 1.87)	Cohort	++	Strength: design and material well described. High number of participants. Weakness: exposure classification (job title + exposure (light, medium, heavy), risk of misclassification). Case definition (hospitalised because of hipOA, risk of selection bias)
Vingård 1992 <sup>28</sup>	Cases: 140 males with disability pension due to hip OA (27 construction workers) Controls: 298 males from the general population	Born 1915–34	73%	Interview Occupational history Job title	Primary diagnosis made by a physician hip OA	Age	Construction workers vs controls	RR 7.0 (3.5 to 14.3)	Case-control	++	Strength: description of material and design. Weakness: diagnosis from physician certificates (risk of misclassification). Subjects in heavy occupations may have an increased risk of getting disability pension (risk of selection bias). Exposure to high workload on hips, not especially related to heavy-lifting (risk of misclassification)
Croft 1992 <sup>6</sup>	Cases: 245 with hipOA Controls: 294 without hip OA	60–75	68%	Blinded interview Occupational history Job title and duration	Joint-space All <2.5 mm Severe <1.5 mm	Age, sport, BMI	Employment in years vs <1 year Severe cases (<1.5 mm) 1–9 years ≥10 years	1.5 (0.7 to 3.4) 3.3 (1.2 to 9.2) 0.5 (0.1 to 2.3)	Case-control	+++	Strength: use of intravenous urograms avoiding risk of selection bias. Weakness: number of severe cases relatively small. Exposure measurement: lift >25.4 kg, frequency not further explained (risk of misclassification)
Jensen 1994 <sup>29</sup>	Male construction workers: total 3281 (hip OA 30) Total males: 1251590 (hip OA 9674)	20–59 in 1981	Register-based	Job title in 1981	Hospitalised 1981–90 ICD-8 713.00 hip OA	Age	Construction workers vs others (102 to 216)	SHR 151	Cohort	++	Strength: high number of participants. The design avoids information bias. Weakness: only job title included (risk of misclassification) Main job registered in 5-year periods (risk of misclassification of trade). Use of diagnostic code as case definition (risk of misclassification)
Coggon 1998 <sup>15</sup>	Cases: 210 males, 401 females (23 construction workers) waiting for hip replacement in three English districts. Controls: 210 males, 401 females (13 construction workers), random sample from general practice in same area	45–91, mean: 70	68%	Interview Occupation held for >1 year from school age Job title	Cases waiting for surgery	–	Construction workers	1.5 (0.8 to 2.8)	Case-control	+	Strength: description of the study. Results reported on construction work are only a small part of the study. Weakness: only numbers of construction workers mentioned. No analysis made. Case definition (waiting list for THR, risk of selection bias). Participation rate relatively low. Retrospective exposure measurement (risk of recall bias). No adjustment for confounders

THR, total hip replacement; SHR, standardised hospitalisation ratio; BMI, body mass index (weight/height<sup>2</sup>); OA, osteoarthritis.  
+, Poor quality score 1–5; ++, medium quality score 6–10; +++, high quality score >10.

**Table 5** Osteoarthritis of the hip and climbing stairs or ladders

Reference	Study population	Age (years)	Participation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/matched by:	Comparisons	Result, OR (95% CI)	Design	Quality of the study (+, ++, +++)	Strength/weakness
Croft 1992 <sup>6</sup>	Cases: 245 with hip OA Controls: 294 without hip OA (males)	60–75	68%	Blinded interview Occupational history Specified physical activity	All JSN <2.5 mm severe <1.5 mm examined by urography	Age, sport, BMI	Climbing ladders 1–19 years ≥20 years Climbing >30 stairs >1 year vs <1 year	Severe cases (<1.5 mm) 0.8 (0.3 to 1.8) 1.6 (0.7 to 3.8) 1.2 (0.6 to 2.5)	Case-control	+++	Strength: high number of participants. Well described design and material. Use of intravenous urograms avoids risk of selection bias. Occupational history with specification of different physical activities. Weakness: number of severe cases relatively small. Exposure measurement: lift >25.4 kg, frequency not explained (risk of misclassification)
Vinggaard 1997 <sup>28</sup>	Cases: 273 females with THR from 4 areas of Sweden Controls: 273 females, random sample from same areas	50–70	90%	Number of stairs during THR age 16–50 years Measured by interview	Waiting for THR	Age, BMI, sports activity, number of children, hormone therapy	Climbing stairs vs low exposure Medium High	Relative risk 1.3 (0.8 to 2.0) 2.1 (1.2 to 3.6)	Case-control	++	Strength: high participation rate. Occupational history by interview with specification of different physical activities. Adjustment for age, BMI, sports. Weakness: retrospective exposure data (risk of misclassification). Number of stairs only classified as low and high (risk of misclassification)
Coggon 1998 <sup>15</sup>	Cases: 210 males, 401 females waiting for THR in 3 English districts Controls: 210 males, 401 females from general practice	45–91, mean: 70	68% of cases, 58% of controls	Interview Occupation held for >1 year from school age Specified physical activity	Waiting for surgery	BMI, hip injury, Heberden's nodes Matched by age and gender	Climbing stairs >30 flights vs no climbing Males <10 years 10–19 years ≥20 years Females <10 years 10–19 years ≥20 years	1.3 (0.7 to 2.5) 2.3 (1.1 to 4.9) 1.8 (0.9 to 3.4)	Case-control	++	Strength: high number of participants. Well described study. Exposure collected by interviews with specification of different physical activities. Results adjusted. Weakness: Cases from a waiting list for THR (risk of selection bias). Participation rate relatively low Retrospective exposure measurement (risk of recall bias). Few women in high exposure group
Yoshimura 2000 <sup>9</sup>	Cases: 103 females, 11 males waiting for hip replacement in 2 districts in Japan Controls: 114 from the local population	>45, mean: 64	91%	Questionnaire Since leaving school, physical activity and main job	Waiting for surgery	Age, gender, residence matched	Climbing stairs >30 flights vs no climbing First job Main job	0.9 (0.4 to 2.0) 1.1 (0.5 to 2.1)	Case-control	++	Strength: same design as Coggon <i>et al</i> and Lau <i>et al</i> . Weakness: few males with OA. Few women reported heavy lifting (>50 kg). Case definition (THR, risk of selection bias). Retrospective exposure data (risk of recall bias). Small number of female participants
Lau, 2000 <sup>21</sup>	Cases: 30 males, 108 females hospitalised in Hong Kong with hip OA Controls: age and gender matched from general practice in the same region	–	–	Interview Job in which they had worked for the longest period before symptom	THR (71%) Waiting for surgery (10%) Radiographic grade 3–4 OA (19%)	Matched by gender and age	Climbing stairs >15 flights/day vs no climbing Males Females	8.7 (1.8 to 42.7) 2.5 (1.0 to 5.9)	Case-control	++	Strength: same design as Coggon <i>et al</i> and Yoshimura <i>et al</i> . Weakness: missing age and participation rate. Only a few subjects with THR, especially men. Case definition (THR, risk of selection bias). Retrospective exposure data (risk of recall bias)

THR, total hip replacement; SHR, standardised hospitalisation ratio; BMI, body mass index (weight/height<sup>2</sup>); OA, osteoarthritis.  
+, Poor quality score 1–5; ++, medium quality score 6–10; +++, high quality score >10.

define corresponding thresholds for lifting frequency. Information bias with respect to exposure in case-control studies and selection bias in studies based on subjects having surgery may have occurred. There may also be a risk of misclassification with respect to *x* ray diagnoses in some studies, but as such misclassification is independent of exposure status the resulting bias would be to attenuate any real associations. For these reasons the evidence of a causal association between heavy lifting and hip OA is considered as moderate to strong.

Thirteen of 14 studies showed a significant increased risk of hip OA among farmers with an OR range of 1.98 to 12.0, an RR of 13.8 (one study) or an SHR of 273 to 286 (two studies). Of these, four studies reached the level of high quality.<sup>16 31 33 36</sup> One had a cohort design<sup>36</sup> and three had a case-control design.<sup>16 31 33</sup> Three of the studies<sup>31 33 36</sup> showed significantly increased risk for hip OA with OR range of 5.8 to 7.35 and an SHR of 286.<sup>36</sup> A number of studies of different design from several countries indicate an increasing risk of hip OA with an increasing degree of years in farming. Information bias with respect to exposure may have occurred in case-control studies and selection bias in studies based on subjects having surgery. In relation to *x* ray diagnoses there is the same possibility for misclassification. For farmers the risk of hip OA seemed at least double after approximately 10 years of farming. For all these reasons the evidence of a causal association between farming >10 years and hip OA is considered as moderate to strong.

One high quality case-control study on construction workers was found.<sup>16</sup> It showed a significantly increased risk of hip OA among construction workers (1–9 years), but no association for ≥10 years. All studies showed a positive association, but only in two of the studies were the differences significant. Therefore the evidence for a relation is considered as limited.

Five studies investigated the relation between climbing stairs and hip OA.<sup>15 16 21 28 29</sup> Three of five studies showed significantly increased risk of hip OA with an OR range of 2.3 to 2.5<sup>15 21</sup> or RR of 2.1. Only the study by Croft *et al*<sup>16</sup> was evaluated as being of high quality. It used radiographic OA as inclusion criteria. The association in this study was not statistically significant. All were case-control studies. Information on exposure was collected retrospectively. In general, people with hip pain experience worse symptoms when climbing stairs. People in occupations which include climbing stairs may seek treatment earlier than other workers because of this pain. The case-control design may lead to a high risk of selection and recall bias in relation to stair-climbing. The evidence of a causal association is therefore considered to be insufficient. No studies investigated the relation between hip OA and climbing on ladders.

There is no information on the relation between hip OA and heavy lifting combined with kneeling or squatting. Thus, it is not clear if heavy lifting combined with kneeling/squatting is a stronger risk factor for hip OA than heavy lifting alone.

## DISCUSSION

### Study design and bias

This review may have some limitations including missing identification of relevant literature, publication bias of the literature, and the method of assessment of the quality of the studies. These limitations are described in detail elsewhere.<sup>15</sup>

Some of the problems with the included studies were related to few participants, use of different diagnostic criteria, and a poor description of the exposure.

Yoshimura *et al*<sup>29</sup> and Lau *et al*<sup>21</sup> carried out case-control studies in Japan and Hong Kong. The design was similar to the design used by Coggon *et al*.<sup>15</sup> Among Japanese and Chinese

subjects, and especially among male subjects, only a few have had THR, probably because of a lower prevalence of hip OA among Asians. The greatest limitation of these studies is the small number of included cases, especially of men. In spite of these factors, the results showed a positive association.

In studies such as Roach *et al*<sup>23</sup> the greatest limitation was a high exclusion rate, where only 48% of the primary study population was used in the final analysis.

In some of the studies the results were only adjusted for age, but not for earlier traumas, BMI or other relevant confounders.<sup>26 27 32 33 35 36</sup>

The development of OA normally takes many years. Pain-disabled people who work in heavy lifting occupations and cannot meet the requirements for managing their physical job tasks may leave their trade (healthy worker effect); this underestimates risk, if only working people are included.<sup>18 32</sup> Many of the studies in this field have also included people who were no longer working in their trade, thus avoiding the healthy worker effect.

### Measurement of outcome

In eight epidemiological studies<sup>16 19 20 30 31 33 35 40</sup> the diagnostic criterion for OA was JSN with the cut-off point ranging from 1.5–4 mm. There is no stringent definition of the cut-off point for JSN. Croft *et al*<sup>16</sup> evaluated two definitions of JSN—2.5 mm and 1.5 mm. Only the more stringent cut-off point was clearly associated with other criteria, pain, other radiographic changes and occupational risk factors. Jacobsen *et al*<sup>41</sup> showed an association between self-reported hip pain at a joint space width <2 mm.

When comparing different radiographic measures, minimal joint-space has in earlier studies been evaluated as the best radiological criterion of hip OA for use in epidemiological studies.<sup>42 43</sup>

THR or waiting for THR have been used as diagnostic criteria in six studies.<sup>15 18 21 25 29 34</sup> and four studies used a diagnostic code for hospitalisation or getting a disability pension because of hip OA,<sup>26 27 32 36</sup> which may lead to selection bias and an over-estimation of a true risk. However the high risk is also reported in surveys which have been conducted in the general population and in subjects whose OA was found coincidentally on *x* rays taken for other purposes (urography, venography, angiography).<sup>20 24</sup>

### Hip OA and gender

The association between hip OA and physical demands has been investigated for women in seven studies.<sup>15 17 18 21 27–29</sup> The association was only significant in two of the studies, with OR range of 2.1 to 2.9.<sup>18 21</sup> All studies revealed more significant results for men than for women. One of the explanations may be that many studies had too few female participants, and women traditionally work in different trades. It is not easy, therefore, to recruit a sufficient quantity of women with high exposure into the studies. The most plausible conclusion is that women are as susceptible to heavy work loads as men and that their risk of getting hip OA is equal to men if they have had the same exposure.

### Exposure measurement

The heterogeneous nature of the exposure in many occupations, the variation over time and the long duration from first exposure to the development of OA makes it difficult to obtain relevant measurements of exposure. For these studies, the

problems in relation to exposure measurements are the same as described by in a previous paper.<sup>15</sup>

### Pathophysiological mechanisms

The pathogenesis of hip OA in relation to workloads has not been clarified. The forces that act on the hip in the standing position are one third of the body weight. When lifting 12.5 kg the weight increases to three times body weight, and climbing stairs increases the load to 5–7 times body weight.<sup>25–44</sup> Obesity may increase the risk of OA by increasing the load on the weight-bearing joints<sup>45</sup> or by changing the hormone balance. The last theory is supported by the fact that obesity also may increase the risk for hand OA.

Another hypothesis is that subchondral micro-fractures may induce OA.<sup>45</sup> Micro-fractures may occur when the joint is in an extreme position or when physical workload exceeds a critical level.<sup>46</sup> These studies indicate a possible pathophysiological mechanism by a mechanical effect and/or micro-fractures during repeated physical workload.

The precise mechanism for an association between hip OA and farming remains a subject for study. Degeneration of the hip may be caused by long-term heavy physical labour in farming. The potential risk factors also include exposure to vibration from tractor driving. These theories could not be confirmed in a study by Thelin *et al*<sup>35</sup> where no relation between hip OA and “work as a farmer at a young age” or “tractor driving” could be confirmed. This may be explained by the fact that most farmers work with tractors and work at a young age and that these factors are something of a proxy for farming. In other studies it was confirmed that farmers have work involving lifting heavy loads, which may be the pathophysiological mechanism.<sup>15–16</sup>

### CONCLUSION

Twelve of 14 studies with different study designs showed a significantly increased risk of hip OA in subjects with heavy lifting and 13 of 14 studies showed a significantly increased risk of hip OA in farmers. The best-evidence synthesis of a causal relation is considered as moderate to strong for both heavy lifting and farming.

There are relatively few studies (five) investigating the association between climbing stairs and hip OA. Although the studies showed a positive association, only some studies showed a significant risk. All studies had the same design, and no studies showed a dose-response relation. The evidence of a causal relation was considered to be limited (stair climbing) and there was no evidence for climbing on ladders.

There is no information on the relation between hip OA and heavy lifting combined with kneeling or squatting. Thus, it is not clear if the combination is a stronger risk factor for hip OA than heavy lifting alone.

Future research should focus on well-designed prospective cohort studies with adequate follow-up time, high quality studies on the risk of different workers in construction industry (for example, concrete workers, carpenters, bricklayers with high lifting demands in their trades) and studies on the dose-response relation with quantification of the amount lifted, frequency of lifting, and duration and amount of stair climbing. Furthermore, investigations are needed on: (1) new methods for outcome measurements (for example, MRI); (2) on exposure measurements for epidemiological studies; and (3) studies clarifying the pathophysiological mechanism of the development of occupational hip OA.

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